Obesity-related decrease in intraoperative blood flow is associated with maturation failure of radiocephalic arteriovenous fistula

Jwa-Kyung Kim, MD,[a] Jae Han Jeong, MD,[b] Young Rim Song, MD,[a] Hyung Jik Kim, MD, PhD,[a] Won Yong Lee, MD, PhD,[b] Kun Il Kim, MD,[b] and Sung Gyun Kim, MD, PhD,[a] *Anyang, Korea*

Objective: **Successful arteriovenous fistula (AVF) maturation is often challenging in obese patients. Optimal initial intraoperative blood flow (IOBF) is essential for adequate AVF maturation. This study was conducted to elucidate the effect of obesity on IOBF and radiocephalic AVF maturation.**

Methods: **Patients with a newly created radiocephalic AVF were included (N = 252). Obesity was defined as a baseline body mass index (BMI) ≥25 kg/m^2, and primary maturation failure was defined as failure to use the AVF successfully by 3 months after its creation. IOBF was measured immediately after construction of the AVF with a VeriQ system (MediStim, Oslo, Norway).**

Results: **The mean BMI was 24.1 ± 3.9 kg/m^2, and the prevalence of obesity was 31.3%. Particularly, 8.3% (21 patients) had a BMI ≥30 kg/m^2. Primary maturation failure occurred in 100 patients (39.7%), and an IOBF <190 mL/min was closely associated with the risk of maturation failure (relative risk, 3.05; 95% confidence interval, 1.52-6.11). Compared with nonobese patients, obese subjects had a significantly higher prevalence of diabetes and elevated high-sensitivity C-reactive protein levels, whereas diameters of vessels were similar. When the patients were further divided into three groups as BMI <25, 25 to 29.9, and ≥30 kg/m^2, patients in the higher BMI group showed significantly lower IOBF and higher maturation failure rate. According to multivariate analysis, the statistically significant variables that determined maturation failure were obesity, previous vascular disease, increased high-sensitivity C-reactive protein levels, and IOBF <190 mL/min.**

Conclusions: **Obese patients had a significantly lower IOBF, and both obesity and low IOBF contributed to the primary maturation failure of AVF. Obesity-associated inflammation and atherosclerosis might play roles in this association. (J Vasc Surg 2015;62:1010-7.)**

Current practice guidelines emphasize the use of an arteriovenous fistula (AVF) as the preferred type of vascular access for chronic hemodialysis patients.[1] AVF is associated with fewer complications, improved access survival, and lower risk of mortality compared with arteriovenous graft or central venous catheter.[2,3] However, fistulas are superior to grafts only if they mature successfully. Indeed, maturation failure has been described as a major limitation of their use, and the current meta-analysis data showed that the primary failure rate of AVF reaches ~30% and ~20% in the lower and upper arm, respectively.[4] Notably, because early intervention for maturation failure appears effective and safe,[5] determining risk factors associated with AVF failure emerges as an important issue. Identification of those risk factors will likely allow early intervention for an immature AVF. Age, gender, pre-existing vascular disease, vessel diameter, and operative procedures are well-established predictors of fistula outcomes.[6,7] In addition, initial intraoperative blood flow (IOBF) is also an important determinant of AVF maturation, and an IOBF <120 to 200 mL/min is known to be a potential risk factor for maturation failure.[8-10]

In recent years, the obesity epidemic is growing both in the general population and in hemodialysis patients, and dialysis patients with higher body mass index (BMI) experience fewer cardiovascular events. According to the prospective Dialysis Outcomes and Practice Patterns Study (DOPPS), overweight (BMI, 25-29.9 kg/m^2) and obese (BMI ≥30 kg/m^2) hemodialysis patients showed lower relative risk of mortality compared with patients with a BMI of 23 to 24.9 kg/m^2.[11-13] However, the vascular access effects of a high BMI remain unclear. In general, the creation and maintenance of AVF is considered more difficult in obese patients because of the increased risk of perioperative complications as well as a decreased maturation rate. The Hemodialysis (HEMO) study reported that obesity was one of the factors associated with reduction in successful AVF construction.[14] However, the exact

From the Department of Internal Medicine, Kidney Research Institute,[a] and Department of Cardiovascular and Thoracic Surgery,[b] Hallym University Sacred Heart Hospital.

This research was supported by Hallym University Research Fund (HURF) 2013-35 and HURF-2014-58.

Author conflict of interest: none.

Additional material for this article may be found online at www.jvascsurg.org.

Correspondence: Sung Gyun Kim, MD, PhD, Department of Internal Medicine, Kidney Research Institute, Hallym University Sacred Heart Hospital, Pyungchon-dong, Dong-An Gu 896, Anyang, Korea (e-mail: imnksk@gmail.com).

The editors and reviewers of this article have no relevant financial relationships to disclose per the JVS policy that requires reviewers to decline review of any manuscript for which they may have a conflict of interest.

0741-5214

http://dx.doi.org/10.1016/j.jvs.2015.05.008

reason for this observed decrease in AVF utilization in the obese is merely speculative, given the retrospective, observational nature of these studies. Furthermore, there has been lack of consensus as to whether different guidelines for fistula placement should be applied in the obese hemodialysis population. Therefore, risk stratification in combination with IOBF might be a valuable means to reduce AVF failure rate in obese dialysis patients.

In this cohort study of incident Korean hemodialysis patients with a newly created radiocephalic AVF, we evaluated the effects of obesity on the primary maturation failure of AVF by assessing its association with IOBF. Our hypothesis was that obesity would be associated with maturation failure of the radiocephalic AVF by lowering of IOBF.

METHODS

Patient population. Among the end-stage renal disease patients with newly created vascular access between January 2006 and June 2014, only those who received a radiocephalic AVF were included. Because brachiocephalic or brachiobasilic AVF often needs translocation or superficialization of the upper arm vein and these procedures require significant surgical skills, patients with AVF in the upper arm were not included in this study to exclude the possibility of maturation failure associated with the surgical procedure. In addition, patients with a previous history of upper limb or shoulder trauma or operation (n = 2) or having central vein stenosis on venography (n = 6) were excluded. Therefore, a consecutive 252 patients were enrolled. The local Institutional Review Board/Ethics Committee approved the study protocol, and written informed consent was obtained from each subject. All of the study procedures adhered to the Declaration of Helsinki.

Patient demographic data including age, gender, underlying cause of renal disease, comorbidities, systolic and diastolic blood pressure (BP), and medication history were obtained. Baseline BMI was calculated as body weight/(height/100)^2, and obesity was defined as a baseline BMI $\geq$25 kg/m^2, according to the Asian International Obesity Task Force and the World Health Organization Regional Office for the Western Pacific Region.[15]

Preoperative physical examination and vascular mapping. Preoperative inspection and palpation of the superficial veins over the forearm were performed carefully by experienced nephrologists and surgeons, and the quality of vessels and their patency were recorded. Pulsations of brachial, radial, and ulnar artery were palpated, and an Allen test was performed to detect the risk of distal ischemia. Preoperative vascular mappings were performed routinely by both duplex ultrasound and venography. Duplex ultrasound was performed by two experienced surgeons from the vascular clinic using 5- to 12-MHz linear transducers (Sonos 5500; Hewlett Packard, Palo Alto, Calif). Vessel diameters, courses, anatomic variation, depth of the vein, and presence of any vascular abnormalities, such as plaques, stenosis, or diversions, were recorded. In addition, all of the patients underwent bilateral venography to evaluate the patency of central proximal venous drainage. The physician then used the preoperative vascular mapping data to propose the most suitable site for the forearm AVF construction. The preferred minimal vein and artery diameters for radiocephalic AVF creation were 2.5 mm and 2.0 mm, respectively.

Surgical procedures and measurement of IOBF. Two surgeons performed all of the procedures under local or regional anesthesia by the same standardized technique to create the AVF, using the minimal touch technique with limited dissection of the cephalic vein and radial artery. The artery was clamped with bulldog clamps, and an end-to-side anastomosis was made with a continuous 7.0 polypropylene suture. Suturing was visualized with magnifying loupes (3.5×). At the operator's discretion, 5000 units of intravenous systemic heparin was administered for 5 minutes before clamping. To prevent vasospasm, the external surfaces of vessels were kept moistened during the operation, and topical papaverine solution was used. The postoperative thrill score was recorded as 1 to 5: 1, very mild thrill; 2, mild thrill; 3, moderate thrill; 4, strong thrill; and 5, very strong thrill. In addition, the presence of atheroma or calcification of the radial artery was recorded under direct visualization during the operation. In this study, quantification of calcification was not performed.

The IOBF volume of the fistula was immediately measured systematically after construction of the AVF. In cases of vasospasm that required the use of papaverine, the measurements were delayed for 5 minutes. Measurements were performed by placing a 3- to 4-mm handheld flow probe (MediStim, Oslo, Norway) around the draining vein 1 to 2 cm downstream from the anastomosis. Direct readings were recorded after stabilization for 30 seconds. At least three readings were made until consistent values were obtained, usually within the first 5 minutes. Systolic and diastolic pressure was recorded concomitantly with flow volume measurements. All of the data were consigned to a dedicated study form immediately after the procedure.

Study end point and follow-up. According to the North American Vascular Access Consortium definition, early primary maturation failure was defined as an AVF that could not be used successfully for hemodialysis 3 months after its creation, despite radiologic or surgical interventions. Late primary maturation failure was defined as the same failure 6 months after the operation.[4,14] Prompt vascular interventions, such as percutaneous transluminal angioplasty (PTA) and accessory vein ligation (AVL), were performed if the AVF failed to mature by 6 weeks after construction, as recommended in the Kidney Disease Outcomes Quality Initiative (KDOQI) guidelines.[1] Failure to mature by 6 weeks was determined clinically by physical examination by nephrologists and dialysis nurses.

All the patients were followed up for at least 6 months. Particularly for patients with pre-emptive AVF formation or who transferred to another dialysis unit, we routinely followed up those patients every 2 to 4 weeks until the AVFs matured adequately.