Formation of Abnormal Fistula on Arteriovenous Fistula in a Patient with Buttonhole Cannulation: A Case Report

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Key Words
Hemodialysis · Buttonhole cannulation · Surveillance

Abstract
Buttonhole cannulation has been suggested as a technique that may lead to a reduction in many complications when compared with other techniques such as rope-ladder cannulation. Despite all above, some complications still continue, which may lead to a dysfunction of the arteriovenous fistula (AVF) and inadequate dialysis, having an impact on the quality of life of the patients or eventually making the vascular access unusable. We report a 47-year-old Chinese male with end-stage renal disease who had maintenance hemodialysis three times a week for 5 years. The AVF on the left wrist was operated 5 years ago and proved to be functionally effective with some monitoring and surveillance measures in the fourth year of hemodialysis. Two months later, the buttonhole cannulation technique was applied due to fistula punctuation difficulty by previous aneurysmal dilatation. After 10 times of buttonhole cannulation, the edema on the left forearm of the patient indicated a dysfunction of the AVF. This was further confirmed by the HD02 hemodialysis monitor and a vascular ultrasound, revealing a recirculation of 87%, an abnormal fistula between the AVF and the vein together with thrombus, and aneurysmal dilatation near the anastomosis. The site of cannulation was changed to avoid heavy recirculation (reduced to 25%), and a new AVF on the left wrist was successfully operated. Abnormal fistula on the AVF and vein during buttonhole cannulation is rarely reported, which reminds us that vascular access surveillance should be done regularly before and during the process of construction to find a possible dysfunction of the AVF in patients undergoing buttonhole cannulation.

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Introduction

A well-functioning permanent vascular access is crucial for the survival of patients on maintenance hemodialysis as it provides sufficient blood flow for dialysis. Because adequate blood flow is provided by the arteriovenous fistula (AVF) with the fewest complications, AVF have been recommended by several guidelines. The National Kidney Foundation’s Kidney Disease Outcomes Quality Initiative (NKF-KDOQI) is keeping in attempts to improve the utilization of the AVF in patients who receive maintenance hemodialysis [1]. However, complications can still occur. It was reported by the United States Renal Data System (USRDS) that hemodialysis access failure remains to be the most frequent cause of hospitalization [2]. All kinds of complications, including stenosis, thrombosis, abnormal establishment of collateral branches circulation, and so on, may lead to a dysfunction of the AVF or inadequate dialysis, which eventually has an impact on the quality of life of the patients or even makes the vascular access unusable.

The buttonhole cannulation, also called the constant site cannulation, has been successfully used in home hemodialysis and dialysis centers to reduce bruising, prolonged bleeding, and aneurysm formation. Abnormal fistula on the AVF and vein during buttonhole cannulation is rarely reported. We describe a case in which recirculation was evidenced by vascular ultrasound.

Case Presentation

We report the case of a 47-year-old male (Chinese), who was diagnosed with end-stage renal disease (ESRD). He received maintenance hemodialysis three times a week for 5 years. The patient had renal anemia and renal hypertension with carotid arteriosclerosis plaque. A mature AVF on the left wrist was operated 5 years ago, and the wrist recovered its function 2 months after the operation. At the end of the fourth year of hemodialysis, the ultrasound dilution technique was applied for surveillance of the function of the fistula, showing a recirculation of zero (Transonic HD02 monitor; Ithaca, NY, USA) and an access flow rate (Qa) of 1,360 ml/min. The spKt/V was 1.28, which indicated that the AVF was functionally effective. Two months later, the buttonhole cannulation technique was applied due to fistula punctuation difficulty with previous aneurysmal dilatation. After 10 times of buttonhole cannulation, the patient experienced gradual edema on the left forearm as well as insufficient blood flow of the fistula [fig. 1]. Emergency hospitalization for 15 days for cardiopalpus, dizziness, and hyperkalemia was necessary. The recirculation of the AVF was 87% with a blood flow (Qb) of 220 ml/min and a spKt/V of 0.75, which indicated a dysfunction of the AVF. This was further confirmed by a vascular ultrasound of the AVF, revealing abnormal fistula between the mature cephalic vein and the radial vein [fig. 2] where blood shunt existed, together with thrombus in the proximal cephalic vein and aneurysmal dilatation in the distal segment [fig. 3] that developed 3 years ago. The site for punctuation was changed, and a reduction of recirculation to 25% with Qb 240 ml/min could be confirmed 2 weeks later. A new AVF on the contralateral side was operated during hospitalization. The utilization of the new AVF began 4 months after the operation and has been working well until now.
Discussion

A well-functioning AVF is the key to long-term maintenance hemodialysis in patients with ESRD. One of the major causes of dialysis inadequacy is the dysfunction of vascular access secondary to vascular access complications. Despite the fact that the AVF has the least complications and is the preferred method of dialysis access, every permanent access may lead to complications associated with low blood flow and recirculation, such as failure of maturation, venous stenosis, thrombosis, and so on. In our case, thrombus was found in the proximal cephalic vein with aneurysmal dilatation in the distal segment. Emergency hospitalization for 15 days was necessary because of cardiopalmus, dizziness, and hyperkalemia. In fact, the most common causes of hospitalization associated with access complications in dialysis patients include insufficient blood flow, vascular access-related infections, limb ischemia, and aneurysms [1].

In the case reported herein, the complication of abnormal fistula on the AVF occurred during the shift from traditional cannulation (rope-ladder cannulation) to buttonhole cannulation. Rope-ladder cannulation, which is characterized by the variation of the needling site, is considered the most frequently used technique in comparison with other kinds of cannulation [3]. Buttonhole cannulation is also called constant site cannulation. The purpose of buttonhole cannulation is to form a scar tissue tunnel track between skin and vascular access to allow a dull-tipped needle to access the AVF following the same path during every dialysis session by means of repeated needle puncture at exactly the same site and angle. This technique may reduce the incidence of vascular access complications with the clinical manifestation of bruising, prolonged bleeding, and aneurysm formation [4]. Several studies have shown that buttonhole cannulation is a valuable technique with less hematoma, aneurysm formation, and cannulation pain than the rope-ladder cannulation technique and that is easy to self-cannulate, which is particularly relevant for home hemodialysis [5–7]. Although growing evidence has shown the advantages of buttonhole cannulation, a generally accepted method of cannulating for the AVF has not been defined yet [1].

In theory, patients with buttonhole cannulation show fewer complications in the view of access, since buttonhole cannulation only needs one puncture site on the blood vessel wall and there is no regional injury of the elastic fiber on the blood vessel, thus reducing the incidence of aneurysm formation and vascular stenosis. However, the cannulation result is influenced by several factors. On the one hand, the angle, direction and depth of cannulation must be identified before the formation of a buttonhole [1]. However, even if the most skilled expert cannulators perform the procedure, slight or even invisible cannulation differences still exist between different operators or between several procedures performed by the same cannulator. On the other hand, in buttonhole cannulation, tourniquet pressure is critical to minimize ‘track shift’, which is characterized by hole shifting away from the endothelialized tunnel. However, dry weight changes and variations in the patient’s fluid status, both intra- and extravascular, may lead to changes that render the cannulation more uncertain, illustrating the difficulty of punctuation [8]. To make some progress in reducing the incidence of vascular access complications caused by buttonhole cannulation, Ball [9] strongly recommended that the same expert should create the tunnels in order to maintain the same angle and depth to the greatest extent. More details have also been raised by the author. One of them is to leave approximately 1/16 inch of the needles exposed when inserting them into the buttonhole tunnels to prevent the hub of the needles from touching the entrance sites, thus making it easy to punctuate, remove the scabs, clean the entrance site, and reduce the risk of injury and infection of the tunnel [10].
The complications induced by buttonhole cannulation itself are sometimes difficult to be separated. Unfortunately, in this case, recirculation monitoring was only applied 2 months before cannulation, so the exact time of abnormal fistula formation in this patient could not be known. In this rare case, edema on the left forearm and insufficient blood flow of the fistula revealed recirculation, abnormal fistula, and thrombus in the previous aneurysmal dilatation, which was confirmed by the Transonic HD02 monitor and ultrasound. Appropriate monitoring and surveillance for the detection of abnormalities concerning vascular access in dialysis patients is essential even under the best protection measures and the most skilled experts. The NKF-KDOQI Work Group recommends an organized monitoring or surveillance approach with regular assessment of clinical parameters of the vascular access [1]. The detection of the access dysfunction contains three aspects: monitoring, surveillance, and diagnostic testing. Monitoring is defined by the NKF-KDOQI as the evaluation of the vascular access by means of physical examination to detect physical signs that suggest the presence of dysfunction, which can be used as a monitoring tool to exclude low blood flow associated with impending vascular access failures. Inspection (look), palpation (touch), and auscultation (listen) are three important components of monitoring, which can help clinical doctors detect initial events of vascular access [1]. Surveillance is an effective method to detect the presence of dysfunction by means of tests or even with special instruments. Surveillance methods [1] include device-based methods such as sequential access flow, recirculation measurements (recommended every month), sequential dynamic or static pressures, and so on. In the case described, ultrasound dilution, which is a practical, noninvasive and reliable indicator of vascular access, was used for function surveillance of the AVF, which is reflected by access flow (Qa) and recirculation. Recirculation surveillance by ultrasound dilution thus not only indicates the existence of vascular stenosis but also other complex vascular complications. Every 3 months, Transonic HD02 monitor was scheduled for patients at our center, since it is not covered by insurance. For patients with a high risk of vascular access dysfunction as our case, such monitor sessions should take place every month. In the view of the dialysis adequacy and Kt/V, on line URR based on UV absorbance may be a more sensitive method to find the inadequate dialysis in real time.

However, no significant evidence has been found to prove prolonged access survival. Although surveillance did not increase the likelihood of vascular access survival [11], it is critical to establish a team consisting of the patient, dialysis staff, vascular access coordinator, nephrologists, interventionalists, and vascular surgeon to take care of and improve the quality and outcomes of vascular access using monitor and surveillance [12].

Conclusion

A well-functioning AVF is the key to long-term maintenance hemodialysis in patient with ESRD. However, one of the major causes of dialysis inadequacy is the dysfunction of vascular access resulting from vascular access complications. Buttonhole cannulation compared to other cannulation methods is a technique that may lead to a reduction in many complications, but it cannot entirely avoid all incidences of vascular access problems. Therefore, before the formation of a buttonhole, the punctuation should be operated by a defined expert cannulator team to ensure that the identified angle, direction, and depth are maintained as well as possible and to pay attention to other details to minimize the incidence of complications as described above. A successful surveillance system should be established, including the participation of patients and medical staff from various departments based on the adequate monitoring, online Kt/V monitor, and the surveillance of the vascular access.
with access blood flow and recirculation to identify a possible dysfunction of the AVF. Regular surveillance with the ultrasound dilation method before and during the process of construction of buttonhole cannulation is suggested to find a possible dysfunction of the AVF so that intervention measures can be taken at the earliest convenience.

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Fig. 1. Enlargement and aneurysmal dilatation of the venous system of the left forearm.
Fig. 2. Abnormal fistulae were detected by vascular ultrasound between the matured cephalic vein and the radial vein where blood shunt existed.

Fig. 3. Aneurysmal dilatation in the distal segment of the cephalic vein (a) and thrombus in the proximal cephalic vein detected by vascular ultrasound (b).