INTRODUCTION

Vascular access dysfunction is the leading cause of hospitalization in chronic hemodialysis. Reported complications of the arteriovenous hemodialysis graft (AVG) include graft thrombosis, stenosis, pseudoaneurysm, arterial steal syndrome and infection (1-3). Iatrogenic graft-to-vein fistula between a vascular access graft and the adjacent native vein occurs rarely. But it can result in vascular access dysfunction and even thrombosis of the graft (2-7). We report an unusual complication of AVG with an iatrogenic graft-to-vein fistula between a prosthetic graft and the adjacent cephalic vein, and thrombosed venous limb of the graft. The AVG with iatrogenic fistula was preserved and used for hemodialysis through the iatrogenic fistula and cephalic vein. Removal of the thrombus of the venous limb was not successful.

CASE REPORT

A 77-year-old male with end-stage renal disease who was maintained on hemodialysis via a left upper arm AVG. He was referred to the interventional radiology department with a complaint of absence of regurgitation and presence of clot from a venous limb puncture site. Puncture and aspiration of the arterial limb of the graft revealed a pulsatile arterial blood flow. Hemodialysis therapy had commenced 34 months previously with the creation of a left prosthetic brachio-axillary AVG construct of polytetrafluoroethylene (wall 6 mm tapering to 4 mm). The patient underwent six sessions of percutaneous transluminal angioplasty (PTA) for venous anastomotic stenosis and left brachiocephalic vein obstruction over the 34 months following his AVG placement.

Physical examination revealed active thrill in the arterial limb of the graft but no thrill in the venous limb. Doppler ultrasonog-
Fig. 1. Fistulography in a 77-year-old male with end-stage renal disease.

A. Fistulography via the arterial limb of graft shows a fistula (black arrow) between the arterial limb of the graft (white arrowheads) and an adjacent native cephalic vein (black arrowheads) of left upper arm. Contrast material (empty arrow) leaked and spread out around the cephalic vein through the cannulation site of venous limb of the graft.

B. Fistulography via the native cephalic vein shows diffuse stenosis in cephalic vein (black arrowheads) and collateral veins (empty arrows).

C. Fistulography via the arterial limb of the graft (white arrowhead) after balloon angioplasty of the cephalic vein stenosis shows residual stenosis in the cephalic vein (black arrowhead) and graft-to-vein fistula (black arrow) with some residual collateral veins (empty arrows). Basilic vein (curved arrow) is visualized by communication with the antecubital vein draining into the cephalic vein.

D. Fistulography after balloon dilatation of cephalic vein revealed the disappearance of the stenosis in the cephalic vein (black arrowheads) and markedly decreased collateral vessels. Basilic vein (empty arrow) is visualized by communication with the antecubital vein draining into the cephalic vein.

E. Doppler study of the arteriovenous hemodialysis graft after the procedure shows a graft-to-vein fistula between arterial limb of the graft and native cephalic vein (arrow).

G = arterial limb of the graft, V = cephalic vein
raphy of the AVG showed patent arterial limb of the graft and thrombosed venous limb of the graft.

Puncture was performed for the patent arterial limb of the graft for thrombectomy of the thrombosed graft. A 0.035-inch guide wire (Radifocus, Terumo Corporation, Tokyo, Japan) could not pass through the thrombus of the venous limb of the graft. When the guide wire and 5 Fr catheter (Impress, Merit Medical System Inc., Houston, TX, USA) were passed through the cannulation site of the thrombosed venous limb of the graft, contrast material leaked and spread out around the cephalic vein. Aspiration thrombectomy was tried using a 7 Fr vascular sheath (Desilets-Hoffman Introducer Set, Cook Inc., Bloomington, IN, USA) through an arterial puncture site on the graft. However, we were unable to remove the thrombus. The thrombus of the venous limb of graft was too firm to remove by the conventional thrombectomy technique routinely used in our hospital. The thrombosed venous limb of the graft was punctured. However, the 7 Fr vascular sheath could not be inserted into the graft due to the firm thrombus, suggesting a chronic stage of the thrombus rather than acute or subacute. Fistulography via the arterial limb of graft revealed a graft-to-vein fistula between the arterial limb of the graft and an adjacent native cephalic vein of left upper arm (Fig. 1A). Venography via the 5 Fr catheter (Impress) inserted into the native cephalic vein revealed a diffuse, long-segment, high-grade stenosis in the cephalic vein and focal stenosis in the cephalic arch with multiple collateral veins (Fig. 1B). The graft-to-vein fistula site corresponded to the cannulation site of the graft for hemodialysis. This graft-to-vein fistula between arterial limb of the graft and native cephalic vein already existed and was visualized during angioplasty of the failing AVG that had been performed about 26 and 17 months previously. At the times of the angiographies, the graft-to-vein fistula was not treated. This was because there was no problem during hemodialysis and the patient was symptom-free despite the graft-to-vein fistula. In the remaining four episodes of PTA for failing AVG, graft-to-vein fistula was not evident on fistulography.

We decided to use the native cephalic vein that had a fistulous connection with arterial limb of the graft for hemodialysis, instead of the thrombosed venous limb of the graft in which thrombectomy failed, without creating a new hemodialysis access. PTA was performed for the stenosis of the cephalic vein and cephalic arch with a Conquest 6 mm × 4 cm balloon catheter (Bard Peripheral Vascular Inc., Tempe, AZ, USA) through the sheath (Accu-sheath, Sungwon Medical, Cheongu, Korea) inserted in the native cephalic vein. Post-PTA venography revealed a graft-to-vein fistula between arterial limb of the graft and an adjacent native cephalic vein of left upper arm (Fig. 1A). Venography via the 5 Fr catheter (Impress) inserted into the native cephalic vein revealed a diffuse, long-segment, high-grade stenosis in the cephalic vein and focal stenosis in the cephalic arch with multiple collateral veins (Fig. 1B). The graft-to-vein fistula site corresponded to the cannulation site of the graft for hemodialysis. This graft-to-vein fistula between arterial limb of the graft and native cephalic vein already existed and was visualized during angioplasty of the failing AVG that had been performed about 26 and 17 months previously. At the times of the angiographies, the graft-to-vein fistula was not treated. This was because there was no problem during hemodialysis and the patient was symptom-free despite the graft-to-vein fistula. In the remaining four episodes of PTA for failing AVG, graft-to-vein fistula was not evident on fistulography.

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vealed residual stenosis in the cephalic vein and arch and collateral vessels (Fig. 1C). Angioplasty was performed for residual stenosis of the cephalic vein and cephalic arch by a Conquest 8 mm × 4 cm balloon catheter (Bard Peripheral Vascular Inc.). A post-PTA venography showed complete resolution of the stenosis and disappearance of collateral veins (Fig. 1D). No further interventions, such as balloon dilation or stent placement for the fistula, were attempted. This was because good thrill was palpated on physical examination of the graft and cephalic vein and contrast flow through the graft and cephalic vein was considered sufficient for hemodialysis. However, these findings were subjective. A later Doppler study of the AVG with a graft-to-vein fistula showed a blood flow of 605 mL/min in cephalic vein just downstream of the fistula. The post-fistula cephalic vein on upper arm was dilated to almost 6.1 mm in diameter (Fig. 1E). There was no specific problem in hemodialysis performed for 7 months after the angioplasty of the failing AVG via the AVG with a fistula by puncturing the arterial limb of the graft and native cephalic vein.

**DISCUSSION**

The graft-to-vein fistula is an abnormal communication between the AVG and the adjacent native vein with preferential blood flow towards the vein (3, 8). This fistula is an uncommon complication of AVG. However, it can lead to the graft thrombosis, with an occurrence rate that is unclear (2, 5, 6). A fistulous connection was also reported in arteriovenous hemodialysis fistula (AVF) (3). Repeated simultaneous and inadvertent cannulation of the graft and overlying native vein for maintenance of hemodialysis might cause the development of graft-to-vein fistula when pre-existing venous outflow stenosis or an obstruction is present (4, 7). When the iatrogenic graft-to-vein fistula occurs by puncture trauma, high intra-access pressure due to the concomitant venous outflow stenosis might persist in the graft-to-vein fistula (2, 3, 5, 7, 8). Thus, persistent graft-to-vein fistula can cause graft thrombosis by the steal phenomenon.

Currently, 34 cases with iatrogenic fistula between hemodialysis access and native vein have been reported in nine English publications (Table 1) (1-9). A graft-to-vein fistula can be asymptomatic and incidentally detected by physical examination, such as a palpable thrill, over the arterial limb or intervention for dysfunction (2, 7, 9). A graft-to-vein fistula can be benign with spontaneous closure. However, it may persist and be symptomatic (3). In addition, the graft-to-vein fistula may cause poor flow at dialysis access, high venous resistance during hemodialysis, graft site swelling, extremity edema, dilated superficial forearm veins, prolonged bleeding at the puncture site and increased risk of graft thrombosis although the role of graft-to-vein fistula in AVG dysfunction and thrombosis is unclear (1-3, 6, 8).

Diagnosis of iatrogenic graft-to-vein fistula requires a careful physical examination (1, 6). Graft-to-vein fistula should be suspected if active thrill is seen in the arterial limb of the graft, but not in the venous limb of the graft. Additionally, the thrill in the arterial side somewhat laterally extends to the adjacent native vein (1, 4). Definite diagnosis of graft-to-vein fistula requires fistulography or duplex ultrasonography (1, 3, 4).

Treatment of the graft-to-vein fistula is not yet standardized, and even the significance of graft-to-vein fistula is unclear due to infrequent occurrence and small number of the patients reported (2, 3). When the graft-to-vein fistula has little effect on hemodynamics and is asymptomatic, it can be observed until it naturally disappears (2, 6-8). A graft-to-vein fistula considered the cause of clinical symptoms, such as AVG partial thrombosis or arm swelling, can be treated by surgical ligation or selective catheterization and an embolization of the fistula tract, followed by mechanical thrombectomy (2, 6, 8). If it is not clear whether a graft-to-vein fistula is the cause of clinical symptoms. If an outflow vein stenosis is present, the first consideration should be to treat the outflow vein stenosis while waiting to see if the graft-to-vein disappears (1, 3). If there is no outflow stenosis, or if the graft-to-vein fistula does not resolve after PTA of stenosis, temporary occlusion of the fistula with objective determination of the effect of such occlusion should be attempted (2, 3). If this results in meaningful flow improvement, the fistula should be treated (3).

Another consideration for maintaining an AVG is how to prevent this rare complication. Avoiding puncture with adjacent or overlying vein, penetration of the graft and rotated puncture site are very important to prevent this complication, because the graft-to-vein fistula developed from repeated and simultaneous puncture of the graft and adjacent vein (1, 8). Any visible veins over the AVG should be carefully accessed and preserved from puncture (1). After withdrawal of the puncture needle,
proper compression of the puncture site is important to prevent fistulous connection between the graft and the adjacent native vein (1).

In the present case, the graft-to-vein fistula was not treated 26 and 17 months previously, because there was no problem during hemodialysis and the patient was asymptomatic during daily life. However, the graft-to-vein fistula did not disappear despite balloon angioplasty of the venous outflow stenosis. Eventually, AVG failed due to thrombosis of the venous limb of the AVG and venous outflow stenosis. We assume that the flow was diverted to the adjacent native cephalic vein through the graft-to-vein fistula connected to arterial limb of the graft. Stenosis of the outflow vein generated a thrombus in venous limb of the graft due to decreased blood flow. The thrombus of the venous limb of graft inevitably became chronic as proven by failure to remove by aspiration thrombectomy by 7 Fr sheath. Negotiation of the guidewire through the thrombus was not possible and the thrombus was too firm to remove by aspiration thrombectomy, unlike the typical situation with thrombosed AVG. We decided to use the thrombosed AVG with a fistula for hemodialysis as the thrombus could not be removed without making a new AVG or AVF. Balloon angioplasty of stenosis of native cephalic vein was successful and hemodialysis could be performed by patent arterial limb of the AVG. In only one case with graft-to-vein fistula between AVG and native vein, was the patent arterial limb of AVG and overlying native vein draining from graft-to-vein fistula used for hemodialysis (2). This is the second case where AVG with graft-to-vein fistula was successfully used for hemodialysis while the venous limb of the graft was useless due to thrombosis.

In conclusion, proper cannulation technique and proper compression of the puncture site is important to prevent an iatrogenic graft-to-vein fistula between a graft and the adjacent native vein. Early recognition of graft-to-vein fistula and proper intervention may reduce the risk of dysfunction or loss of the dialysis access. With AVG thrombosis with iatrogenic graft-to-vein fistula, proper management consists of thrombectomy of the graft and treatment of iatrogenic fistula with or without PTA of venous outflow stenosis. If thrombectomy of the graft is not possible, a patent arterial limb of the graft and adjacent native vein connected through iatrogenic fistula can be used for hemodialysis if adequate blood flow is maintained.

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만성혈전으로 막힌 혈액투석용 동정맥 인조혈관에서 인조혈관과 정맥 사이에 발생한 의인성 누공을 이용한 성공적인 투석

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혈액투석용 인조혈관 동정맥루에서 인조혈관(prosthetic arteriovenous graft)과 자가 정맥 사이에 발생한 의인성 누공은 드물지만 중요한 합병증이다. 저자들은 의인성 누공이 발생한 혈액투석용 인조혈관 동정맥루와 이로 인해 인조혈관의 정맥가지에 혈전이 생긴 증례를 보고하고자 한다. 혈액투석용 인조혈관 동정맥루에서 인조혈관 정맥가지의 혈전이 제거되지 못했지만 인조혈관을 유지한 채 의인성 누공과 노족피부정맥을 이용해 성공적으로 투석할 수 있었다.

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