sequelae (1). Potential treatments include removal and application of external pressure (pull and pressure), open surgical repair, endovascular stent graft placement or balloon tamponade, and percutaneous closure using a closure device (1,2). A closure device is increasingly being recognized as an alternative to surgery or endovascular approach in this iatrogenic injury. In the literature, the use of the Angio-Seal vascular closure device (St. Jude Medical, Inc., St. Paul, Minnesota) and more recently the Perclose suture-mediated closure device (Abbott Vascular) was described (1,2).

The use of the StarClose device in the setting of arterial injury during CVC insertion has been limited to the subclavian and axillary artery (3,4), and the feasibility of arterial closure using the StarClose device in the CCA was unknown. We believe CCA closure using the StarClose device under ultrasound guidance has several inherent benefits. First, the metallic construct of the key components of the device allows good visualization on ultrasonography. For example, the vessel locator wings (Fig 2), the clip applicator shaft (Fig 3), and the nitinol clip (Fig 4) are easily visualized as corresponding echogenic structures on ultrasonography. This allows visual monitoring at each key step and complements haptic feedback to ensure successful deployment in an unusual location. Second, because the CCA is a superficial structure, it is readily visualized using ultrasound. Our case demonstrated the possibility of StarClose deployment as a bedside procedure using ultrasound guidance for monitoring during the procedure and assessment after the procedure. This can be a distinct advantage for patients in the intensive care unit because transportation of patients to another location (eg, angiography suite) sometimes can be challenging. In addition, the hemostatic nitinol clip is totally extraluminal without an intraluminal component, in contradistinction to the footplate of the Angio-Seal device and suture loop of the Perclose device, which resides within the vessel lumen. The lack of an intraluminal component is hypothetically ideal in the CCA, the latter being the main neurovascular axis. Lastly, ultrasonography allows immediate visual confirmation of successful closure and patency of the CCA. In the event of closure failure, direct external compression under ultrasound guidance could be performed.

REFERENCES
Occlusion of blood vessels with the use of endovascular techniques is a fundamental concept for interventional management of urgent and emergent vascular conditions (1,2). However, complete and durable vessel occlusion is difficult to achieve with the currently available mechanical devices, most common among which are coils or plugs. The endoluminal occlusion system (EOS; ArtVentric, Carlsbad, California) is a family of catheter-based, expandable endoluminal mechanical occlusion devices. Technical feasibility and safety of these devices has been shown in animal models (3,4). The EOS device received US Food and Drug Administration approval in December 2014 and has been used in select venous and arterial indications in humans internationally. We report the clinical use of the EOS in a patient with postoperative splenic injury requiring splenic artery occlusion before anticoagulation for underlying deep vein thrombosis (DVT) and thrombophlebitis.

Institutional review board approval was exempted for the present case report. A 40-year-old woman underwent left adrenalectomy for ganglioneuroma. The surgery was complicated by splenic hemorrhage seen on computed tomography (CT) on postoperative day (POD) 6 (Fig 1). Substantial left upper-extremity swelling developed on POD 27, with ultrasonography (US) showing marked DVT along with thrombophlebitis. The surgeons were hesitant to start full-dose anticoagulation with heparin in view of her splenic hemorrhage. Surgical intervention with splenectomy potentially could have led to further complications in light of existing intraperitoneal hematoma from recent splenic hemorrhage. The interventional radiology service was consulted to embolize the proximal splenic artery to decrease the risk of splenic hemorrhage and start the anticoagulation safely. The splenic embolization with EOS was done on POD 29 (Fig 2).

After initial splenic arteriograms demonstrated no active extravasation or pseudoaneurysms, the 5-F diagnostic catheter was removed and exchanged over a Wholey wire (ev3, Plymouth, Minnesota) for the 6-F EOS device guide catheter with an inner dilator. The wire was removed, and the deployment process was initiated by distension of the covered portion of the device under imaging guidance with 20% contrast solution. After confirming proper target position between the dorsal pancreatic artery and pancreatica magna artery, the spring-loaded portion of the device was deployed to secure the device in place. After a suitable position was achieved, the delivery wire was released and device was detached. Occlusion was immediate and complete (Fig 2).

Titration to full-dose anticoagulation with heparin was initiated, and the patient was “bridged” to outpatient enoxaparin injections as required for DVT (1 mg/kg twice daily). The patient was tolerating full-dose anticoagulation 6 weeks after the procedure, with follow-up US showing decreasing thrombus burden and phlebitis within her left upper extremity. As of the time of manuscript preparation, the patient has had no bleeding issues clinically related to her spleen, and no further abdominal imaging of the spleen has been performed.

Precise and controlled endovascular vessel occlusion is a major component of interventional therapies targeted toward a wide range of urgent and emergent clinical conditions. Coils are the most commonly used mechanical devices for vessel occlusion, but a large number may be needed for complete occlusion. AMPLATZER plugs (St. Jude Medical, St. Paul, Minnesota) offer a range of mechanical occlusion devices, but they are not covered and may not lead to proper occlusion in the setting of coagulopathy (2). The Micro Vascular Plug (Reverse Medical, Irvine, California) has been designed for vessel occlusion through microcatheters but is currently limited to smaller vessel diameters. The EOS device potentially offers immediate occlusion as a result of its covered design. The EOS device is a self-expanding nitinol coil covered with an impermeable polytetrafluoroethylene membranous cap. The coil provides sufficient radial force to expand the membrane and minimizes postdeployment migration. The EOS is delivered by using a 6-F guide catheter with an inner dilator allowing for relatively easy access into tortuous vessels. When the device has been deployed, it expands within the vessel, shortening slightly in length, and the final length depends on the diameter of the target vessel. The EOS device is available in sizes of 6 mm, serving 3.0–4.8-mm vessels, and 9 mm, serving 4.5–7.8-mm vessels. The possible
clinical indications of the EOS device include management of venous (eg, varicocele, ovarian varices, varicose veins) and arterial (eg, emergency arterial embolization in trauma patients) conditions. As no late imaging was obtained in the present case, durable occlusion with the EOS device could be assessed in future studies.

To conclude, the EOS may provide a safe and reliable method of immediate vessel occlusion in the peripheral arterial circulation. Its short- and long-term clinical efficacy in patients remains a subject for future research.

REFERENCES