He presented to the emergency department 15 days after surgery with bilateral lower extremity ischemia. All infrainguinal pulses were nonpalpable, and Doppler signals were absent in both feet. He had sensory loss in both feet, with impaired mobility. Abdominal computed tomography (CT) with intravenous administration of contrast agent revealed complete endograft collapse and an endoleak (**Fig, b** and **c**).

The patient underwent bilateral femoral artery cutdowns under general anesthesia. After bilateral open femoral catheterization, two guide wires were passed to the thoracic aorta. Balloon remodeling was performed first, and then we decided to deploy at the collapsed site a 32-mm diameter, 40-mm long proximal cuff (Excluder) through the endoprosthesis. The cuff was ballooned after deployment. Bilateral limb thrombectomy with a Fogarty catheter was performed, restoring blood flow to the femoral arteries. Movement of the iliac limbs during the passage of the Fogarty catheter was not noted.

Postoperatively, the patient's sensory and motor examination and pulses were normal. An abdominal CT scan at postoperative day 3 showed restoration of the shape of the endograft and blood flow through the limbs with remnant thrombus. There was still a small endoleak (**Fig, d**). CT angiography performed 6 months and 12 months after the secondary procedure showed a normal endograft lumen, without any signs of endoleak or migration and no residual thrombus. During follow-up, the patient had palpable peripheral pulses.

Endograft collapse is a rare complication reported to occur mainly in thoracic aortic grafts. Factors predisposing to graft collapse in the thoracic aorta include excessive oversizing, tight aortic arch diameter, and poor wall apposition of the graft (1). Most cases of thoracic endograft collapse involved the Gore TAG endoprosthesis. Possibly the mechanical properties of the particular endograft and its packaging and release mechanism predispose to material infolding under specific conditions.

This complication is extremely rare in cases of EVAR of AAA, with only three reports in the literature (2–4). In the first case, an Excluder endograft collapsed proximally 1 month after implantation. It was discovered incidentally on the 1-month follow-up CT scan. No endoleak was shown because the examination was performed without intravenous contrast enhancement. The patient was asymptomatic (2). Stent graft collapse was treated endovascularly with cuff implantation and balloon dilation (2). In the second report, an AneuRx endograft (Medtronic, Inc, Minneapolis, Minnesota) collapsed 9.5 years after implantation because of distal migration. It was discovered incidentally and treated with open conversion (3). In the third case, an Endologix Powerlink endograft (Endologix, Inc, Irvine, California) collapsed 1–6 months after implantation because of "bird's beak" effect. The patient was asymptomatic and was treated endovascularly with thoracic endograft and bare stent deployment (4).

Regarding our patient, possible causes that might have led to this complication include the angulation of the proximal neck and stent graft oversizing. Because of the reverse taper configuration of the infrarenal neck with a proximal diameter of 25 mm and distal diameter of 29 mm, a 31-mm endograft was used; this resulted in 24% oversizing in the proximal part of the neck, greater than the maximum suggested by the graft manufacturer. Oversizing might have led to perimeter folding and insufficient apposition of the endograft to the aortic wall.

Endograft collapse is a rare complication of EVAR of AAA. It is a result of proximal neck angulation, excessive oversizing, and mechanical properties of the endograft. EVAR of stent graft collapse seems to be a feasible solution.

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Heat Sink during Radiofrequency Ablation of a Hepatocellular Carcinoma Abutting a Large Hepatic Cystic Lesion

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Editor:

Hepatocellular carcinoma (HCC) is the most common primary hepatic tumor and one of the most common cancers worldwide. Surgical resection of hepatocellular carcinomas and liver transplant are considered to be the gold standard treatments. Radiofrequency ablation is a standard therapeutic option for patients who are not candidates for surgical resection (1).

Technical end points vary among commercially available RF ablation systems. The LeVeen RF ablation system (Boston Scientific, Natick, Massachusetts) detects the electrical impedance (Ohm) of the hepatic tissue during the delivery of RF energy. Complete ablation of target tissue with this RF ablation system is achieved when tissue desiccation causes the increase of the impedance in the

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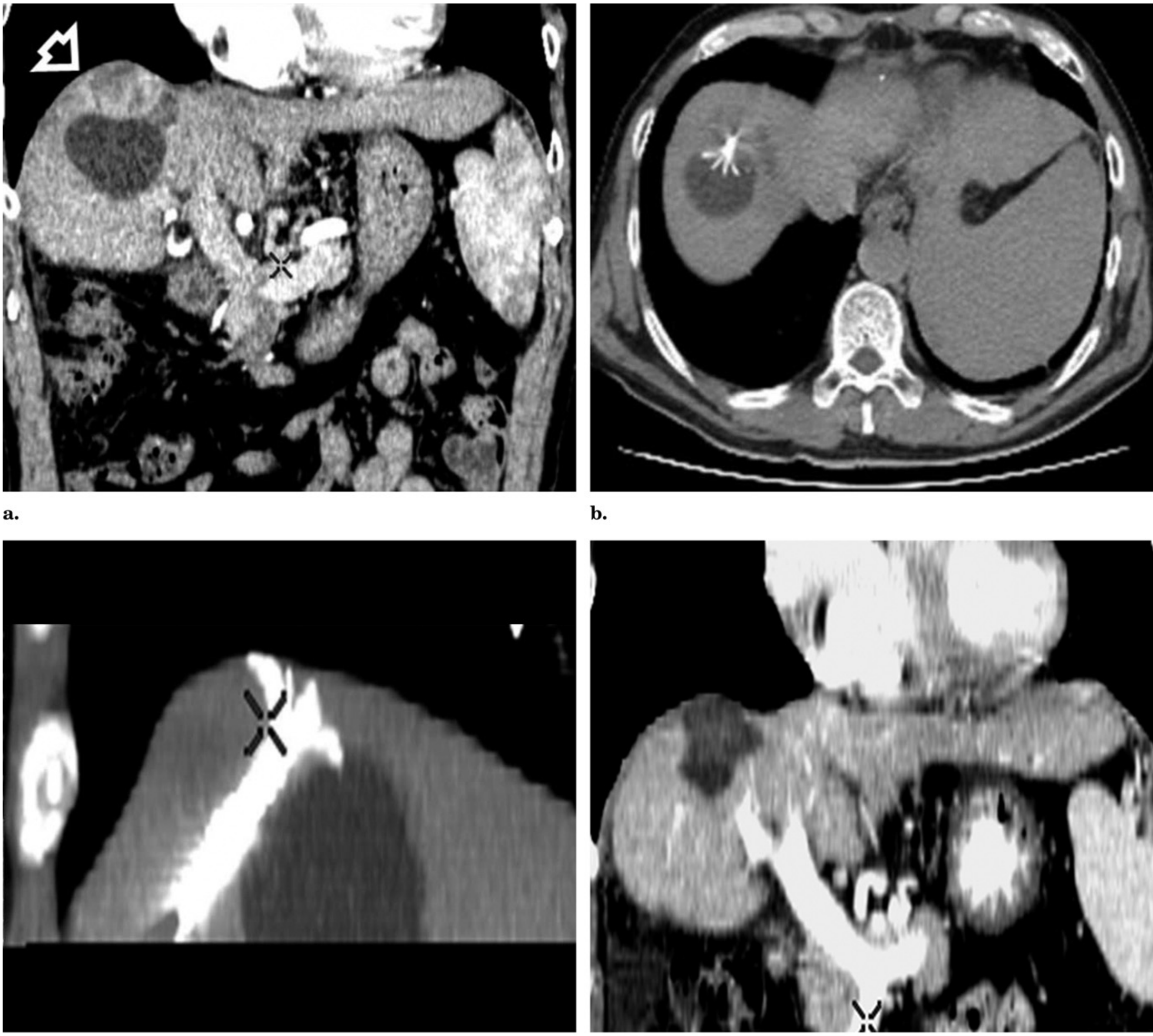

a. b. c. d.

Figure. **(a)** Preprocedural coronal contrast-enhanced CT images show contiguity between the HCC (arrow) and a large hepatic cyst. Intraprocedural axial **(b)** and sagittal reformatted CT images **(c)** show the needle electrode with the prongs fully deployed coming in contact with the liquid in the cyst. **(d)** Follow-up coronal contrast-enhanced CT image does not show residual tumor and relapse of the cyst.

tissue. This prohibits the passage of electrical current, and the power output from the generator falls to zero (ie, roll-off) (2).

We report a case of inability to reach the roll-off during a RF ablation of a hepatic neoplasm located next to a liver cyst that was completely reversed by prompt drainage of the cyst.

A 66-year-old man was referred to our department for a workup after a biopsy-proven diagnosis of HCC (30 × 25 mm) in segment VIII. The patient had a history of hepatitis C virus related to chronic liver disease, and he had undergone a surgical resection of an HCC located in segment VI and a percutaneous cryoablation of another HCC localized in segment III. Preprocedural laboratory values were: aspartate aminotransferase, 60 U/L (range, 0–54 U/L); alanine aminotransferase, 50 U/L (range, 0–34 U/L); total bilirubin, 18 μmol/L (range, 3.4–23.8 μmol/L); α-fetoprotein, 4 ng/mL (range, 0–20 ng/mL); platelets, 95.000/μL (normal value, 150.000–300.000/μL); and international normalized ratio (INR) 1.5 (normal value, 0.9–1.2). The patient was classified as Child-Pugh Class A. Preprocedural computed tomography (CT) scan showed contiguity between the HCC and a large hepatic cyst (50 × 45 mm; **Fig a**).

A multidisciplinary panel of hepatologists, oncologists, surgeons, and radiologists agreed that RF ablation was the right treatment for the patient, who gave written informed consent to the procedure.

RF ablation was performed using the LeVeen RF ablation equipped with a 200-W generator. The LeVeen needle electrode used was a 15-gauge, 15-cm-long insulated cannula that contained 10 individual hook-shaped electrode arms. The device had a maximum diameter of 40 mm when fully deployed.

At the beginning of the procedure the needle electrode was inserted by a subcostal approach and deployed into the tumor under ultrasound and CT guidance. Treatment was commenced at 80 W and continued by increasing RF power in 10-W steps at 30-second intervals to a maximum power of 130 W, which was kept for 5 minutes according to the manufacturer protocol. A maximum power of 190 W was then reached and kept for 15 minutes without achieving roll-off. Because the fully deployed needle electrode came in contact with the liquid in the cyst (**Fig b,c**), we decided to stop the procedure and drain the cyst under ultrasonographic guidance using a 21-gauge needle, 15 cm long. Sixty milliliters of liquid were drained. The procedure was then restarted at 80 W, and it was continued, increasing the power until roll-off occurred at 130 W after 3 minutes. A second burn was performed at the same location reaching rolloff at 120 W after 2.5 minutes. No immediate complications were evident. CT follow-up at 19 months showed no tumor recurrence (**Fig d**).

Lesion selection or technical aspects of the individual ablation may account for failure to reach roll-off (2). The efficacy of RF ablation may be limited by adjacent high-flow vascular structures, which act as a cooling circuitry widely known as the *heat-sink phenomenon* (2). Indeed, the heat-sink phenomenon is an important drawback of the RF ablation procedure for the treatment of hepatic tumors. It becomes particularly problematic when one treats a tumor located near a large blood vessel with a high-flow velocity. This phenomenon reduces the size of the thermal ablation zone by taking heat away through a rapid stream of low-temperature blood. The heat-sink phenomenon is considered the major obstacle to a successful rolloff (2).

Currently, no studies have confirmed that stationary fluids, such as large fluid-filled cysts, may cause the heat-sink phenomenon. Several studies focused on artificial ascites as an experimental model to study the effect of stationary liquids on RF ablation outcome. It has been shown that the cooling effect of artificial ascites does not cause a heat-sink effect (3).

Lobo et al (4) studied the effect of varying the electrical conductivity in the proximity of the RF electrode, using an NaCl gel–filled well within an agar phantom and an RF power generator source with a fixed maximum power and current capacity, such as the one used in our procedure. They found that increasing tissue electrical conductivity (ie, increasing NaCl concentration) decreased the extent of heating. The explanation is that increasing tissue conductivity, despite improved energy deposition, increased the energy required to heat the given volume of tissue. Thus, if the amount of energy required is beyond the maximum power of generator, there will be insufficient heating and consequently an unfit tissue necrosis (4).

Most liver cysts have an electrolyte composition similar to serum, which is rich in ions such as Na^+ and Cl^- (5). Because the tines of the electrode that we used were in contact with both the liver tissue and the fluid inside the cyst, our case may resemble a two-compartment model (liver parenchyma and fluid inside the hepatic cyst) with regions of very different electric conductivity, such as the model developed by Lobo et al (4). In our case, the increased conductivity increased the amount of energy required to heat the target tissue, with the probably consequent inhibition of the roll-off phenomenon.

Our case of failure to reach roll-off could be interpreted as an in-vivo model that confirms the clinically relevant RF phenomenon demonstrated by Lobo et al (4), ie, an increase in tissue conductivity may act as a thermal sink depending on generator capabilities.

Several techniques to increase roll-off have been proposed. In laparoscopic RF ablation roll-off rates may be increased by reducing tumor perfusion. Other techniques that facilitate roll-off include retraction of the tines or the use of a smaller-diameter radial array. We did not retract the tines to increase power density, as we preferred to use the 40-mm array in an attempt to maximize the “surgical margin” of cauterized liver around the tumor. We also did not replace the needle because an intercostal approach would have been necessary to avoid the cyst, with the consequent increased risk of pneumothorax. Moreover, given the empirical and nonexperimental nature of our observation, we can only assume that the lack of roll-off was a result of the adjacent cyst.

Our observation regarding the effect of a fluid-filled cyst adjacent to our ablation zone shows that the increase of RF conductivity in a stationary liquid may act like a thermal heat sink. In performing RF ablation, interventional radiologists must be careful to avoid not only blood vessels but also any in-vivo structures that may increase tissue conductivity. In particular, when a tumor is near a large cyst, radiologists should consider cyst drainage or aspiration, particularly if the desired RF ablation endpoint is not being achieved.

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Intrahepatic Collateral Supply to the Previously Embolized Right Gastric Artery: A Potential Pitfall for Nontarget Radioembolization

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Editor:

Despite the promising therapeutic effects of hepatic radioembolization, serious gastrointestinal ulceration can result from nontarget deposition of radioactive microspheres through hepaticoenteric anastomoses (1). One such anastomosis, the right gastric artery (RGA), shows extensive anatomic variability in its site of origin from the hepatic arteries and can be missed during angiography. Identifying and coil embolizing the RGA and other hepaticoenteric anastomoses enable the angiographic equivalent of vascular skeletonization, a technical end point the objective of which is to limit gastrointestinal complications arising from nontarget radioembolization. Herein, we report a series of five patients with an anatomic variant involving duplication of the proximal RGA, with an accessory vessel providing antegrade flow from within the liver to the main RGA in the lesser curvature of the stomach despite prophylactic embolization of the main origin of the RGA. The institutional review board approved this retrospective report. All data were handled in compliance with the Health Insurance Portability and Accountability Act.

All of the 187 consecutive patients undergoing radioembolization treatment underwent preparatory angiography and preemptive coil embolization of hepaticoenteric anastomoses. A total of 136 patients (73%) underwent selection and embolization of the RGA. Patients who did not undergo RGA embolization included those that had prior surgical resection or ligation of the RGA and those who required only selective (segmental or lobar) treatment well distal to the origin of the RGA. Confirmation of skeletonization was performed using digital subtraction angiography and C-arm computed tomography (2).

The existence of a collateral vessel arising from a hepatic artery reconstituting the distal RGA, which we will refer to as the *accessory* RGA or aRGA, was discovered retrospectively in a patient in whom gastric ulceration developed despite successful coil embolization of the main RGA. Since then, four other cases of collateral reconstitution of an embolized RGA have been identified prospectively, and these patients have been treated successfully without gastrointestinal complications.

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Table. Clinical and Technical Summary

Pt No	Age/ Sex	Diagnosis	Territory Treated by Radioembolization	Origin of RGA	Origin of aRGA	Treatment Method of aRGA	Outcome
1	44/F	Metastatic colon carcinoma	Whole liver, single administration from PHA	LHA	LHA, distal to RGA	None (aRGA was not recognized at the time of treatment)	Gastric antral ulcer, successfully treated with PPI
2	57/F	Metastatic neuroendocrine carcinoma	Whole liver, single administration from PHA	LHA	LHA, distal to RGA	Coil embolized	Uncomplicated
3	60/M	Metastatic colon carcinoma	Whole liver, single administration from PHA	LHA	Proximal RHA	Intentional guide wire disruption	Uncomplicated
4	54/F	Metastatic colon carcinoma	Whole liver, two lobar administrations	LHA	LHA, proximal to RGA	Two separate lobar treatments distal to origin of aRGA	Uncomplicated
5	74/F	Cholangiocarcinoma	Segments IV-VIII, two lobar/segmental administrations	LHA	LHA, distal to RGA	Separate right lobar and segment IV treatments distal to origin of aRGA	Uncomplicated

Note.—PHA = proper hepatic artery, PPI = proton pump inhibitor.