Urgent endovascular repair for ruptured aortic aneurysm using computed tomography image fusion

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Abdominal aortic aneurysm rupture remains a cardiovascular catastrophe with strikingly high morbidity and mortality rates. Endovascular aneurysm repair management has recently emerged as a valuable treatment modality for ruptured abdominal aortic aneurysm, but better outcomes have to be reached. Image fusion may potentially improve perioperative outcomes in selected patients, guiding navigation and device implantation and limiting contrast dosage during interventions. We report an 83-year-old man presenting with an 80-mm infrarenal aortic aneurysm rupture suitable for endovascular aneurysm repair. Endovascular navigation and stent graft deployment were achieved using computed tomography image fusion for the first reported case in English. (J Vasc Surg Cases 2015;1:102-4.)

Image fusion is a recent advance in imaging technology. During fluoroscopy, a previously acquired computed tomography (CT) angiography (CTA) is overlaid onto the three-dimensional (3D) fluoroscopic data in real time. As imaging systems at many centers are updated, this technology will become increasingly available. This technique is used daily in our center for elective cases.[1,2] Having gained experience, we now use it for select emergency cases.

Ruptured abdominal aortic aneurysm (rAAA) is associated with strikingly high morbidity and mortality rates.[3] Delay of aortic cross-clamping or endovascular exclusion is a major prognostic factor for the patient's survival. Endovascular aneurysm repair (EVAR) has emerged during the past decade as a valuable treatment modality for rAAA. We present the first reported case of endovascular treatment for rAAA using CT image fusion. Written informed consent was obtained from the patient for publication of this case report and accompanying images.

CASE REPORT

An 83-year-old man was referred to our center for sudden abdominal pain. His medical history included hypertension, dyslipidemia, a cerebral vascular accident with subsequent right carotid bypass surgery, and atrial fibrillation with warfarin anticoagulation.

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Blood pressure at admission was 83/40 mm Hg. The electrocardiogram result was normal. Blood tests revealed hemoglobin of 8.2 g/dL, international normalized ratio of 2.12, serum creatinine of 1.98 mg/dL, pH of 7.31, partial pressure of carbon dioxide of 31 mmHg; HCO_3 of 15.6 mEq/L, and lactate of 68.5 mg/dL.

An urgent CTA revealed an 80-mm infrarenal AAA rupture suitable for EVAR. Anatomical measurements showed a proximal aortic neck length of 25 mm under the right renal artery with a 25-mm major diameter. A large left retroperitoneal hematoma confirmed rupture of the aneurysm (Fig 1).

Emergency EVAR was performed in the angiography suite (Allura FD20; Philips Healthcare, Best, The Netherlands). With the patient draped and under general anesthesia, a low-dose cone-beam CT (CBCT) acquisition was obtained without an iodinated contrast injection. The preacquired CTA volume was overlaid with the intraoperative CBCT using vessel calcifications and soft tissue as landmarks. The endovascular procedure was achieved using the preacquired CTA over the live two-dimensional fluoroscopy, using 3D road mapping.

We inserted a bifurcated Zenith endograft (Cook Inc, Bloomington, Ind), through the right common femoral artery exposed by surgical access. This 3D road mapping was used to deploy the device, and no contrast injection was needed (Fig 2). Only a final control angiogram requiring 30 mL of contrast medium (a rate of 15 mL/s) was performed to check stent graft position, patency of the renal and internal iliac arteries, and total exclusion of the AAA (Fig 3).

Procedure duration was 140 minutes, and fluoroscopy time was 28 minutes. The radiation dose measured by the dose area product was 400.5 Gy · cm^2.

The patient's postoperative course was uneventful and he recovered completely, with normal renal function on discharge. A control CTA at 72 hours showed no endoleak and an appropriate graft position.

DISCUSSION

rAAA remains a cardiovascular catastrophe with an overall mortality of 80%.[3] The incidence of rAAA is

Fig 1. Preoperative computed tomography (CT) scan shows the hemoretroperitoneum of an infrarenal ruptured aneurysm.

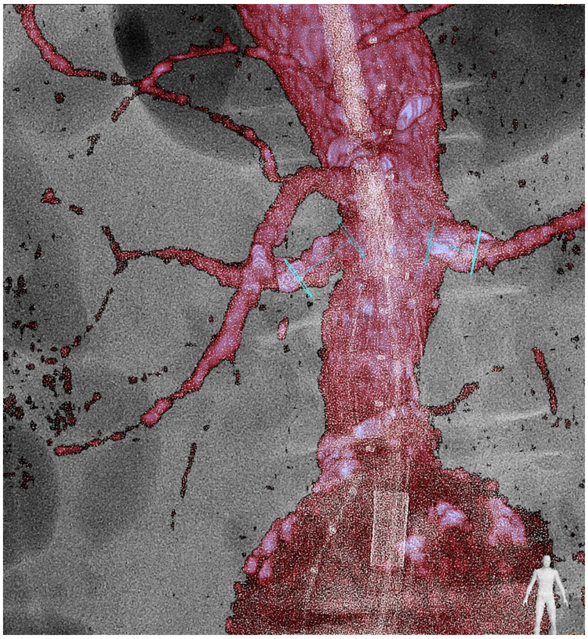

Fig 2. The stent graft is deployed under the renal arteries using live fluoroscopy superimposed over the previously acquired computed tomography (CT) angiogram (CTA).

~8.0/100,000 people per year. Since the first report by Marin et al[4] in 1994, many others have applied EVAR for rAAA, with varying degrees of success. Nevertheless, early results suggested a decrease in overall mortality for patients treated by an endovascular approach, with a pooled mortality rate from rAAA after EVAR of 24%.[5] A recent meta-analysis including randomized controlled trials supports the use of EVAR in suitable patients and open repair as a reasonable alternative.[6]

Renal dysfunction is a serious complication after rAAA repair caused by hypoperfusion from hemorrhagic and hemodynamic shocks with ischemia-reperfusion injury, associated with the use of iodinated contrast to perform intraoperative arteriography. For many authors, renal dysfunction is a major predictor for postoperative outcome. The rate of postintervention long-term dialysis requirement is as high as 17%.[7]

C-arm CBCT is an advanced imaging capability that uses C-arm flat panel fluoroscopy systems to acquire and display 3D images. To guide device implantation and endovascular navigation, these CT-like images can be registered or fused with the preoperative CTA using vessel calcifications and soft tissue as landmarks, thus allowing fluoroscopic navigation over the diagnostic CTA. This technology allows the use of iodinated contrast to be minimized or eliminated during EVAR.[8,9]

The average volume of iodinated contrast agent used for intraoperative imaging during EVAR for rAAA ranged from 100 to 200 mL.[10-12] The procedure reported here required only 30 mL of iodinated contrast for the final completion angiography. A final angiogram using only 15 to 20 mL of contrast medium could have been performed, but at the beginning of our experience for emergency cases, we preferred to have a best-quality image to confirm successful endograft deployment and aneurysm exclusion. We believe that a final control angiogram remained necessary for rAAA repair to check total exclusion of the aortic aneurysm and avoid a postoperative death from a missed endoleak. Given this, image fusion, has the potential to reduce postoperative renal dysfunction and may confer a benefit to patients for short-term and long-term outcomes. There is evidence to suggest that repeated doses of contrast agent may contribute to the development of lifelong nephrotoxicity.[13]

Having gained experience, we can combine at the same time the patient's draping and anesthesia with CBCT acquisition and the image fusion procedure to minimize loss of time before stent graft insertion. Once the CBCT acquisition is fused with the preacquired CTA, it can be used to guide the accurate placement of endovascular devices. Although limited data exist, our empiric data support claims by other authors[14] that CBCT fusion reduces operating time with increasing experience compared with standard EVAR techniques.

We believe that image fusion may improve outcomes for EVAR during rAAA repair, minimizing use of iodinated contrast and reducing the length of intervention, especially in complex procedures and in patients with renal impairment. Nevertheless, as imaging systems at many centers are updated, this technology will become increasingly available, and for this reason it is imperative that practitioners become familiar with these technologies and their potential applications. The results of case report support that image fusion can be safely used during EVAR for rAAA.

Others authors have shown how carbon dioxide-guided angiography has the potential to minimize the use of iodinated contrast in EVAR.[15,16] This technology has been used for many years for venograms and peripheral angiograms, and its application in EVAR procedure is growing. Few authors have reported the use of carbon dioxide-guided angiography for EVAR during rAAA repair. Knipp et al[17] demonstrated a significant reduction in the use of iodinated contrast for patients undergoing endovascular repair of rAAA, with carbon dioxide as the

Fig 3. Left, A two-dimensional final angiogram **(Right)** superimposed on the preacquired computed tomography (CT) angiography (CTA) data set shows perfect position of the device, without coverage of principal collateral arteries, and the total exclusion of the rupture. There is no evidence of endoleak.

principal contrast agent, although the change in creatinine between admission and discharge was not statistically significant. Association between carbon dioxide-guided angiography and the 3D road map could be interesting to reduce contrast volume injection. To our knowledge, however, the use of carbon dioxide-guided angiography has not yet been reported in association with image fusion. Further cases reports and studies are necessary to assess its feasibility and utility on renal dysfunction after EVAR.

CONCLUSIONS

Using image fusion for urgent EVAR of rAAA is feasible. This technique facilitates endovascular navigation, reduces contrast volume, and may demonstrate higher technical success rates than current methods.[8,9,13] Further studies should be mandated to confirm this observation.

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