

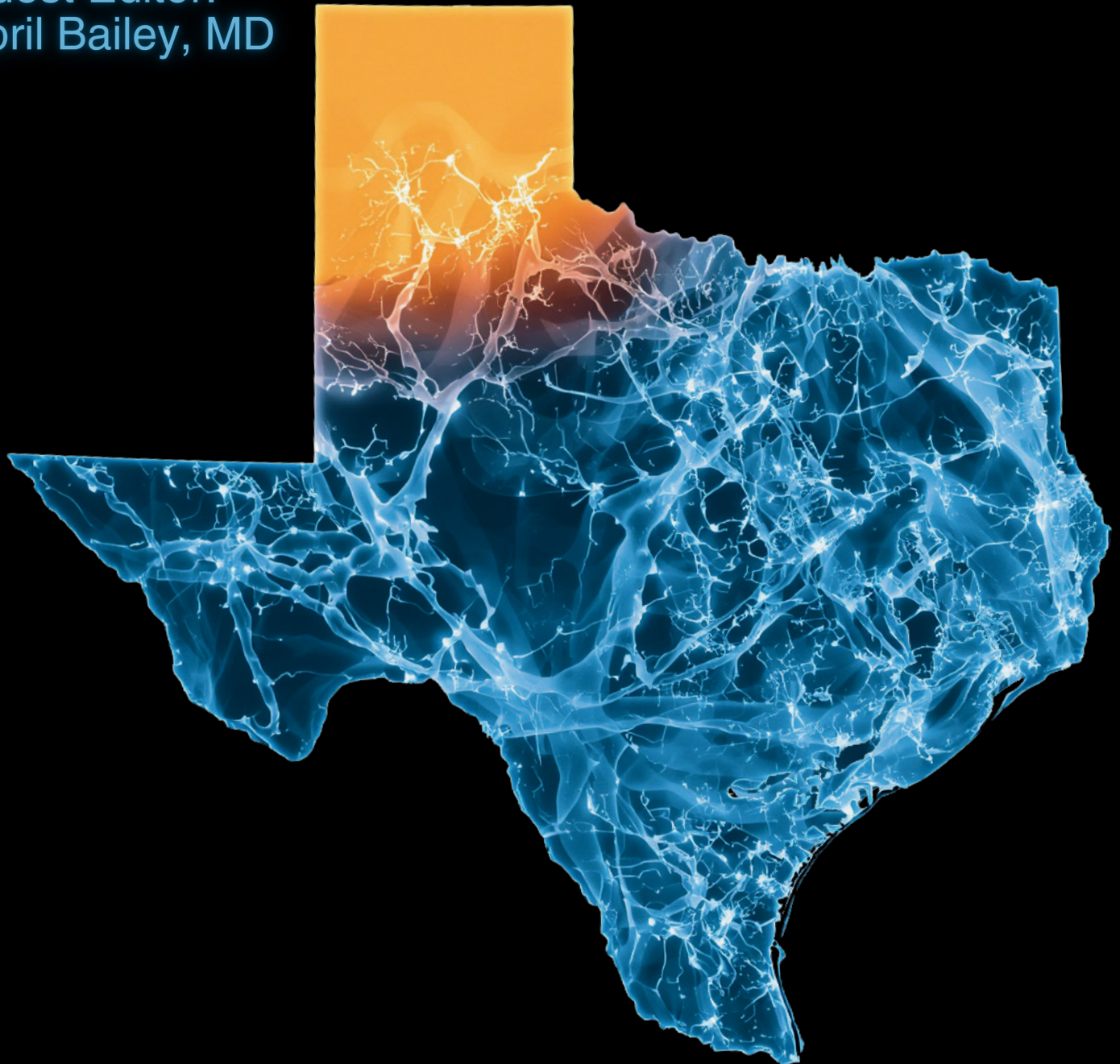
PANHANDLE HEALTH

A QUARTERLY PUBLICATION OF THE POTTER-RANDALL COUNTY MEDICAL SOCIETY

SUMMER 2026 | VOL 36 | NO.3

Medical Imaging and Interventional Radiology

Guest Editor:
April Bailey, MD



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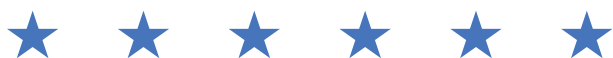
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PANHANDLE HEALTH

A Publication of the Potter-Randall County Medical Society

SUMMER 2026 | VOL 36 | NO. 3

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Executive Director's Message

by Katt Massey, Executive Director, Potter-Randall County Medical Society



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A quick survey that will help us
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with any questions.

Medical Imaging and Interventional Radiology offer a fascinating perspective on healthcare—one that allows us to look beyond what is visible on the surface and, quite literally, into the depths of ourselves.

I've often thought about a college friend who worked on an oil rig and lost his thumb in an accident. Imaging helped surgeons understand exactly what was left of that thumb and how best to treat it. Afterwards, my friend gave my roommate and me the photo of the skin graft. I remember more than once just staring at it, kind of in wonder. On the other end of the spectrum, I've received an MRI

or two for nothing more dramatic than a sprained ankle, which I got from just standing there, and my ankle gave out. Geeze!

Different stories, different circumstances, but the same remarkable technology helping guide care with precision and confidence.

Whether it's an X-ray, CT scan, MRI, ultrasound, or a minimally invasive image-guided procedure, physicians use these tools every day to uncover answers, support treatment decisions, and improve lives. It's extraordinary to think that medicine now allows us to explore the hidden

workings of the human body with such clarity, often revealing things we didn't know about ourselves.

As the world continues to advance in imaging and interventional radiology technology, we'll be able to learn even more about what lies within. After all, few fields in medicine can claim that they spend their days quite literally looking into the depths of the human body, and perhaps, in a small way, the depths of our soul.

Wild, in the best way!

Katt

PANHANDLE HEALTH

A PUBLICATION OF THE POTTER-RANDALL COUNTY MEDICAL SOCIETY

Editorial Policy and Information for Authors

Purpose: *Panhandle Health* strives to promote the health and welfare of the residents of Amarillo and The Texas Panhandle through the publication of practical informative papers on topics of general interest to most physicians while maintaining editorial integrity and newsworthiness.

Spectrum: The Journal seeks a wide range of review articles and original observations addressing clinical and non-clinical, social and public health, aspects as they relate to the advancement of the state of health in the Texas Panhandle. Pertinent letters to the editor, new submissions, and obituaries are accepted pending editorial review. The Editorial Board accepts or rejects submissions based on merit, appropriateness, and space availability.

Submission Process: Material should be emailed to katt.massey@prcms.com or mailed to Katt Massey, 1721 Hagy Blvd. Amarillo, Texas 79106. A recent photograph of the author (optional) and a curriculum vitae or biographical summary are also to be submitted.

Conflict of Interest: Authors must disclose any conflict of interest that may exist in relation to their submissions.

Journal Articles: Manuscripts should be double-spaced with ample margins. Text should be narrative with complete sentences and logical subheadings. The word count is generally 1200 to 1500 words. Review articles and original contributions should be accompanied by an abstract of no more than 150 words.

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References: References to scientific publications should be listed in numerical order at the end of the article with reference numbers placed in parentheses at appropriate points in text. The minimum acceptable data should include:

Journals: Authors, article title, journal, year volume, issues number, inclusive pages.

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Editing: Accepted manuscripts are edited in accordance with the *American Medical Association Manual of Style*.

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President's Message: How the Texas Medical Association Represents You.

by Ryan McKenna MD, MBA

It was my privilege to represent the Potter-Randall County Medical Society at TexMed, the annual meeting of the Texas Medical Association. It was my first time to attend TexMed, and, despite numerous briefings, I truly had no idea what I was about to experience. Luckily, I was accompanied by Rodney Young, MD, a seasoned Trustee of the TMA, and Nicole Lopez, MD, who currently sits on the Committee on Medical Education and Health Care Quality, both of whom have a tremendous amount of experience at the meeting. Also joining me were Jenna Lane, MD and Cesar Cardenas, MD, both of whom also had their first experience at the meeting. Katt Massey, PRCMS Executive Director, was able to attend as well and was invaluable helping guide us through the process.

Friday, I arrived at Corpus Christi's beautiful Hilliard Center, located on Shoreline Blvd with a beautiful ocean view. The first speaker was the outgoing TMA president, Jayesh Shah. He gave a rousing speech about the current state of affairs of the TMA, the challenges that we as physicians face every day, and the future that he hopes we will help shape. Dr. Shah is eloquent, inspirational, and has a keen sense of humor. He introduced the keynote speaker, someone whom I have long since admired: Bernard Harris, MD.

Dr. Harris is not only a physician but an accomplished astronaut as well, with two missions (and one spacewalk) under his belt. He earned his MD from Texas Tech, which filled me with pride to share my alma mater with him. He trained as a flight surgeon at Brooks Air Force Base and is currently engaged in multiple businesses and philanthropies. Dr. Harris spoke about his training and his experi-

ence traveling into space. He taught us about changes in human physiology with zero gravity and the medical experiments he performed in space. We learned how he conducted physical exams on other astronauts on board the shuttle and how much we have learned about medicine from our endeavors in space. Finally, he spoke about the recent Artemis missions and what the future holds for both space travel and medicine. Dr. Harris was one of the best keynote speakers I have ever heard, and I will remember his talk for quite some time.

After this, all of the candidates up for election were presented, and each gave a well-prepared speech to advocate for their candidacy. This was an opportunity to get to know the established leaders of the TMA and to get a glimpse at the future talent that will shape this organization.

Next, we had a financial wellness panel, moderated by our very own Rodney Young, MD. The panel featured financial planners, accountants, liability insurance agents, and other professionals. As I often speak about financial planning, I found this panel to be an excellent source of education about a topic that sometimes takes a back seat in medical education. The speakers presented great financial advice that is valuable for all levels of physicians--even those currently in medical school. At this point, I adjourned for the day, while Dr. Young and Dr. Lopez were busy in discussion with their various committees.

Saturday morning began with a two-hour discussion with a group I am affiliated with, the Lone Star Caucus. What is the Lone Star Caucus? As you can imagine, many of the voters on TMA policy

have interests specific to their geographic regions and cities. As it turns out, the medical societies of the most populous counties (such as Harris, Tarrant, Dallas, Bexar, and Travis) have so many physician representatives that their votes could sway major policy decisions in the TMA, sometimes leaving smaller counties (such as Potter and Randall counties) with a diminished voice in elections. The solution was the formation of the Lone Star Caucus, which is an organization representing every small county in Texas. The result is that we are one of the largest political groups present at the TMA, and the only one whose main interests are in small city and rural medicine.

At the Lone Star Caucus meeting, we discussed which candidates best reflect our visions and values. We also discussed, in detail, upcoming key policy votes and what they would mean for us. Together, we decided on the best use of our votes at the upcoming House of Delegates meeting. This process took about 2 hours. By the end of the meeting, we were all signed up for a GroupMe thread, which would be live for voting at the House of Delegates meeting. This gave us real-time information about Lone Star Caucus recommendations on votes that came up during the meeting.

Finally, the grand finale, the reason we were there--to make our voices heard and to represent the interests of the physicians of the Potter-Randall County medical society. This meeting was moderated by Speaker John Flores, MD and Vice Speaker Mark Casanova, MD. I must say that these two were incredibly charming, eloquent, and patient. They kept the meeting going and made sure that it was engaging. At this point, we began vot-

ing on the various candidates and TMA policy positions that will shape the TMA legislative agenda. These votes will provide a game plan for the TMA and for our political action committee as they attempt to influence our political leaders in the upcoming Texas Legislative Session. The policies range from our position on scope of practices laws, Stark laws, physician ownership of hospitals, maintenance of certification programs, and public health policies. While the individual committees presented their plans and recommendations, individual delegates used the GroupMe information from the Lone Star Caucus to help us to best represent our local physicians.

These votes were announced by the incoming TMA president, Bradford Holland, MD, who shared his vision for the future of medicine in Texas. His thoughts will be published soon, and I encourage every physician to read them, as they are exciting.

I am writing this today not only to explain the purpose of our trip, but also to encourage all physicians to be involved in this process. The meeting was not only important, but educational and fun. It was great to see how TMA policy is created and how our professional values are upheld. I would like to urge all PRCMS members to actively seek out ways to represent your and other physicians' interests. It is only when we stand together that we can make meaningful progress in the increasingly politicized world of medicine. If you are interested, please reach out to Katt Massey at the PRCMS, and we will find ways for everyone who is interested to help shape the future of Texas Medicine.

Our Next Issue Of *Panhandle Health*

Features:

Medical Education at Texas Tech in Amarillo

Guest Editor:
Cesar Cardenas, MD

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ELLIE GAZING AT THE GALVESTON NAVAL MUSEUM



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ON THE FRIDGE, AND JOIN US!

Alena Martin & Madeline Lennard

2026

JUNE 24TH: 7 PM

CELEBRATE DOCTORS DAY AT THE SOD POODLES GAME. HOSTED BY THE ALLIANCE AND SOCIETY.

JULY 16TH: 5 PM

FAMILY BBQ HOSTED AT THE CITADEL

SEP 12 : 6 PM

COUPLES SOCIAL AT LAKE TANGLEWOOD

SEP 29TH: 10 AM

TMAA CONNECT OVER COFFEE AND MORNING MAHJONG AT PALACE COFFEE IN WOLFLIN

OCT 15TH: 5:30 PM

POP-UP WINE NIGHT.

NOV 10TH :5:30 PM

MAHJONG GAME NIGHT.

DEC 12TH: 1 PM

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FAMILIES OF THE PANHANDLE

2027

JAN 27TH: 5:30 PM

MAHJONG NIGHT! INFORMATION TO FOLLOW

MARCH 5TH: 6PM

ANNUAL WINE DINNER AT AMARILLO CLUB

APRIL 1ST: 5:30PM

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MAY 4TH: 6PM

MAHJONG GAME NIGHT



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Guest Editorial

by April Bailey, MD

LIFE HAPPENS, AND SO DOES IMAGING.

The volumes of imaging done has grown significantly in my career, and, hopefully, the value it brings to the care of our patients has also grown to the same magnitude. At times, imaging is a second set of eyes to make sure everything is OK. At other times, we get to meet your patient on the worst day of their lives (even if from afar, from a dark reading room as a diagnostic radiologist, or from behind a surgical mask and a thick layer of lead as an interventionalist).

Diagnostic and Interventional Radiology (IR) are born of the same group of doctors using imaging to guide not only diagnosis but also minimally invasive procedures, through percutaneous and intravascular access. The specialization of radiologists through fellowships was already prevalent during my training. Subsequently, in 2012, Interventional Radiology was recognized as a distinct primary specialty (i.e., separate from diagnostic radiology), now with dedicated Integrated and Independent IR residencies. With this recognition, the sciences have flourished in both realms. Stroke and pulmonary thrombectomy, once available only in large centers, are now performed in areas like the Panhandle, with excellent outcomes and sufficient cases to remain proficient. Transjugular Intrahepatic Portosystemic Shunt (TIPS), vertebral kyphoplasty and Basivertebral Nerve Ablation (BVNA) can be provided without travel to large academic centers--with huge benefits to the patients needing them.

The expectations for diagnostic radiologists have also grown exponentially, not only in the breadth of studies we read and nuclear treatments we provide, but also

in the degree of detail and complexity expected from our reports and the necessary understanding of ever-changing surgical procedures, in order for us to truly provide a service to the ordering provider and the patient.

Our practices must evolve, and we are excited for the potential time saving that artificial intelligence (AI) will bring. Perhaps AI will reduce the time we need to touch every image. Perhaps its data will give a concise overview that is easier to understand than a wordy report. Maybe it is a second set of eyes for the radiologist--or maybe the only eyes on some exams. Still, at the helm will be a local radiologist, making sure everything is running correctly and overriding when the AI is incorrect (as it frequently is, with what is available today).

Figuring out the balance of human and computer, the legal ramifications not only for doctors and patients but systems too, and simply deciphering which AI works and which does not, may be the future role of the radiologist. The truth is we need AI to keep up, as the volume of exams has outpaced the number of radiologists graduating, working, and not-retiring!

As always, your local radiologist will be ever present, to take your call when the study needs another

look, the tumor wasn't measured the same way, or the diagnosis is too exotic. We are happy to see your faces in our dark little rooms to study the images together. We are always there if the ordering physician becomes the patient, or if their loved-one is sick. Not to be nostalgic, but that opportunity to be the doctor's doctor is what drew many of us to radiology in the first place.

April Bailey, MD is a radiologist with High Plains Radiological Association. She has enjoyed being with the group since 2017 and looks forward to caring for people in the Texas panhandle for many years to come. Her fellowship training is in women's imaging (obstetric and gynecologic care) as well as body MRI.

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From Shadows to Suction Devices: The Evolution of Stroke Imaging and Intervention

by John Andrew, MD

For much of modern medical history, stroke was a diagnosis made at the bedside and confirmed—if at all—after the fact. Therapeutic nihilism prevailed. Physicians could localize deficits with remarkable clinical precision, but lacked the tools to visualize cerebral pathology in real time or to intervene meaningfully. Over the past five decades, however, the convergence of advanced imaging and endovascular innovation has transformed stroke from a largely untreatable condition into one of the most dynamic and time-sensitive domains in medicine.

THE PRE-IMAGING ERA: CLINICAL LOCALIZATION WITHOUT VISUALIZATION

Before the advent of cross-sectional imaging, stroke diagnosis relied entirely on neurologic examination. Distinguishing ischemic from hemorrhagic stroke was often speculative, and treatment was largely supportive. Early angiography, developed in the mid-20th century, provided the first glimpse of cerebral vasculature, but it was invasive, time-consuming, and poorly suited for emergent triage.

A PERSONAL GLIMPSE: MATCH DAY AND EARLY PERCEPTIONS OF RADIOLOGY

When I matched into radiology in 1981, the field carried a very different reputation than it does today. A common saying at the time was, “It’s 4 p.m. You can’t find a radiologist in the hospital—they’re all on the golf course.” It reflected a perception of radiology as a quieter specialty, somewhat removed from acute patient care. During my first year of residency, someone told me, “It’s just simple pattern recognition, John. A trained monkey could do this.” There were hundreds of patterns, and I could recognize...five.

Except in that glorious October lunch and learn conference for PG1s when (with a couple of lucky guesses) I got seven!! YESSSS!!! By year 3, I could spot a subtle pneumothorax. Sometimes. Halfway through Neuro fellowship, I felt the “characteristic pop” of the needle traversing the dura on a lumbar puncture. Hallelujah!! Around that same time, nuclear magnetic resonance imaging began to emerge, and some non-radiologists joked that NMR stood for “No More Radiologists.” Ironically, the opposite proved true. As NMR evolved into MRI, it became one of the most powerful diagnostic tools in medicine and helped drive an explosion in the scope and complexity of radiology. History suggests that transformative technologies tend to expand the field rather than eliminate it, though exactly how AI will reshape our role remains to be seen.

THE CT REVOLUTION: MAKING STROKE VISIBLE

The introduction of computed tomography in the 1970s marked the first major inflection point. Godfrey Hounsfield, working from the premise that “one view is no view,” developed a scanner capable of acquiring x-ray data from 360 degrees around the patient using a doughnut-shaped gantry, sliding table, and computerized reconstruction. Suddenly, imaging expanded from the handful of densities visible on plain radiographs—air, fat, water, bone, and metal—to thousands of shades measured in ...wait for it... Hounsfield units. For the first time, we could reliably distinguish normal brain from hemorrhage and were able to visualize soft tissues and organs throughout the body. CAT scan, baby! Noncontrast CT rapidly became the cornerstone of acute stroke evaluation because of its ability to exclude intracranial hemorrhage. This single capability fundamentally altered

management by enabling safer consideration of reperfusion therapies. While early CT was insensitive to hyperacute ischemia, the ability to rule out hemorrhage paved the way for thrombolytic therapy. By the 1990s, the approval of intravenous alteplase (tPA) established the first evidence-based acute stroke treatment. The phrase “time is brain” became embedded in clinical culture, emphasizing rapid imaging and decision-making. One important limitation of IV thrombolytics, however, was the tight treatment window—usually 3 to 4.5 hours from “last known normal.” Patients with “wake-up” strokes were rarely candidates for IV thrombolytics.

MRI AND THE RISE OF TISSUE-BASED DIAGNOSIS

Magnetic resonance imaging introduced a new level of sensitivity, particularly with diffusion-weighted imaging, which could detect ischemia within minutes of onset. This marked a transition from purely time-based criteria toward tissue-based diagnosis. Advanced MRI sequences, including perfusion imaging, allowed clinicians to distinguish irreversibly infarcted core from salvageable penumbra. This concept would later underpin extended treatment windows for both thrombolysis and thrombectomy. Although CT remained the workhorse because of speed and availability, MRI increasingly shaped clinical decision-making, particularly in ambiguous or “wake-up” strokes.

CT ANGIOGRAPHY AND PERFUSION: IMAGING THE OCCLUSION

The next evolution was not simply better imaging, but more targeted imaging. CT angiography enabled rapid identification of large vessel occlusions, while CT

perfusion provided physiologic data about cerebral blood flow and tissue viability. These modalities allowed clinicians to move beyond the binary question of hemorrhage versus no hemorrhage toward a more nuanced understanding: Is there a treatable occlusion? Is there salvageable brain? This shift was critical in selecting patients for endovascular therapy, particularly in extended time windows. Imaging became not just diagnostic, but decisional—guiding intervention and predicting potential benefit.

EARLY ENDOVASCULAR THERAPY: PROMISE AND LIMITATIONS

Endovascular approaches to stroke began as early as the 1980s, when intra-arterial thrombolysis was first reported. Early pioneers demonstrated that direct vascular access could restore perfusion in otherwise devastating strokes. The 1990s and early 2000s saw the development of mechanical thrombectomy devices such as the MERCI retriever and early aspiration systems. Although these devices achieved recanalization in some patients, functional outcomes remained inconsistent, and early randomized trials failed to show clear clinical benefit. These limitations were due in part to patient selection. Without advanced imaging, many patients underwent intervention despite large established infarcts or poor collateral circulation.

2015: THE PIVOTAL TURNING POINT

The year 2015 represents a watershed moment in stroke care. Trials such as MR CLEAN, ESCAPE, EXTEND-IA, SWIFT PRIME, and REVASCAT demonstrated unequivocal benefit of mechanical thrombectomy in patients with anterior circulation large vessel occlusion. What changed was not just device technology, but imaging selection. These trials leveraged CTA and perfusion imaging to identify patients with small infarct cores and viable penumbra. The result was a dramatic improvement in functional outcomes and a redefinition of the standard of care. Mechanical thrombectomy rap-

idly became the gold standard for eligible patients, fundamentally altering stroke systems of care.

THE MODERN ERA: SPEED, SYSTEMS, AND EXPANDED WINDOWS

Today, stroke imaging and intervention operate within highly coordinated system designed to minimize time to reperfusion. The modern workflow—noncontrast CT, CTA, and selective perfusion imaging—can often be completed within minutes of arrival. Importantly, imaging has enabled expansion beyond traditional treatment windows. Carefully selected patients may benefit from thrombectomy up to 24 hours from “last known well”, provided imaging demonstrates a favorable mismatch between infarct core and penumbra. This represents a fundamental shift: time remains critical, but tissue viability now drives decision-making. Telestroke systems have further expanded access to acute neurologic expertise in rural hospitals, allowing rapid imaging review and transfer coordination across regions such as the Texas Panhandle.

ONGOING EVOLUTION: SIMPLIFICATION AND INNOVATION

Interestingly, the field continues to evolve toward both greater sophistication and strategic simplification. While perfusion imaging was once central to patient selection, recent data suggest that, in many cases, rapid identification of large vessel occlusion with favorable noncontrast CT findings may suffice. At the same time, advances in imaging technology—including artificial intelligence and automated perfusion analysis—are streamlining workflows and improving diagnostic consistency. Machine learning models are increasingly being developed to predict treatment response and guide decision-making. Modern suction devices and aspiration systems now achieve high rates of recanalization with improved safety profiles, and procedural strategies continue to evolve.

THE ROLE OF THE COMMUNITY PHYSICIAN

For primary care physicians, particularly in regions such as the Texas Panhandle, these advances underscore the importance of early recognition and rapid triage. Stroke systems depend on front-line providers to activate pathways that enable timely imaging and transfer when necessary. Understanding the capabilities and limitations of modern imaging is essential. A noncontrast CT that excludes hemorrhage is only the beginning; CTA can identify patients who may benefit from thrombectomy even in extended windows. A strategy of giving an IV thrombolytic in the ED when appropriate and then transferring the patient for more advanced studies and possible thrombectomy can be an important bridging strategy. Early coordination with stroke centers can help with these decisions and can dramatically alter patient outcomes.

CONCLUSION

Recently, I was sitting in a donut shop when a waitress I see often asked, “Mister, do you like your job?” I told her I did very much. “What do you do?” she asked. “I read x-rays,” I said. “Sometimes I work with my hands.” She looked puzzled. “What, to turn the pages while you’re reading?” “No. I read the x-rays to find the problem. Then I work with my hands to try to fix it. Kind of like a plumber. If pipes leak, I try to plug the leak. If arteries are blocked, I try to remove the obstruction and restore flow.” She asked, “Is it fun?” I thought about it for a moment. “The good days,” I told her, “are like walking on air. The bad days will break your heart.”

Dr. John Andrew was born in Paducah, Texas and grew up in Houston, where his mother served on the pediatric faculty at Baylor College of Medicine. John has practiced radiology in Amarillo for 39 years. He is the father of two daughters who currently practice in Amarillo, Ruth Grant MD (psychiatry) and Rachel Weinheimer MD (colorectal surgery).



Basivertebral nerve ablation (BVNA)

A New Tool in the Management of Vertebrogenic Chronic Low Back Pain (CLBP)

by Samir Hadi, MD, Neurointerventional and Interventional Radiologist

Low back pain is the leading global contributor to years lived with disability. Roughly 52 million Americans and 619 million people worldwide are affected. Chronic low back pain (CLBP) is associated with depression, anxiety, sleep disturbances, opioid use, and major healthcare expenditures. Despite our advances in many fields of medicine, about 90% of low back pain is considered “nonspecific”, meaning that many patients lack a precise diagnosis, leading often to ineffective or excessive treatment.

Treatment of CLBP is often frustrating for patient and provider alike. Most patients with vertebrogenic pain have not responded (or have had unsatisfactory pain relief) with lifestyle modifications, physical therapy, and anti-inflammatory drug treatment. Many have had spinal injections, facet radiofrequency ablation, neurostimulation, and even spinal surgery. New treatment approaches are clearly needed for these patients.

The central concept of this overview is that, in a subset of these patients, chronic axial low back pain originates from the vertebral endplates and is transmitted via the nerve (the basivertebral nerve) that innervates each vertebral body. This is termed “vertebrogenic” back pain. And I will show that, in a significant proportion of these patients, destruction of this nerve within the vertebral body itself by radiofrequency ablation can lead to meaningful and long-lasting pain relief.

WHAT IS VERTEBROGENIC CLBP?

Only a subset of patients with CLBP are likely to have vertebrogenic pain. These patients commonly have midline (axial) LBP. That is to say, radicular symptoms are minimal, and the epicenter of the

pain is in the midline, rather than in the paraspinal region. Typically, vertebrogenic pain is worse with sitting or forward flexion (bending forward). Importantly, these clinical features are associated with so-called Modic Type 1 and 2 changes on spinal MRI.

Modic changes are abnormalities in the endplates of the vertebral bodies themselves (rather than the disk or paraspinal structures). First described by Modic and colleagues at the Cleveland Clinic in the 1980s (1), Modic Type 1 changes are associated with inflammation and edema at the vertebral endplate; these changes show up as areas of low T1 and high T2 signal intensity, particularly at the margins of the endplate. Modic Type 2 changes are associated with fatty changes in these same areas, i.e., high T1 signal intensity but, this time, iso- to high-signal intensity on T2 imaging as well. Both Modic Types are strongly associated with CLBP (4-fold higher prevalence of Modic changes in patients with CLBP). This suggests that the vertebral body itself may be the source of the pain. Modic Type 3 changes (bony sclerosis) are not associated with CLBP.

WHAT IS THE INNERVATION OF THE VERTEBRAL BODY?

Each vertebral body is innervated by a basivertebral nerve (BVN), a branch of the spinovertebral nerve. Each basivertebral nerve enters the vertebral body through a posterior foramen at the mid-vertebral body level (i.e., not at the disc level); this tiny opening and its distal channel can sometimes be identified on MRI imaging. The BVN carries nociceptive signals from the entire vertebral body, including both endplates (which is where the Modic changes are found).

This small nerve is composed of non-myelinated fibers, which may be important in the durability of response that many patients have to BVNA. Anatomical studies have indicated that the BVN does not regrow after RFA (as opposed to the larger, myelinated fibers outside the vertebral body). This provides the anatomic rationale for intraosseous nerve ablation (i.e., BVNA).

HOW IS BVNA PERFORMED?

It is important first to re-emphasize that patients best suited for BVNA represent a select group. As mentioned, they have chronic (>6 months) low back pain with primarily vertebrogenic features (predominantly axial pain, minimal radicular features, and flexion-provoked symptoms) plus Modic Type 1 or 2 changes on MR imaging. Eligible patients should not have evidence of large disc herniation, compression fractures, dynamic spondylolisthesis, or severe spinal stenosis. BVNA targets the lumbosacral spine, primarily the L3-S1 vertebral bodies; so the axial pain should be in this area. It is estimated that this subset may represent 5-10% of patients with CLBP.

BVNA is contraindicated in certain subgroups, including patients who are skeletally immature or who are pregnant. Active infection should not be present, and the ablation zone should not be too close to surrounding sensitive structures. Finally, BVNA should not be performed in patients with severe cardiac or pulmonary compromise or in those with pacemakers or defibrillators.

BVNA is an outpatient procedure that is performed under conscious sedation. The radiofrequency probe is advanced under fluoroscopic guidance, using a

transpedicular approach, until the vertebral body is entered. Placement of the probe is crucial. The ablation zone extends about 5 mm from the probe tip, with areas over 10 mm from the tip considered safe; therefore, we keep the probe at least 10 mm from the posterior vertebral wall (and hence from the spinal canal). The posterior 30-50% of the vertebral body is targeted. We position the probe so that it is 30-50% anterior to the posterior wall and about 40% below the superior endplate.

Once the probe is in place, we deliver the radiofrequency pulse; the procedure usually takes 20-30 minutes for each level. Since two vertebral endplates are typically involved in Modic changes (the inferior endplate of the upper vertebra and the superior plate of the lower one), each procedure requires that 2 contiguous vertebrae be denervated. If more than one disc level is involved, we can usually treat both disc levels (up to a maximum of 4) at the same time.

After the procedure, the patient is monitored in the recovery room with analgesia as needed. Once pain control is adequate and the patient is able to ambulate, they are discharged to outpatient follow-up, usually in 2 weeks and again in 8 weeks, with activity level defined by physical therapy.

WHAT IS THE EVIDENCE THAT BVNA IS EFFECTIVE?

Two major studies have provided the basis for FDA approval of BVNA. The first was the SMART trial (1), which randomized 225 patients to BVNA vs. a sham procedure. Patients were evaluated using both a subjective pain scale and the Oswestry Disability Index (ODI), a commonly used measure of functional status. At 3 months, the ODI decreased (improved) by 20.5 points in the BVNA group (vs. 15.2 points in the sham group). At 3, 6, and 12 months, subjective pain scores showed significant improvements in the BVNA group as well. Importantly, follow-up for up to 5 years has shown that

these results are durable. Many patients achieve 50-75% reduction in pain; some even have complete resolution of their previously-refractory pain.

The second important trial was the INTRACEPT trial (2), which randomized 140 patients either to BVNA or to standard care. 3-month results showed statistically improvement in both subjective pain score and ODI (25.3 point improvement in the BVNA group vs only 4.4 in the control group). The trial was terminated by an independent data monitoring group because of the dramatic improvement in the treated cohort. The original cohort has continued to show significant improvement with no device-related events for up to 2 years.

Further observational studies have confirmed and enlarged upon these results. They have confirmed favorable outcomes in terms of subjective pain and objective functional results. Long-term safety has been confirmed (e.g., no increase in vertebral compression fractures). Opioid use is significantly reduced (40-60% decrease) in the BVNA patients. BVNA was found to be highly cost-effective, with improvements in healthcare expenditures, (including lumbar surgeries) at 5 years. It is important to emphasize that this degree of improvement may not be seen if strict qualifications for BVNA (as listed above) are not observed.

In summary, BVNA appears to offer significant pain relief and functional improvement to a subset of patients with chronic low back pain. These patients have a clinical presentation consistent with vertebrogenic pain (axial pain, worse with forward flexion, no radicular features) and Modic Type 1 and 2 changes on MR imaging. One-time ablation of the pain fibers (the basivertebral nerve) within the vertebral body by radiofrequency ablation is designed to interrupt this pain pathway. Again, it is important to emphasize that the BVN transmits pain from the entire vertebral body, including the endplates (which is where the Modic

changes occur). Controlled studies have demonstrated meaningful and durable improvements in pain in functional status in BVNA-treated patients. To achieve these results, proper patient selection has proven to be essential. Nonetheless, with proper patient selection and careful attention to technical detail, BVNA provides an important addition to our treatment options to help improve the lives of these suffering but often difficult-to-manage patients.

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Dr. Samir Hadi is a board-certified radiologist, with fellowship training in neurointerventional and body interventional radiology. He has a particular interest in neuroendovascular and spine procedures. Dr. Hadi is proud to say that Amarillo has been his home for the past year. His chief source of joy and happiness is his family, but he also enjoys working on old cars and his Indian Chieftain motorcycle.



Pulmonary Embolism and the Role of Interventional Radiology (IR) in its Treatment

by Nilay V. Mehta, MD

Venous thromboembolism (VTE) affects an estimated 900,000 people in the United States every year. The CDC estimates that VTE kills 60,000-100,000 Americans every year. As a diagnostic category, VTE encompasses both deep vein thrombosis (DVT) and pulmonary embolism (PE). The most common cause of pulmonary embolus is dislodgement and subsequent embolization of a clot from DVT in the lower extremities to the pulmonary arteries (1). Although IRs are sometimes involved in the treatment of DVT as well, I will focus on the management of PE in this article.

DIAGNOSIS OF PULMONARY EMBOLISM

The most common signs and symptoms of PE are shortness of breath, chest pain, tachycardia, palpitations, and cough/hemoptysis. Our Emergency Medicine colleagues are immensely important as the first line of diagnosis. This involves rapid identification of these signs and symptoms and obtaining necessary lab work and imaging studies. Important labs for risk stratification in PE include D-dimer, troponin, and BNP.

Computed tomography pulmonary angiography (CTPA) is the current imaging standard for the diagnosis of PE. It is incredibly sensitive and specific for identifying both clot within the pulmonary arteries and secondary effects of this clot on the lungs and heart. The presence or absence of infarct patterns in the lungs can indicate the acuity or chronicity of the emboli. Right ventricular: left ventricular ratio (RV:LV ratio) measurements help assess the effect of the PE on the heart by indicating evidence of right heart strain. These secondary effects are important in determining the best course of action for treatment. Additionally, CTPA can be useful in identifying other sources of the

patient's symptoms when PE is not found (pneumonia, heart failure, aortic syndromes, etc.).

STRATIFYING RISK AND TREATMENT MODALITIES FOR PATIENTS WITH PE

A coalition of medical societies (including the Society of Interventional Radiology, American Heart Association, and American College of Emergency Physicians) recently released updated guidelines for the evaluation and treatment of PE. While those of us in the field are still digesting some of the finer points, the biggest change is the emphasis on stratifying clinical presentations of

• B = Symptomatic PE with low clinical severity score (e.g., PESI class I-II, sPESI=0, Hestia=0)

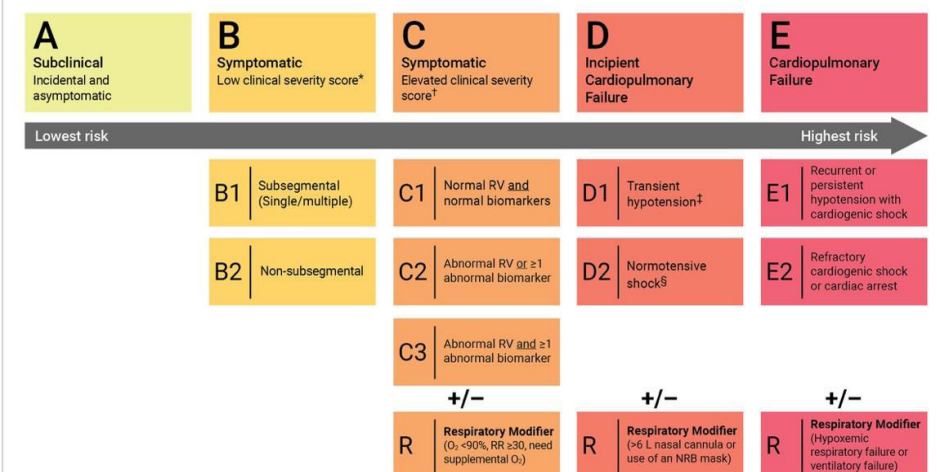
• C = Symptomatic PE with elevated clinical severity score (e.g., PESI class III-V, sPESI ≥ 1 , Hestia ≥ 1)

• D = Incipient cardiopulmonary failure (e.g., normotensive shock)

• E = Cardiopulmonary failure (PESI= Pulmonary Embolism Severity Index)

And what would a consensus statement about categories be without sub-categories? They are included below for your reference.

AHA/ACC Acute PE Clinical Categories



2026 Adults With Acute Pulmonary Embolism
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patients with PE. Previous stratification guidelines used terms such as “sub-massive” or “massive” to guide treatment, while a slightly more recent version utilized “risk” (low, intermediate, and high) for the same purpose (4). The most recent suggestion is as follows (2):

• A = Subclinical – incidental and asymptomatic

PE TREATMENT

Treatment for PE has evolved significantly over the last 150 years (3). Anticoagulation remains the mainstay of medical management and prevention of VTE. Anticoagulation is still recommended for patients in Category A or B. For higher risk or unstable patients, sur-

gical embolectomy was the first intervention that was studied. Modern iterations of surgical embolectomy require thoracotomy, cardiopulmonary bypass, and arteriotomy for blood clot removal. The morbidity and mortality of open surgery have improved over time, but they remain high.

Systemic thrombolysis with tPA evolved as a treatment in patients with hemodynamic compromise and is still utilized today in certain settings. However, it carries the risk of major bleeding and is not indicated in many patient populations who tend to suffer from PE (recent surgery, history of cancer, recent stroke, etc.). For this reason, systemic thrombolysis is reserved for patients with immediate hemodynamic collapse who may not be able to be transported for other diagnostic or treatment modalities.

Interventional radiology has been on the forefront of innovation in minimally invasive percutaneous methods for both diagnosis and treatment of many different vascular and solid organ diseases. This certainly holds true in the realm of PE treatment. The newest guidelines now recommend consideration of IR for PE Categories C through E—that is to say, for patients presenting with high-risk history (e.g., age>80, cancer, chronic cardiopulmonary disease) or clinical features (e.g., HR>110, SBP<100, O₂ saturation<90) according to standard risk assessment tools.

IRs treat PE in minimally invasive fashion by accessing the common femoral (usually) or internal jugular veins. They then navigate these veins back to and through the heart to access the pulmonary arteries. Based on the technology and data of the era, this is where the modalities have evolved and diverged.

The two primary methods for treatment of clot within the pulmonary arteries have evolved over the last 20 years:

- Low dose local thrombolysis, also known as catheter directed thrombolysis (CDT)

- Thrombectomy, either mechanical or aspiration.

CATHETER DIRECTED THROMBOLYSIS

In CDT, the IR accesses the pulmonary arteries as described above. Catheters (5 to 8 French) with multiple side-holes are advanced into the main pulmonary artery trunk and extend into the right and left pulmonary arteries. The catheters are secured in place. Thrombolytics (usually tPA) are then slowly infused into each of the catheters for varying durations depending on institutional practices and current literature, with the average time of infusion ranging from 12 to 24 hours. Since thrombolytics are utilized, the patient is observed in the ICU for the duration of the infusion protocol. At completion of the infusion, the physician may choose to do a follow-up angiogram to assess for resolution of thrombus or may simply remove the catheters.

In 2014, the Ekos catheter was approved for use for the treatment of PE with ultrasound-assisted thrombolysis. Ekos catheters come equipped with small ultrasound transducers within the catheters that, when connected to a generator, emit low wavelength ultrasound pulses during the infusion. The ultrasound waves unwind fibrin strands within the clot to make it more permeable, so that tPA is able to infuse more deeply within the clot. In theory, this leads to better clot dissolution and clearance. After the introduction of the Ekos catheter, several studies have recommended decreased tPA infusion duration and dosage, citing non-inferiority of the lowered dose versus longer lysis protocols.

Both of these are pharmacologic methods of clot dissipation and require tPA, though at much smaller doses than would be given for systemic thrombolysis. As a result, CDT confers a lower bleeding risk compared to systemic therapy. Again, it is necessary that the patient remain in the ICU during thrombolysis protocols. Patient selection is comparable to systemic thrombolysis as described

above—that is to say, categories C3, D, or E (severe hemodynamic compromise or shock). Clot is dissolved in incremental fashion during the lysis as opposed to immediate removal with other modalities including systemic lysis. This can result in delayed restoration of normal RV and pulmonary arterial hemodynamics. In addition, while tPA is very effective at dissolving acute clots, it is relatively ineffective at removing subacute or organized clots.

ASPIRATION OR MECHANICAL THROMBECTOMY

Endovascular thrombectomy methods focus on single-session removal of clot burden during the intervention. Early methods relied on fragmentation or rheolytic methods of clot disruption. This would break up the clot, but lacked the ability to remove the fragments in large volumes. Some rheolytic modalities added the ability to locally infuse tPA for a short period of time within the culprit clot, followed by an attempt to aspirate the fragmented clot after infusion. Fragmentation or rheolytic methods have largely fallen out of favor given risks of symptomatic bradycardia and hypotension from adenosine release as well as renal failure from release of free hemoglobin.

Today, the most common method for PE thrombectomy is Large Bore Aspiration Thrombectomy (LBAT). The pulmonary arteries are accessed as described above. With this method, larger catheters (16-24 French) are advanced into the clot, which is removed with high powered aspiration. Aspiration is achieved utilizing a vacuum locked syringe attached to the catheter or via a vacuum machine with sterile attachment to the aspiration catheter.

Two devices currently lead the market for LBAT. The Inari Flowtriever currently has the largest bore aspiration catheter available at a 24 French size (16 and 20 French Inari catheters are also available). Clot removal is achieved with a vacuum-locked 60 cc syringe creating 175 cc/second of aspiration power when opened.

Clot material and blood are aspirated into the syringe. The blood and clot mixture is then transferred into a Blood Saver system, which filters the blood into a separate syringe so that it can be returned to the patient via an access site sheath side port. The advantage of this system is the ability to remove large clots in a single session with significantly reduced procedural blood loss.

The Penumbra Indigo aspiration system utilizes 12 to 16 French catheters powered by an electromechanical pump to remove clot. Blood and clot material are aspirated into a canister. The Penumbra system does not currently have a system to filter blood or return it to the patient. For this reason, the operator must be aware of blood loss and possible need for supplemental blood transfusion if necessary.

LBAT has significantly changed the efficacy, safety profile, and cost-effectiveness of PE treatment. Pulmonary emboli can now be treated with LBAT in a single session without the use of thrombolytics. ICU monitoring pre and post procedure is not absolutely required as in CDT, since thrombolytics are not utilized. However, ICU monitoring is often necessary for hemodynamic monitoring or for any concomitant conditions.

While lytics dissolve acute clot well, LBAT is also able to remove subacute and chronic clot, which are commonly encountered (as DVT can embolize at any stage). Since clot is removed at the time of intervention, almost immediate relief of right heart strain is observed. Recent studies have demonstrated superiority of treating PE with LBAT versus either CDT or anticoagulation alone. The STORM-PE randomized controlled trial demonstrated superiority of aspiration thrombectomy over anticoagulation alone in reduction of right heart strain within 48 hours, lower oxygen requirements, and decreased rates of clinical deterioration (5). In a comparison of LBAT versus CDT, the PEERLESS trial showed superiority of LBAT with lower rates of clinical deterioration and decreased ICU utilization (6). No statistically significant differences in adverse events or major bleeding were seen in the comparison groups of either study.

The diagnosis, risk stratification, medication strategy, and treatment modalities for pulmonary embolism have significantly changed over time. We continue to refine our understanding of not only how best to reverse any hemodynamic compromise immediately, but also the long-term cardiopulmonary effects that VTE can have. Effective strategies require a multi-disciplinary approach to stratify and treat these patients. Interventional radiologists have been on the forefront of this treatment and continue to work toward saving those suffering from pulmonary embolism.

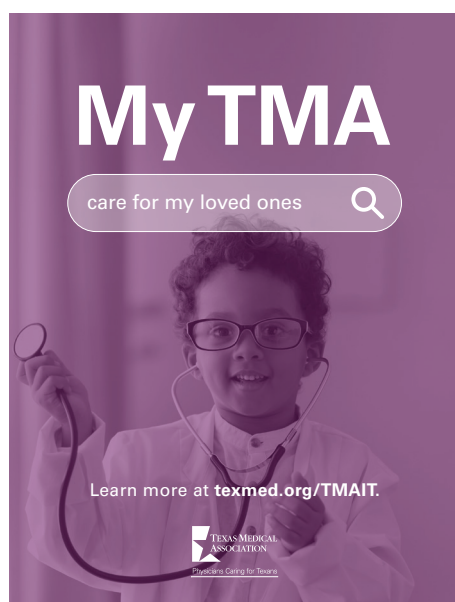
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The New Age of Cardiac Imaging

by Luke Lennard, MD

Cardiac imaging has transformed the way clinicians diagnose and manage cardiovascular disease. Once limited to physical examination, electrocardiography, and invasive catheter-based procedures, modern medicine now offers highly sophisticated noninvasive techniques capable of visualizing cardiac anatomy, function, perfusion, and tissue characteristics in remarkable detail. Modalities such as echocardiography, cardiac computed tomography (CT), cardiac magnetic resonance imaging (MRI), and nuclear imaging each provide unique diagnostic strengths that contribute to comprehensive cardiovascular assessment.

These technologies have improved the early detection of coronary artery disease, cardiomyopathies, valvular abnormalities, congenital heart disease, and myocardial injury, while also guiding treatment decisions and risk stratification. As cardiac imaging continues to evolve, driven by advances in artificial intelligence, faster acquisition protocols, and improved spatial resolution, advanced cardiac imaging has become an essential component of modern cardiovascular care.

Today, we can noninvasively visualize coronary plaque, quantify myocardial scarring, and assess flow dynamics—often without a single arterial puncture.

Cardiac computed tomography (CCT) and cardiac magnetic resonance imaging (CMR) have become indispensable in modern cardiovascular care. Understanding their complementary strengths is essential for selecting the right test for your patient's clinical scenario.

CARDIAC CT (CCT): ANATOMY AND CORONARY ASSESSMENT

Cardiac CT excels in the evaluation of coronary anatomy and atherosclerotic plaque. Using a rapidly rotating X-ray source and advanced reconstruction algorithms, CCT generates high-resolution 3D images of the heart and coronary arteries.

KEY APPLICATIONS:

- **Calcium Scoring:**

A fast, noncontrast scan used for cardiovascular risk stratification. A calcium score of 0 suggests very low risk, whereas scores >400 indicate a high atherosclerotic burden and support aggressive preventive therapy (e.g., statins).

- **Coronary CT Angiography (CTA):**

With iodinated contrast, CTA visualizes both calcified and noncalcified plaque, including high-risk “vulnerable” plaque features that may not yet cause significant stenosis. It also evaluates:

- Congenital coronary anomalies (e.g., anomalous origin)
- Myocardial bridging

- **Pre-procedural Planning:**

Essential for transcatheter aortic valve replacement (TAVR) planning and coronary artery bypass graft (CABG) assessment.

- **Post-procedural Evaluation:**

Useful for assessing left atrial appendage occlusion devices (e.g., Watchman) for complete thrombosis or complications such as peri-device leak or incomplete thrombosis (see figure 1).

- **Pericardial and Aortic Disease:**

Accurately evaluates pericardial thickening, calcification, effusion, and constriction, as well as aortic aneurysms, dissections, and congenital abnormalities.

Figure 1 - peridevice gap (see arrow) and contrast filling the apex of the Watchman device



ADVANTAGES:

- High spatial resolution for detailed coronary anatomy and plaque characterization
- Rapid data acquisition (typically seconds to minutes)
- Wide availability and relatively lower cost compared to CMR

LIMITATIONS:

- Exposure to ionizing radiation
- Requires heart rate control (often with beta-blockers) for optimal image quality
- May require iodinated contrast

CARDIAC MRI (CMR): TISSUE CHARACTERIZATION AND FUNCTION

Cardiac MRI is the gold standard for myocardial tissue characterization and functional assessment. Using magnetic fields and radiofrequency pulses, CMR provides high-contrast images without ionizing radiation.

KEY APPLICATIONS:

• **Tissue Characterization (Late Gadolinium Enhancement – LGE):** After gadolinium administration, delayed imaging identifies myocardial scar patterns:

- **Ischemic pattern (subendocardial to transmural):** consistent with prior myocardial infarction
- **Nonischemic patterns (mid-wall or epicardial):** suggest myocarditis, infiltrative disease (e.g., sarcoidosis, amyloidosis), or cardiomyopathy

• **Functional Assessment:**

Highly accurate quantification of:

- Left ventricular ejection fraction (LVEF)
- Ventricular volumes and mass
- Valvular stenosis and regurgitation

• **Myocardial Viability:**

Differentiates viable (hibernating) myocardium from irreversible scar—critical for decisions about revascularization

• **Inflammation and Edema:**

T2-weighted imaging detects myocardial edema, while LGE patterns define injury

• **Infiltrative and Structural Disease:**

Sensitive for detecting:

- Iron overload (hemochromatosis)
- Fat infiltration (arrhythmogenic right ventricular cardiomyopathy)
- Amyloid deposition (see figure 2)
- Structural abnormalities (e.g., left ventricular noncompaction)

• Claustrophobia or intolerance in some patients

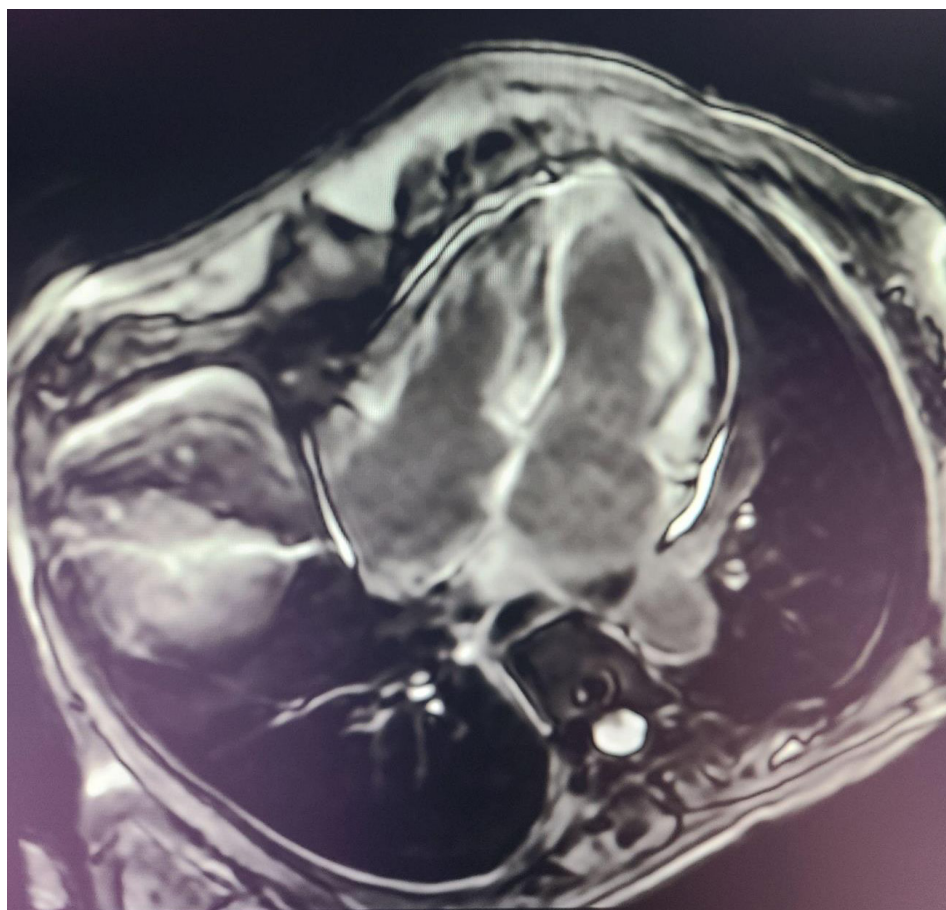
- Limited availability compared to CT
- Contraindications in patients with non-MRI-compatible implants

• Gadolinium use is cautioned in advanced renal failure due to risk of nephrogenic systemic fibrosis

CLINICAL SCENARIOS

Consider a patient presenting with new-onset heart failure of unclear etiology. CMR can differentiate among

Figure 2 - Diffuse late gadolinium enhancement of both ventricles and atria suspicious for infiltrative disease (e.g., cardiac amyloidosis)



ADVANTAGES:

- No ionizing radiation
- Superior soft tissue contrast and multiparametric assessment

LIMITATIONS:

- Longer scan times (typically 30–60 minutes)
- Sensitivity to patient motion and breath-holding ability

ischemic cardiomyopathy (silent MI), myocarditis, infiltrative diseases such as sarcoidosis or amyloidosis, and genetic cardiomyopathies—often providing a definitive diagnosis without invasive testing.

Consider a patient with stable angina and history of prior coronary artery bypass grafting and stenting. CCT can

provide high accuracy for in-stent restenosis (stent >3mm) and gives superior visualization of grafts compared with invasive coronary angiography.

Consider a patient with suspected pericardial disease. CMR can evaluate for pericardial thickness and pericardial effusion, and can also evaluate for constrictive pericarditis using cine acquisitions to look for septal flattening or septal bounce. CCT is better at evaluating for pericardial calcifications, which can indicate constrictive pericarditis

Consider a patient with acute chest pain (low-intermediate risk) or suspected coronary artery disease (symptomatic). CCT provides excellent anatomical detail with rapid rule-out capability (i.e., high negative predictive value).

THE FUTURE OF CARDIAC IMAGING

Emerging technologies continue to expand the capabilities of both modalities:



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• FFR-CT (Fractional Flow Reserve from CTA):

AI-driven computational fluid dynamics applied to coronary CTA can estimate the hemodynamic significance of coronary lesions, reducing unnecessary invasive angiography.

• Lower Radiation Doses:

Photon-counting detector technology, AI-based reconstruction algorithms, and prospective gating (requires low heart rate) are some ways that radiation dose can be decreased when using CCT.

• T1 and T2 Mapping (CMR):

Quantitative tissue characterization enables detection of diffuse fibrosis and early myocardial disease before conventional imaging changes occur.

• 4D Flow MRI:

Advanced flow imaging allows visualization of complex hemodynamics, such as vortex formation in aneurysms or turbulent flow across stenotic valves, aiding surgical timing and decision-making.

CONCLUSION

As you can see, cardiac CT and cardiac MRI represent remarkable technological achievements that have transformed cardiovascular diagnosis. They are complementary tools. CCT is typically the modality of choice for coronary anatomy and plaque evaluation, while CMR provides unmatched insight into myocardial tissue and function.

As machine learning and automation become integrated into image acquisition and interpretation, cardiac CT and MRI are expected to provide faster, more personalized, and increasingly predictive cardiovascular care, allowing clinicians to identify disease earlier and tailor therapies with greater precision.

Modern cardiac imaging is inherently collaborative—leveraging advanced technology and multidisciplinary expertise to deliver precise, patient-centered care.

Close collaboration between referring clinicians, cardiologists, and radiologists to provide clear clinical context is essential for allowing optimized imaging protocols and maximizing diagnostic yield. When uncertainty arises, direct consultation often clarifies the most appropriate imaging pathway. Please don't hesitate to reach out to your local radiologist with any questions regarding the best imaging techniques for your patient.

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The Role of PET/CT Scans in Oncology: The New Gold Standard?

by Andrew W. C. Mak, MD, MBA

INTRODUCTION

Diagnostic imaging has long been crucial in the diagnosis, treatment monitoring, and surveillance of various malignancies. Along with pathology, and lab results, objective physical findings, and subjective complaints of symptoms, imaging forms one of the key pillars that drive treatment in oncologic care. The advent of computed tomography (CT) catapulted the identification and assessment of malignancies that was previously unthinkable more than half a century ago. For all its advantages, there exists one scan that may even beat CTs in its diagnostic prowess.

Initially designed in the 1970s, positron emission tomography (PET) saw meaningful clinical use in the 1980s but did not become a standard diagnostic tool until the late 1990s and early 2000s. Manufacturers of modern PET scanners often have merged the technology with that of CTs or MRIs, thereby enhancing their diagnostic power. While there exists a variety of radiotracers that can be used, modern PET/CTs typically employ 18F-fluoro-2-deoxy-D-glucose (FDG) or “radioactive sugar”, as I frequently refer to it for my patients. Cancer cells typically exhibit higher glucose metabolism than non-cancer cells due to their increased expression of glucose transport proteins and glycolysis (1). This preferential accumulation of FDG in cancer cells often allows for the differentiation of cancerous versus non-cancerous tissue. Furthermore, different radioactive isotopes have been developed for specific cancer types that are currently in use or being evaluated.

Patients have a better visualization of their cancer when we review these images together, since highly metabolically active

cancerous tissue manifests as bright yellow, orange, and/or pink hues. As such, PET/CTs are more functional scans that show cancer activity and complement the anatomic information provided by CTs. However, clinicians must caution their patients that certain inflammatory and infectious conditions can mimic the relatively brighter resolution typically exhibited by neoplastic cells. Therefore, the radiologist’s official interpretation serves as the final arbiter of the PET/CT reads.

APPLICATIONS IN ONCOLOGY

PET/CTs have been deployed far across the oncology and malignant hematology world, supported by guidelines from the National Comprehensive Cancer Network (NCCN). Its utility in diagnosis, treatment monitoring, and ultimately surveillance has led to a fine-tuned and often predictable treatment course for patients. While not mandatory for every patient, PET/CTs are essentially omnipresent in a variety of malignancies, especially lung cancer, head and neck cancer, melanoma, lymphoma, and multiple myeloma. Generally speaking, albeit with some exceptions and disparate clinical practice patterns, clinicians use PET/CTs less frequently in other cancers like breast, gastrointestinal, and kidney cancers, as existing imaging modalities, such as CTs and ultrasounds, often provide sufficient diagnostic information so that the additional PET/CT diagnostic power may not change treatment planning. In situations where there are ambiguous findings, PET/CTs can upstage a patient from an early and curable cancer to one that is advanced and requires palliative treatment.

APPLICATIONS FOR LUNG NODULES AND LUNG CANCER

The evaluation of lung nodules and potential lung cancer represents one of

the most powerful applications of PET/CTs. Clinicians can use PET/CTs to evaluate the malignant potential of pulmonary nodules, whereby those larger than 3 cm are usually malignant and those at least 8-10 mm or larger can qualify for further evaluation (2). Nodules that demonstrate spiculated, stippled, or eccentric appearances with increased FDG activity often warrant biopsy via bronchoscopy with brush cytology or transbronchial biopsy, transthoracic needle aspiration, or surgical resection (2). Overall stability on serial imaging over months to years generally indicates a benign etiology. When nodules are smaller than 1 cm, determining malignant potential becomes more challenging, given a smaller amount of metabolically active malignant cells required for PET diagnosis. Despite the excellent diagnostic potential of PET/CTs, pulmonary nodules can illuminate in various inflammatory conditions, such as infectious and granulomatous conditions like bacterial pneumonias, aspergillosis, and granulomatosis with polyangiitis (2).

Given the high incidence and prevalence of lung cancer in the world, PET/CTs have been instrumental in the care of this particular malignancy, especially for diagnosis and baseline staging. Oncologists and their respective teams often can determine the three aspects of lung cancer from these scans, namely the tumor characteristics (T), nodal involvement (N), and presence of any metastasis (M). Developed by the American Joint Committee on Cancer (AJCC), the TNM staging system clearly delineates the various combinations of cancer presentations to formulate the proper treatment for each patient.

While plain CTs are generally adequate to evaluate tumor characteristics,

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PET/CTs can differentiate between benign and malignant effusions and evaluate for pleural thickening or nodularity (2). PET/CTs proved to be superior in its accuracy to CTs alone in evaluating for locoregional and distant lymph node involvement, given the combined anatomic and metabolic information, and can guide sampling with modalities like bronchoscopy, mediastinoscopy, or intraoperative exploration during definitive surgical resection. Of paramount importance, PET/CTs possess an excellent negative predictive value that will stage patients adequately without further invasive procedures, while the positive predictive value is reasonable. PET/CTs have been documented to be superior to conventional imaging techniques in evaluating all site-specific metastases, such as adrenal, bone, and liver as well as occult metastases, with optimal sensitivity and specificity at diagnosis (2). PET/CTs fall short in diagnosing intracranial metastases given the high FDG uptake of brain tissue. The kidneys and bladder typically exhibit high FDG avidity as well and therefore cannot be properly evaluated with PET/CTs. In the Radiation Oncology setting, PET/CTs can often lead to smaller planning target volumes, thereby resulting in lower dose exposure to healthy tissue (2).

Some clinicians use PET/CTs for treatment monitoring during or after treatment with chemotherapy, targeted therapy, immunotherapy, radiation, and surgical techniques. However, the utility of PET/CTs over conventional CTs at this juncture in the patient's clinical journey remains disputed, given the higher radiation exposure, risk of false positives, increased cost, and additional logistical challenges associated with the former. Clinicians need to order PET/CTs in a manner that can reduce the possibility of false positives, most often being residual inflammatory and/or necrotic tissue. For example, PET/CTs should be ordered 3 months or later after completion of radiotherapy. Additionally, the reading radiologist and treating clinician need

to consider the clinical context when the scan is performed. While PET/CTs offer higher sensitivity and specificity compared to CTs, the latter usually suffices to monitor patients who have lung and other solid organ cancers currently on treatment, even in the metastatic setting. Conventional imaging such as CT offers a more cost-effective, logistically favorable, and anatomically accurate modality with a faster image acquisition and turnaround time to assess treatment response for non-metastatic and metastatic disease, especially in settings where PET/CTs are difficult to obtain or simply not available.

TAILORING PET SCANS FOR SPECIFIC MALIGNANCIES

Neuroendocrine tumors (NETs) represent a heterogeneous group of malignancies that vary widely in presentation and treatment response. However, over 90% of gastroenteropancreatic NETs including non-functioning NETs (except for insulinomas) have high concentrations of somatostatin-receptors (SSTRs) (3-4). PET imaging has taken advantage of this unique aspect and developed SSTR analogs that can be used as radiotracers, such as ⁶⁸Gallium dotatate and ⁶⁴Copper Dotatate. Baseline diagnostic PET using one of the specialized radiotracers have become the norm for diagnosing advanced NETs due to this high expression of SSTRs and predict treatment response to somatostatin analogues such as octreotide and lanreotide. Data has shown that treatment changes occur more frequently with SSTR-PETs than conventional CT or MRI alone (4). However, clinicians need to consider the increased sensitivity of SSTR-PETs so as to not prematurely change course. As advantageous as SSTR-PETs are for diagnosis, it remains an open question how useful they are for monitoring response and surveillance. Moreover, these scans need to be performed after a washout period if analogs like octreotide and lanreotide are used, namely 24 hours and 3-4 weeks after short- and long-acting analogues, respectively.

Prostate-specific membrane antigen (PSMA) PET imaging represents another tumor-specific scan to detect prostate cancer throughout the body. As the name suggests, PSMA is a surface protein expressed by various prostate cancers (5). Like all imaging modalities, PSMA PETs can miss a prostate cancer diagnosis if the suspected cancer does not express PSMA, thereby resulting in non-detection of said tumor. Fortunately, this happens in only a small minority of cases. Furthermore, PSMA can be expressed by other cancers and non-cancer-related conditions. Typically, oncologists and urologists order PSMA scans to evaluate for metastases or after surgery or radiotherapy in the setting of a rising prostate-specific antigen (PSA) level. Like SSTR-PETs, PSMA PET scans can be used to determine eligibility for treatment modalities.

CONSIDERATIONS REGARDING PET/CT SCANS

Although the benefits of PET-CTs are quite clear, we need to bear in mind some limitations about this imaging modality as a whole. As previously stated, the FDG uptake can sometimes lead to the false positive reads, especially within 3 months of receiving radiotherapy, where the inflammation of the tissues from ionizing radiation lingers and results from tumor death. As such, clinicians need to consider the timing and necessity of PET/CT scans, especially when CTs offer equivalent information. Patients generally experience little to no side effects from these scans with the most common being fatigue, headache, and taste changes (5). Rarely are there allergic reactions. Like CTs, PET/CTs add on to cumulative radiation exposure for patients. Depending on the CT or PET/CT's settings, the additional radiation exposure associated with the latter can range from 3-17x higher than the former. The radiation dose for PET/CTs is generally 200-250 times higher than that of conventional chest x-rays.

The availability and cost of PET/CT scans also remain a persistent bottle-

neck, even in well-resourced communities and large cities. Often, health systems can only justify the acquisition of one or two PET/CT scanners for all clinicians to use. To my knowledge, Amarillo and Lubbock are the only two cities in the Texas Panhandle that have PET/CT scans available. Furthermore, depending on a patient's coverage, certain insurance carriers will only cover one or two PET/CT scans a year, even if multiple scans are indicated and permitted under the NCCN guidelines or when the patient develops a recurrence or progression. Clinicians often need to balance the likelihood of approval for their PET/CTs versus the type of insurance patients have. The costs of PET/CT scans in the form of copays and deductibles are higher than CTs in most cases as well. For example, a patient with more limited means living farther away may still succeed on a surveillance protocol of CTs rather than PET/CTs even if they have a highly FDG-avid malignancy initially like lymphoma.

FINAL WORDS

Clinicians will likely order more PET/CTs in the ensuing decades, mirroring the projected rise of many cancers. As clinicians become more comfortable with ordering them for the appropriate reasons, insurances likely will cover them as well. Hopefully, the availability of these machines throughout the country will increase, and the costs associated with purchase and maintenance will decrease. Perhaps one day, PET/CTs will supplant CTs entirely, much like the latter did with X-rays.

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Prostate MRI

by April Bailey, MD

In collaboration with our local urologists, we have 3 main types of patients in which prostate MRI is especially helpful.

HOW IS MRI USEFUL IN THE MANAGEMENT OF PROSTATE CANCER?

First, before biopsy. If the family history, PSA, and exam are not quite enough to warrant biopsy or the patient is reluctant, a prostate MRI may add additional information, either favoring clinical follow up or moving to biopsy. The next is when a negative biopsy has already been performed but the clinical suspicion is worrisome for underlying cancer. After biopsy, it is best to wait 8 weeks before performing MRI, as the blood products affect our ability to differentiate tumor. MRI is especially helpful in identifying anterior gland tumors which may elude detection without careful attention to that area during sampling. Cognitive fusion has been very successful in our area, as we have the luxury of working together frequently with our urologists and because our images are annotated for the urologist who will do the biopsy. Imaging-guided fusion biopsies are possible, where we use real time ultrasound or MRI as guidance to target specific areas identified on the multiparametric MRI. A computer uses landmarks to fuse the multiparametric MR image onto the real time ultrasound or MRI during the biopsy. Finally, MRI is helpful after a diagnosis of prostate cancer. It can aid in surgical planning for prostatectomy or suggest advanced disease that may move the patient toward less invasive treatment. In addition, prostate MRI also allows an additional tool in offering active surveillance. Finally, radiation oncologists use these exams to tailor their treatment to the disease present and to avoid sensitive structures

HOW DOES MRI HELP DISTINGUISH BENIGN FROM MALIGNANT LESIONS?

One goal with MRI is to help differentiate the low-grade prostate cancer that isn't going to kill the patient from the aggressive, life-altering types. One tool we use is Diffusion Weighted Imaging (DWI) which measures the random Brownian motion of water molecules. Cellular tumors impede the movement of water to a higher degree and therefore having higher DWI values. The Apparent Diffusion Coefficient (ADC) is the slope of the curve formed from DWI values obtained at varying b-values (A b-value is the strength and duration of the diffusion gradients in DWI). Sampling the tissue at multiple b-values results in a very accurate curve, and the slope of that curve is the ADC. Basically, ADC is a really fun math-map for radiologists! A high DWI and very low ADC values correlate with greater cellularity and thus with more aggressive tumors. Patients with high grade or larger tumors may use this information to opt for more aggressive treatments. On the other hand, patients with smaller tumors may elect surveillance given age and/or comorbidities. As a result, MRI can provide information for urologists to provide more patient/tumor specific options.

HOW ABOUT THE STRENGTH OF THE MAGNETIC FIELD?

Other questions relate to the best strength of the magnetic field employed (3 Tesla (T) vs. 1.5T), the use of surface coils vs. surface plus endorectal coils and the need for gadolinium contrast. In your area, your radiologist should be able to tell you the best system to get the best exam for your patients. For our area, our 1.5T magnets with high channel density

coils are much better than available 3T magnets. Remember, at 3T the magnetic field strength is much higher, but the propensity to artifacts is orders of magnitude larger as well. Most patients can be imaged at 1.5T. Common implants (e.g., pelvis or hip prostheses) can be problematic, but we can almost always get a diagnostic exam even in these circumstances.

WHAT ARE THE ADVANTAGES AND PRECAUTIONS NEEDED FOR GADOLINIUM CONTRAST?

Regarding gadolinium, the terminology here is biparametric (no contrast) vs. multiparametric (gadolinium-enhanced) exams. With the growing requests for prostate MRI, there is a backlog, and we are trying to find ways to speed it up. Your radiologist can advise you as to what works best in your area. We do multiparametric exams locally. The contrast is helpful to make sure we don't miss anything, especially since we do not place endorectal coils inside the patients (for multiple reasons). MRI uses gadolinium-based contrast. Gadolinium is not nephrotoxic (it won't hurt kidneys) but it should not be routinely used in patients on dialysis. (Given the comorbidities of dialysis, screening prostate MR is unproven and aggressive surgery rarely indicated). I have given gadolinium to patients on dialysis for prostate MRI if they were being considered for renal transplant, as a way to screen for occult malignancy. On a case by case basis, if the risk of giving gadolinium one time in a patient in renal failure is warranted, we can override the standard recommendation and, with the consent and cooperation of the nephrologist, cautiously administer the contrast agent. Repeated exams would be ill-advised. Prostate MR usually requires a radiologist trained in body MRI for proficient evaluation of the gland. Additionally, facilities

that do prostate MRI should do several every day; it is too hard to do this type of exam once or twice a month and provide consistently diagnostic exams.

A multiparametric exam is done to provide a PIRADS score (Prostate Imaging-Reporting and Data System score). This allows us to communicate our findings efficiently and in a standardized way to the ordering urologists and clinicians. PIRADS score is one to five, with 1=very low to 5=very high risk (see table 1). The scoring system is based on a combination of findings and the different zones of the prostate anatomically. Different parts of the prostate have different imaging and enhancement patterns. Generally speaking, a combination of T2 weighted small field-of-view images, DWI and ADC mapping, and dynamic post-contrast images will allow us to describe lesions. T2 provides the most anatomical images; on T2 images the cancer will be dark. The diffusion images give us information about the cellularity of the lesion. High b-values and multiple sample acquisitions allow for the most representative ADC values. Finally, the dynamic

holds onto the contrast, differentiating scar from tumor.

WHAT IS THE ROLE OF MRI IN SCREENING AND SURVEILLANCE?

In the United States, screening for prostate cancer is with Prostate-Specific Antigen (PSA) blood test. Sometimes digital rectal exam (DRE) is incorporated. Several studies in The New England Journal of Medicine (JAMA) with data from Sweden have demonstrated that incorporating MRI reduces overdiagnosis of clinically insignificant cancer (by approximately 50%), reduces the number of biopsies done, and improves detection of clinically significant cancers. At the same time, The United Kingdom National Screening Committee advised against routine PSA screening for all men (never mind MRI!). With these somewhat contradictory directions in the world, I can share that we frequently perform prostate MRI in our area and our local urologists are excellent at deciding who would benefit from the exam. Our exams provide an additional piece of data to help tailor treatment for each patient’s disease. Also, it is not uncommon for us to detect

hasn’t already had a prostate MRI, our local Radiation Oncologists often order the exam for targeted radiation. Although detecting cancer in lymph nodes is highly dependent on size, we can still offer more information for our urologists and radiation oncologists treating the patients found to have malignancy.

Although prostate MRI is a very specialized exam, I do think it warrants discussion for a general audience, as prostate cancer is the most common cancer diagnosed in men and given the rapid growth and adoption of this technology by our specialist teams. Many patients may ask questions about having a prostate MRI, and these questions may come to the primary care provider first. Describing the clinical scenarios when prostate MR can be most helpful, providing a broad overview of what we are looking at in the exams, and explaining how the results will read—all will hopefully allow readers to make informed decisions with their patients.

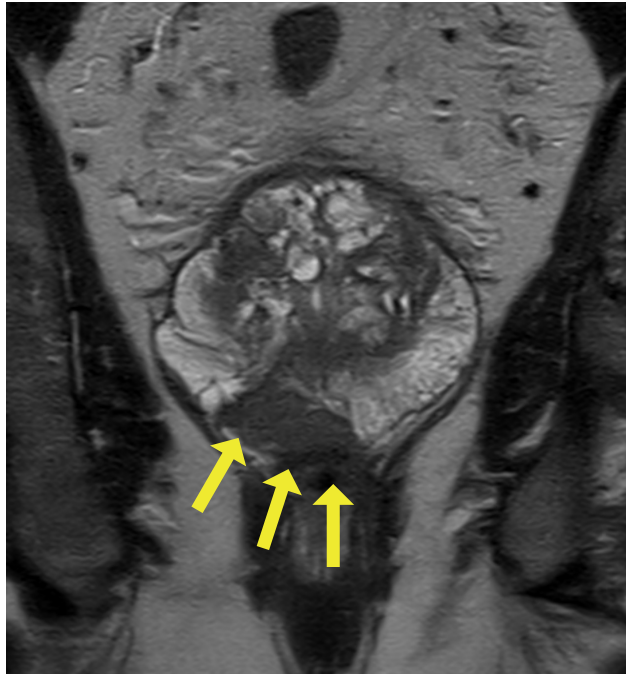
April Bailey, MD is a radiologist with High Plains Radiological Association. She has enjoyed being with the group since 2017 and looks forward to caring for people in the Texas panhandle for many years to come. Her fellowship training is women’s imaging (obstetric and gynecologic care) as well as body MRI.

PIRADS Score	
PIRADS 1	Very low (clinically significant cancer highly unlikely)
PIRADS 2	Low (clinically significant cancer unlikely)
PIRADS 3	Intermediate (clinically significant cancer equivocal)
PIRADS 4	High (clinically significant cancer likely)
PIRADS 5	Very high (clinically significant cancer highly likely)

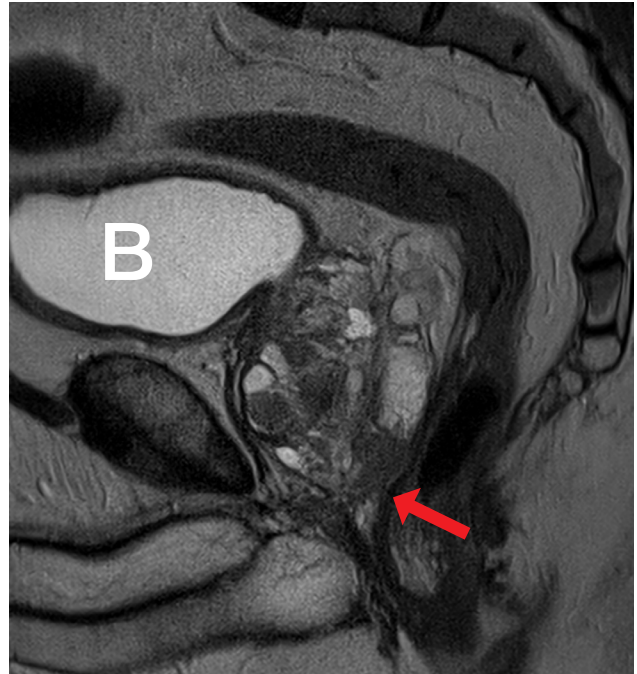
post contrast images allow us to watch the way blood flows through the gland. Tumors tend to enhance early (arterial flow), then wash out (rapid venous drainage), but inflammation and benign prostatic hypertrophy can have similar enhancement patterns; so other components of the exam become differentiating. Scarring enhances progressively and

incidental cancers in the bladder which may change the type of surgery offered. More rarely, we have detected incidental rectal malignancy, lymphoma and metastatic disease which may result in a very different course of treatment, allowing us to involve the right physicians more rapidly in the patient’s care. After a diagnosis of prostate cancer, if the patient

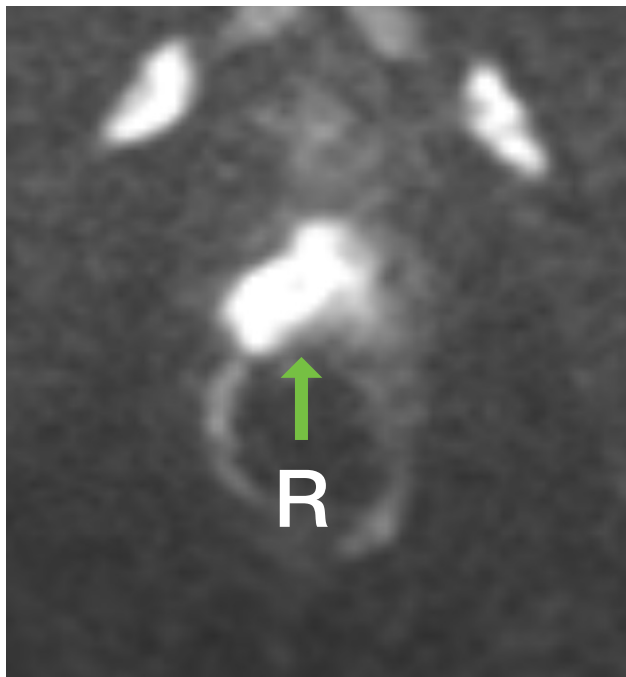
A.)



B.)



C.)



D.)

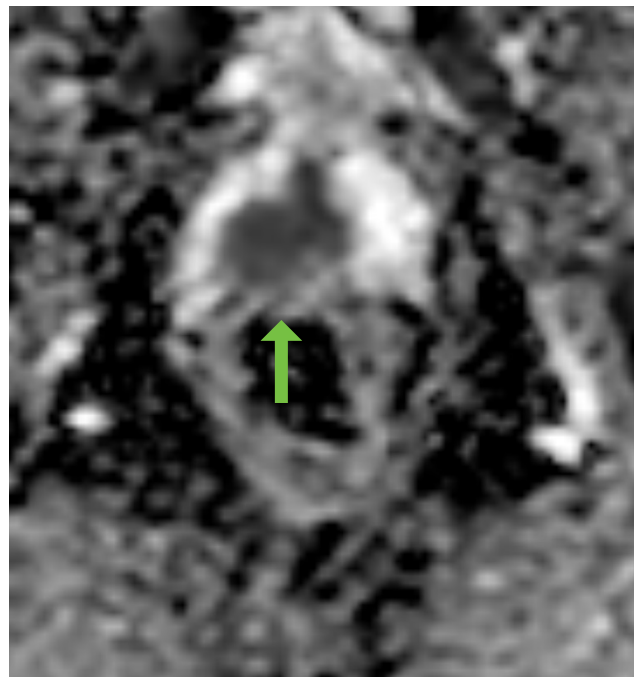


Image 1:

A.) Coronal T2-weighted image with yellow arrows denoting a hypointense prostate tumor at the apex, with more volume in the right side of the gland. This location may complicate urethral anastomosis.

B.) Sagittal T2-weighted image with red arrow denoting the apical tumor. The bladder is labeled "B"

C.) Axial high b-value DWI showing intense restricted diffusion in the tumor. The rectum is labeled "R"

D.) Axial ADC map showing markedly low signal intensity, suggesting a high grade tumor. PIRADS 5



From Shadows to Enhancement: The Evolution of the Mammogram and the Radiologist's Voice in the Texas Panhandle.

by Lova Arenivas, M.D.

THE DOCTOR EMERGES FROM THE DARK

For decades, the radiologist was often perceived as a “ghost in the machine”, a disembodied voice in a dictated report, tucked away in a dimly lit room permeated by the scent of developer chemicals. In the early days of breast imaging, we were interpreters of shadows, looking for the subtle architectural distortions or “sand-like” grains of calcium that might signal a hidden malignancy on a mammogram.

Early in my career, I was actively discouraged from pursuing radiology. Advisors and peers warned that I would lose the “human element” of medicine, suggesting that the lack of direct patient contact would lead to professional isolation. However, the reality of modern breast imaging is the exact opposite. Today, the breast radiologist is a front-line clinical partner. We counsel, manage, diagnose, and more recently treat both cancers and benign diseases through interventional techniques like cryoablation.

In the Texas Panhandle, I am fortunate to treat multigenerational families, following grandmothers, mothers, and daughters through their health journeys over many years. This transformation from “doctor in the dark room” to bedside clinician has paralleled a profound technological evolution. In my own time as a radiologist, I have been part of the sweeping change from analog film to Contrast-Enhanced Mammography (CEM). This shift has moved mammography from viewing the breast as a static structure to visualizing its biology.

THE TECHNOLOGICAL TIMELINE: FROM THE VAGUE TO THE VIVID

The history of mammography is a journey from the vague to the vivid, defined by a constant battle against the limitations of human tissue and the physics of imaging.

THE ANALOG ERA (1960s – 1990s)

During the analog era, we were limited by the physical properties of film. If a woman had dense breast tissue, the “white” of fibroglandular tissue could easily obscure the “white” of a small tumor, a phenomenon often compared to looking for a polar bear in a snowstorm or a penny in a glass of milk. Detection relied on subtle architectural changes or microcalcifications, often caught only after a lesion had grown significantly in a woman with dense breast.

DIGITAL MAMMOGRAPHY (2000s)

The transition to Full-Field Digital Mammography (FFDM) in the early 2000s allowed for image manipulation. We could finally adjust contrast and brightness, but we were still analyzing a flattened, two-dimensional representation of a three-dimensional organ. While digital imaging was a major leap for storage and workflow, the “masking effect” of dense tissue remained a primary hurdle for detection.

THE 3D REVOLUTION: TOMOSYNTHESIS (2011 – PRESENT)

The true sea change arrived with Digital Breast Tomosynthesis (DBT), which gained FDA approval in 2011. By taking a series of low-dose images from different angles and reconstructing them into thin slices, tomosynthesis allowed us to “scroll” through the breast. This reduced “summation artifacts,” where overlapping normal tissue mimics a mass.

While 3D imaging significantly improved detection and reduced recall rates, it still focused on anatomy—the shape, density, and margins of a lesion.

THE FUNCTIONAL LEAP: CONTRAST-ENHANCED MAMMOGRAPHY (CEM) (MAINSTREAM 2020s)

CEM represents the transition from structural to functional imaging. It operates on the physiological principle of angiogenesis: for a tumor to grow beyond a few millimeters, it must hijack the body’s blood supply, creating a network of new, hyper-permeable vessels. By using intravenous contrast, we can now see which tissues are biologically active, rather than just which tissues are structurally dense.

THE SCIENCE OF CEM: VISUALIZING TUMOR BIOLOGY

During a CEM exam, the patient receives an intravenous injection of non-ionic iodinated contrast. After approximately two minutes, specialized hardware captures dual-energy exposures—a low-energy image (equivalent to a 2D mammogram) and a high-energy image. A subtraction algorithm then cancels out the normal background density. The resulting recombined image highlights only the areas where iodine has pooled. Because cancer vessels soak up this contrast, the tumor literally lights up against a dark background. We are no longer just looking at what a tumor looks like; we are seeing what it does.

ACR ALIGNMENT AND SUPPLEMENTAL SCREENING

In line with the American College of Radiology (ACR) Appropriateness Criteria, CEM is increasingly recognized as a potent tool for supplemental screen-

ing. The ACR notes that, for women with dense breasts or those at intermediate risk (such as those with a personal history of breast cancer or high-risk lesions), supplemental screening can be life-saving.

Specifically, the ACR and NCCN have moved toward supporting CEM as a viable alternative to breast MRI when the latter is unavailable or contraindicated. CEM maintains a high sensitivity (approximately 95–96%) and a Negative Predictive Value (NPV) exceeding 98%, providing clinical certainty in dense-breast populations where traditional mammography might be limited.

patients. In one study, CEM identified 92.7% of cancers in extremely dense breasts, where 2D/3D mammography caught only 71.5%. (see cases 4 & 5).

STREAMLINING THE PATH TO DIAGNOSIS

The RACER trial demonstrated that using CEM as a first-line diagnostic for patients recalled after an abnormal screening mammogram dramatically reduced the need for the “diagnostic cascade.” In that study, 27.7% of women reached a final diagnosis after CEM alone, compared to only 1.1% using conventional imaging. This is vital in our region, where an extra appointment may represent a 300-mile round trip.

DIAGNOSTIC DILEMMAS

CEM can help evaluate chronic symptoms despite a negative or equivocal initial evaluation—for example, in a post-lumpectomy patient in whom there is a clinical question of recurrence versus scar. (See Case 1).

THE RURAL REALITY: BARRIERS TO CARE IN THE PANHANDLE

The disparities between rural and urban centers in Texas are stark. In the Panhandle, a patient might drive 40 to 150 miles just to reach a specialist in Amarillo. If a diagnostic evaluation is indeterminate, a wait time of several weeks for an MRI can lead to “diagnostic anxiety.”

THE MRI-GUIDED BIOPSY BOTTLENECK

This gap is exacerbated by specialized interventional limitations and systemic friction. In Amarillo, only one facility offers MRI-guided biopsy, a scarcity that creates a significant diagnostic bottleneck. When a patient has a suspicious finding on breast MRI requiring biopsy, they are funneled into a situation that is not easy to navigate. Some patients choose not to have the procedure, leading to diagnostic delay. MRI-guided biopsies are more expensive than their mammographic or ultrasound counterparts, posing a further financial barrier. Finally, technical complexities often arise. Because localization is magnet-specific, a patient who had their diagnostic scan at a different facility may have to undergo a repeat MRI on the biopsy-capable magnet to ensure precise targeting. This redundancy increases medical costs and delays care.

For the referring physician, the administrative complexity of coordinating between disparate facilities and navigating insurance authorizations for repeated scans is substantial. Consequently, the combination of travel, expense, and logistical complexity often leads to poor patient compliance. Many women, overwhelmed by the process, fail to follow through with recommendations. This leads to diagnostic delays and late-stage

CEM Limitations

Category	Limitation / Issue	Key Details
Safety	Iodinated contrast reactions	Occur in ~0.3% to 0.8%; mostly mild, but moderate and severe reactions can occur
Safety	Contrast-associated acute kidney injury (AKI)	Screening recommended
Radiation	Increased radiation dose	Higher than standard mammography due to dual-energy acquisition, but within acceptable limits
Technical	Limited field of view	Axilla, medial breast, and chest wall areas may not be fully visualized
Imaging capability	Lack of kinetic information	Unlike MRI, CEM does not provide time-signal intensity curves (no dynamic enhancement data)

CLINICAL UTILITY

CEM excels where standard imaging falls short, particularly in problem-solving scenarios.

THE DENSE BREAST DILEMMA

Mammography sensitivity can drop to 50% in patients with extremely dense tissue (ACR Category D), but CEM maintains a sensitivity of 90-97% in these

PREOPERATIVE STAGING OF NEWLY DIAGNOSED BREAST CANCER

CEM can assess extent of disease.

ASSESSING RESPONSE TO NEOADJUVANT CHEMOTHERAPY

CEM can evaluate tumor response to neoadjuvant therapy as a cost-effective alternative to MRI. (see case 3).

findings, causing profound frustration for the patient and the care team.

CONTRAST-ENHANCED MAMMOGRAPHY: THE ACCESSIBLE ALTERNATIVE

CEM serves as a powerful mitigation for these gaps. Because it uses slightly modified mammography units, CEM and CEM-guided biopsy can be integrated into the local workflow. It offers MRI-level performance without the MRI-level barriers of cost, claustrophobia, or specialized interventional waitlists.

Many patients prefer CEM over MRI as it is faster, more comfortable, less noisy and less anxiety-producing. (See Table 1).

THE RADIOLOGIST’S EVOLUTION: OUT OF THE DARK ROOM

As technology has become more sophisticated, the “doctor in the dark room” has become an obsolete trope. The modern breast radiologist is part diagnostician, part interventionalist, and part counselor. We perform ultrasound and biopsies, place localization markers, and treat, all while sitting across from patients to deliver results directly.

This shift has required a personal evolution. We have had to find our voices. It is one thing to describe a “spiculated mass” in a report; it is another to explain to a mother of three what that mass means for the next six months to a year and indeed for the rest of her lifetime. We are no longer just interpreting pixels; we are managing human anxiety and providing the clarity that leads to diagnosis, treatment and (thankfully, in the majority of cases) a cure.

Outcomes improve in this specialized model. Data indicate that dedicated breast radiologists detect nearly 80% more cancers per 1,000 screenings (6.0 vs. 3.4) compared to generalists. Furthermore, comprehensive centers utilizing CEM have been shown to reduce diagnostic delays by an average of 10–12 days, facili-

itating faster transitions to oncology and surgery.

A CALL TO COLLABORATION: THE ROAD AHEAD

The evolution of breast radiology is not a solo journey. For the referring physician, the “Radiologist-as-Consultant” model is your greatest asset. We are no longer here just to provide a BI-RADS score; we are clinical partners here to help you navigate the diagnostic pathway.

When you encounter a patient with dense breasts, high lifetime breast cancer risk, or a physical finding or clinical symptom that doesn’t match the report, consider CEM. In a region where MRI-guided biopsy is a limited resource fraught with logistical and financial hurdles, CEM offers an accessible, functional alternative that keeps the diagnostic process local, efficient, and affordable.

As we move from the shadows of the past and toward a brighter future, our goal remains the same: to find cancer at its earliest, most curable stage. My journey from a discouraged student to a multigenerational clinician has taught me that the most important “resolution” in imaging isn’t measured in pixels, but in the time we save and the trust we build across generations.

The dark room is gone; the light is on, and the door is open.

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The editorial assistance of Gemini was used in the writing of this paper.

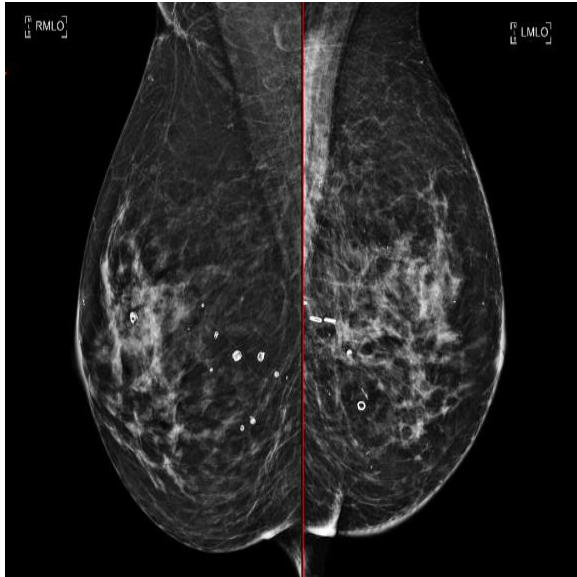
Lova Arenivas, M.D. is a clinical breast radiologist at Texas Breast Specialists–Amarillo/Texas Oncology. A graduate of UT Southwestern Medical School, she completed her residency and breast imaging fellowship at Baylor University Medical Center in Dallas. She remains deeply committed to the Texas Panhandle and feels privileged to have spent the last 15 years serving this community.

Table 1. Regional Access Disparity: The Texas Panhandle vs. Metro Texas

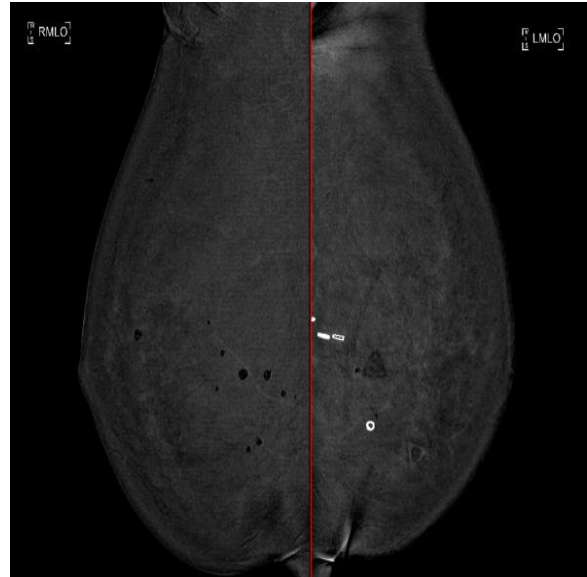
Region	MRI Providers	MRI-Guided	Travel Burden	Typical Wait
Texas Panhandle	~2	1 Site	40–150 miles	2–4 Weeks
Dallas Metro	~87	Numerous	<15 miles	1–5 Days
Houston Metro	~84	Numerous	<15 miles	1–5 Days

GALLERY OF CASES

CASE 1. New lump at lumpectomy site



Digital mammogram



CEM images

64 y/o female status post lumpectomy and radiation of the left breast for left invasive ductal carcinoma. She presents with a new lump in the left breast near the lumpectomy site. She has dense breast on the digital images. Postsurgical architectural distortion and increased density noted in the left breast. It's difficult to tell whether these are postsurgical changes versus new mass. Contrast-enhanced mammogram is negative. Triangular-shaped marker marks area of palpable concern. No suspicious enhancement at the site.

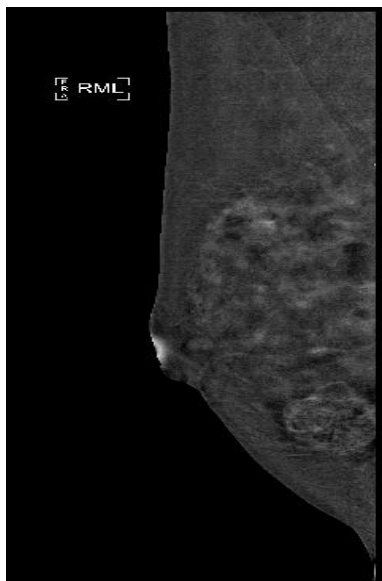
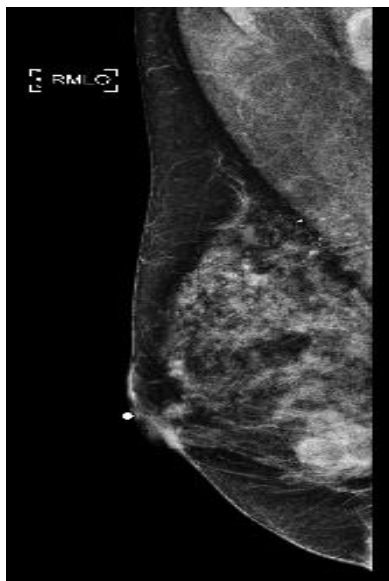
CASE 2. Normal



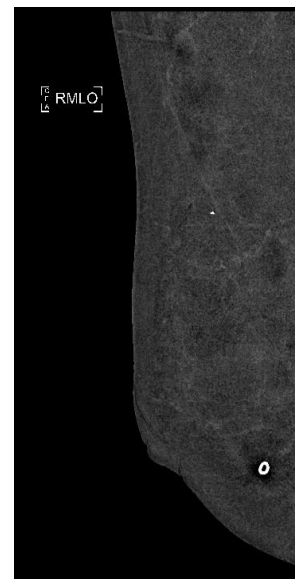
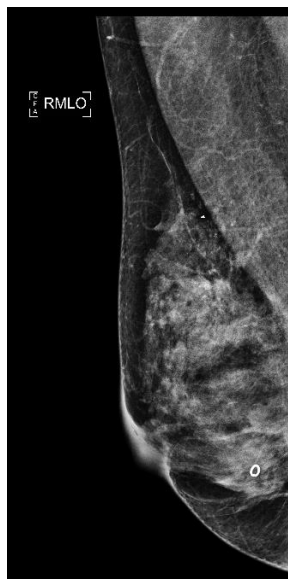
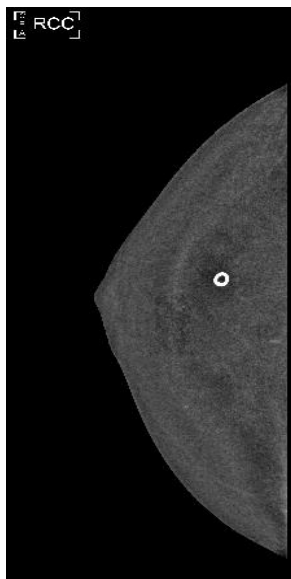
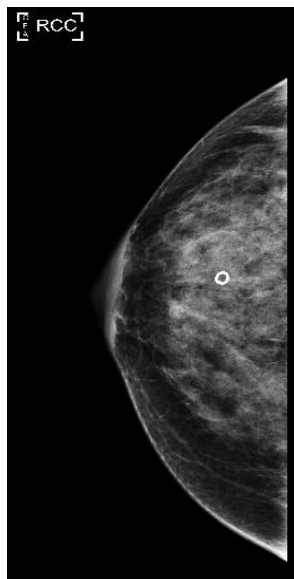
This is a good example of a negative case and a good case to compare routine digital mammogram versus contrast mammogram. 43-year-old woman with extremely dense breasts. Normal negative contrast-enhanced mammogram. Normal enhancement of axillary lymph nodes.

GALLERY OF CASES

CASE 3. Neoadjuvant chemotherapy



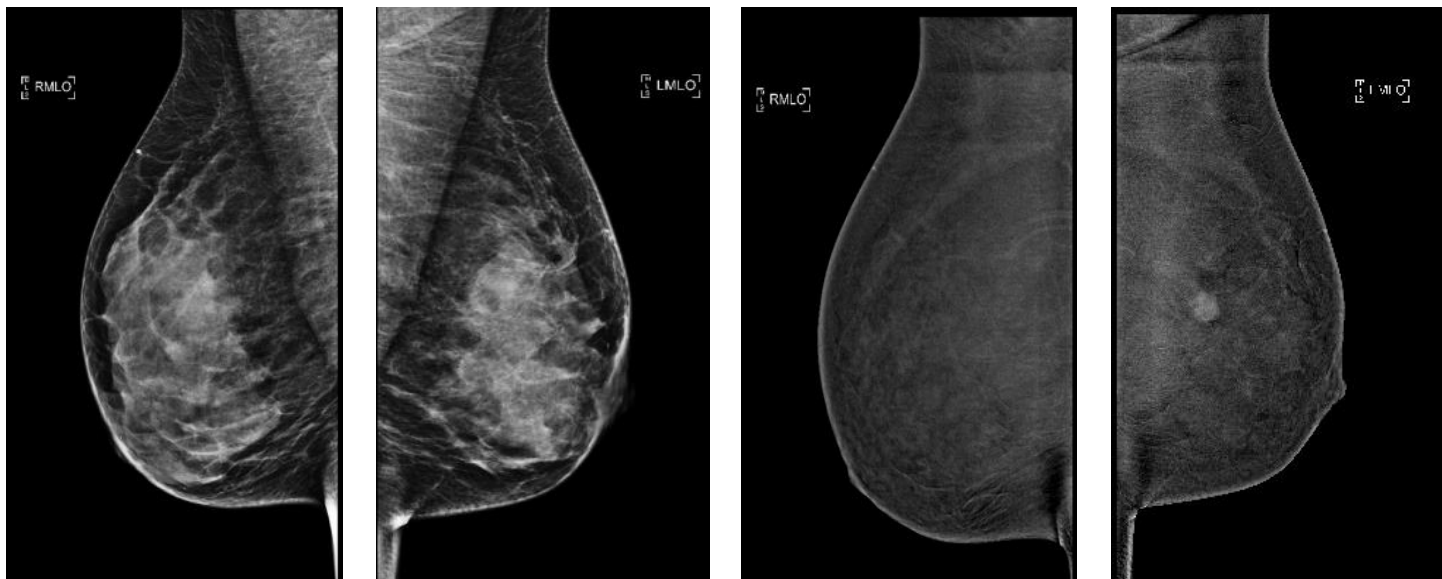
49-year-old woman with a right breast mass. Mammogram shows a mass in the lower inner right breast. Contrast-enhanced mammogram shows marked bilateral background parenchymal enhancement with a heterogeneously enhancing lobulated mass in the lower inner quadrant. This was proven to be invasive ductal carcinoma. She was treated with neoadjuvant chemotherapy prior to definitive treatment.



This is the post neoadjuvant mammogram which shows positive treatment response to neoadjuvant treatment. The mass is nearly imperceptible on both digital mammogram and contrast mammogram.

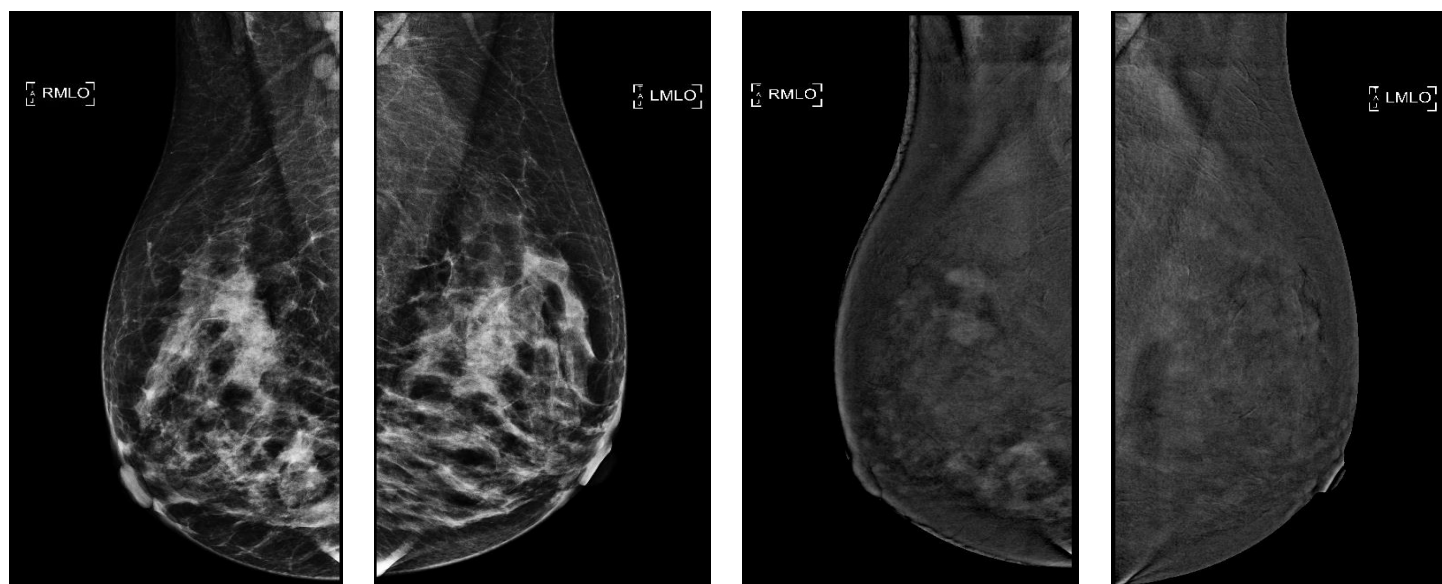
GALLERY OF CASES

Case 4. Dense breasts. Negative digital mammogram but malignancy on CEM



33-year-old female with history of previous benign excisional biopsy in the left breast presents for a new left breast lump. Extremely dense breast on the 2D mammogram shows no abnormality. There is a single enhancing oval mass at site of concern in the upper inner left breast. Mass was subsequently biopsied and proven to be invasive ductal carcinoma.

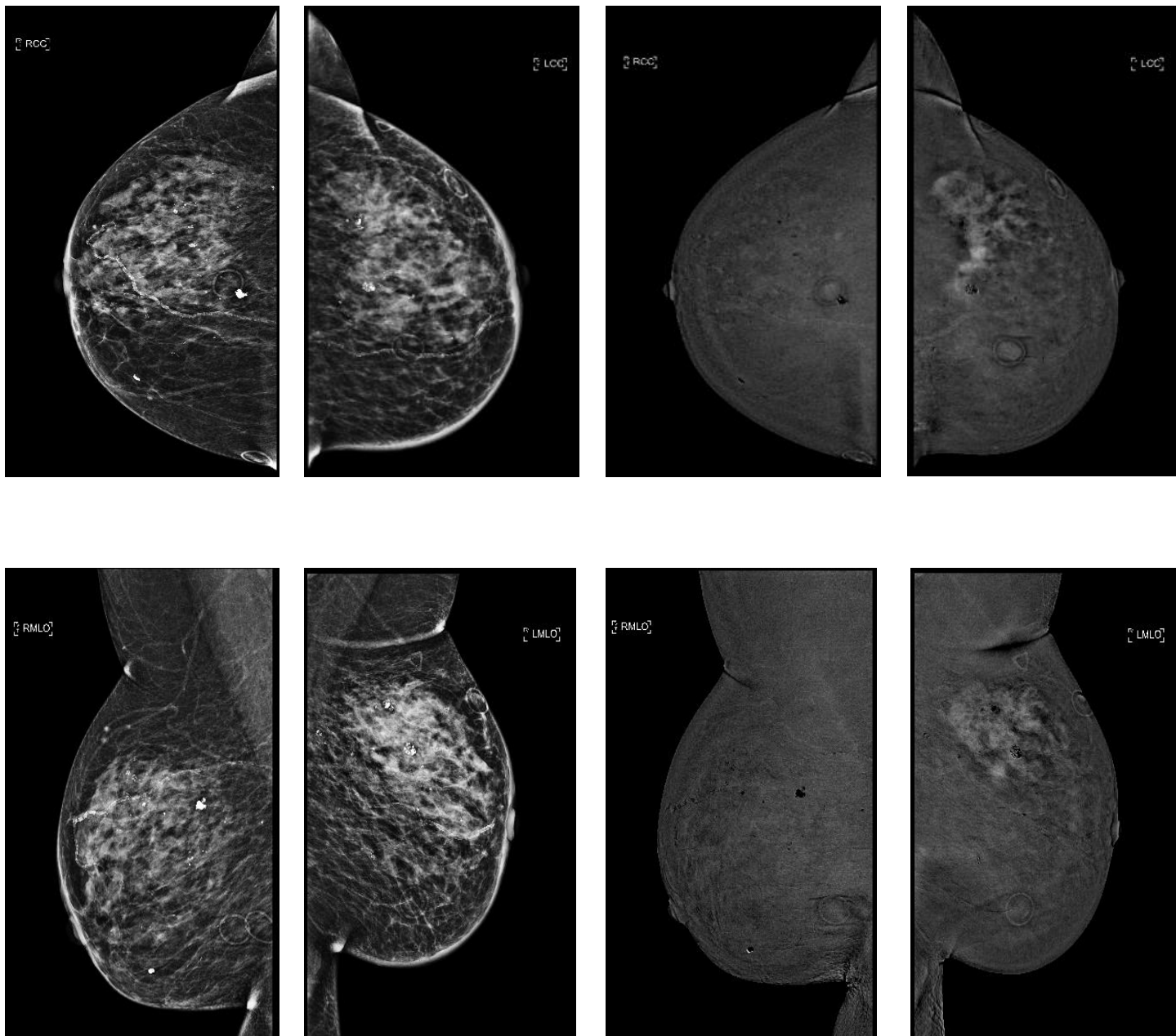
Case 5. Dense breasts. Benign cyst but CEM shows diffuse cancer



50-year-old female with palpable area of concern in the right breast. Patient has dense breasts. There is an asymmetry centrally in the right breast on the digital mammogram. Area of concern was a cyst but contrast mammogram shows multifocal areas of moderate to marked non-mass enhancement throughout the right breast which are mammographically occult. Multiple areas were subsequently biopsied and proven to be invasive ductal carcinoma.

GALLERY OF CASES

Case 6. Architectural distortion on 2D mammogram with aggressive cancer on CEM



75-year-old female with dense breast and complicated mammogram was recalled from screening exam for possible architectural distortion in the left breast. Contrast-enhanced mammography shows a large regional area of non-mass enhancement involving the upper outer quadrant of the left breast. Area of enhancement is much larger than detected area of distortion on the contrast-enhanced mammogram. Tissue biopsy yielded diagnosis of invasive ductal carcinoma with positive left axillary nodal involvement.



Pediatric Radiation Dose Reduction Strategies: Practical Techniques and Application to Community Medicine

by Michael Daniel, MD
Division Chief of Pediatric Radiology
High Plains Radiological Association

INTRODUCTION

As the utilization of diagnostic imaging continues to increase in patient evaluation and treatment guidance, optimizing imaging selection and radiation exposure has become increasingly important. This is especially true in pediatric imaging, which exists at the intersection of diagnostic necessity and long-term patient safety. Over the past two decades, radiology has moved decisively toward minimizing radiation exposure while preserving diagnostic accuracy. This evolution has been driven by technological advances, epidemiologic research, and advocacy from organizations such as the American College of Radiology (ACR), the Society for Pediatric Radiology (SPR), and the Image Gently Alliance. The result is not merely a set of guidelines, but a broader philosophy of pediatric imaging: every examination must be justified, and every imaging parameter optimized for the individual child (1).

RADIATION RISK AND THE NEED FOR DOSE REDUCTION

Children are inherently more sensitive to the biologic effects of ionizing radiation than adults. Rapidly dividing tissues and longer life expectancy increase the likelihood that radiation-induced cellular injury may manifest later in life. The continued application of the linear no-threshold model assumes that even low doses of radiation carry some degree of risk. Although the absolute risk associated with a single computed tomography (CT) examination is small, cumulative exposure becomes important in children requiring repeated imaging for chronic or complex conditions. CT remains one of the largest contributors to medical radiation exposure in children, with millions of pediatric examinations performed each year in the United States (2).

Recent studies underscore the potential effects of CT utilization on cancer risks in both the pediatric and general populations. For children exposed to a cumulative dose of at least 30 mGy (roughly the equivalent of 3 CT exams of the abdomen and pelvis), the excess risk of hematologic malignancies by the age of 21 is estimated to be 25.6 per 10,000 individuals (7). (Imagine the number of leukemias if every child in Amarillo received 3 abdominal CTs!) Another risk model across all age groups in the United States estimates that the approximately 93 million CT exams performed in 2023 could result in up to 103,000 radiation-induced cancers among the 62 million individuals imaged. Using the current rate of CT utilization and average dose parameters, there is potential for CT-induced malignancies to account for up to 5% of new cancer diagnoses annually across all populations (6).

From a practical standpoint, the most powerful dose-reduction strategy remains simple: avoid unnecessary imaging. Current recommendations from the ACR Appropriateness Criteria and the SPR emphasize careful modality selection and encourage the use of non-ionizing imaging alternatives when those options can provide equivalent diagnostic information. Consequently, the discussion has shifted from simply reducing radiation dose to avoiding radiation exposure altogether when possible.

ULTRASOUND-FIRST IMAGING STRATEGIES

Ultrasound has become a cornerstone of pediatric imaging because it uses no ionizing radiation, is widely available, is relatively inexpensive, and provides real-time imaging capability. Pediatric patients are often ideal candidates for ultrasound

because thinner soft tissues and lower body fat improve acoustic windows and image quality. Ultrasound is commonly the first-line modality for conditions such as hypertrophic pyloric stenosis, intussusception, renal pathology, and suspected appendicitis. Over the past decade, “ultrasound-first” diagnostic pathways have significantly reduced CT utilization without increasing complication rates or missed diagnoses (3).

Despite these advantages, ultrasound has limitations. Diagnostic accuracy is highly operator-dependent and may vary according to the experience of the technologist and interpreting physician. This variability is especially relevant in community and rural hospitals, where pediatric imaging expertise may be limited. Ultrasound can also be less effective in obese patients or when bowel gas obscures deeper structures. Even under these circumstances ultrasound often functions effectively as a screening examination, reserving CT for equivocal or complicated cases.

MRI AND SEDATION CONSIDERATIONS

Magnetic resonance imaging (MRI) represents the second major pillar of non-ionizing pediatric imaging. MRI offers superior soft tissue contrast and is less operator-dependent than ultrasound, making it particularly valuable for neurologic, musculoskeletal, and (increasingly) abdominal imaging. Since 2015, improvements in MRI technology—including faster acquisition sequences, enhanced motion correction, and rapid MRI protocols—have substantially expanded its pediatric applications and reduced examination times.

MRI, however, introduces a different risk-benefit consideration: specifically, the need for sedation in young children. Unlike CT, which is typically completed within seconds, MRI requires prolonged patient immobility. Infants and younger children often require sedation or general anesthesia to complete diagnostic-quality studies. Although the risks of sedation are generally low, they are not insignificant and may include respiratory depression, airway compromise, or adverse medication reactions. Concerns also persist regarding the potential neurodevelopmental effects of repeated or prolonged anesthesia exposure during early childhood, although current evidence remains inconclusive. Additionally, sedation requires specialized personnel, monitoring capabilities, and recovery resources, which may limit MRI availability in smaller or resource-constrained institutions (4).

When comparing CT and MRI in pediatric patients, clinicians and radiologists must balance competing risks. CT is rapid, widely accessible, and usually does not require sedation, but it exposes patients to ionizing radiation. MRI eliminates radiation exposure and provides superior soft tissue characterization, but may require sedation and greater institutional resources. Imaging selection therefore depends heavily on the clinical scenario. In acute trauma with suspected intracranial hemorrhage, CT remains the preferred modality because of its speed and high sensitivity for acute blood products. Conversely, MRI is generally favored for serial follow-up of neurologic disorders to avoid cumulative radiation exposure and because of improved tissue characterization. The growing availability of rapid MRI protocols is increasingly shifting this balance by reducing the need for both radiation and sedation in select clinical settings (4).

PRACTICAL DOSE REDUCTION STRATEGIES

These issues are particularly important in community and rural hospitals, where

pediatric-specific MRI protocols or dedicated sedation teams may not be available. In many such settings, CT remains the most practical imaging option. Nevertheless, meaningful radiation dose reduction remains achievable through optimization strategies that can be implemented across diverse practice environments.

Dose reduction in conventional radiography and CT is guided by the ALARA (“As Low As Reasonably Achievable”) principle, which emphasizes balancing diagnostic image quality with minimal radiation exposure. Pediatric imaging reinforces the principle that “one size does not fit all”, and protocols must be individualized rather than standardized across all patients. One of the most effective interventions is the implementation of weight-based CT protocols. Even on older scanners, reducing tube current (mA) and tube voltage (kVp) according to patient size can substantially lower radiation dose while maintaining image quality. Lowering kVp is particularly effective because it can markedly reduce radiation exposure while preserving tissue contrast (1).

Additional strategies include limiting multiphase examinations, restricting scan coverage to the area of clinical concern, and utilizing iterative or deep learning–based reconstruction techniques to maintain image quality at lower doses. Participation in quality improvement initiatives such as the ACR Dose Index Registry also allows institutions to benchmark performance and identify opportunities for protocol optimization. Education of technologists, radiologists, and referring clinicians remains equally important, as inappropriate imaging requests and poorly optimized protocols continue to contribute to unnecessary radiation exposure (5).

Interestingly, many pediatric imaging strategies have influenced adult radiology practice as well. Although adults are generally less radiosensitive than children,

significant variability in CT dose exists across institutions. Concepts pioneered in pediatric imaging—including diagnostic reference levels, reduction of unnecessary multiphase imaging, and advanced image reconstruction techniques—are now widely applied in adult imaging protocols. In this regard, pediatric radiology has served as a model for broader improvements in imaging safety.

FUTURE DIRECTIONS

Looking forward, emerging technologies continue to reshape pediatric imaging. Deep learning reconstruction algorithms, photon-counting CT systems, and artificial intelligence–driven protocol optimization promise further reductions in radiation dose while improving image quality. Simultaneously, advances in ultrasound and rapid MRI continue to expand non-ionizing imaging alternatives (5).

CONCLUSION

Ultimately, pediatric dose reduction is not defined by a single technology or protocol, but by an evolving culture of safety and thoughtful clinical decision-making. It requires continuous reassessment of risk and benefit, careful modality selection, and a willingness to adapt as technology and evidence evolve. Whether practiced in a tertiary pediatric center or a rural community hospital, the objective remains consistent: obtain the diagnostic information necessary while exposing the child to the least possible risk.

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Dr. Daniel joined HPRA in 2012 and, along with his wife and three daughters, has been a part of the Amarillo community for the past 14 years. He received his medical degree from Texas Tech University Health Sciences Center in Lubbock, followed by a residency in Diagnostic Radiology at Scott & White Hospital and Clinic (TAMUHSC) in Temple, TX. He then completed a Pediatric Radiology fellowship at Children's Medical Center Dallas (UT Southwestern). In his spare time, Dr. Daniel enjoys traveling with his daughters for club volleyball and fly fishing.

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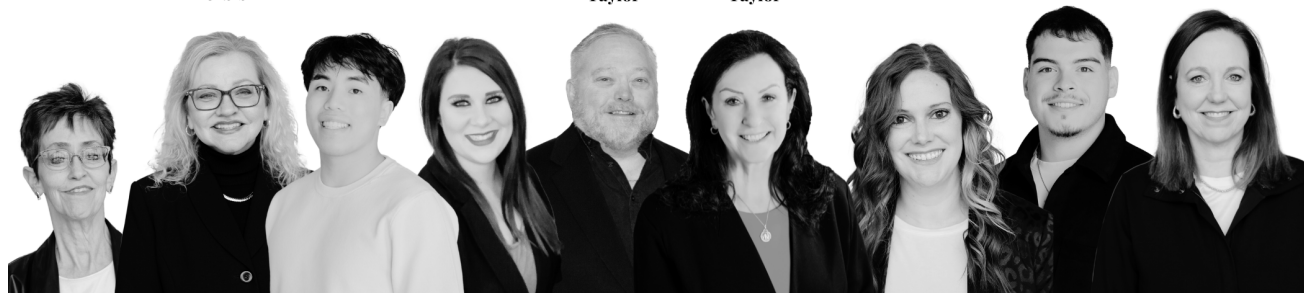
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MRI Safety of Cardiac Devices: Not a Quick or Easy Process

by April Bailey, MD

There is no “MR safe” cardiac pacemaker or defibrillator, but patients with conditional devices can safely undergo magnetic resonance imaging. This may seem confusing, and it is definitely worth reviewing.

Magnetic Resonance Imaging (MRI) is an indispensable tool in evaluating patients, given superior soft tissue contrast to other modalities available like Computed Tomography (CT) and Ultrasound (US). In lieu of ionizing radiation, MRI uses very strong magnetic fields and radio waves to create the images. This takes time (patients must lie still in the machine for many minutes), and extreme caution must be used working around the magnetic field. Everyday items with ferromagnetic properties can become lethal projectiles. Implanted devices and shrapnel can displace, torque, conduct electricity, or heat up inside of the patient. Skin burns can occur from the electrical currents.

Every day, our MR technologists review every implant in every patient, and every person who enters the MR environment. Hours are spent identifying the type of implant, researching its MR safety data, and determining how to safely image every person. The nomenclature is very specific. Devices are: **MR safe** (go for it!), **MR conditional** (OK within limited parameters), and **MR unsafe** (usually a no-go). The safety profiles are device specific, not generic for each kind of implant. For example, IVC filters in general are not rated, but each type of IVC filter (Bard Denali, Bard Eclipse, Cook Gunther Tulip, etc.) has its own safety profile and conditions that must be met. These conditions, which relate to the energy deposited

into the patient, the need for cooling, and the type of MR system (field strength and direction, types of coils used, etc.) are specific for each device.

The situation becomes more complicated with cardiac pacemakers and defibrillators (for ease, I will continue with the generic term “cardiac devices”). As a radiologist, my job is often to find alternative imaging that may answer the clinical question and keep the patient out of the MRI suite. This is often the quickest and safest way and can usually be done same day.

The lowest-risk cardiac devices currently available start out as MR conditional (not MR safe). Even with a MR conditional device, confirming that the device is still MR conditional is not an easy process. We start by gathering information about the cardiac device (type, manufacturer, model number), and then we obtain radiographs. In order for the original safety profile for that particular implanted device to remain in effect, the leads must also be from the same manufacturer, standard to that device. Any change to the device or leads invalidates the previous testing and, instead of being MR conditional (as the original device started), a change occurs, most commonly resulting in the device being considered MR unsafe (termed **MR non-conditional** in this realm). These are the highest risk patients we can image, so the risk must make a clinical difference.

We review radiographs to ensure the information about the device we have is reflective of what is still in the patient. If the device was exchanged, were the original leads extracted or are the old leads still

in place? Any abandoned leads? Broken leads? Any other implanted devices in proximity to the leads or the battery pack?

Our next question: is the cardiac device still functional? Will it go into MR mode (a setting within the cardiac device itself) or a compatible equivalent mode? Is the battery reserve adequate to complete the study? It is easy to see that the answers to all these questions do not reside in the radiology department alone! In our area, we are very lucky to have a specialized team to accomplish these goals. Our team includes a cardiologist with expertise in both the MR environment and cardiac electrophysiology and a Magnetic Resonance Safety Officer (MRSO) and Magnetic Resonance Medical Director (MRMD) from the Radiology Department. Having this team helps bridge the knowledge gap and allows us to perform exams on patients with cardiac devices as safely as possible.

This process is not fast. It requires a clinic visit to gather the necessary information, interrogate the device, and get preliminary imaging--then, usually, a second visit to do the procedure. This is not something that can happen in the middle of the night or on weekends. Very quickly, this detailed process can lead to a MR conditional device being considered MR nonconditional (again, MR nonconditional confers the highest risk of an adverse event occurring during the MRI procedure).

It is very difficult to monitor a patient when they are in the MRI tube. For instance, an ECG is degraded by artifacts during image acquisition, and the tracing may not represent the cardiac activity of

the patient. For a MR nonconditional cardiac device, the patient needs to be able to communicate with us. These exams are scheduled when the type of MRI machine needed is available, with the device representative from the manufacturer as well as the cardiologist onsite. The cardiologist is immediately available to provide transvenous pacing in case the cardiac device fails or the patient cannot tolerate the settings programmed within the cardiac device when it goes into MR mode.

Having this team is truly a luxury and wonderful benefit to our community. Still, there are no safe “short cuts.” This is not a place to be a medical cowboy or to push the limits. Having our team and this process in place, however, allows us to confidently offer the MR service to most patients who have an implanted cardiac device.

Unfortunately, as you can tell, the nomenclature is confusing. I have had doctors and cardiologists tell hospitals

in the panhandle that “*the pacemaker is safe for MRI*” when the situation is more complicated than that. In truth, the patient can be imaged in a safe way, minimizing risks, but not casually or routinely. There have been near misses and life-threatening events. Last July, a patient with a cardiac device in Tennessee died during an attempted MRI; this event is currently being investigated. Earlier that year, a woman in India died during her MRI with a cardiac device, as reportedly no one recognized her distress (although her husband was with her). The process required to provide these exams safely is time-consuming and, from the outside, can seem disruptive, but ultimately these precautions are necessary for the safety of the patient.

Recognizing the clinical need for MR exams in patients who have cardiac devices, I am grateful to our team for working daily to help these exams get done. I recognize that there may be frustration at times, but the steps we take

are to ensure patient safety while obtaining the exams needed to answer clinical questions. At times, using an alternate modality may be quickest way to get the information you need. When ultimately the MR is the only or best option, we will work through the process outlined above to be able to provide the necessary exam. Your local radiologists are here to help—we work hard to find answers and get the team together for your patients when they need us.

April Bailey, MD is a radiologist with High Plains Radiological Association. She has enjoyed being with the group since 2017 and looks forward to caring for people in the Texas panhandle for many years to come. Her fellowship training is women’s imaging (obstetric and gynecologic care) as well as body MRI.

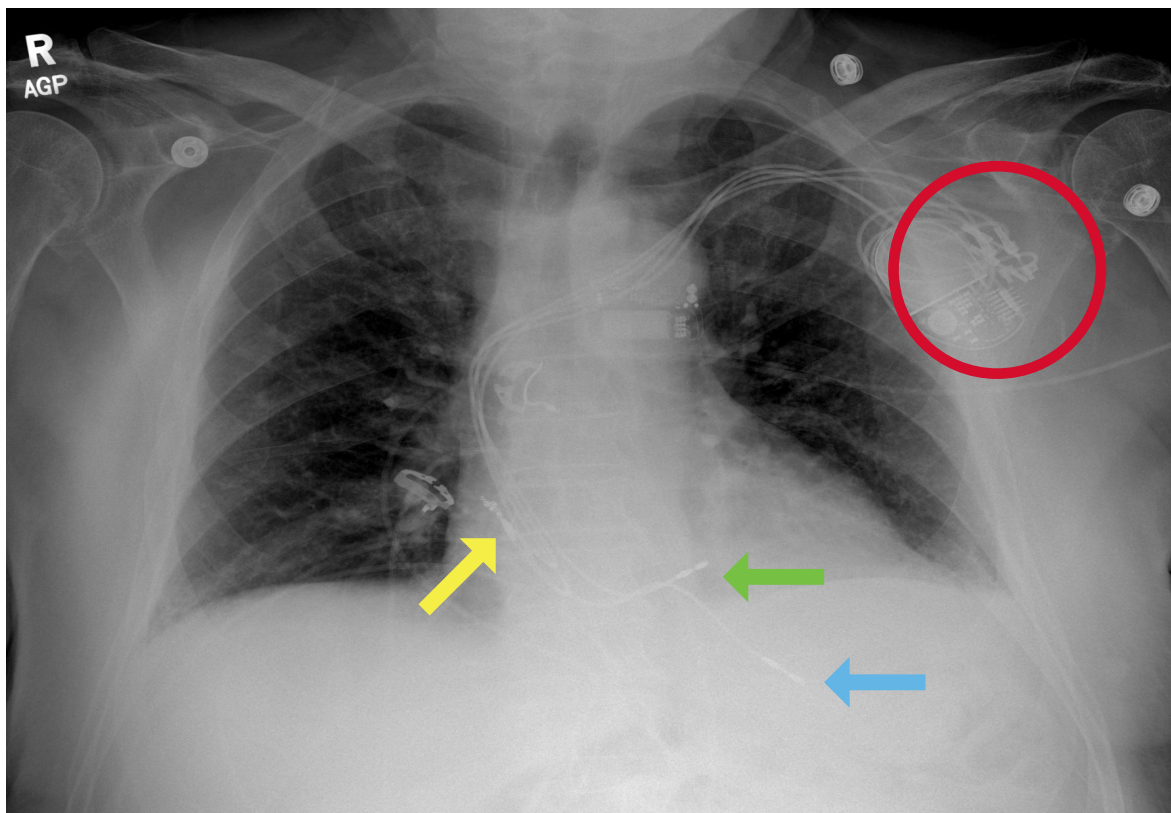


Image 1. AP Chest radiograph with left chest cardiac device. There is an abandoned lead. Yellow arrow denoting abandoned and active atrial leads. Short green arrow showing a new left bundle branch area pacing lead. Blue arrow denoting the original ventricular lead. The red circle showing the disconnected, abandoned lead at the battery pack.



PLUVICTO: A New Era of Targeted Radiation Therapy for Advanced Prostate Cancer

by Irfan Ahmed, MD and Curtis Reneau, MSHA



Prostate cancer remains one of the most common cancers affecting men worldwide (1). While many cases are diagnosed early and treated successfully, advanced forms of the disease, especially those that spread beyond the prostate, can be far more challenging. In recent years, a promising therapy called **Pluvicto®** has emerged as an innovative and targeted treatment option for select patients with advanced prostate cancer.

This article aims to explain Pluvicto in clear, simple terms: about its history, how it works, who it helps, and what patients can expect.

A BRIEF HISTORY: FROM CONCEPT TO CLINIC

Pluvicto (scientific name: lutetium-177 vipivotide tetraxetan) represents the culmination of decades of research in nuclear medicine and targeted cancer therapy. The idea behind it is elegant: combining a molecule that can “seek out” cancer cells with a radioactive particle that can destroy them.

This type of treatment, called **radioligand therapy**, was developed through research in Europe and later tested in large international clinical trials. Based on strong evidence showing improved survival in patients with advanced prostate cancer, the U.S. Food and Drug Administration (FDA) approved Pluvicto in March 2022.

WHAT MAKES PLUVICTO DIFFERENT?

Unlike traditional chemotherapy, which affects both healthy and cancerous cells, PLUVICTO is a **precision therapy**. It targets a specific marker found on prostate cancer cells known as **PSMA (prostate-specific membrane antigen)**.

Most advanced prostate cancers express high levels of PSMA, making it an ideal “target” for therapy.

MECHANISM OF ACTION: HOW PLUVICTO WORKS

Think of PLUVICTO as a “guided missile”:

- 1. Targeting:** The drug contains a ligand (a targeting molecule) that specifically binds to PSMA on the surface of prostate cancer cells.
- 2. Delivery:** Attached to this ligand is a radioactive isotope called lutetium-177.
- 3. Cell destruction:** Once it interacts with its receptor, the drug is internalized into the cancer cell and releases radiation, damaging the cell’s DNA and causing it to die.

Importantly, this radiation (primarily beta particles) mostly travels only a very short distance, which helps limit damage to surrounding healthy tissues, though some nearby cells can still be affected.

WHO IS ELIGIBLE FOR PLUVICTO?

Pluvicto is not a first-line treatment. It is typically used in patients with:

- **Metastatic prostate cancer** (cancer that has spread beyond the prostate)
- **Castration-resistant disease** (cancer that continues to grow despite hormone therapy)
- **PSMA-positive tumors** (confirmed via specialized imaging scans)
- Prior treatment with:
 - o Hormonal therapies (androgen receptor pathway inhibitors)
 - o Often chemotherapy (such as docetaxel)

This means Pluvicto is generally reserved for patients whose cancer has progressed despite these standard treatments.

BENEFITS OF PLUVICTO

Clinical trials have demonstrated several meaningful benefits:

1. Improved Survival

Patients receiving Pluvicto lived longer compared to those receiving standard therapy alone (2). For instance, in a recent Lancet trial of patients who have progressed despite initial androgen blockade, Pluvicto (when compared to switching the patient to another androgen blocker) prolonged progression-free survival by 5 months (from 7.8 to 13 months) (3).

2. Symptom Relief

Many patients experience reduction in cancer-related symptoms such as bone pain.

3. Targeted Approach

Because it selectively targets PSMA-expressing cells, it often causes fewer systemic side effects than traditional chemotherapy.

4. Quality of Life

For patients with limited options, Pluvicto can help slow disease progression while maintaining functional status.

POTENTIAL SIDE EFFECTS

Like all cancer therapies, Pluvicto is not without risks. However, its side effect profile is generally manageable.

Common Side Effects

- Fatigue
- Dry mouth
- Nausea
- Decreased appetite
- Constipation

Blood-Related Effects

- Low red blood cells (anemia)
- Low white blood cells (infection risk)
- Low platelets (bleeding risk)

Other Considerations

- Mild kidney function changes
- Radiation exposure precautions (these include limiting close personal contact for 2 days and avoiding exposure to children or pregnant women for a week)
- Rare but serious bone marrow suppression or renal toxicity

Patients are typically monitored closely with blood tests and imaging during treatment.

WHAT TO EXPECT DURING TREATMENT

Pluvicto is administered as an intravenous infusion, usually **every 6 weeks for up to 6 cycles**.

Because it is a radioactive treatment:

- Patients may need to follow short-term radiation safety precautions (see above)

- Hydration is encouraged to help clear the drug from the body

Treatment is usually performed in specialized centers with expertise in nuclear medicine or radiation oncology.

THE BIGGER PICTURE: A SHIFT IN CANCER TREATMENT

Pluvicto represents a major step forward in personalized cancer therapy treatments tailored to the biology of a patient's tumor.

For patients with advanced prostate cancer who have exhausted traditional options, it offers:

- A scientifically elegant approach
- A meaningful extension of survival
- Hope where few options previously existed

Ongoing research is exploring whether Pluvicto can be used earlier in the disease course and in combination with other therapies. A recent small study has suggested that 2-4 cycles of Pluvicto given concomitantly with initial androgen blockade has some benefit, and pilot

trials in patients with regional spread are underway.

FINAL THOUGHTS

As a radiation oncologist, I view Pluvicto as part of an exciting evolution in cancer care, where treatments are becoming smarter, more precise, and increasingly patient-centered.

While it is not a cure, it is a powerful tool that is already improving outcomes for many patients with advanced prostate cancer. As research continues, therapies like Pluvicto may redefine how we approach cancer treatment in the years ahead.

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Curtis Reneau, MSHA is the executive director of the Panhandle Cancer Care Center. He was born and raised in Amarillo, where he graduated from San Jacinto Christian Academy. Curtis is a former radiation therapist and has spent his last 14 years in healthcare as a Healthcare Leader. His goal is to make a positive impact in the Amarillo healthcare community by increasing the accessibility and quality of care.



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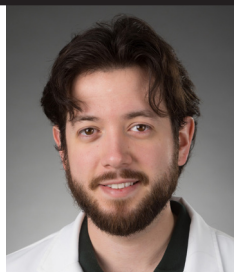
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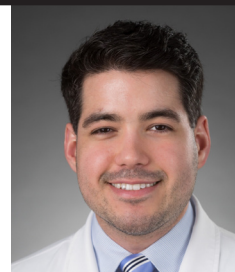
by Ernesto Ponce Cruz, MS3; Quratulain Shekoh, MS3; Alejandro Ponce Cruz, MS3; Joselin Garcia, MS3; Aiman Shekoh, Taha Hassan, MD; Aiman Rasheed, MD; Tarek Naguib, MD, FACP



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Point-Of-Care Ultrasound (POCUS) is use by a bedside clinician of ultrasound to answer a specific diagnostic question or guide a medical procedure in real time. The concept was developed by the military for use on the battlefield, as older ultrasound (US) devices were large (and unwieldy), making them inaccessible for combat medics. A Defense Advanced Research Projects Agency (DARPA) grant facilitated the creation of the SonoSite 180, an early lightweight, hand-carried ultrasound (1). This technological breakthrough paved the way for the highly mobile ultrasound units (such as the GE Venue GO or the Sonosite PX) that we use today.

PRACTICAL APPLICATIONS

For the front-line provider, such as hospitalist, intensivist, emergency physician or outpatient practitioner, Point-Of-Care Ultrasound (POCUS) delivers high-yield, immediate diagnostic and procedural utility across multiple clinical domains.

A practitioner can utilize a focused lung ultrasound to rapidly identify diffuse B-lines, instantly indicating pulmonary congestion or edema. By incorporating targeted cardiopulmonary POCUS, providers significantly increase diagnostic confidence and accuracy compared to standard clinical judgment alone, safely reducing the need to refer dyspneic patients to external imaging centers (2). This immediate diagnostic clarity empowers clinicians to rapidly initiate targeted interventions such as adjusting hypertension medications or administering diuretics for patients presenting with acute shortness of breath.

These tools can dramatically accelerate the diagnostic timeline for outpatient complaints like right upper quadrant (RUQ) pain. A practitioner can rapidly utilize a curvilinear probe to visualize the gallbladder, where the immediate confirmation of bright, hyper-reflective stones casting dark acoustic shadows instantly confirms the diagnosis of cholelithiasis. This anatomical certainty justifies acute management in the clinic and expedites specialist surgical referral, eliminating delays associated with formal radiology scheduling (2).

POCUS also functions as a tiebreaker in soft tissue evaluation by instantly differentiating simple cellulitis from a hidden fluid pocket or abscess, correctly altering clinical management and preventing unnecessary drainage (2). For joint injections or aspiration, POCUS provides live visual guidance, replacing reliance on blind anatomical landmarks and thus increasing procedural accuracy, reducing the incidence of dry taps, and minimizing patient discomfort.

In family planning and OB/GYN clinics, POCUS serves as an indispensable triage tool. For patients presenting with early pregnancy, bleeding, or abdominal pain, a bedside scan can immediately confirm an intrauterine pregnancy, thus rapidly excluding a life-threatening ectopic pregnancy and reducing time to diagnosis (2). Furthermore, the instant visualization of a fetal heartbeat during a routine checkup offers immediate reassurance, circumventing the logistical need for a separate, formal ultrasound appointment.



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THE NEXT GENERATION

While older, cart-based ultrasound units provided the backbone for hospital diagnostics for years, the recent addition of hand-held units has dramatically expanded the scope of POCUS.

You might be wondering: “Wouldn’t I have to have a powerful computer sitting in my pocket?”, and you would be correct! Your smartphone is no longer just useful for scrolling social media. With the advent of silicon chips and smartphone technology, physicians can now connect an ultrasound probe (like the Butterfly iQ+) directly to a smartphone or tablet.

The probe collects the data and makes the smart device process it all, allowing instant results from a device that can easily slip into the pocket of a white coat.

Portable devices have become very affordable. Historically, older probes used expensive, fragile piezoelectric crystals to generate sound waves. Newer devices (like the Butterfly iQ+) have replaced these crystals with thousands of microscopic sensors carved into a single silicon chip. This has made the probes incredibly durable and has slashed the price from \$30,000 down to around \$2,500. For rural clinics, this facilitates the implementation of these tools; in addition, replacement probes are fabricated in factories rather than specialized labs, offering quick and reliable stock (3).

These hand-held devices add value to the clinical encounter; instead of losing the patient to an outpatient imaging center in a different city for a simple fluid check, the practitioner can perform the scan in 60 seconds at the bedside. Dedicated, well-established CPT billing codes (4) have been formalized, meaning that the clinic is fairly compensated for their time and expertise, while the patient saves on travel time, specialist co-pays, and diagnostic delays. The apps that control these devices are HIPAA compliant, encrypting and delivering the imaging directly to the EMR, leaving nothing locally within the device. This is a great resource to help support the financial survival of many rural clinics across the Texas Panhandle, creating an incentive for more rural hospitals and clinics to

provide bedside imaging for their practitioners.

THE PANHANDLE

The Texas Panhandle presents unique healthcare challenges defined by long transportation times and geographical barriers between local critical access hospitals and tertiary trauma centers like University Medical Center (UMC) in Lubbock and Northwest Texas Healthcare System (NWTHS) in Amarillo. In towns like Childress and Dalhart, a general practitioner can perform an eFAST (Extended Focused Assessment with Sonography in Trauma) exam while air medical transport is en route. This capability ensures that the surgical team is prepared for immediate intervention upon arrival by identifying a tension pneumothorax or an intraperitoneal bleed ahead of time.

Beyond acute trauma, POCUS serves as a critical extension of the physical exam in these geographically isolated settings, significantly improving clinical triage (5). Rather than reflexively transferring a patient to Lubbock or Amarillo for potential DVT or cholecystitis, local clinicians can utilize bedside imaging to accurately determine the true urgency of specialist referral. By safely ruling out major emergencies in-house, POCUS prevents unnecessary and costly medical transports. For a patient population facing significant geographical and financial barriers, keeping this diagnostic capability local contributes to the delivery of accessible, patient-centered care (5).

Furthermore, integrating POCUS into their practice broadens the clinical scope and autonomy of the rural practitioner. Given the Panhandle’s reliance on farming and agriculture, the local population faces an elevated risk of soft tissue infections and foreign body injuries. A PCP in Dumas, for instance, can utilize a high-frequency linear probe to precisely localize an abscess, metal shard, or organic splinter at the point of care, enabling in-office extraction and com-

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pletely bypassing the need for a distant specialist or ED referral.

CONCLUSION

POCUS is now established as an essential extension of the physical exam, revolutionizing clinical decision-making across diverse settings. The innovation of affordable, hand-held devices, replacing bulky carts and fragile crystals with durable, silicon-chip technology, has democratized the availability of ultrasound. By integrating seamlessly into electronic medical records, POCUS can improve cash flow and sustainability of rural care. For rural practitioners, this capability provides immediate diagnostic certainty, accelerating care for common complaints like pulmonary congestion, cholelithiasis, and soft tissue infections, and ensuring accurate procedural guidance. Crucially, POCUS can serve as a critical force multiplier in geographically isolated, resource-limited areas like the Texas Panhandle. By enabling rapid trauma triage, preventing costly and unnecessary medical transports, and establishing a sustainable local revenue stream via dedicated CPT codes, POCUS ensures accessible, patient-centered care. As medical curricula fully embrace POCUS, it is moving ultrasound from an outsourced technology to a core tool essential for modern practice.

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Ernesto Ponce Cruz is a 3rd year medical student at TTUHSC School of Medicine. Ernesto is dedicated to pursue internal medicine as a career. He loves to learn about different technologies as a hobby, especially ones that revolve around tools that are practical and applicable to the average person. He also enjoys illustrating digital comics in his free time.

Quratulain Shekoh is also a 3rd year medical student at TTUHSC. Originally from Houston, she says that the Panhandle now feels like her second home. Outside of medicine, she enjoys learning new skills through home economics.

Alejandro Ponce Cruz is a third-year medical student at Texas Tech University Health Sciences Center training in Amarillo. He was born in Cuba where he learned to speak Spanish, grew up in Canada, and is now living in the United States focusing on a future career in Internal Medicine. His primary clinical passions lie within the fields of cardiology and nephrology. In his free time, Alejandro enjoys working out, running, and watching movies.

Joselin Garcia is a third-year medical student at Texas Tech University School of Medicine. Having spent most of her childhood in Denver City, Texas, she developed a strong commitment to serving underserved communities and improving access to healthcare. As the first person in her family to attend both college and medical school, she values perseverance, community, and meaningful patient care. Outside of medicine, she enjoys running, weightlifting, cooking, reading, and spending quality time with her family.

Aiman Shekoh is a junior undergrad majoring in public health but on the pre-med track. She has a passion for community wellness

and preventative care. Outside of school, Aiman works as a certified makeup artist and enjoys connecting with others through meaningful conversations and acts of care.

Dr. Taha Hassan is an internal medicine resident at TTUHSC Amarillo with plans to pursue a fellowship in hematology and oncology. Originally from Alameda, California, he moved to Dallas in seventh grade and has called Texas home ever since, eventually making his way to Lubbock for medical school at TTUHSC. Outside of the hospital, he can usually be found in the gym — powerlifting and strength training are long-standing passions — or playing basketball whenever he can round up a game.

Dr. Aiman Rasheed grew up in a small town in Punjab, Pakistan. She trained in anesthesia in Pakistan before discovering a growing interest in internal medicine, which eventually led her to begin residency training in the United States. She is currently finishing her intern year and is enjoying her time in Amarillo while continuing to explore her future fellowship interests. Outside of medicine, she enjoys spending time with family and friends, hosting get-togethers, baking, and photography.

Dr. Tarek Naguib, MD, MACP has been a cornerstone of medical practice and education in the Panhandle for over 18 years. Board certified in both nephrology and infectious diseases, he has served as regional chair of the Department of Internal Medicine at TTUSOM since 2017. Tarek has a strong commitment to the American College of Physicians, the largest professional organization of internists in the US. He has been a board member of the Texas chapter of the ACP and, in 2025, was awarded mastership in the ACP, the highest clinical honor that the College confers.



Severe Lemierre Syndrome with Septic Shock, Respiratory Failure, and Deep Neck Abscess

by **Santhoshi Vaidhyula MD**, **Walter Bridges MD**, **Tetyana L Vasylyeva MD**, **Jeffrey Black MS3**, **William G Petersen MD (pulmonary/critical care)**, **Wyatt Weinheimer MD (ENT)**

INTRODUCTION

Lemierre syndrome is a rare but life-threatening complication of acute oropharyngeal infection characterized by septic thrombophlebitis of the internal jugular vein with metastatic septic embolization. The syndrome is classically associated with *Fusobacterium necrophorum*, an anaerobic gram-negative bacillus, and is historically referred to as the “forgotten disease” of the antibiotic era. Lemierre syndrome typically begins with bacterial or viral pharyngitis, followed by invasion into the lateral pharyngeal space, septic thrombosis of the internal jugular vein, and hematogenous dissemination of the infection to distant organs, most commonly the lungs.

CASE PRESENTATION

A previously healthy 21-year-old woman developed severe sore throat and cervical lymphadenopathy and was treated with amoxicillin for presumed streptococcal pharyngitis. Persistent fatigue and progressive cervical swelling later prompted evaluation for infectious mononucleosis, and corticosteroid therapy was initiated. Approximately four weeks later, the patient presented with high-grade fever, progressive unilateral neck swelling, hemoptysis, pleuritic chest discomfort, worsening respiratory distress, and septic shock. She required admission to the critical care unit for aggressive hemodynamic resuscitation and close pulmonary monitoring. Despite initial fluid resuscitation with multiple intravenous saline boluses, the patient developed shock and worsening hypoxic respiratory failure requiring multidisciplinary evaluation and intensive monitoring.

The laboratory profile demonstrated profound systemic inflammatory response

with markedly elevated CRP and sedimentation rate. Severe anemia and reactive thrombocytosis reflected prolonged inflammatory stress and critical illness. Elevated procalcitonin supported severe bacterial infection despite normal white blood cell count, which may occur in overwhelming sepsis or partially-treated infection. Overall, the laboratory findings correlated with disseminated necrobacillosis, septic shock physiology, pulmonary septic embolization, and prolonged inflammatory disease burden.

DIAGNOSTIC EVALUATION

Computed tomography imaging demonstrated a multiloculated abscess posterior to the left sternocleidomastoid muscle with extensive surrounding inflammatory changes. Additional imaging revealed bilateral pulmonary infiltrates consistent with septic emboli, pleural effusions, hepatosplenomegaly, pericardial effusion, diffuse edema, and suspected internal jugular vein thrombosis. Otolaryngology consultation confirmed a deep neck abscess, and incision and drainage were performed. Cultures from the abscess grew *Fusobacterium necrophorum*, establishing the diagnosis of necrobacillosis associated with Lemierre syndrome.

HOSPITAL COURSE AND MANAGEMENT

The patient required coordinated multidisciplinary management involving infectious disease, pulmonology, hematology, otolaryngology, pharmacy, nutrition services, and critical care specialists. Broad-spectrum antimicrobial therapy was initiated and escalated to include piperacillin–tazobactam, metronidazole, linezolid, and eventually prolonged intravenous ertapenem therapy. Persistent pleural effusions associated with pulmo-



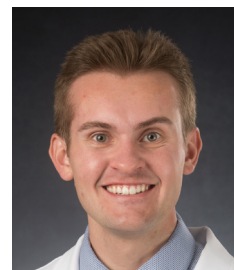
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Laboratory Findings on Admission

Laboratory	Result	Reference	Interpretation
Hemoglobin	8.1 g/dl	12.0-16.0	Severe anemia consistent with inflammatory/chronic disease
Hematocrit	23.6%	37-47%	Marked reduction supporting significant anemia
Platelets	503 K/uL	130-140	Reactive thrombocytosis from severe inflammation
RDW	14.6%	11.5-14.0	Mild anisocytosis
Procalcitonin	0.36 ng/ml	<0.05	Elevated; supports active bacterial infection/sepsis
CRP (High Sensitivity)	2.440 mg/dl	<1.0	Marked inflammatory response
Sedimentation Rate	78 mm/hr	<2C	Severe systemic inflammation
Calcium	8.5 mg/dl	8.6-10.3	Mild hypocalcemia
Creatinine	0.57 mg/dl	0.60-1.30	Low creatinine likely due to low muscle mass
WBC	5.3	4.8-10.8	Normal count despite severe infection
Neutrophils	67.1%	40-74%	Relative neutrophil predominance

nary consolidations required chest tube placement. Given concern for septic thrombophlebitis involving the internal jugular vein, anticoagulation therapy with rivaroxaban was initiated. Over several weeks, her inflammatory markers gradually improved and her pulmonary status stabilized. The patient was ultimately discharged home with home-health services, prolonged antimicrobial therapy, anticoagulation, and close outpatient follow-up.

DISCUSSION

This case demonstrates the classic progression of Lemierre syndrome following antecedent streptococcal pharyngitis and probable Epstein-Barr virus infection. Several mechanisms may contribute to the development of invasive anaerobic infection following viral illness, including mucosal disruption, altered local flora, immune dysregulation, and delayed recognition. Advanced Lemierre syndrome carries substantial morbidity due to respi-

ratory failure, septic embolization, pleural involvement, and multi-organ inflammatory response. Delayed diagnosis remains common because initial symptoms frequently resemble uncomplicated viral pharyngitis. Early recognition, prompt imaging, surgical source control, broad anaerobic antimicrobial coverage, and aggressive supportive care remain essential for favorable outcomes.

CONCLUSION

Lemierre syndrome remains a rare but potentially fatal invasive infection requiring a high degree of clinical suspicion. Young adults presenting with persistent fever, unilateral neck swelling, respiratory symptoms, and systemic inflammatory findings following recent pharyngitis should undergo prompt evaluation for invasive anaerobic infection. This case highlights the importance of multidisciplinary collaboration, early imaging, targeted antimicrobial therapy, and surgical

drainage in reducing morbidity and mortality associated with Lemierre syndrome.

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Originally from Hyderabad, India, Dr. Santhoshi Vaidhyula completed her medical education at Malla Reddy Institute of Medical Sciences in Hyderabad. She is currently a PGY-1 Pediatrics resident at Texas Tech University Health Sciences Center in Amarillo, Texas, where she enjoys caring for children and continuing to grow as a physician. Outside of medicine, she loves traveling, exploring new places, cooking, and spending quality time with family and friends. She values meaningful connections, cultural experiences, and lifelong learning, all of which continue to shape her personal and professional journey.

Dr. Walter Bridges has been involved in student and resident education in Amarillo since he came here as a third-year medical student in 1986. He completed a Med-Peds combined residency in 1992. His practice since then has been in the realm of pediatrics, although he was involved as program director of the combined med-peds residency. Walter is an expert in the care of special needs children, and has for many years served on the editorial board of Panhandle Health.

Dr. Tetyana Vasylyeva has spent 45 years in the care of children, primarily children with kidney disease. She was initially trained in Ukraine, where she was a professor at Dnipropetrovsk State Medical Academy. After emigrating to the U.S., she completed a pediatrics residency (at TTUSOM Amarillo)

and a pediatric nephrology fellowship. She is now professor of pediatrics and Assistant Regional Dean for Research at TTUSOM-Amarillo. Dr. Vasyleva is the immediate past president of the Potter-Randall County Medical Society.

Originally from Utah, Jeffrey Black is a third-year medical student at Texas Tech University Health Sciences Center School of Medicine who also completed his MBA during medical school. He plans to pursue a career in otolaryngology and is actively involved in research and healthcare leadership. Outside of medicine, Jeffrey enjoys freestyle skiing, motorsports, and outdoor recreation.

Drs. Petersen and Weinheimer were directly involved in the care of our patient. Their care and expertise are much appreciated by the care team.

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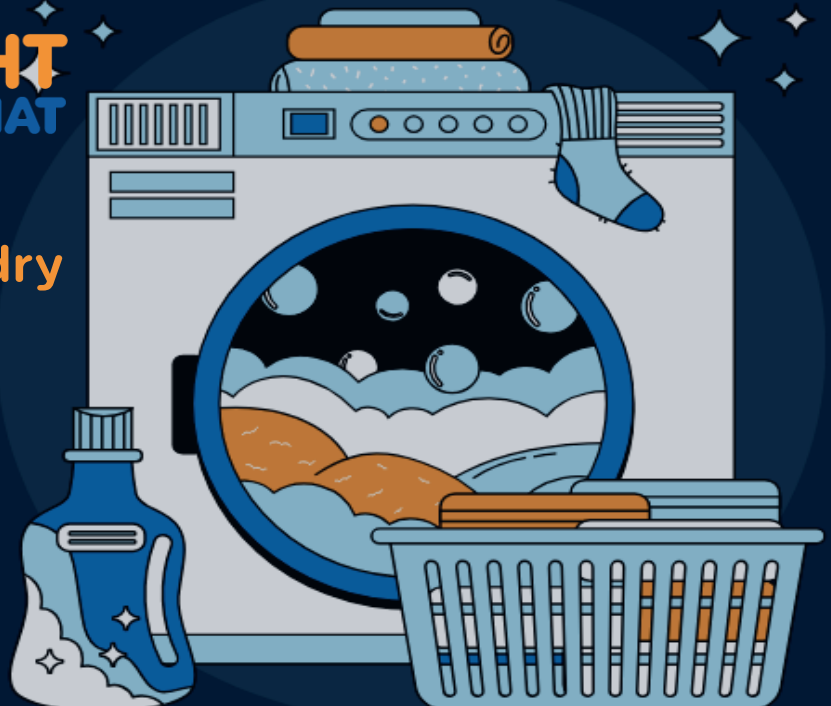
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