Editor's Choice — A Shaggy Aorta is Associated with Mesenteric Embolisation in Patients Undergoing Fenestrated Endografts to Treat Paravisceral Aortic Aneurysms

S.D. Patel, J. Constantinou, H. Hamilton, M. Davis, K. Ivancev *

Department of Vascular Surgery, Royal Free Hospital NHS Foundation Trust, London NW3 2QG, UK

WHAT THIS PAPER ADDS

This study is the first to look at thrombus volume and aortic shagginess as predictors of mesenteric embolisation following fenestrated endovascular aneurysm repair. As such, it highlights the important factors associated with this rare complication. We hope that this work will lead us and others to undertake more detailed studies that will ultimately allow stratification of the risk of embolisation, and thus eventually to the development of strategies to avoid it.

Objectives: Bowel ischaemia is a life-threatening complication of endovascular aneurysm repair. This study aims to evaluate the factors associated with mesenteric ischaemia in patients undergoing fenestrated aortic endografts to treat paravisceral aneurysms.

Methods: Consecutive patients undergoing double or triple fenestrated stent graft insertion were retrospectively analysed. No patients were declined surgery based on anatomic complexity. Preoperative demographics, procedure-related variables, and anatomical factors were examined. Using 3D software, the aortic thrombus volume from the coeliac axis to the lowest renal, aortoiliac tortuosity, and aortic irregularity index (as graded by 3 independent assessors, graded 0—3 based on severity) were compared. Univariate analysis was performed to identify risk factors for the development of bowel ischaemia.

Results: Ninety-nine patients underwent elective aneurysm repair (64 triple fenestrations and 35 double fenestrations), 5% of which developed bowel ischaemia, and of these 80% (4/5) died. Mesenteric ischaemia was significantly associated with increased aortic irregularity (median [range], 2 [1—3] vs. 1 [0—2], $p = .005$, ischaemia vs. no ischaemia) and increased thrombus volume (37 $\pm$ 8 vs. 21 $\pm$ 12, $p = .007$) but not aortoiliac tortuosity (1.4 [1.2—1.5] vs. 1.30 [1.2—1.7], $p = .3$), inferior mesenteric or internal iliac artery patency. Mesenteric ischaemia was also associated with a significantly higher preoperative creatinine (mean $\pm$ SD: 183 $\pm$ 74 vs. 111 $\pm$ 43, $p = .007$).

Conclusions: The presence of aortic irregularity and increased thrombus volume in the paravisceral segment predicts the occurrence of mesenteric and renal ischaemia in patients treated with fenestrated endografts. This is likely to be related to graft manipulation and catheterisation of visceral vessels.

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INTRODUCTION

Ischaemia of the bowel is a rare complication of endovascular infrarenal aortic aneurysm repair (EVAR).[1,2] The pathophysiology may involve a combination of hypoperfusion related to hypotension, graft coverage of the inferior mesenteric artery (IMA), or embolisation into the IMA or internal iliac arteries from the manipulation of the endograft in the aorta and iliac vessels.[2,3] When treating paravisceral aortic aneurysms with fenestrated stent grafts (FEVAR) the superior mesenteric artery is cannulated and stents placed. Consistent with this, we observed that bowel ischaemia related to FEVAR occurs in the superior mesenteric artery (SMA) as well as the IMA distribution. The risk of mesenteric ischemia after FEVAR appears to be between 1% and 3%, on the basis of published data.[4,5] We observed that the aortic morphology may also prove to be a powerful determinant of this complication and that its incidence was higher in patients with atheromatous laden aortic lumen. Both peripheral[6] and visceral[7,8] spontaneous embolisation has been described in patients with diffuse aortic atherosclerotic disease, and has been termed "shaggy aorta syndrome". The aim of this study was to evaluate the factors associated with mesenteric embolisation in

* Corresponding author. K. Ivancev, Department of Vascular Surgery, Royal Free Hospital NHS Foundation Trust, Pond Street, London NW3 2QG, UK.
E-mail address: krassi.ivancev@gmail.com (K. Ivancev).

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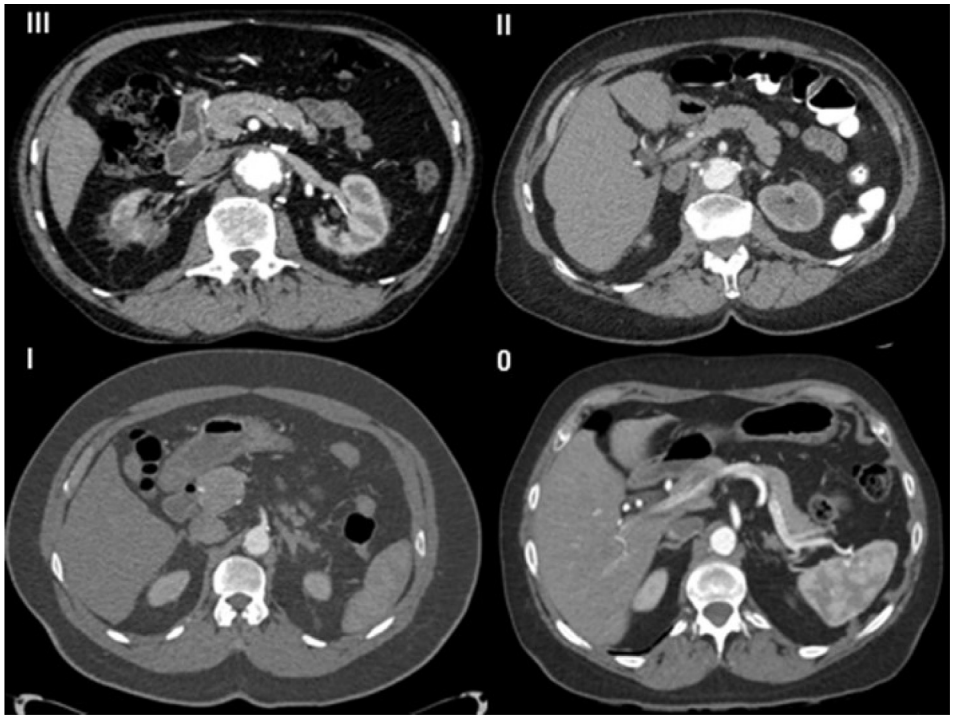

Figure 1. Aortic irregularity (shaggy index). Grade III = most severe, very extensive atheromatous disease with diffuse ulcers associated with soft, loosely held debris, Grade 0 = clean non-atheromatous.

patients treated with fenestrated aortic endografts. Our objectives were to determine whether a shaggy aorta, volume of aortic thrombus, and vessel tortuosity were causative factors for mesenteric ischaemia.

METHODS

We studied consecutive patients undergoing double and triple fenestrated stent graft insertion for paravisceral aneurysms. Importantly, no patients were declined surgery based on anatomical complexity. The data from all patients treated with FEVAR were prospectively collected and recorded in a computerised database incorporating multiple variables such as preoperative demographics, procedure-related variables, and anatomical factors such as aneurysm size and patency of major vessels. This database along with spiral computed tomography angiogram (CTA) images were retrospectively reviewed to identify factors related to the development of mesenteric ischaemia. Preoperative cardiopulmonary work-up consisted of spirometry, echocardiography, and 12-lead electrocardiogram (ECG) in all cases, and cardiopulmonary exercise testing in those deemed high risk.

Stent graft planning and insertion

In our centre aneurysms are selected for FEVAR repair if they are deemed unsuitable for standard infrarenal EVAR (necks $<$10 mm in length or $>$32 mm in diameter). The fenestrated device used in all cases was the Zenith platform (Cook Medical, Bloomington, IN, USA). Fenestrations and scallops were planned to match the locations of the target vessel ostia using high-resolution spiral CTA scans and 3D workstations (Aquarius iNtuition Viewer, Aquarius, TeraRecon, San Mateo, CA, USA).

All procedures were performed in a dedicated hybrid operating theatre with a fixed imaging system. The detailed device description and implantation technique has been well described.[9] During the procedure, activated clotting time (ACT) was maintained between 250 to 300 seconds with bolus heparin doses. Extra-corporeal axillo-bifemoral (ABF) bypass grafts were used for all triple fenestrated cases in order to reduce the incidence of lower limb ischaemia and subsequent reperfusion injury. A through-and-through wire was also inserted, utilising the axillary end of the ABF as a conduit, to facilitate graft insertion and manipulation. Carbon dioxide angiography was used selectively in patients with chronic renal impairment. All patients had a completion angiogram to check for endoleaks and patency of target vessels.

Postoperatively all patients were transferred to an intensive therapy unit. All patients received thromboprophylaxis and antiplatelet agents unless contraindicated. Patients were transferred to the vascular ward after 24 hours depending on clinical progress. Duplex ultrasound was routinely performed to assess stent patency and for the presence of endoleaks prior to discharge. CT angiography was performed within 3 months of the procedure and immediately postoperatively if there was a clinical suspicion of a complication.

Definitions and statistical analysis

Chronic renal insufficiency was defined as an estimated glomerular filtration rate (eGFR) $<$60 mL/min/1.73 m^2. Acute renal failure was defined as a relative decrease in renal function of greater than 30% (eGFR or rise in serum creatinine).