

# Ultrasound-guided puncture of the femoral artery for total percutaneous aortic aneurysm repair

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## PURPOSE

The purpose of this study was to evaluate the outcomes of ultrasound-guided femoral artery access for total percutaneous endovascular repair of abdominal and thoracic aortic aneurysms.

## MATERIALS AND METHODS

Total percutaneous aneurysm repair of the abdominal and thoracic aorta was performed in 52 consecutive patients (46 males, 6 females; mean age, 64.6±16 years; age range, 24–93 years) in a total of 85 access arteries. Of the aortic aneurysms repaired, 33 were abdominal, and 19 were thoracic. Ultrasound-guided puncture of the access artery was performed in all patients. The access artery was closed with a Prostar XL device at the end of the procedure.

## RESULTS

The outer diameter of the vascular sheaths or the stent graft system ranged from 14 F to 27 F. All but one patient achieved successful closure of the arterial puncture with the closure device. One patient required surgical cutdown because of device failure. Two patients required long-duration manual compression. Technical success was achieved in 49 patients (94%). Forty-five patients (87%) were discharged on the first postoperative day. There were no complications of the access arteries one day or one month postoperatively, as determined by ultrasonography and computed tomography examinations, respectively. The mean diameters of the access arteries prior to and one month after the procedure were unchanged, as demonstrated by computed tomography.

## CONCLUSION

Ultrasound-guided puncture of the common femoral artery for percutaneous closure of the access site has a high technical success rate and a very low complication rate. The addition of ultrasound guidance decreases the difficulty of the procedure and helps to avoid some of its complications.

*Key words:* • aortic aneurysm • closure device • access artery • ultrasonography

Successful endovascular treatment of aortic aneurysms relies on stent-graft delivery from a remote access artery. As endovascular aneurysm repair (EVAR) has evolved over the past two decades, improvements in arterial access techniques have made the insertion of stent-grafts easier and have improved procedure outcomes. Traditionally, stent grafts were inserted using surgical cutdown of the femoral arteries. Surgical cutdown is a technique that is well known by vascular surgeons, is safe and has the advantage of controlled artery closure. However, this technique requires a physician who is experienced in open surgical techniques, and it should ideally be performed in the operating room with regional or general anesthesia. Additional drawbacks include the interruption of lower limb perfusion due to temporary clamping of the access artery and postoperative scar tissue that makes future access to the femoral artery difficult. The major disadvantage of the procedure is wound complications related to surgical cutdown (1).

With the development of devices with smaller profiles and improvements in technologies for percutaneous closure devices, total percutaneous repair of abdominal aortic aneurysms (AAA) and thoracic aortic aneurysms (TAA) can now be performed safely. The possible benefits of percutaneous closure of the femoral artery are decreased wound complications, more frequent use of local or regional (as opposed to general) anesthesia, shorter operation and hospitalization times, and earlier patient mobilization (2). Ultrasound (US) guidance of femoral artery puncture may further increase the technical success of the procedure and decrease complications (3). In this paper, we present our initial experience with the use of US guidance for femoral artery puncture for endovascular aortic aneurysm repair.

## Materials and methods

Between November 2008 and May 2010, total percutaneous aneurysm repair of the abdominal (n=33) and thoracic (n=19) aorta was performed in 52 consecutive patients, using a total of 85 access arteries, and the outcomes were prospectively evaluated. Forty-six patients in the study were men (88%), and 7 were women. The mean age of the participants was 64.6±16 years (range, 24–93 years). Percutaneous closure of the access artery was performed with a Prostar XL percutaneous vascular surgical system (Abbott Vascular, Redwood, California, USA), which is approved for use with sheath sizes up to 24 F. The stent grafts used in this study were bifurcated Endurant or Valiant (Medtronic, Santa Rosa, California, USA) or bifurcated Excluder (WL Gore, Flagstaff, Arizona, USA) stent grafts. The procedures were performed electively in 48 patients and post-rupture in four patients. Patients were enrolled consecutively in the study, under the condition that they met the criteria for endovascular aneurysm repair. The exclusion criteria were the presence

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of a prosthetic graft in the access artery or femoral artery aneurysm, but no patients with these criteria were treated during the study period.

Written informed consent was obtained from each patient after describing the procedure in detail. The study was approved by the institutional review board of the university. In all patients, single-wall puncture of the the common femoral artery (CFA) was performed with an 18 G needle under US guidance with a 9-MHz linear transducer (Siemens, Antares, Erlangen, Germany). The artery was completely imaged with US, and the diameter was measured prior to the procedure. The transducer was held in a transverse direction on the groin. The puncture was always made at the common femoral artery, approximately 1 cm proximal to its bifurcation point. The puncture site was moved a few millimeters in either the superior or inferior direction if there was calcified plaque at the planned puncture site. The planned puncture point was the midpoint of the artery in the transverse plane. After the first puncture, a 6 F vascular sheath was inserted, and diagnostic angiograms were obtained. Then a Prostar XL closure device was inserted. The "Preclose technique" was used for percutaneous closure (4, 5) with only one Prostar XL device for each access artery. The guide wire was removed, and the device was advanced until adequate blood marking was achieved through the marker lumen, indicating that the sutures and the needles were inside the artery lumen. Four nitinol needles were then deployed, and the sutures were removed from the hub but not tied. The device was removed after inserting a guide wire through the wire lumen. After placing the sutures of the Prostar XL closure device, either a large vascular sheath compatible with the stent graft system (WL Gore) or the stent graft itself (Medtronic) was introduced into the artery. After deployment of the stent graft system, the suture knot was prepared. The stent delivery catheter was removed, and the sutures of the closure device were tied immediately with a sliding knot. A knot pusher was used to ensure proper tightening of the knot and positioning of the knot near the vessel wall. Patients received a bolus of 5 000 IU of heparin after sheath insertion. Heparin was

neither reversed nor continued after the procedure. Patients were instructed to take 100 mg/day aspirin for life following the procedure. All patients were seen on the first postoperative day, and clinical and sonographic examinations of the access arteries were performed to ensure that there were no complications such as hematoma, dissection, pseudoaneurysm formation or thrombosis.

Patient variables were evaluated, and the outcomes measured included technical success, requirement for conversion to surgery, diameter change in the access artery, and complications related to the access site. Technical success was defined as having no need for additional procedures in the access artery, including manual compression. The diameters of the common femoral arteries were recorded with computed tomography (CT) before and one month after the procedure in all patients. Statistical analysis was performed using a commercially available software (Statistical Package for Social Sciences, version 13.0, SPSS Inc., Chicago, Illinois, USA).

## Results

Endovascular treatment for aortic aneurysm was successful in all cases and no patients required conversion to surgical repair of the aneurysm. All US-guided punctures were successful. In all patients, the midpoint of the common femoral artery could be punctured. Twenty-one patients had calcification on the CFA, and in 13 patients (25%), there were focal calcifications on the anterior wall of the CFA. In all patients with anterior calcifications, it

was possible to find an area without calcification and to avoid puncturing a calcified area using US guidance. None of the patients had circumferential calcification of the CFA. One patient had bilateral groin scars, and the sutures of a closure device were placed on both CFAs. Four patients had tortuous iliac arteries. Three patients were obese (body mass index >30 kg/m<sup>2</sup>); however, none were morbidly obese. The outer diameter of the vascular sheath or the stent graft system ranged from 14 F to 27 F (mean, 21.2 F; median, 20 F) (Table). Fifty-three of the 85 access arteries (62%) had a sheath size equal to or larger than 20 F. The type of anesthesia administered was local with sedoanalgesia for 34 patients (65%), regional for 13 patients (25%), and general for 5 patients (10%).

Regarding the access arteries, one patient (2%) required conversion to surgery because the knot pusher of the closure device entered the artery at the end of the procedure during suture tightening. Hemostasis could not be achieved with manual compression. The artery was manually compressed for surgical exposure, and a surgical team repaired the artery with primary suturing. Two patients had pull-out of one of the two sutures used in the procedure. A safety guide wire was not kept in the artery, and only one suture could be used for the knot. Manual compression was required for 35 and 50 min for these patients, with no adverse sequel. Technical success was achieved in 49 out of 52 patients (94%). Fifty-one patients (98%) completed the procedure without requiring surgical intervention. Two device

**Table.** Number and outer diameter of closure devices

Size (F)	AAA		TAA	
	Number	Percentage	Number	Percentage
14	25	30%		
18	7	8%		
20	27	32%		
22	7	8%		
24			17	20%
27			2	2%
Total	66	78%	19	22%

AAA, abdominal aortic aneurysm; TAA, thoracic aortic aneurysm.

failures occurred that affected the access arteries. One was due to deflection of one needle after needle deployment. All needles were reinserted into the device by rotating the handle 90 degrees clockwise and pushing the marker with its nitinol needle back to its original position. The device was successfully exchanged for a new one, and closure of the arterial puncture site was successful at the end of the procedure. The second device failure occurred because the marker at the hub of the closure device could not be rotated 90 degrees counterclockwise before needle deployment. The device was replaced, and there was successful closure of the arterial puncture site at the end of the procedure. The length of the hospital stay ranged from 1 to 5 days (mean, 2.2 days). Forty-five patients (87%) were discharged on the first postoperative day.

No major or minor complications related to the closure device occurred at the access site after the procedure. The access arteries were normal in all cases, with no complications on the first postoperative day (as visualized with US) or one month postoperatively (as visualized with CT). The mean diameters of the access arteries showed no differences before and one month after the procedure (10.31 mm vs. 10.99 mm for the right CFA,  $P = 0.38$ ; 10.64 mm vs. 10.59 mm for the left CFA,  $P = 0.68$ ).

## Discussion

This study showed that total percutaneous repair of aortic aneurysms with US guidance has high technical success and very low complication rates. One surgical conversion to surgery and two suture losses occurred in the first 20 patients. After these incidents, no technical problems were encountered, with the exception of problems directly related to the device. Previous studies with small patient populations had a relatively high technical failure or complication rates for percutaneous closure of the access artery; these high rates are likely related to the learning curve necessary to master the use of the closure device. However, although a small patient population was used in this study, acceptable success and complication rates were obtained. It is likely that the use of US-guided puncture of the CFA was one of the factors underlying the low technical failure and

complication rates. One Prostar XL device was sufficient to establish hemostasis for all 24 F or 27 F stent graft systems or vascular sheaths. Previously, it was established that one device was sufficient to achieve hemostasis for all sheath sizes (5). The length of the hospital stay decreased with increased experience of the physician with the closure device. Local anesthesia was used more frequently as the physician became more confident with the use of the device.

Precise suture placement is an important step in using a closure device to seal an artery. US-guided puncture of the access artery has the advantage of enabling excellent puncture of the CFA (1 cm above the deep femoral artery) and avoiding superficial femoral artery puncture. A puncture that is too low or too high may increase retroperitoneal bleeding or arterial thrombosis, respectively. Palpation of the artery may be difficult, especially in obese patients, and may result in puncture of the lateral arterial wall with ineffective placement of the sutures of the closure device. US-guided puncture enables the physician to perform a single-wall puncture at the midpoint of the artery while avoiding calcified sections of the artery and results in improved subsequent positioning of the crossing sutures in the anterior arterial wall. These advantages become especially important when placing sutures to close a large hole in an artery using a vascular surgical device. There is only one study showing the effectiveness of US guidance for puncture of the access vessel in the treatment of aortic aneurysms. This study showed that access site complications were significantly reduced in the group undergoing US-guided puncture compared to the group undergoing surgical cut-down (3).

There is no consensus on patient selection for the use of percutaneous closure devices, but the access vessel should be of adequate size. Many studies have shown that obesity or morbid obesity, severely or circumferentially calcified CFA, tortuous iliac arteries, large introducer sheath size (larger than 18 F or 20 F), a scarred groin, the presence of a graft in the access artery, and inexperience with the procedure increase the likelihood of technical failures or complications (2, 4–7). In some studies, these risk factors were

exclusion criteria for the use of the percutaneous closure device; in other studies, they were not (6–8). Obesity or morbid obesity can increase the complication rate of the percutaneous approach, but successful percutaneous treatment of these patients has the advantage of reducing the rate of wound complications, which is high in cases of surgical cutdown in obese patients.

The technical success rate with the percutaneous closure device ranged from 66% to 100% (1–6). The technical success rate is usually lower in earlier studies or studies with small patient populations, whereas recent studies or studies with large patient populations usually have a technical success rate exceeding 90% (1, 4, 5, 9). The current and previous studies confirm that, as experience with the closure devices increases, the technical success rate increases, and the complication rate decreases (5).

The complications associated with open femoral arterial exposure for aortic aneurysm repair are infection, arterial dissection, arterial thrombosis, pseudoaneurysm formation, groin hematoma lymphoceles and femoral nerve injury, which occur in up to 14% of patients (10, 11). A midterm analysis study of EVAR in 186 patients showed an 8% wound infection rate; a 6.5% rate of local wound complications, including wound necrosis and dehiscence; and a 4.8% rate of lymphocele formation (12). Complications related to the percutaneous closure of the access site for the treatment of aortic aneurysms are bleeding, groin or retroperitoneal hematomas, arterial dissection in the femoral or iliac arteries, pseudoaneurysm formation, compromised distal flow, and problems related to the closure device, such as entrapment of the needles, thrombosis due to narrowing or severe intimal dissection of the artery (2, 7, 13, 14). Bleeding and an inability to achieve hemostasis were the main complications requiring conversion to surgery in previous studies. We had only one conversion to surgery, and no other complications were observed one day and one month postoperatively as assessed by US and CT, respectively. Starns et al. (4) reported no difference in the luminal diameter of the access artery between preoperative and postoperative CT angiograms, which is in accordance with our results.

Randomized and nonrandomized prospective studies have shown that technical success and complication rates were similar in the percutaneous closure or surgical cutdown groups. However, percutaneous closure was more favorable with respect to mean operation duration, anesthesia time and the use of local or regional anesthesia (9, 15, 16). Patients often complained of back pain due to mandatory postprocedural bed rest, which was usually related to a coexistent pathological spinal condition that is frequently seen in this patient population (17). In this study, the use of a percutaneous closure device allowed the majority of patients to be discharged on the first postoperative day and allowed for early mobilization. When a closure device is used, the physician performing the aortic aneurysm repair does not need to be experienced in open surgical techniques. The largest prospective study conducted to date showed that severe calcification of the CFA and physician inexperience (<30 cases) were significantly correlated with early conversion to femoral cutdown. Sheath size and scars in the groin were also correlated with early conversion but to a lesser degree. The same prospective study also showed that obesity was not a risk factor for complications in contrast to many previous studies (5).

Total percutaneous repair of abdominal and thoracic aortic aneurysms with US-guided puncture has high technical success and low complication rates. Most patients can be discharged on the first postoperative day. The possible benefits of early

discharge include a decrease in problems related to long-term bed rest and increased patient satisfaction. However, the results obtained in this study need to be confirmed with prospective, randomized studies.

#### Conflict of interest disclosure

The authors declared no conflicts of interest.

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