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● *Original Contribution*

ULTRASOUND-GUIDED PHARMACOMECHANICAL THROMBOLYSIS AND ANGIOPLASTY FOR TREATMENT OF ACUTE THROMBOTIC PROSTHETIC ARTERIOVENOUS ACCESS: 5-YEAR EXPERIENCE WITH 154 PROCEDURES IN A SINGLE CENTER

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Abstract—Pharmacomechanical thrombolysis (PMT) and percutaneous transluminal angioplasty (PTA) for the treatment of acute thrombotic prosthetic arteriovenous access (PAVA) are conventionally guided by radiography, which may cause radiation injury and requires the use of radiographic contrast media. The aim of the present study was to summarize our experience with ultrasound-guided PMT and PTA as an alternative to radiographic guidance. Between December 2012 and October 2016, 114 patients with acute thrombosis of PAVA were treated urgently with ultrasound-guided PMT and PTA to restore blood flow. The patients were followed up every 3 mo postoperatively. The 114 included patients underwent 154 episodes of ultrasound-guided PMT and PTA and were followed up for a mean of 20.7 ± 9.1 mo. The technical success rate was 91.6%, and the clinical success rate was 97.4%. Post-intervention-assisted primary patency rates at 3, 6, 12 and 24 mo were 90.8%, 78.8%, 66.3% and 50.9%, respectively. Post-intervention secondary patency rates at 3, 6, 12 and 24 months were 96.3%, 94.5%, 90.6% and 85.4%, respectively. PMT and PTA for the treatment of PAVA were performed successfully under the guidance of ultrasound with a success rate similar to that under radiographic guidance, thus avoiding radiation injury and contrast medium use, although close surveillance and timely intervention are imperative to ensure long-term patency. (E-mail: lumingxi@zju.edu.cn)

Key Words: **Ultrasound, Prosthetic arteriovenous access, Hemodialysis, Thrombolysis, Angioplasty.**

INTRODUCTION

Since first described by Brescia et al. in 1966, autogenous arteriovenous access (AAVA) has been accepted as the preferred method of vascular access for hemodialysis. However, a significant number of patients may not have appropriate vessels for creating AAVA, and therefore, prosthetic arteriovenous access (PAVA) is considered an alternative (Grima et al. 2018). The rates of creating a new PAVA in dialysis patients are 13%, 12% and 25% in Japan, Europe and the United States, respectively (Pisoni et al. 2018).

Thrombosis is a common complication of PAVA and the leading cause of PAVA dysfunction, with a yearly occurrence rate of 0.25% to 1.4% per patient (Tae et al. 2015). Since its advent in in 1989, the pharmacomechanical thrombolysis (PMT) technique for the treatment of thrombosed PAVA (Bookstein et al. 1989) has had clinical outcomes similar to those of surgical thrombectomy (Hongsakul et al. 2015). In addition, about 85% cases of thrombotic arteriovenous access have a background of stenosis (Kanterman et al. 1995), and therefore, recanalization of the thrombosed PAVA should be followed up closely after proper management of the stenosis. Percutaneous transluminal angioplasty (PTA) is an effective means for treating stenosis of PAVA according to the Kidney Disease Outcomes Quality Initiative (KDOQI) Clinical Practice Guidelines (National Kidney Foundation 2006). The efficacy of PMT can be improved in terms of primary patency when it is combined with PTA (Cynamon and Pierpont 2002).

Pharmacomechanical thrombolysis and PTA are conventionally guided by radiography in most studies reported

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in the literature (Choi et al. 2012; Cooper 2003;Van 2004; Hongsakul et al. 2015; Quencer and Friedman 2017), but this method carries risk because of the exposure of both the patient and the medical staff to x-rays. In addition, contrast media are often required during angiography, which not only increases medical costs, but may induce some adverse effects, such as allergy and impairment of residual renal function. Therefore, a more minimally invasive guidance method is required for PMT and PTA.

With the knowledge that some ultrasound-guided endovascular treatments for vascular access have been reported (Bacchini et al. 2007; Kumar et al. 2017; Wakabayashi et al. 2013), ultrasonography may be an ideal alternative for guiding PMT and PTA for the treatment of thrombosed PAVA. The aim of the study described here was to report our experience with ultrasound-guided, modified PMT and PTA for the treatment of thrombosed PAVA.

METHODS

Patient data

This single-center retrospective study included 114 hemodialysis patients with thrombotic PAVA who underwent ultrasound-guided PMT and PTA at Sir Run Run Shaw Hospital (Hangzhou, China) between December 2012 and October 2016 and were followed up until July 1, 2017. The study protocol was approved by the ethics committee of the hospital. All data concerning these interventions were collected and recorded, including demographic data, intra-operative features, post-operative evaluations and follow-up results.

Acute thrombosis of PAVA was diagnosed by the absence of thrills and ultrasound examination. The inclusion criteria for ultrasound-guided PMT and PTA were thrombosis within 1 week and PAVA of the upper extremity. Excluded were patients who were unable to work cooperatively, had an unstable general condition and had severe hyperkalemia, acute congestive heart failure, access created within the past month, infection at the access site, active bleeding, hypersensitivity to urokinase or heparin and thrombosis affecting the axillary vein. Written informed consent for the procedure was obtained from all patients.

Operator

All procedures including ultrasonography were performed by three senior nephrologists who had received training in vascular ultrasound and interventional therapy for vascular access. At the time of ultrasound-guided PMT and PTA, each of the three nephrologists had more than 5 y of experience in ultrasound-guided PTA. They carried out the same operation specification and follow-up protocol.

Procedures

All procedures were performed in the operating room under the guidance of a medical ultrasonic diagnostic instrument (M7, Mindray, Shenzhen, CN; DC-6, Mindray, Shenzhen, CN; Vivid I, GE, Boston, USA) with a high-frequency linear-array transducer (9−12 MHz). The procedures were performed under local anesthesia and consisted of the following steps.

1. Pre-procedural examination: Ultrasonography of the entire PAVA was performed to assess inflow, graft, outflow and range of the thrombus. Signs that may indicate possible stenosis include reduced external diameter of the vessel (Fig. 1A), thickening of the vascular or graft wall (Fig. 1B) and reduced distance between the anterior and posterior intima (Fig. 1B, C).
2. Venous access and arterial access: After local anesthesia with 1% lidocaine, the PAVA was cannulated toward the venous anastomosis under the guidance of ultrasound (Fig. 2A) 3 to 5 cm from the arterial anastomosis. A 6-French introducer sheath (Terumo, Tokyo, Japan) was inserted for venous access. Another 6-French introducer sheath was inserted approximately 3 to 5 cm from the venous anastomosis and directed toward the arterial anastomosis as arterial access.
3. Thrombolysis: A 0.035-in guide wire (HiWire, Cook, Bloomington, IN, USA) was advanced from venous access under the guidance of ultrasound beyond the venous anastomosis, and appeared as a strong linear echo on ultrasound (Fig. 2B). Then, a UNI*FUSE infusion system (UNI*FUSE, Angiodynamic Inc., Glens Falls, NY, USA) was inserted to infuse the thrombolytic agent, with the tip of the catheter placed beyond the end of the thrombus. The UNI*FUSE infusion system included a sideslit catheter with multiple tiny sideholes over a length of 10 cm and a modified occluding ball wire, which appeared as a tubulous echo with two marks at both ends of the sidehole segment on ultrasonography (Fig. 2C). The 100-mL solution of thrombolytic agent contained 200,000 U urokinase (Choi et al. 2012) and 2500 U heparin mixed in normal saline. The thrombolytic agent was injected with the pulse spray and pull-back technique to expose the entire thrombus to the thrombolytic agent. The spray signal could be detected in color Doppler flow (CDF) imaging (Fig. 2D). The catheter was then inserted into the arterial side of the PAVA from the arterial access to perform thrombolysis in the same way.
4. Percutaneous transluminal angioplasty: After the thrombolytic agent had been present for 20 min (Choi et al. 2012), ultrasound-guided PTA was performed from the outflow to the inflow to correct the stenosis and macerate the residual thrombus whether or not blood flow re-appeared. The stenosis or residual thrombus was detected when blood flow re-appeared. If