CTA revolutionizes treatment of peripheral vascular disease

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We continue to be both amazed and intrigued by the hype showered on cardiac CT angiography and the corresponding lack of hype given to peripheral vascular CTA. No doubt, 64-slice cardiac or coronary CTA is potentially a revolutionizing technology, but PV-CTA has already revolutionized the comprehensive diagnosis and treatment of peripheral vascular disease.

We continue to be both amazed and intrigued by the hype showered on cardiac CT angiography and the corresponding lack of hype given to peripheral vascular CTA. No doubt, 64-slice cardiac or coronary CTA is potentially a revolutionizing technology, but PV-CTA has already revolutionized the comprehensive diagnosis and treatment of peripheral vascular disease.

This cardiac CTA infatuation should come as no surprise, as most new technologies are initially tailored toward percutaneous coronary interventions and then adapted to treat PVD. We have experienced this process over the last two decades; endovascular technologies have only recently been designed specifically for PVD. PV-CTA is just as important a tool for treating PVD as any novel device or pharmaceutical technology. As the honeymoon with cardiac CTA wears thin due to multiple practice and clinical issues, including reimbursement, credentialing, and turf wars, PV-CTA continues to shape the comprehensive treatment of PVD with far fewer challenges. PV-CTA may even be the savior for many practices and centers that want to maintain cardiac CTA or pursue a new comprehensive cardiovascular CTA program.

An estimated 18 to 20 million patients have peripheral arterial disease in the U.S. Twenty million diabetic patients and a similar number of patients with peripheral venous disease easily make the clinical population significantly greater for PV-CTA than cardiac CTA. An estimated three to four million symptomatic PVD patients are misdiagnosed or go untreated, and twice that number are asymptomatic and, therefore, untreated as well. This latter asymptomatic group would include patients with > 4.5-cm abdominal aortic aneurysm, significant internal carotid artery disease, renal artery stenosis, and celiac artery/superior mesentery artery (CA-SMA) disease.

PV-CTA is the ideal noninvasive tool to identify this large asymptomatic patient population for which less invasive endovascular therapies are now available. A paradigm shift to earlier diagnosis and treatment facilitated by PV-CTA has improved our patients' outcomes and dramatically changed our practice. PV-CTA has the potential to improve overall outcomes in millions of PVD patients yearly.

**BENEFITS OF PV-CTA**

Validation studies done with PV-CTA have demonstrated superior accuracy in comparison to traditional angiography. This is especially true in clinical vascular scenarios in which traditional angiography has limitations or risk. After almost four years experience in our outpatient office setting with 16- and 64-slice PV-CTA and several thousand peripheral vascular interventions following PV-CTA, we have identified several clinical benefits.

- **Accurate diagnosis.** The combination of clinical examination and outpatient PV-CTA has yielded a near-100% accurate preprocedural diagnosis in most PVD patients. The diagnosis is often rendered in the office in minutes following a scanning time of less than 30 seconds, and PV-CTA has facilitated all aspects of PVD treatment. Onsite PV-CTA and traditional angiography validation studies have been performed at our facility in all vascular territories with greater than 95% sensitivity and specificity, providing further confidence in preprocedural diagnosis.

- **Treatment planning.** PV-CTA facilitates reliable procedure planning, including revascularization options and devices. Lesion morphology characterizations assist treatment planning and periprocedural decision making. Calcified lesions are treated differently from soft lesions, and thrombus-containing lesions are treated differently from intimal hyperplastic
lesions (Figure 1). All abdominal aortic aneurysms and internal carotid artery planning and treatment recommendations, including open surgical revascularization, are now made using CTA, eliminating the risks of traditional angiography. The number of periprocedural peripheral vascular intervention "surprises" we encounter today is greatly diminished.

- **Vascular access.** An underestimated benefit of PV-CTA is the ability to assist in vascular access planning, which is much more complex in peripheral vascular intervention than percutaneous coronary intervention. The PVD patient often has limited vascular access, with poor femoral pulses, complex femoral grafts, heavy femoral calcification, significant groin scarring from previous procedures, and previously deployed stents impinging on the common femoral artery (Figures 2A and 2B). For these reasons, complications are high in peripheral vascular interventions, and we have drastically decreased their incidence since adopting PV-CTA. The choice of alternate vascular access directed by PV-CTA has also significantly expanded our use of endovascular interventions and improved outcomes in many patients who otherwise would have required major open surgical revascularization procedures (Figures 2C and 2D).

- **Fewer overall complications.** PV-CTA has almost totally eliminated the need for diagnostic traditional angiography (risk of stroke during carotid angiography has always been 1% to 2%). Contrast-induced nephropathy has been reported in 14% of percutaneous coronary intervention patients, with high mortalities and morbidities. The incidence and impact of contrast-induced nephropathy in peripheral vascular intervention is unknown and likely underestimated. The PVD patient is generally 10 to 15 years older than the percutaneous coronary intervention patient and invariably requires multiple procedures and secondary reinterventions. The incidence of diabetes and chronic renal insufficiency is also two to three times higher in PVD patients, mandating well-planned strategies to manage contrast exposure.

The risk of contrast-induced nephropathy is highly associated with intra-arterial contrast exposure but less associated with intravenous contrast exposure as used during PV-CTA. Contrast CT-induced nephropathy should be exceedingly rare if outpatient oral and IV hydration protocols are used. We have developed protocols to decrease IV contrast volume exposure to 70 cc, while retaining imaging quality (see table). Consequently, our periprocedural peripheral vascular intervention intra-arterial contrast volume use has dramatically decreased from combining this CTA contrast planning strategy with clinically validated IV hydration protocols and the frequent application of targeted renal therapy. Using these strategies, we have significantly decreased our incidence of contrast-induced nephropathy and almost eliminated the need for dialysis in even our highest risk peripheral vascular intervention patients.

Targeted renal therapy refers to direct bilateral intrarenal artery infusion of fenoldopam, a selective dopamine-1 receptor agonist and renal arteriolar vasodilator. Therapy is delivered peripostprocedural by the FDA-approved, commercially available Benephit Infusion System. Targeted renal therapy has been shown to decrease contrast-induced nephropathy during percutaneous coronary intervention by negating and reversing pathogenic contrast-induced vasoconstriction. In addition to decreasing vascular access and contrast-induced nephropathy complications, PV-CTA has allowed us to significantly shorten our periprocedural peripheral vascular intervention times and facilitated procedural efficiency, which reduces radiation exposure to the patient and staff. PVD and diabetes patients are now known to be hypercoagulable and paradoxically associated with both increased hemorrhagic and thrombotic complications. Our incidence of periprocedural thrombotic complications has also decreased with the shortened procedural times and maximized efficiency. Shortened peripheral vascular intervention procedural times invariably result in lower clinical and economic costs.

- **Selected peripheral vascular scenarios.** Stents and calcium are problematic for coronary CTA and still considered a significant limitation in the percutaneous coronary intervention patient. Significant calcification is still somewhat problematic in infrapopliteal vessels but much less of a limitation in all other peripheral vascular vessels. Sixty-four-slice CTA imaging quality and resolution capabilities now allow for extraluminal nonvascular tissue characterization and intraluminal plaque morphology evaluation, with potentially far-reaching clinical implications. Because peripheral stents are much larger than percutaneous coronary intervention stents, they pose minimal limitation to PV-CTA (Figure 3A). PV-CTA after stenting is considered advantageous because in-stent restenosis and major stent fractures are easily
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imaged. Other subtleties associated with stents, including edge dissections (Figures 3B through 3D), stent compression, and minor stent fractures, are also well suited for PV-CTA imaging (Figures 4A and 4B).

Chronic mesenteric ischemia manifested by CA-SMA disease is a poorly understood and rarely diagnosed but not uncommon vascular condition. Historically, it has been associated with high mortality and morbidity and has required traditional angiography for diagnosis and surgical revascularization for treatment. PV-CTA provides an ideal tool for earlier diagnosis and endovascular treatment. Abdominal CTA easily images all visceral vessels and should increase the number of patients diagnosed with early-stage chronic mesenteric ischemia, which is now treated much like renal artery stenosis with percutaneous transluminal angioplasty/stenting. (Figures 4C and 4D). Vertebral artery disease is another example of a common condition, rarely diagnosed and undertreated, that is easily imaged during carotid-vertebral CTA and treated by percutaneous transluminal angioplasty/stenting.

Deep venous thrombosis continues to be a common undertreated condition, though interventional therapies now available are associated with improved outcomes. Venous CTA imaging has become valuable in our practice in assessing and treating patients with iliofemoral and axillosubclavian DVT. Venous CTA is particularly helpful in identifying the extent of the thrombus burden because ultrasound is limited in central venous iliac, and axillosubclavian venous assessment. The future of venous CTA holds the same promise in the treatment of DVT as that experienced with peripheral arterial disease.

- **Miscellaneous-incidental.** Sixty-four-slice CV-CTA retains the nonvascular benefits of CT. Most large-scale image-based cancer screening programs have not been found to be cost-effective. The highly selective PVD population may become an exception, considering this is an older population with high incidence of smoking, diabetes, and hypertension. The upper and lower lung fields are usually visualized during carotid and extremity CTA, often providing insight into pulmonary pathology. Abdominal and iliac artery aneurysms are commonly diagnosed during PV-CTA for claudication. Similarly, solid tumors, soft-tissue pathology, and even orthopedic conditions are regularly identified in this highly selected elderly population, potentially providing a path for improved healthcare outcomes (Figure 4E).

**COMPREHENSIVE PVD TREATMENT**

Stenting is currently the preferred treatment in peripheral vascular intervention, but drug-eluting stents remain unapproved for this application. Therefore, high rates of in-stent restenosis, secondary reintervention rates (20% to 25%), and multiple procedures are the rule, not the exception. Because PV-CTA has significantly fewer stent limitations than MR angiography, it becomes an ideal noninvasive follow-up tool after peripheral vascular intervention, further expanding its clinical and economic usefulness. Medicare-approved follow-up CTA protocols are already in existence for following abdominal and thoracic aortic aneurysm progression and postendovascular aneurysm repair endoleak surveillance. Currently, about 30% of our group's total cardiovascular CTA volume can be categorized as follow-up PV-CTA.

PV-CTA has been integral to the success of our overall comprehensive CV-CTA program. Every day, we witness the limitations of cardiac CTA, making it more challenging to maintain a cost-effective comprehensive CV-CTA program. Just the additional throughput time required for coronary versus PV-CTA makes it almost cost-prohibitive to dedicate a large portion of the day-to-day CV-CTA volume to coronary examinations. PV-CTA simply does not pose the limitations of coronary CTA, and it has been a "savior" to the overall success of our comprehensive CV-CTA program.

The real reason to embrace PV-CTA, however, is the enormous unmet clinical need to aggressively diagnose and treat PVD, a marker for death, with mortality rates three to five times higher than for patients diagnosed with coronary artery disease and most cancers. An ankle-brachial index is even more predictive of death than an ECG. The two leading causes of death in PVD remain myocardial infarction and stroke, underscoring the need for multiple disciplines, including cardiology, to become involved with comprehensive CV-CTA.

For two decades, our group has advocated early, aggressive treatment of PVD and helped train hundreds of healthcare providers and clinicians in this approach. It is our opinion that PV-CTA is a
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revolutionary tool available today that can improve treatment of PVD. n
The authors are founding members of the Society of Cardiovascular Computed Tomography and would like to acknowledge the organization's work in CV-CTA education, advocacy, and credentialing. Please see www.scct.org for more information regarding CV-CTA or the society. The authors wish to thank Ms. Kelly Tilbe for assistance with manuscript preparation. Dr. Allie is chief of cardiothoracic and endovascular surgery, and Mr. Hebert is director of cath lab services, both at Cardiovascular Institute of the South in Lafayette, LA. Dr. Walker is medical director of Cardiovascular Institute of the South in Houma, LA. Both Drs. Allie and Walker serve as consultants for Toshiba and Bracco.

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