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Role of cone-beam CT augmented by navigational software in the single-session management of gastrointestinal hemorrhage and infected deep postoperative fluid collections

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ABSTRACT

Utilization of cone-beam CT with navigational software augmentation allows performance of both vascular and nonvascular interventions in a traditional fluoroscopy suite without need for additional hardware. The improvements in target identification and procedure time associated with use of these technologies suggest that they may be particularly beneficial in emergent settings where decreased procedure time correlates with improved outcomes. We illustrate these potential advantages through the successful single-session management of a clinically unstable patient with both gastrointestinal (GI) hemorrhage and infected postoperative fluid collections.

1. Introduction

The advent of flat panel cone-beam CT (CBCT) made possible the concurrent use of angiographic and cross-sectional imaging guidance in a traditional fluoroscopy suite without the need for additional hardware [1]. The more recent development of navigational software has provided further flexibility in the performance of both vascular and nonvascular interventions and, depending on the application, has been shown to improve target identification, procedure time, radiation dose, administered contrast volume, and outcomes [2–6]. Though initially developed for oncologic use, these technologies are increasingly finding new applications and may be particularly suited to situations of high acuity in which reduced time to procedural completion correlates with improved outcomes [7,8]. We illustrate these potential advantages through the successful single-session management of a hemodynamically unstable patient with both gastrointestinal (GI) hemorrhage and infected postoperative fluid collections, each procedure alone having traditionally required the use of a distinctly different interventional suite.

2. Case report

Institutional review board approval was note required for this report. A 67-year-old man with a history of diabetic nephropathy post renal transplantation, and hypoxic respiratory failure currently tracheostomy- and PEG-dependent, was admitted following pancreaticoduodenectomy for resection of a pancreatic ACTH-secreting neuroendocrine tumor. The postoperative course was complicated by persistent leukocytosis in the setting of multiple rim-enhancing peripancreatic fluid collections, and on post-operative day 16 by an acute GI bleed resulting in a 24-hour hemoglobin drop from 10.1 g/dL to 8.1 g/dL. A CT angiogram (CTA) obtained at that time demonstrated active extravasation into the pancreaticojejunostomy limb without definitive identification of the hemorrhagic source; the abdominal collections were also redemonstrated (Fig. 1A,B). Given the patient's hemodynamic instability, IR was consulted for urgent identification and embolization of the bleeding source and possible percutaneous drainage of the collections. Intervention was emergently undertaken.

The procedure was performed under general anesthesia with the patient supine. Right common femoral artery access was obtained and a Bentson guidewire and 5-Fr Cobra 2 catheter (AngioDynamics, Latham, NY) used to sequentially interrogate the celiac axis and superior mesenteric artery (SMA) with the use of arterial-phase CBCT. This initial CBCT consisted in a 5-second-long spin at 50 frames per second spanning 200 degrees. X-ray delay after the start of the injection was based on pre-CBCT DSA, and injection was continued throughout the rotation

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[1] J.C-H. has no conflict of Interest.

[2] D.C.M. is a paid consultant for GE Healthcare.

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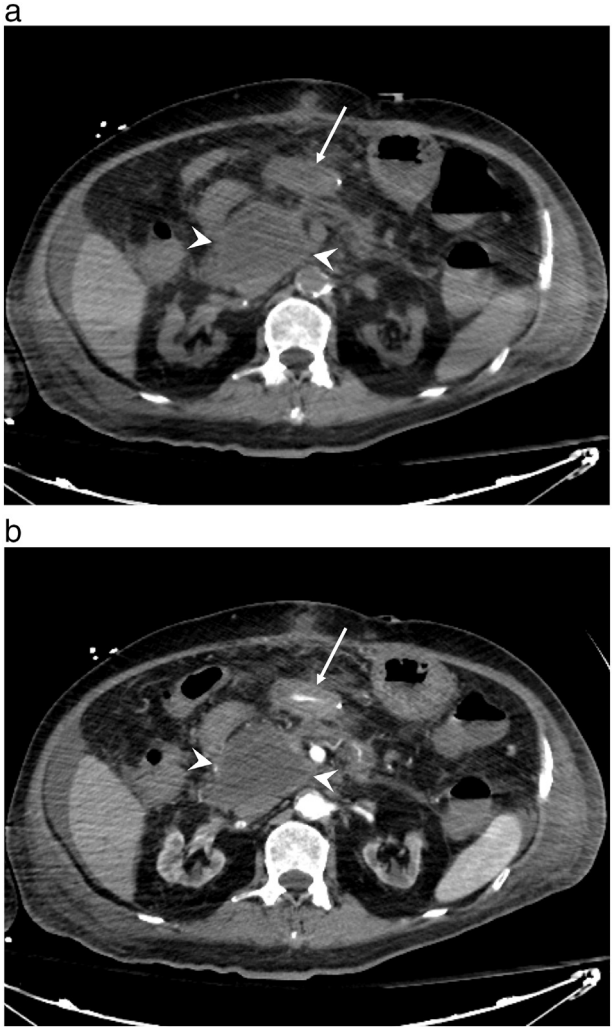

Fig. 1. Axial pre-contrast (A) and arterial phase (B) images demonstrate active extravasation into the pancreaticojejunostomy limb (arrows). A rim-enhancing peripancreatic fluid collection is also present (arrowheads).

to ensure good vessel filling. Active extravasation was identified from a small pseudoaneurysm arising from a distal branch of the inferior pancreaticoduodenal artery, the path to which was not identifiable.

To rapidly identify the feeding vessels, automated vessel detection (AVD) software (FlightPlan for Liver; GE Healthcare, Chicago, IL) was utilized to map the approach (Fig. 2A–C). In brief, the CBCT dataset was transferred to a workstation in the control room where a radiology technologist performed image analysis under the supervision of the operating angiographer. A 3D-volume rendered arteriogram was generated and, after indication of the catheter tip and placement of an ROI around the pseudoaneurysm, the software automatically highlighted the damaged vessel based on proximity to the indicated ROI. The highlighted vessel was then overlaid onto the active fluoroscopic images to provide a navigational roadmap.

A 2.6-Fr 0.025-inch LANTERN Delivery Microcatheter (Penumbra, Alameda, CA) was advanced coaxially into the inferior pancreaticoduodenal artery using the overlay for guidance. Tip position was confirmed via angiography, and a Gelfoam slurry was injected until stasis was achieved. All wires and catheters were then removed, and hemostasis obtained with a 6-Fr Angio-Seal VP vascular closure device (Terumo Corporation, Shibuya, Tokyo, Japan).

Although the patient was temporarily stabilized via achievement of hemostasis, he remained septic and at risk of further deterioration. As such, the referring team emphasized the importance of draining the

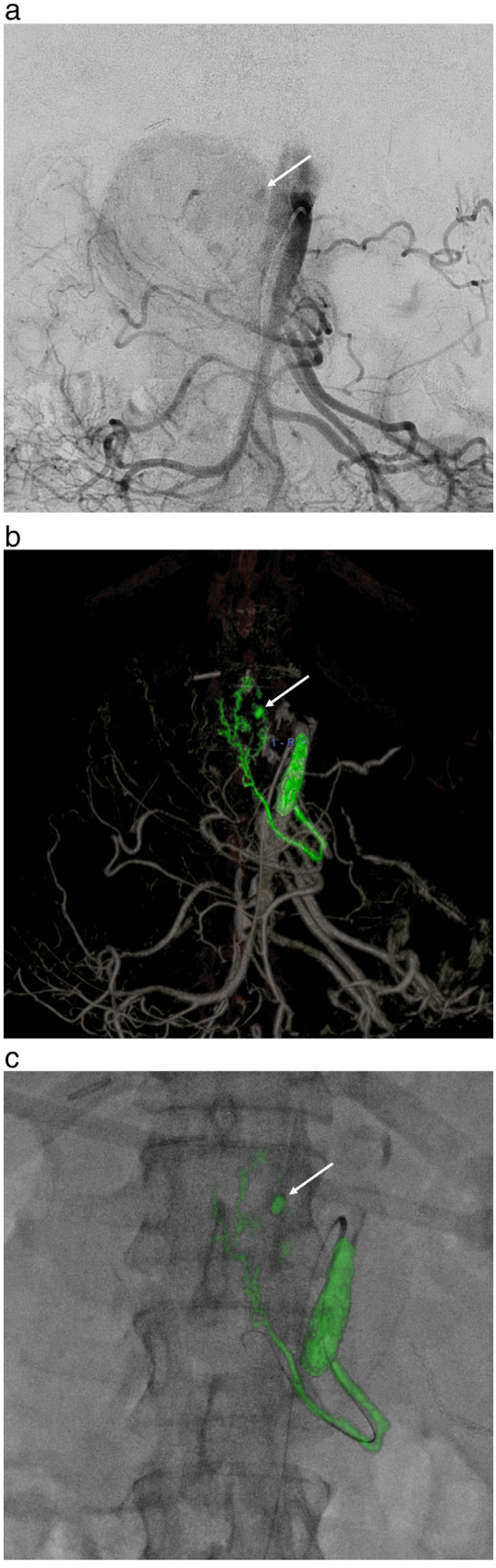

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Fig. 2. (A) Superior mesenteric artery digital subtraction angiogram demonstrates a faintly visible pseudoaneurysm (arrow) without clear feeding vessel. (B) 3D reconstruction of a CBCT with FlightPlan analysis better illustrates the pseudoaneurysm (arrow) and additionally highlights the feeding vessels in green. (C) Superimposed of the overlay onto the active fluoroscopic image provides angiographic guidance to the pseudoaneurysm (arrow). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

intraabdominal collections and queried the feasibility of doing so while the patient was already in the IR department. In lieu of transferring the ventilated, sedated patient to the CT guidance room where the procedure would otherwise have been performed, it was decided to proceed with drainage using CBCT with fluoroscopic overlay (Needle Assist; GE Healthcare, Chicago, IL). A CBCT was obtained in the region of interest, the desired path of travel selected, and the point of entry indicated via overlay. Under fluoroscopic guidance using alternating orthogonal "bullseye" and "progress" views, an 18-G trocar needle was advanced into the fluid collection; once in position a second CBCT was obtained to confirm position (Fig. 3A–D). A 10-Fr 35 cm locking pigtail drainage catheter was placed, resulting in 30 cc of sanguinopurulent output. The drain was sutured in place and the patient transported to SICU in stable condition. He experienced no further GI hemorrhage, his leukocytosis resolved, and he stabilized clinically.

3. Discussion

Although the minimally invasive nature of transarterial embolization makes it the preferred treatment for acute GI hemorrhage, the need for sequential angiographic investigation in search of the damaged vessel can delay hemostasis, particularly in cases of complex arterial branching and slow bleeding. The demonstrated benefits of AVD software for facilitating target vessel identification and decreasing procedure time as applied to liver-directed embolization make it a potentially promising adjunct in the management of acute GI hemorrhage [3,9]. The feasibility of this application has already been demonstrated with reported vessel detection rates of 90–100%, including in several cases in which the hemorrhagic site was occult on standard angiography

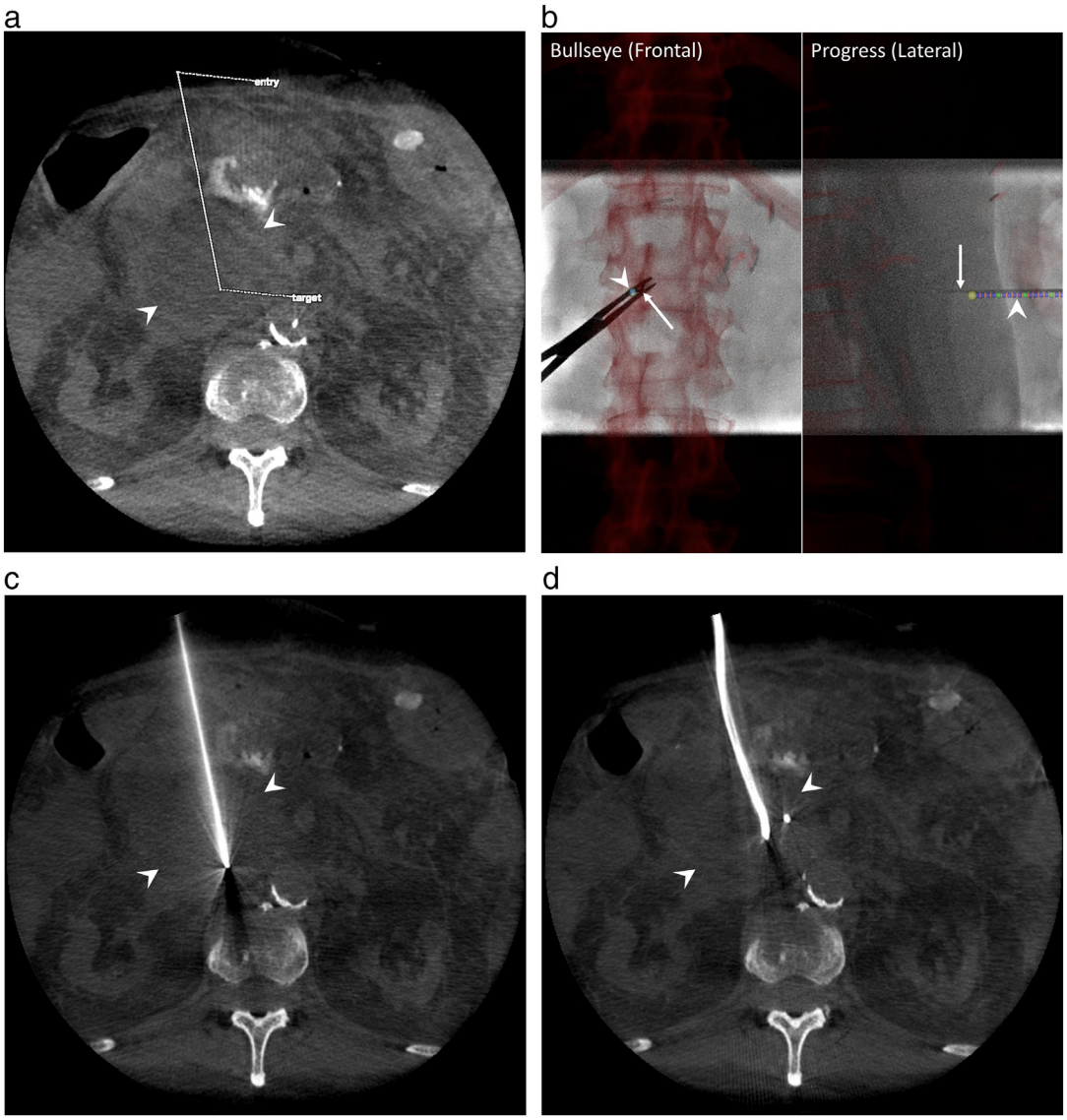

Fig. 3. (A) An axial CBCT image was used to map needle trajectory to the collection (arrowheads); the oblique white line indicates the planned path. (B) Needle Assist software then generated an overlay (arrowheads) which was superimposed on the fluoroscopic image. This overlay was used with alternating bullseye (left) and progress (right) views to guide needle (arrows) advancement. (C) Axial CBCT image obtained to confirm needle location within the collection (arrows). (D) Final axial CBCT image confirming catheter position within the collection (arrows).

[7,8,10].

The current case was particularly well suited to the application of this software given the combination of non-visualization of the target vessel on pre-procedural CTA, slow rate of extravasation, and complex postoperative arterial anatomy. Additionally, while the patient's history of renal transplantation was not a contraindication to the intravenous administration of iodinated contrast, minimization of administered contrast volume was nonetheless a priority and facilitated by the roadmap overlay obviating the need for repeated contrast injection.

Additionally, the availability of CBCT with fluoroscopic overlay made possible drainage of the abdominal collections in the same procedural setting. When compared to conventional CT guidance for abdominopelvic abscess drainage, CBCT is associated with reduced procedural times with comparable technical success rates and radiation doses [6]. Of particular advantage to the current case was the ability to perform the procedure in the fluoroscopy suite immediately following embolization. As the patient was both clinically unstable and already sedated under general anesthesia, transfer to a different setting was both technically challenging and potentially unsafe. In addition, delay in abscess drainage risked further clinical deterioration.

In conclusion, this case represents the first reported use of CBCT augmented by navigational software to provide both angiographic and cross-sectional imaging guidance in a single setting. This technology provides the interventional radiologist with increased flexibility in the performance of common vascular and non-vascular procedures. Given the potential advantage of decreased procedure time, its use should be considered for diagnosis and treatment in challenging and time-sensitive cases.

References

[1] Chehab MA, Brinjikji W, Copelan A, Venkatesan AM. Navigational tools for interventional radiology and interventional oncology applications. Semin Intervent Radiol 2015;32:416–27.
[2] Ronot M, Abdel-Rehim M, Hakime A, et al. Cone-beam CT angiography for determination of tumor-feeding vessels during chemoembolization of liver tumors: comparison of conventional and dedicated-software analysis. J Vasc Interv Radiol 2016;27:32–8.
[3] Iwazawa J, Ohue S, Hashimoto N, Mitani T. Comparison of the number of image acquisitions and procedural time required for transarterial chemoembolization of hepatocellular carcinoma with and without tumor-feeder detection software. Radiol Res Pract 2013;2013:580839.
[4] Cornelis FH, Borgheresi A, Petre EN, Santos E, Solomon SB, Brown K. Hepatic arterial embolization using cone beam CT with tumor feeding vessel detection software: impact on hepatocellular carcinoma response. Cardiovasc Intervent Radiol 2018;41:104–11.
[5] Abi-Jaoudeh N, Fisher T, Jacobus J, et al. Prospective randomized trial for image-guided biopsy using cone-beam CT navigation compared with conventional CT. J Vasc Interv Radiol 2016;27:1342–9.
[6] McKay T, Ingraham CR, Johnson GE, Kogut MJ, Vaidya S, Padia SA. Cone-beam CT with fluoroscopic overlay versus conventional CT guidance for percutaneous abdominopelvic abscess drain placement. J Vasc Interv Radiol 2016;27:52–7.
[7] Iwazawa J, Ohue S, Hashimoto N, Mitani T. Accuracy of software-assisted detection of tumour feeders in transcatheter hepatic chemoembolization using three target definition protocols. Clin Radiol 2014;69:145–50.
[8] Carrafiello G, Ierardi AM, Duka E, et al. Usefulness of cone-beam computed tomography and automatic vessel detection software in emergency transarterial embolization. Cardiovasc Intervent Radiol 2016;39:530–7.
[9] Deschamps F, Solomon SB, Thornton RH, et al. Computed analysis of three-dimensional cone-beam computed tomography angiography for determination of tumor-feeding vessels during chemoembolization of liver tumor: a pilot study. Cardiovasc Intervent Radiol 2010;33:1235–42.
[10] Miyayama S, Yamashiro M, Nagai K, Sugimori N, Iwata K, Sakuragawa N. Usefulness of dual-phase cone-beam computed tomography during arteriography and automated tumour-feeder detection software in transarterial embolization for obscure arterial bleeding in the abdomen. J Med Imaging Radiat Oncol 2018;62:364–9.