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Case Reports

Banding a Hemodialysis Arteriovenous Fistula to Decrease Blood Flow and Resolve High output Cardiac Failure: Report of a Case

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Abstract: We report herein the successful surgical treatment of a patient with high-output cardiac failure which developed from a high-flow hemodialysis arteriovenous fistula of the Brescia-Cimino type. Banding correction of the venous limb of the fistula with a woven Dacron prosthesis resulted in marked improvement of the cardiac failure. An ultrasonic study showed the fistula flow of 3.2 l/min to be as high as 40% of the resting cardiac output, or 8.0 l/min, before banding, while an intraoperative electromagnetic study was useful for controlling the degree of banding and showing the decrease of fistula flow from 3.7 l/min to 1.4 l/min.

Key Words: hemodialysis, arteriovenous fistula, high output, cardiac failure, banding correction

Case Report

A 49-year-old man was admitted to Saiseikai-Chuo Hospital with general fatigue, dyspnea, and facial edema in February, 1986, where he was diagnosed as having chronic renal failure. His history revealed that he had suffered from hypertension since the age of 30, for which he had received insufficient treatment, and that in 1983, at the age of 46, he had developed exertional angina. After a biopsy of his left kidney was taken for further study, uncontrollable bleeding developed and the left kidney had to be removed. His chronic renal failure progressed and he began long-term hemodialysis therapy in March, 1986 via a Brescia-Cimino type side-to-end arteriovenous (AV) fistula between the radial artery and cephalic vein.

In January, 1988, at the age of 51, he experienced rest angina which lasted for 5–10 min and was treated medically; however, in May he developed severe persistent chest pain and was admitted to Saiseikai-Nanbu Hospital with a diagnosis of acute myocardial infarction. His peak creatinine phosphokinase level was 976 IU/l. In June, he underwent coronary angiography due to persistent postinfarction angina at rest, which revealed that the right coronary artery was totally obstructed, the left anterior descending branch (LAD) was 99% stenosed in segment 7, and both intermediate (IM) and obtuse marginal (OM) branches of the left coronary artery were 99% stenosed. The left ventricle was hypokinetic in the anterolateral and apical regions with an ejection fraction of 52%. An abdominal aortic aneurysm measuring 50 mm in maximum diameter was also found. On June 18, 1988, he was admitted to Yokohama City University Hospital for coronary arterial bypass grafting (CABG), where grafting of the saphenous veins to the LAD, IM, and OM was performed on June 20. Postoperative coronary angiography demonstrated all grafts to be patent and that the left ventricular wall motion and ejection fraction, which was now 56%, had improved. However, hemodynamic measurements demonstrated a slight abnormality of the left ventricular function. The mean pressures were found to be 6 mmHg in the right atrium, 21 mmHg in the pulmonary artery, and 12 mmHg in the pulmonary wedge, while the left ventricular end-diastole was 20 mmHg. By thermodilution, the cardiac output at rest was 6.25 l/min/m^2 body surface area (BSA). No further chest pain was experienced after the CABG. On June 14, 1989, 1 year after the CABG, the abdominal aortic aneurysm, which was 52 mm in diameter and 48 mm in length, was excised and replaced by a Y-shaped woven Dacron prosthesis. After the surgery, the patient was able to return to work for a short time. However, in August of the same year, he developed left arm swelling, dyspnea on exertion, and chest discomfort at rest. He was admitted in class 3 heart failure. His left arm was

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markedly swollen and the circumferences of the left wrist, forearm, upper arm, and axilla were 18 cm, 27 cm, 29 cm, and 30 cm, respectively; the corresponding measurements in the right arm were 16 cm, 22 cm, 22 cm, and 23 cm, respectively. The veins were markedly dilated from the region of the hemodialysis AV fistula in the left forearm to the left shoulder and neck. A thrill was noted over the left axilla and the liver edge was palpable three finger widths inferior to the costal margin. A chest X-ray demonstrated left atrial dilatation and pulmonary vascular congestion. The costothoracic ratio was 52%. The blood pressure was 148/76 mmHg and the pulse was regular at 84 beats/min. Before dialysis, the serum creatinine was 8.9 mg/100 ml and the hematocrit was 25.4%. An electrocardiogram (ECG) demonstrated an old inferior wall myocardial infarction and left ventricular enlargement. Fistulography demonstrated marked dilatation of the venous limb from the anastomosis of the AV fistula to the axilla with extremely rapid flow. No venous stenosis was found. Ultrasonography (US) demonstrated that the hemodialysis fistula A–V flow rate, of 3.2 l/min, was 40% of the resting cardiac output of 8.0 l/min, and the cardiac index was 5.4 l/min/m^2 BSA. It also demonstrated that the left ventricular stroke volume was 88.2 ml, and the AV fistula anastomosis internal diameter was 5.2 mm. Based on these findings, the patient was diagnosed as having high-output heart failure and left arm swelling secondary to the high-flow hemodialysis fistula.

On November 27, 1989, the patient underwent fistula revision. The AV fistula flow, as measured by an electromagnetic flow meter, was 3.7 l/min. The exterior of the distal venous limb measured 10 mm × 8 mm at the anastomosis, and 15 mm in diameter 1 cm proximal from the anastomosis. The flow was reduced to 1.4 l/min by constricting the distal venous limb from 15 mm to 7 mm in external diameter with a 2-cm-wide woven Dacron band.

By the 5th postoperative day, the patient's condition had improved both subjectively and objectively, and subsequently, he experienced no further dyspnea on exertion or chest discomfort on exercise. Moreover, the tension in the left arm decreased and he was once again able to return to work. He continues to do well 3 years and 6 months after the revision. The NYHA functional classification of his heart failure has decreased to class I and his most recent plain chest X-ray shows improvement of the previously noted pulmonary vascular congestion and left atrial dilatation (Table 1, Fig. 1).

Discussion

Since Brescia and Cimino introduced an internal AV shunt for chronic hemodialysis in 1966,[1] the Brescia-Cimino AV fistula has been the first choice for vascular access.[2] The most frequent comlication of the Brescia-Cimino type AV fistula is thrombosis, while less

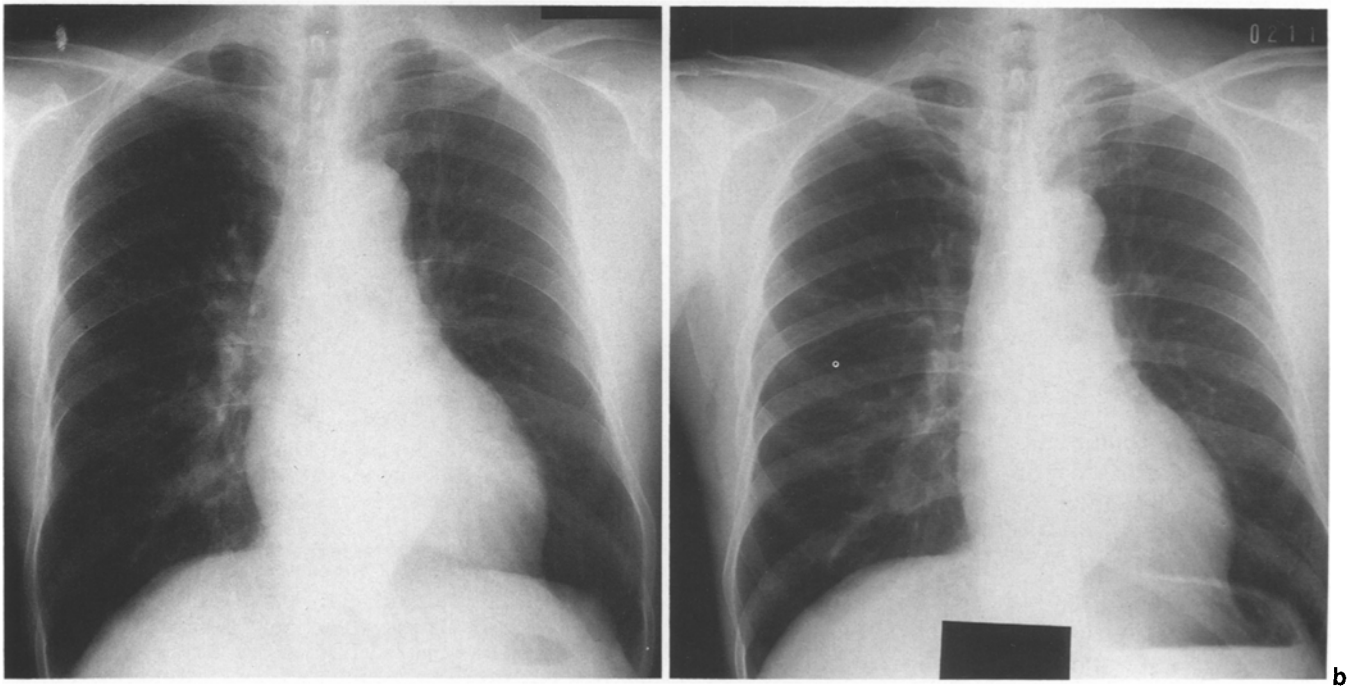

Fig. 1. a Before banding, left atrial dilatation and pulmonary congestion were noted, with a costothoracic ratio of 52%. **b** After banding, the findings were improved, the costothoracic ratio now being 48%

Table 1. The hemodynamic effect produced by hemodialysis arteriovenous (AV) fistula banding

	Before banding	After banding
NYHA classification	class III	class I
Fistula flow[a]	3.7	1.4
CI	5.2	3.3
LVSV	88	64

[a] Fistula flow (l/min) was measured by an electromagnetic flow meter. The cardiac index (CI, l/min/m^2 BSA) and left ventricular stroke volume (LVSV, ml) were calculated from ultrasonography

commonly encountered complications include aneurysms, infection, hemodynamic alterations, and hand swelling;[3] however, a peripheral AV fistula for hemodialysis increases cardiac output. In fact, Johnson and Blythe reported that occluding an AV fistula decreased the cardiac output by 640 ml/min,[4] while Kanatsu et al. reported the AV fistula flow to be around 956 ml/min, with a range of 390–2,050 ml/min, being 12.5%, with a range of 5.4–18.2%, of the cardiac output.[5] Furthermore, Menno et al. reported an average increase in cardiac output of 18.4%.[6]

Ahearn and Maher reported two patients whose AV fistulas contributed to their developing an extremely high cardiac output and severe cardiac failure.[7] Anderson et al. reviewed nine patients with high output cardiac failure and presented six new cases in which the decrease in cardiac output with temporary fistula occlusion was 1.5 l/min, with a range of 0.3–11.0 l/min.[8] Kitamoto et al. reported that any AV fistula which exceeded 12% of the cardiac output or 1000 ml/min caused an insufficiency of cardiac function.[9] Clinically, an AV fistula exceeding 20% of the cardiac output was recognized as "a large shunt in a narrow sense", while an AV fistula not exceeding 20% of the cardiac output but causing cardiac failure in a patient at risk of developing cardiac failure was recognized as "a large shunt in a wide sense".[10]

In our patient, the preoperative AV fistula was 3.2 l/min and 40% of the rest cardiac output according to the US findings was "a large shunt in a narrow sense". The past history of myocardial infarction was another risk factor toward cardiac failure. The intraoperative electromagnetic study showed that the AV fistula flow decreased from 3.7 l/min to 1.4 l/min after the banding correction, following which the symptoms of cardiac failure and hand swelling markedly improved.

Several methods have been used for the correction of high-flow AV fistulas, including closure of the fistula, the application of hemoclips and the banding procedure which involves narrowing of the vessel lumen with Teflon tape.[7,8] To manage the cardiac steal syndrome after polytetrafluoroethylene (PTFE) prosthesis implantation as a vascular access for hemodialysis, narrowing of the lumen of the prosthesis with a longitudinal incision and sutures, or banding of the prosthesis with a PTFE cardiovascular patch may be applied. In our patient we chose the banding procedure,[11,12] but to sufficiently decrease the fistula flow, a 2-cm-wide prosthesis was necessary. The relatively rough surface of the woven Dacron prosthesis was supposed to achieve better adhesion to the venous limb with less risk of slipping out.

In summary, preoperative AV fistula flow measurement was effective for diagnosing a high-flow hemodialysis AV fistula, while intraoperative electromagnetic flow measurement was useful for determining the degree of banding. The banding technique used for the surgical correction of a high-flow hemodialysis AV fistula with a woven Dacron prosthesis to the venous limb of the fistula resulted in marked improvement of the cardiac failure in this patient.

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