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Case Report

Decrease in hand and cerebral oxygenation after percutaneous transluminal angioplasty for arteriovenous fistula stenosis in a patient on chronic hemodialysis ☆,☆☆

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ABSTRACT

A 79-year-old woman who was on chronic hemodialysis due to diabetic nephropathy and had previously undergo surgery for radiocephalic arteriovenous fistula (AVF) in her right wrist needed percutaneous transluminal angioplasty (PTA) for stenosis at the juxta-anastomotic access site. After successful PTA, the systemic blood pressure decreased from 144/93 mm Hg to 117/67 mm Hg in response to the increase in AVF blood flow. Furthermore, the regional oxygen saturation (rSO_2) value in her dorsal hand decreased from 67.9% to 64.9% and, simultaneously, the cerebral rSO_2 decreased from 63.6% to 60.1%. Our experience indicates that the PTA procedure may affect the rapid deterioration of systemic oxygenation, including that in the hand and brain, in association with the increase in the AVF blood flow and change in systemic circulation.

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Introduction

Vascular access is necessary for hemodialysis. A native arteriovenous fistula (AVF) is considered the preferable access route for maintenance hemodialysis [1] because it is durable and can withstand repeated puncturing, with a lower risk of vascular access-associated problems such as access failure and infection than an arteriovenous graft or a tunneled hemodialysis catheter [2]. However, AVF itself would decrease the blood flow to the distal tissues and might lead to deterioration of the distal tissue oxygenation, including that in the hand. After AVF creation, distal tissue hypoperfusion could cause some complications, including steal syndrome and hemodialysis access-induced distal ischemia [3], and a hand with AVF using the radial artery was reported to possibly have lower tissue oxygenation [4]. Therefore, in percutaneous transluminal angioplasty (PTA), which is the current standard treatment for arteriovenous stenosis, peripheral oxygenation might decrease as the AVF blood flow increases. In addition, the degree of AVF blood flow was reportedly associated with the decrease of coronary oxygen supply via the changes in hemodynamics [5]. Therefore, AVF creation or the increases in AVF blood flow after PTA might decrease the systemic oxygenation in patients on chronic hemodialysis. Indeed, cerebral oxygenation was reported to be remarkably lower in patients on chronic hemodialysis than in healthy subjects and chronic kidney disease patients without chronic hemodialysis and AVF creation [6–8]. However, reports on the association between AVF status and systemic oxygenation, including hand oxygenation on the AVF side and cerebral oxygenation, are scarce. Here, we report a case with deteriorated hand and cerebral oxygenation after the improvement of AVF blood flow using PTA at AVF stenosis.

Case report

Our patient was a 79-year-old woman on chronic hemodialysis due to diabetic nephropathy, who underwent surgical treatment of a radiocephalic AVF in her right wrist 4 years ago. She repeatedly had juxta-anastomotic access stenosis; therefore, she underwent PTA 5 times. PTA had to be performed again due to stenosis recurrence at the juxta-anastomotic access, the flow volume (FV) of which was low (200 mL/min) and the resistance index (RI) of which was high (0.80) in her right brachial artery on ultrasonography. To confirm the influence of changes in AVF blood flow before and after PTA to the hand and cerebral oxygenation, the regional oxygen saturation (rSO_2), a marker of tissue oxygenation, using INVOS 5100c saturation monitor (Covidien Japan, Tokyo, Japan) was evaluated on the dorsal side of her right hand and forehead before and after PTA. She provided written informed consent before undergoing PTA. The stenosis was adequately expanded using a 5-mm balloon (YOROI; Kaneka Corp, Osaka, Japan) (Fig. 1), and the FV increased to 980 mL/min and the RI decreased to 0.57 in her right brachial artery after the PTA. In response to the FV increase, the systemic blood pressure decreased from 144/93 mm Hg to 117/67 mm Hg. In addition, the rSO_2 value in her dorsal hand decreased from 67.9% to 64.9% and, simultaneously, cerebral rSO_2 decreased from 63.6% to 60.1% (Table 1).

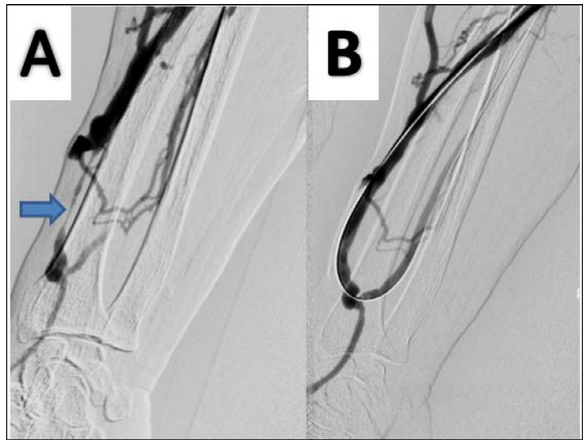

Fig. 1 – (A) Stenosis of the juxta-anastomotic access (→) in the hand with vascular access. (B) Angiography after successful percutaneous transluminal angioplasty using a 5-mm balloon.

Table 1 – Changes in vascular access-associated parameters and oxygenation status of the hand and brain before and after PTA.

	Before PTA	After PTA
Blood pressure (systolic/diastolic, mm Hg)	144/93	117/67
FV at right brachial artery (mL/min)	200	980
RI at right brachial artery	0.80	0.57
Right hand rSO_2 (%)	67.9	64.9
Cerebral rSO_2 (%)	63.6	60.1

PTA, percutaneous transluminal angioplasty; FV, flow volume; RI, resistance index; rSO_2, regional oxygen saturation.

Discussion

Systemic blood circulation plays an important role in maintaining tissue oxygenation by providing a constant oxygen supply, especially in the brain. Cerebral rSO_2 values were reportedly lower in patients on chronic hemodialysis than in healthy subjects [6–8] and were influenced by several factors, including pH, hemodialysis duration, serum albumin concentration, presence of diabetes mellitus, and renal anemia [7,9]. Furthermore, a decreased cerebral rSO_2 level was associated with cognitive impairment [10]. Therefore, preventing a cerebral oxygenation deterioration would be important in the clinical setting of hemodialysis therapy.

Vascular access, including the AVF, is essential to hemodialysis therapy; however, the existence of blood flow to the AVF involves several problems. First, it would be possible to decrease the blood flow to the distal tissues. The decrease in blood and oxygen supply to the distal tissues deteriorates the distal tissue oxygenation, leading to steal syndrome and

hand ischemia [3]. Hand rSO_2 values were significantly lower in the thenar with AVF than in those without AVF (42.5% ± 13.3% vs 45.8% ± 12.9%, respectively; $P = .002$) [4], and hand oxygenation at the AVF side significantly decreased during hemodialysis (55% ± 16% to 45% ± 14%; $P < .0001$) [11]. In this case, hand oxygenation at the AVF side rapidly decreased after PTA, possibly caused by the blood flow decrease in the distal tissues via the improvement in AVF blood flow by PTA. Furthermore, PTA success is favorable for patients to achieve sufficient hemodialysis efficacy throughout the maintenance of a sufficient blood flow during hemodialysis. However, AVF creation was reportedly associated with hemodynamic changes because of the reduced peripheral resistance [12], and increased right ventricular preload and left ventricular afterload [13]. In addition, AVF creation also significantly decreased blood pressure in end-stage renal disease [14]. Based on these reports, the increase in AVF blood flow in acute response to PTA procedure might lead to hemodynamic instability of the systemic circulation, and systemic oxygenation, including that within the brain, is likely to decrease because of the decrease in oxygen supply to the systemic tissues. Furthermore, it was also reported that the coronary oxygen supply decreases as AVF blood flow increases [5]. In this case, AVF blood flow rapidly improved from 200 mL/min to 980 mL/min after PTA and the rapid deterioration of the cerebral oxygenation was confirmed, in addition to the systemic blood pressure decrease in response to PTA procedure. Therefore, acute changes in systemic oxygenation associated with the increase in AVF blood flow induced by PTA should be noted in the clinical setting of hemodialysis therapy.

In conclusion, we report a case with deteriorated hand and cerebral oxygenation after successful PTA. Our experience demonstrates that the PTA procedure might affect the rapid deterioration of systemic oxygenation, including in hand and brain, associated with the increase in AVF blood flow and the change in systemic circulation.

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