

Reduced Metal Artifacts on CT Utilizing the Medtronic MVP™ Microvascular Plug System

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Embolotherapy has become a major component of modern interventional radiology practice. Whether treating life-threatening hemorrhage, occluding debilitating vascular malformations, or blocking unwanted vessels for flow redistribution, interventional radiologists must have complete understanding of the various embolic platforms at their disposal. This understanding includes not just the benefits of each device, but also the relative weaknesses. One area of great interest, which is common to every device, is the ability to evaluate treatment response on imaging after embolization. A major limitation of many of the currently available embolic devices is metallic artifact, particularly when using CT imaging. Typically, metal artifact presents as light and dark streaks emanating from the embolic device resulting in obscuration of adjacent image quality. Metal artifact results from several factors, including beam hardening, Compton scatter, photon depletion (decreased signal to noise), and edge effects from nonlinear partial volume. The end result of all of these factors is loss of useful information around the embolic device, rendering accurate interpretation almost impossible.

There have been many metal artifact reduction strategies developed to mitigate the effects of metal artifacts in both conventional and C-arm CT scans. Many of these strategies involve altering acquisition conditions (adjusting scan parameters, utilizing dual energy techniques, etc), modifying preprocessed data (noise suppression and beam hardening/scatter reduction techniques), employing novel reconstruction algorithms (projection completion, iterative reconstruction), or optimizing postprocessed images.¹ Despite the relative successes of each of these strategies, none have found mainstream utility due

to various reasons, such as possible increased patient radiation doses,² need for time-consuming and expensive processes,³ or limitations in licensing due to proprietary

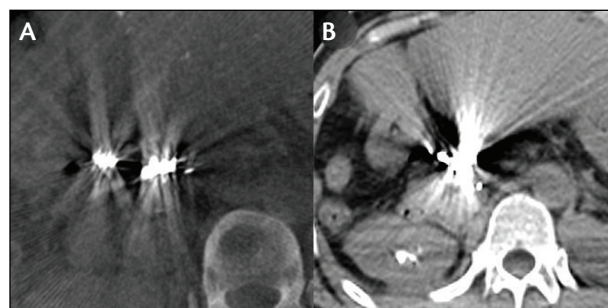


Figure 1. Metallic streak artifacts adjacent to coils on C-arm CT (A) and conventional helical CT (B).

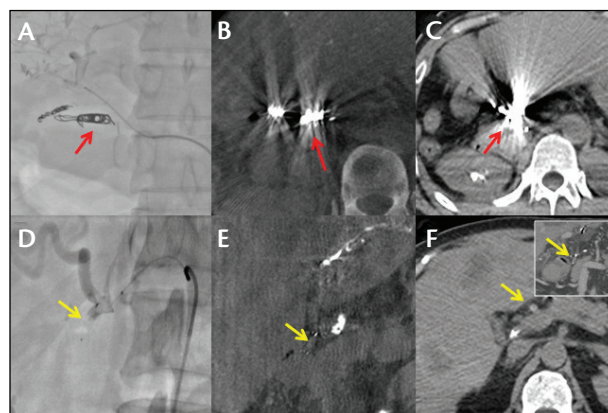


Figure 2. GDA embolization with coils (red arrows) seen on angiography (A), C-arm CT (B), and helical CT (C) versus the 5-mm MVP™ microvascular plug (yellow arrows) seen on angiography (D), C-arm CT (E), and helical CT (inserted panel corresponds to the coronal multiplanar reconstructed [MPR] image) (F).

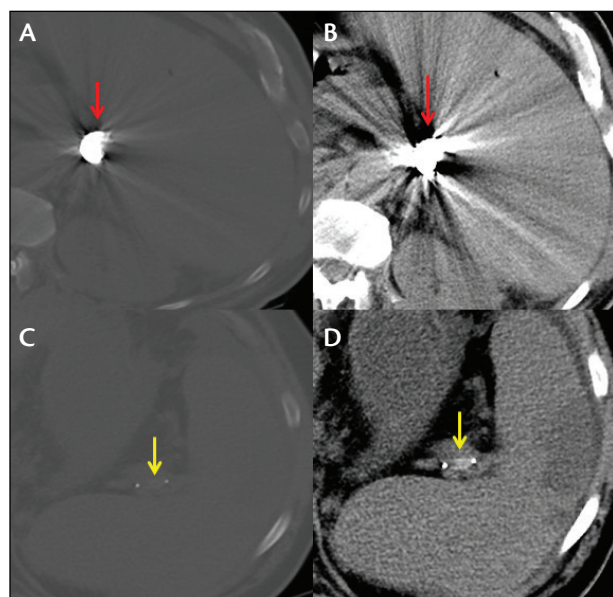


Figure 3. Proximal splenic artery embolization. CT scans after embolization of the main splenic artery for treatment of hypersplenic thrombocytopenia using either coils (red arrows) or the 7-mm MVP™ microvascular plug (yellow arrows) comparing bone window (A, C) and soft tissue window (B, D).

patients. Although these various strategies may become more widespread with improvements, the best method to deal with metal artifact is to optimize the embolic device to minimize the causes of the artifacts. Devices that are larger and denser or made up of higher Z (atomic number) metals typically result in more beam hardening and scatter. Traditional embolics, such as

coils and plugs, require dense packing or contain large amounts of metal leading to significant metal artifacts. This can significantly limit soft tissue visualization around the embolic device on subsequent CT imaging (Figure 1).

MVP™ MICROVASCULAR PLUG AND TRADITIONAL COILS

The MVP™ microvascular plug (Medtronic) is an innovative embolization device that is cleared by the US Food and Drug Administration and is indicated to obstruct or reduce the rate of blood flow in the peripheral vasculature. Unlike other embolic devices, which rely on high density and volume for occlusion, the MVP™ microvascular plug is composed of a unique polytetrafluoroethylene (PTFE)-covered nitinol design, resulting in rapid vessel occlusion with minimal metal artifacts. Because vessel occlusion is derived primarily from the PTFE covering, very little metal is necessary to result in successful vessel embolization. Figure 2 demonstrates two separate patients undergoing embolization of the gastroduodenal artery (GDA) as part of the planning for subsequent liver-directed yttrium-90 radioembolization treatment. Due to the high metal content and dense packing of the GDA coils, there is significant metallic streak artifact adjacent to the coil pack on both C-arm CT and conventional helical CT scans. In contrast, when utilizing a single 5-mm MVP™ microvascular plug, not only was the GDA completely occluded, but there was essentially no apparent metal artifact on subsequent C-arm CT or conventional helical CT. Even with the use of the larger microvascular plugs, metal artifact is still very minimal compared to coils due to the optimized PTFE-covered nitinol scaffold

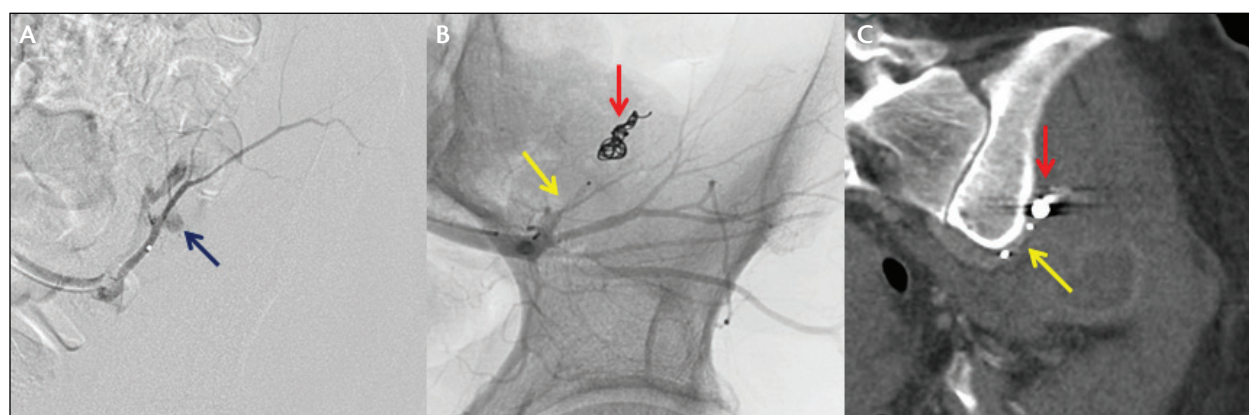


Figure 4. Acute hemorrhage. Embolization of a branch of the left superior gluteal artery utilizing coils to occlude the distal artery ("back door") and a single 3-mm MVP™ microvascular plug to occlude the branch origin ("front door"). Digital subtraction angiogram demonstrating frank extravasation with arteriovenous communication (black arrow) (A). Nonsubtracted angiogram with distal coil pack (red arrow) and proximal MVP™ microvascular plug (yellow arrow) (B). Coronal MPR image demonstrating streak artifact adjacent to the coil pack (red arrow) and no artifact around the MVP™ microvascular plug (yellow arrow) (C).

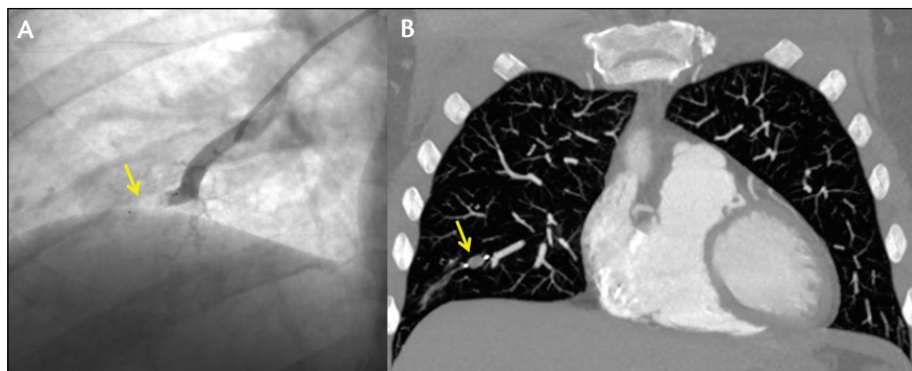


Figure 5. A pAVM. A 5-mm MVP™ microvascular plug (yellow arrow) postdetachment within a branch of the right pulmonary artery (A). Coronal MPR image after right pAVM embolization demonstrating the 5-mm MVP™ microvascular plug (yellow arrow) (B).

design. Patients with splenomegaly and thrombocytopenia can be treated with proximal splenic artery embolization (Figure 3).⁴ Despite the use of a larger 7-mm MVP™ microvascular plug, the overall effect on conventional helical CT acquisitions is negligible in contrast to a similarly treated patient using conventional metallic coils. In fact, subjacent soft tissue detail remains exceptional with the MVP™ device due to the lack of significant metal artifact. This difference in degree of artifact between coils and the MVP™ microvascular plug is most apparent when the two devices are present in tandem. In Figure 4, both coils and a single 3-mm MVP™ microvascular plug were used to sandwich a bleeding branch of the left superior gluteal artery following injury from a core needle biopsy. In this case, coils were used to embolize the distal segment of the injured artery in order to occlude the “back door” from retrograde bleeding, and a single 3-mm MVP™ microvascular plug was used to occlude the inflow to the injured segment (“front door”). A subsequent coronal MPR image with both embolic devices reconstructed within the same plane reveals the superior imaging potential of the microvascular plug compared to the coils with respect to artifact.

Because the MVP™ device contains very minimal high-density material, it does not have significant beam hardening (streak artifacts) or adjacent photon depletion (loss in signal), which may result in both loss of contrast and detail. With the MVP™ device, rapid and successful vessel occlusion can still be achieved without compromising subsequent CT image quality on surveillance imaging. In Figure 5, a single 5-mm MVP™ microvascular plug was successfully used to embolize the main feeding artery branch of a pulmonary arteriovenous malformation (pAVM). Despite the presence of adjacent motion from the heart, metal artifact is essentially absent, resulting in

high-quality vascular and lung parenchymal detail.

CONCLUSION

Metallic artifacts seen on both C-arm and conventional helical CT imaging after vascular embolization has been a challenging problem with traditional embolics. Although numerous strategies have been developed to mitigate imaging artifacts around these embolic devices, there are still many limitations in each of these approaches,

preventing wide scale adoption. Furthermore, these techniques may even create secondary artifacts under certain conditions.⁵ Utilizing an embolic device like the MVP™ microvascular plug enables low metallic interference through its design while providing safe and effective performance. ■

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