

# Successful endovascular treatment of severe chronic mesenteric ischemia facilitated by intraoperative positioning system image guidance

Satish C. Muluk, MD,<sup>a</sup> Mahmoud Elrakhawy, MD,<sup>a</sup> Bart Chess, MD,<sup>a</sup> Carlos Rosales, MD,<sup>a</sup> and Vikash Goel, MS,<sup>b</sup> Pittsburgh, Pa; and Cleveland, Ohio

## ABSTRACT

We report our initial experience using the intraoperative positioning system (IOPS), a novel endovascular navigation system that does not require contrast or radiation, in the treatment of chronic mesenteric ischemia (CMI). We used IOPS to help treat three of four consecutive patients with CMI. Technical problems prevented successful use in one patient. For the patients for whom IOPS was used effectively, catheterization of the mesenteric artery was accomplished more quickly than for the patient for whom IOPS was not effective. Our experience has shown that IOPS can be safely and effectively used for CMI and can reduce the contrast load and radiation dose. (*J Vasc Surg Cases Innov Tech* 2022;8:60-5.)

**Keywords:** Chronic mesenteric insufficiency; Endovascular navigation; Intraoperative positioning system; IOPS

Endovascular therapy is the first-line therapy for chronic mesenteric ischemia (CMI); however, it can involve significant time, contrast, and radiation.<sup>1-4</sup> Of four consecutive CMI cases, three were facilitated by the use of a novel navigation tool. The intraoperative positioning system (IOPS; Centerline Biomedical, Inc, Cleveland, Ohio) is a three-dimensional image guidance system for endovascular interventions based on electromagnetic tracking. All cases were performed with the patient under moderate conscious sedation. All the patients provided written informed consent for the report of their case details and imaging studies.

## CASE REPORT

**Patient 1.** An 81-year-old woman had presented with weight loss and postprandial abdominal pain. She had undergone open aortic aneurysm repair. Computed tomography (CT) angiography (CTA; Fig 1, A) revealed a tortuous 4-cm paravisceral aorta, near-total celiac artery (CA) occlusion, an occluded inferior mesenteric artery, and critical superior mesenteric artery (SMA) stenosis.

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From the Division of Vascular Surgery,<sup>a</sup> Allegheny Health Network; and the Centerline Biomedical, Cleveland.<sup>b</sup>

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Correspondence: Satish C. Muluk, MD, Allegheny General Hospital, 14th Floor, South Tower, 320 East North Ave, Pittsburgh, PA, 15212 (e-mail: [muluk@usa.net](mailto:muluk@usa.net)).

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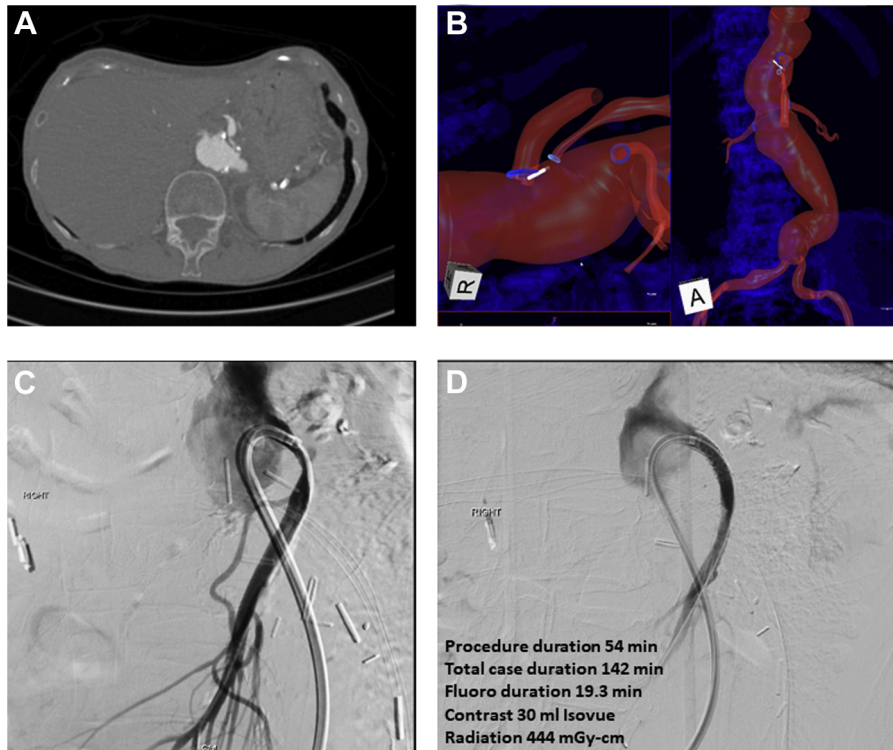
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An aortic model was created using the preoperative CTA. This model was aligned to the patient with the aid of intraoperative cone-beam CT generated by the Artis Zeego imaging system (Siemens Healthcare, Erlangen, Germany). A 6F, Ansel 1, 45-cm vascular sheath (Cook Medical Inc, Bloomington, Ind) was inserted. The IOPS wire was inserted into a SOS catheter (Angiodynamics, Latham, NY) and advanced using the IOPS console images, without fluoroscopic guidance (Fig 1, B). The SMA was cannulated within 45 seconds. Cannulation was confirmed by fluoroscopy. After an unsuccessful attempt to seat the catheter in the SMA, wire access was lost. The SMA was accessed again with IOPS after replacing the Ansel 1 sheath with a 6F TourGuide steerable sheath (Medtronic, Inc, Minneapolis, Minn). Contrast injection confirmed severe stenosis in the proximal SMA (Fig 1, C), which was treated with a 6-mm × 22-mm iCAST covered stent (Atrium Medical Corp, Hudson, NH). The completion angiogram (Fig 1, D) demonstrated wide patency. Clinical improvement was observed at follow-up.

**Patient 2.** A 75-year-old woman had presented with chronic visceral artery disease. She had undergone SMA angioplasty via groin access; however, stent placement was unsuccessful because of tracking difficulty. At the current presentation, she was experiencing recurrent postprandial abdominal pain and nausea. CTA (Fig 2, A) demonstrated recurrent 70% proximal SMA stenosis. Brachial access was planned because of the previous difficulty from the groin.

An aortic model was created using the preoperative CTA and aligned to the patient with the aid of an intraoperative spin CT scan. The left brachial artery was accessed and, after systemic heparinization, a 6F, 75-cm Ansel 1 sheath was advanced into the visceral aorta. The IOPS wire was inserted into an MPA catheter. Subsequently, the SMA was catheterized without fluoroscopic guidance (Fig 2, B). Cannulation was



**Fig 1.** **A**, Axial image from pretreatment computed tomography (CT) angiogram for patient 1 demonstrating severe stenosis of the origin of the superior mesenteric artery (SMA). **B**, Intraoperative positioning system (IOPS) model for patient 1. The images demonstrate the position of the IOPS wire (*bright white line segment*) just before achievement of SMA cannulation. Multiple projections can be viewed simultaneously in real time. **C**, Angiogram from patient 1 demonstrating successful cannulation of the SMA with the TourGuide sheath. **D**, Completion angiogram from case 1 demonstrating successful placement of the SMA stent. **Inset**, Key case details. *Fluoro*, Fluoroscopy.

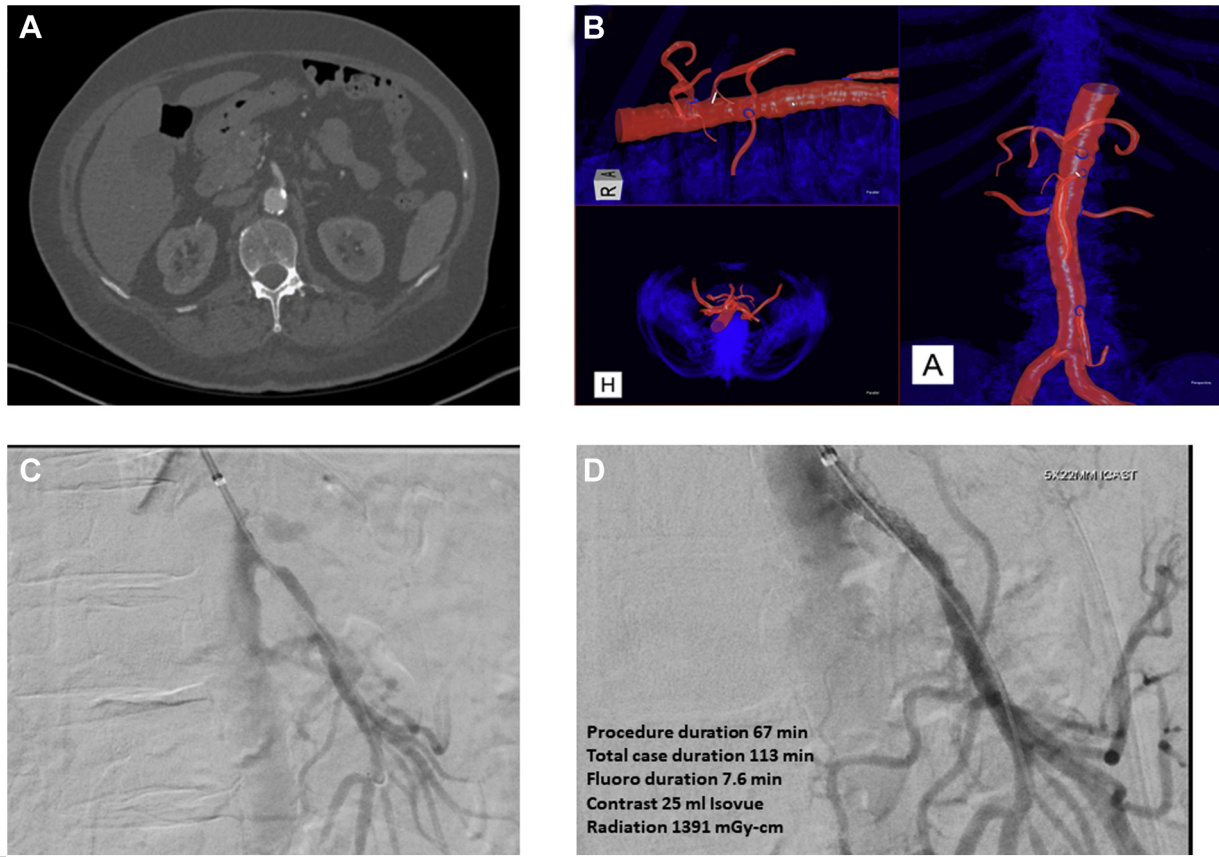
achieved within ~60 seconds after initial IOPS imaging. Contrast injection demonstrated 70% ostial stenosis (Fig 2, C). The SMA was treated with a 5-mm × 22-mm iCAST stent. Angiography showed wide patency (Fig 2, D). The sheath was withdrawn into the aorta, after which the IOPS was used to catheterize the CA, again without fluoroscopic guidance. Angiography showed severe stenosis, which was deemed unsuitable for endovascular therapy. Her symptoms had resolved at early postoperative follow-up.

**Patient 3.** A 69-year-old woman had presented with recurrent severe postprandial abdominal pain. She had known CA and infrarenal aortic occlusion and had previously undergone right axillary bifemoral bypass and SMA stenting. CTA showed severe in-stent stenosis (Fig 3, A).

The right brachial artery was accessed. A 6F sheath was advanced into the abdominal aorta. The original plan was to use IOPS; however, on review of the IOPS display, the guidewire position did not match the expected location, possibly owing to

an overlay mismatch caused by shifting of the trackpad (Fig 3, B). Thus, conventional techniques were used instead. After multiple attempts using fluoroscopy, the severely stenosed stent was accessed and a catheter advanced (Fig 3, C). This cannulation required ~7 minutes. The lesion was successfully treated using a covered stent.

**Patient 4.** A 64-year-old man had presented with abdominal pain and weight loss. CTA demonstrated severe CA and SMA disease (Fig 4, A). An aortic model was created using the preoperative CTA and aligned to the patient using an intraoperative cone-beam CT scan. A SOS catheter was advanced into the aorta. With the IOPS wire and without fluoroscopic guidance, the SMA was cannulated without difficulty (Fig 4, B) within ~90 seconds. However, difficulty occurred in advancing the catheter, consistent with the presence of severe stenosis. Wire access was given up, and the sheath was switched to a 6F, 45-cm TourGuide steerable sheath (Medtronic, Inc). The SMA was easily recannulated using IOPS. Contrast imaging demonstrated



**Fig 2.** **A**, Representative axial image from pretreatment computed tomography (CT) angiogram for patient 2 demonstrating severe stenosis of the origin of the superior mesenteric artery (SMA). **B**, Intraoperative positioning system (IOPS) model for patient 2. The images demonstrate the position of the IOPS wire (*bright white line segment*) in multiple projections during IOPS-guided SMA cannulation. **C**, Intraprocedure angiogram demonstrating cannulation of SMA for patient 2. **D**, Completion angiogram from patient 2 demonstrating successful placement of the SMA stent. **Inset**, Key case details. *Fluoro*, Fluoroscopy.

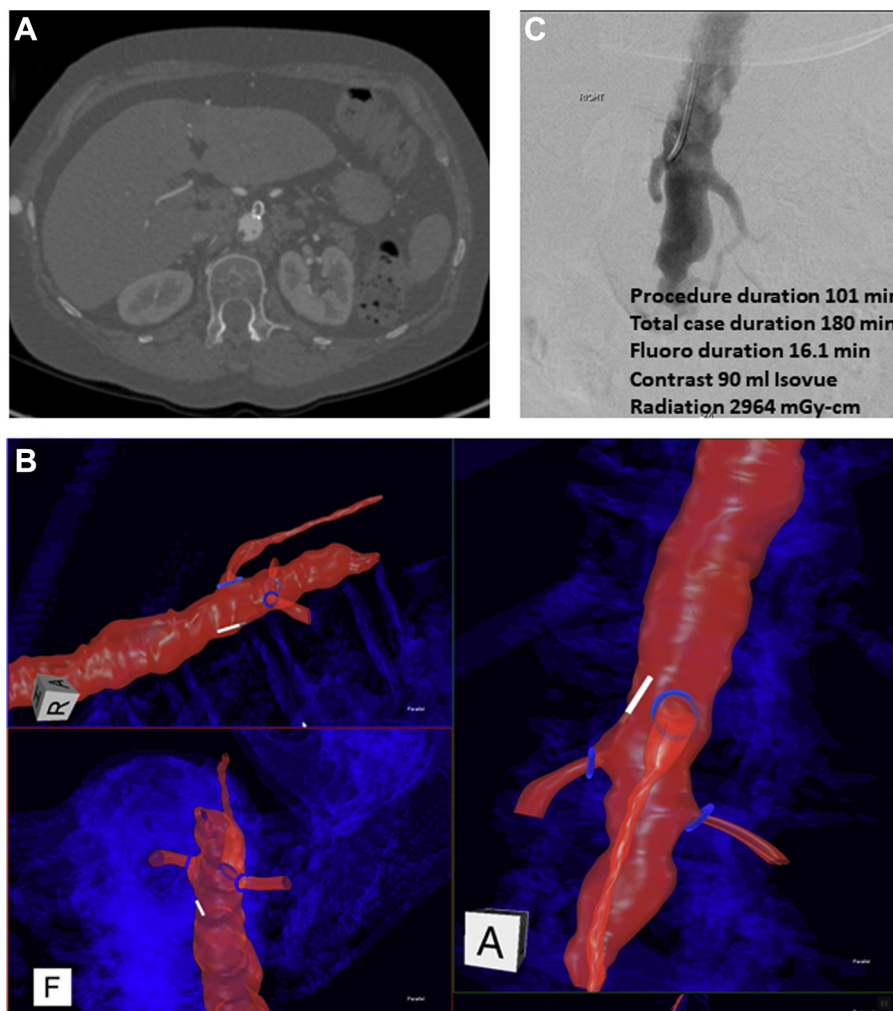
80% stenosis (Fig 4, C). With appropriate shaping, the TourGuide sheath was advanced. The lesion was treated with a 6-mm × 22-mm iCAST stent (Atrium Medical Corp). Arteriography demonstrated a widely patent stent with good flow into the CA distribution (Fig 4, D).

## DISCUSSION

Endovascular CMI treatment is often challenging and can cause embolic complications. The prolonged procedure time, combined with steep oblique views, can lead to high radiation dosages. Advances in imaging such as IOPS offer the opportunity to enhance cannulation and reduce fluoroscopic times. Our early experience suggests that IOPS' real-time navigation could improve the outcomes by reducing the procedural times and providing better visualization and control.

Of the four consecutive cases in our report, IOPS facilitated rapid catheterization (range, 45-90 seconds) of the target artery in three patients cases without fluoroscopy or contrast administration. In the case of IOPS registration error, traditional fluoroscopy and contrast were used, with an SMA cannulation time of 7 minutes.

IOPS (Fig 5) provided 3D electromagnetic navigation of interventional devices as an adjunct to fluoroscopy. Image guidance is provided using 3D maps of the vasculature, generated from thin-slice contrast-enhanced preoperative CTA. The CT scan should have been performed within 180 days, and the vascular morphology must not have changed significantly. Physicians and technicians must be trained before using IOPS. Centerline Biomedical provided 30-minute hands-on training



**Fig 3.** **A**, Representative axial image from pretreatment computed tomography (CT) angiogram for patient 3 demonstrating near occlusion of the origin of the superior mesenteric artery (SMA), which contained an old stent. **B**, Intraoperative positioning system (IOPS) model for patient 3. The images demonstrate the position of the IOPS wire (*bright white line segment*). However, the apparent location and movement of the wire did not match the contours of the model. IOPS was, therefore, abandoned for this patient. **C**, Angiogram demonstrating successful cannulation of the origin of the SMA for patient 3. **Inset**, Key case details. *Fluoro*, Fluoroscopy.

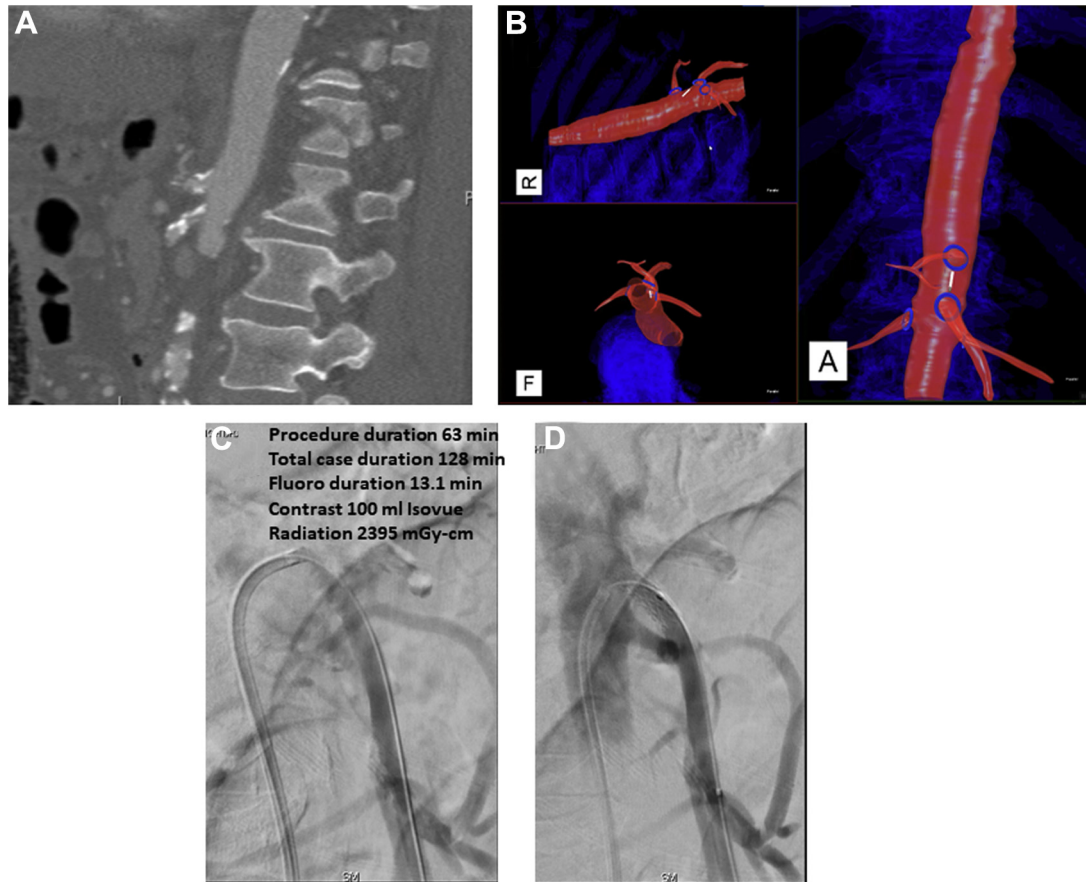
with a phantom and provided support during the procedures.

The ultra-high-definition display provides up to four simultaneous maps and depicts the tips of the tracked catheters and guidewires. The viewing angle and magnification of each map can be independently customized. A cut-plane mode permits visualization from an angle inside the aorta. Electromagnetic sensors, embedded within the devices and not exposed to the circulation, permit real-time tracking. The catheter hubs have cables that connect to a tableside interface.

The guidewire has a connector at the proximal end for this purpose (Fig 5).

The workflow is similar to that for fluoroscopic fusion, with the addition of an electromagnetic field generator, attached under the table without tools and largely hollow. At present, the generator is contraindicated for patients with pacemakers, implanted defibrillators, or high-density metallic implants.

At the start of the procedure, a self-adhesive sterile fiducial tracking pad is attached to the patient's lumbar region, and the angiography system is used to perform a



**Fig 4.** **A**, Preoperative computed tomography (CT) enterography study demonstrating severe celiac artery (CA) and superior mesenteric artery (SMA) stenoses. **B**, Intraoperative positioning system (IOPS) model for patient 4. The images demonstrate the position of the IOPS wire (*bright white line segment*) in multiple projections during IOPS-guided SMA cannulation. **C**, Intraprocedure angiogram demonstrating cannulation of the SMA via a TourGuide sheath. **D**, Completion angiogram for patient 4 demonstrating successful placement of the SMA stent. **Inset**, Key case details. *Fluoro*, Fluoroscopy.

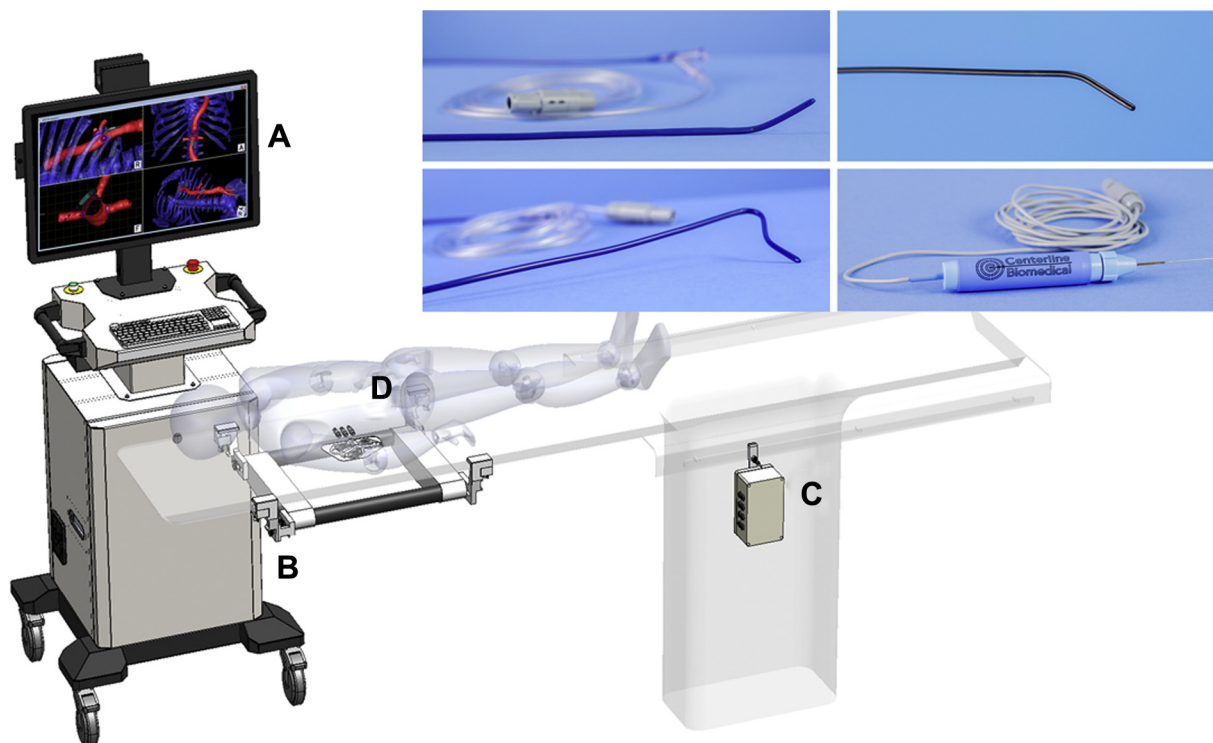
noncontrast-enhanced cone-beam CT scan. The cone-beam CT volume is then loaded onto the IOPS cart and manually aligned with the preoperative CT volume. This work can be performed in parallel with achieving vascular access, with minimal effects on the procedure time.

During intervention, the IOPS devices can be visualized with on-screen image guidance. The console is operated by a technician under physician instruction. The IOPS guidewires and catheters can be used together or combined with off-the-shelf 0.035-in. catheters and guidewires, as needed. The technology has

been used by our group and others for visceral and renal cannulation during complex aortic aneurysm procedures.

## CONCLUSIONS

These cases have demonstrated that percutaneous mesenteric revascularization for CMI with the aid of IOPS can be safely accomplished even for patients with high-grade lesions and vessel occlusions. The use of this technology can help to make mesenteric revascularization easier with fewer procedural complications.



**Fig 5.** Diagram of the Intraoperative positioning system (IOPS) system, including mobile cart (A), tracking field generator (B), tableside interface (C), and fiducial tracking pad (D). The trackpad is affixed to the patient. Within reasonable limits, patient movement will not affect tracking of the IOPS catheters and wires. **Inset,** IOPS sensor-equipped catheters (simple and reverse curve) and guidewire with detachable connector.

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