Eur J Vasc Endovasc Surg (2016) 52, 613—619

Impact of Shaggy Aorta in Patients with Abdominal Aortic Aneurysm Following Open or Endovascular Aneurysm Repair

H. Kwon [a], Y. Han [b], M. Noh [b], J.G. Gwon [b], Y.-P. Cho [b], T.-W. Kwon [b,*]

[a] Department of Surgery, Hallym University Sacred Heart Hospital, Hallym University College of Medicine, Pyeongchon Anyang, Republic of Korea
[b] Division of Vascular Surgery, Department of Surgery, Asan Medical Center, University of Ulsan College of Medicine, Seoul, Republic of Korea

WHAT THIS PAPER ADDS

The impact of shaggy aorta on 30 day morbidity and mortality and long-term survival was studied in patients having abdominal aortic aneurysm repair. To the authors' knowledge, this is the first study to investigate the clinical impact of shaggy aorta in bothopen and endovascular aneurysm repair, including effects on long-term survival. It was found that shaggy aorta is a prominent risk factor associated with 30 day morbidity and mortality. Poor long-term survival was expected in patients with shaggy aorta. The present results provide valuable background evidence for physicians treating patients with shaggy aorta and for future studies.

Objective: To analyze the impact of the presence of shaggy aorta on 30 day morbidity and mortality and long-term survival in patients undergoing abdominal aortic aneurysm (AAA) repair.
Methods: This retrospective observational study included 447 consecutive patients who underwent AAA repair between January 2009 and December 2012. The study included 209 patients (47%) having open surgical repair (OSR) and 238 patients (53%) having endovascular aneurysm repair (EVAR).
Results: Of the 447 patients having elective AAA repair, 48 patients (11%) had shaggy aorta. Both the OSR ($p = .005$) and EVAR group ($p = .007$) demonstrated a higher 30 day morbidity and mortality in patients with shaggy aorta. On multivariate regression analysis, patients with shaggy aorta had 4.1 fold (95% CI = 1.7—9.7; $p = .002$) increase in 30 day morbidity and mortality. According to the Kaplan-Meier analysis, patients with shaggy aorta had significantly decreased long-term overall survival in comparison with the non-shaggy group (log-rank test; $p = .005$), and this resulted from comorbidities.
Conclusions: Shaggy aorta is a prominent risk factor associated with 30 day morbidity and mortality. Poor long-term survival was expected in patients with shaggy aorta.

Article history: Received 11 February 2016, Accepted 16 August 2016, Available online 24 September 2016
Keywords: Abdominal aortic aneurysm, Shaggy aorta, EVAR, Embolization, Survival

INTRODUCTION

Although the term "shaggy aorta" refers to an irregularly shaped and spiculated aorta, which is determined by visual characteristics on computed tomography (CT) angiography, an agreed definition of the condition does not yet exist.[1,2] Shaggy aorta is related to early adverse events following open surgical repair (OSR) and endovascular aneurysm repair (EVAR) for abdominal aortic aneurysm (AAA).[3,4] Peripheral and visceral embolization from a diffusely atherosclerotic aorta has been called shaggy aorta syndrome.[2,4] Although both OSR and EVAR for shaggy aorta are associated with early complications, EVAR is thought to lead to complications more often than OSR. OSR takes place in an "open space," which means that debris can be flushed out. EVAR, in contrast, is performed in an "enclosed space" using a stiff wire to deliver the graft.[3]

EVAR has become more common worldwide during the last decade, especially after controlled trials found that it reduces peri-operative mortality compared with OSR.[5–7] Although there is no doubt that EVAR is the preferred method for patients who are at higher risk or have shorter life expectancy, treatment decision making for individual patients is still difficult because of durability concerns.[8] Recent studies have sought to identify pre-operative variables that influence clinical outcomes following EVAR and OSR, to assist surgeons with clinical decision making.[9,10] Most studies, however, have focused on conventional risk factors, such as cardiac and pulmonary risk, without considering the anatomical features of the AAA, including aortic shagginess. Although recent studies suggest possible predictors such as age, female sex, American Society of Anesthesiologists (ASA) score, and chronic obstructive

* Corresponding author. Division of Vascular Surgery, Department of Surgery, Asan Medical Center, University of Ulsan College of Medicine, 88, Olympic-ro 43-gil, Songpa-gu, Seoul, 05505, Republic of Korea.
E-mail address: twkwon2@amc.seoul.kr (T.-W. Kwon).
1078-5884/© 2016 Published by Elsevier Ltd on behalf of European Society for Vascular Surgery.
http://dx.doi.org/10.1016/j.ejvs.2016.08.010

pulmonary disease (COPD), there is a paucity of studies of shaggy aorta in comparison with these classic risk factors.[8,9,11]

In this study, a retrospective analysis was conducted of the effects of shaggy aorta on 30 day morbidity and mortality in patients who underwent AAA repair. In addition, long-term overall survival and its determinants after AAA repair were evaluated.

MATERIALS AND METHODS

This was a retrospective observational study that employed data obtained by patient medical record review. The study protocol was approved by the hospital institutional review board. After 46 patients with ruptured AAA and two patients who concomitantly had thoracic aortic aneurysm were excluded, 447 consecutive patients who underwent AAA repair between January 2009 and December 2012 were included. Of these, 209 (47%) underwent OSR and 238 (53%) EVAR. The treatment that was applied to individual patients was determined by the morphology of the AAA, the patient's risk factors, and life expectancy.

A shaggy aorta was defined as a diffuse, irregularly shaped atherosclerotic change involving more than 75% of the length of the aorta from the aortic arch to the visceral segment with atheromatous plaque thickness greater than 4 mm, as confirmed by contrast enhanced CT. Both criteria had to be met for inclusion in the shaggy aorta group. Patients with diffuse, mild atherosclerotic change without unstable atheroma and focal pathologic lesion such as intramural thrombus, penetrating aortic ulcer, and calcified plaque without diffuse atherosclerotic change were not included in the shaggy aorta group. CT angiograms were reviewed by two vascular surgeons and one radiologist. Inter-observer error in identifying shaggy aorta was found to be <10% (Pearson correlation = 0.9, $p < .001$) (Fig. 1).

To evaluate pre-operative risks, patient comorbidities including age, hypertension (HTN), diabetes mellitus (DM), coronary artery disease (CAD), cerebrovascular accident (CVA), chronic obstructive pulmonary disease (COPD), and peripheral arterial disease (PAD) were obtained from the medical records. Pre-operative workup such as laboratory studies, including 12 lead electrocardiography, was performed in all cases. Cardiopulmonary studies consisting of echocardiography (435 cases; 97%), dipyridamole thallium-201 myocardial perfusion scan (429 cases; 96%), and spirometry (394 cases; 88%) were performed. CAD was defined as a previous history of myocardial infarction, coronary artery bypass surgery, and percutaneous coronary intervention. Abnormal thallium findings were recorded when the results showed reversible changes in large areas. Heart failure (HF) was defined as an ejection fraction <40% on ECG. CVA was recorded when patients had a history of a previous stroke or transient ischemic attack. COPD was defined as a forced expiratory volume in 1 s (FEV_1)/forced vital capacity (FVC) ratio of <70% accompanied by the symptoms of COPD. Chronic renal failure (CRF) was defined as an estimated glomerular filtration rate <60 mL/minute/1.73 m^2. PAD was recorded when patients had a history of medication or intervention for symptomatic peripheral vascular disease. The ASA score was determined by anesthesiologists before AAA repair.

All open surgical procedures were performed under general anesthesia using a standard technique and the transperitoneal approach. Aortic cross clamping during OSR was mostly performed in the infrarenal aorta, except in 21 cases where it was in the suprarenal aorta. Endovascular procedures were performed under general or regional anesthesia, followed a standard vascular protocol, and used a Gore Excluder (W.L. Gore & Associates, Inc., Flagstaff, AZ, USA), Cook Zenith (Cook Medical Inc., Bloomington, IN, USA), Talent and Endurant (Medtronic, Minneapolis, MN, USA), AneuRx (Medtronic, Santa Rosa, CA, USA), or SEAL stent graft (S&G Biotech, Seoul, Korea).

The procedures were performed in the operating or intervention room by the surgeon or interventionist. Intra-operative data consisted of the type of anesthesia, procedure time, volume of intra-operatively transfused packed red blood cells, and procedure related complications. Post-operative variables included length of stay in the intensive care unit and hospital and 30 day morbidity and mortality. The primary outcome was 30 day morbidity and mortality. Clavien-Dindo class IV complications[12] were used to determine morbidity, including myocardial infarction, acute renal insufficiency requiring dialysis, ventilation >48 h, unplanned intubation, central nervous system complications (e.g. coma or stroke), and post-operative bleeding requiring

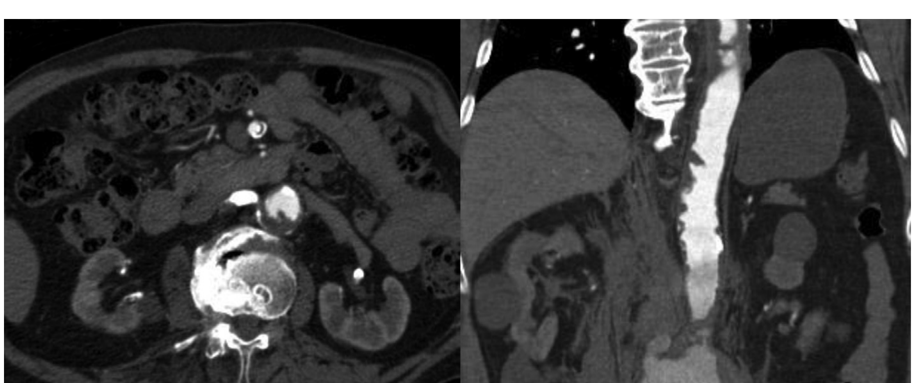

Figure 1. Features of a shaggy aorta on contrast enhanced computed tomography.