Imaging and Radiation Research (2022) Volume 5 Issue 1
doi:10.24294/irr.v5i1.1746

CASE REPORT

Use of ultrasound in difficult to cannulate arteriovenous fistulas in hemodialysis

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ABSTRACT

Vascular access in hemodialysis is one of the pillars of success of the program. Therefore, efforts should be directed firstly to achieve the greatest number of vascular accesses of the arteriovenous fistula type, and secondly to reduce complications related to access cannulation in order to functionally preserve the access. Several strategies have been described to improve this last aspect; this article describes the use of ultrasound to improve the probability of successful cannulation in cases considered difficult by the nursing team.

Keywords: Arteriovenous Fistula; Cannulation; Hemodialysis; Ultrasound; Renal Failure

ARTICLE INFO

Received: 22 January 2022
Accepted: 9 March 2022
Available online: 15 March 2022

1. Introduction

Generally, cannulation of the fistula by the nursing staff is done blindly: guided by palpation of the vein and guided by trill and auscultation of the murmur. However, on some occasions the process becomes difficult, either because of its location, length, width or, more frequently, its depth (>1 cm); in some cases, a second surgery is required to superficialize the venous path and be able to channel them[1].

One of the recent measures to improve and facilitate arteriovenous fistula (AVF) cannulation in hemodialysis is the use of ultrasound[2]. Ultrasonography to guide cannulation is becoming more widespread, despite the lack of high-level evidence; in some settings, the use of ultrasound has even begun to be considered as the standard of care for hemodialysis catheter implantation[3], improving the percentage of successful puncture. The implementation of this technique has begun to improve the percentage of successful AVF cannulation in the first use of the fistula, reducing the rate of complications compared to blind cannulation[4].

Both the increasing average age of dialysis patients with multiple comorbidities and the pressure for early cannulation of a new AVF are risk factors for puncture-related infiltration of the AVF, which can lead to the risk of requiring a new catheter in order to continue dialysis while the complication resolves. Therefore, with an aging population in dialysis units and an increasing number of AVFs being constructed, it is inevitable that “difficult access” will become a common problem[5].

2. Presentation of cases

We present three patients who had native AVFs constructed; one had a basilic humeral AVF (HB fistula) (**Figure 1**), another had a cephalic humeral AVF (HB fistula) (**Figure 2**) and the other had an AVF cephalic humerus (**Figure 3**); all had been mature for 7 to 10 weeks.

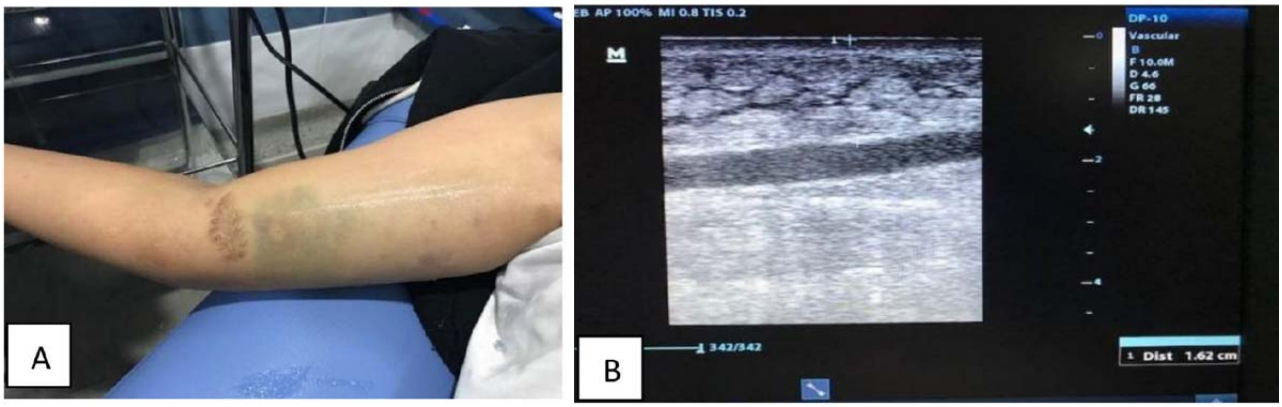

Figure 1. Patient 1. **(A)** Right humero basilic arteriovenous fistula of 9 weeks of construction. No trajectory is observed due to its depth. **(B)** Ultrasound of right humero basilic arteriovenous fistula. Depth of 1.62 cm is observed.
Source: document obtained during the study.

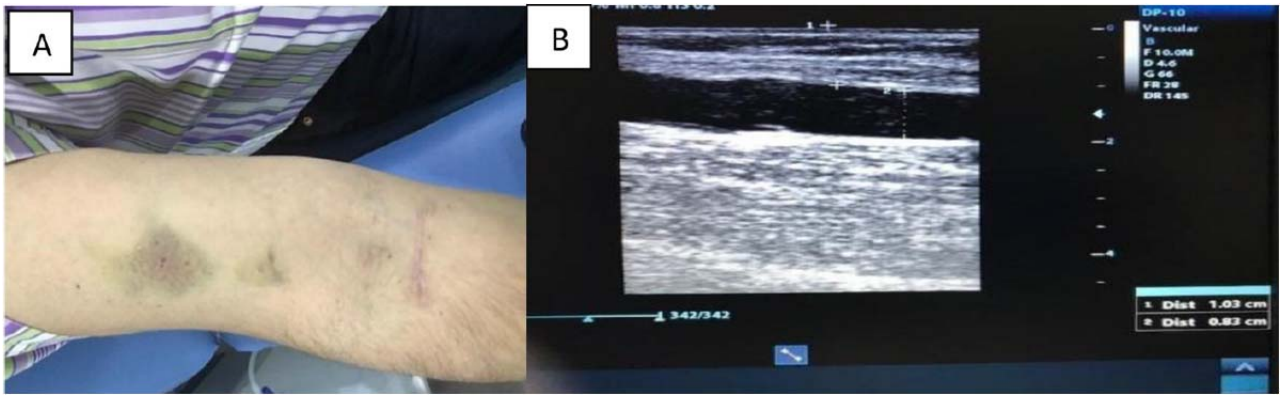

Figure 2. Patient 2. **(A)** Humero cephalic arteriovenous fistula. No dilatation is observed due to its depth. **(B)** Ultrasound of humero cephalic arteriovenous fistula. Depth of 1.03 cm and diameter 0.83 cm is observed.
Source: document obtained during the study.

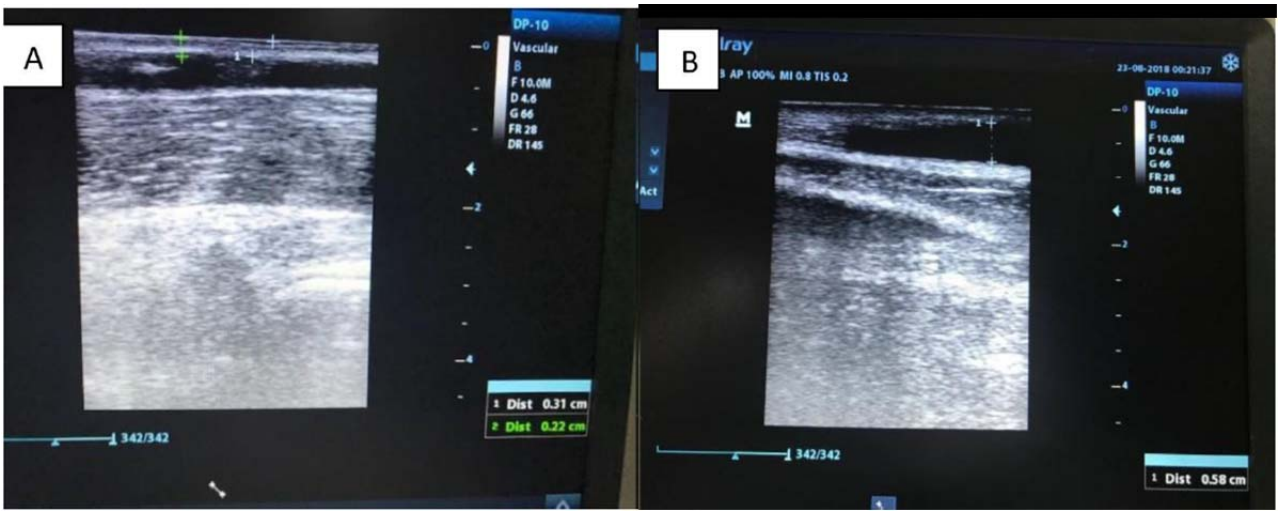

Figure 3. Patient 3. Radiocephalic fistula. **(A)** Diameter of the tract of 0.35 cm is observed at 7 weeks of construction. **(B)** The same tract is observed at 9 weeks of construction with a diameter of 0.63 cm, which facilitated its cannulation.
Source: document obtained during the study.

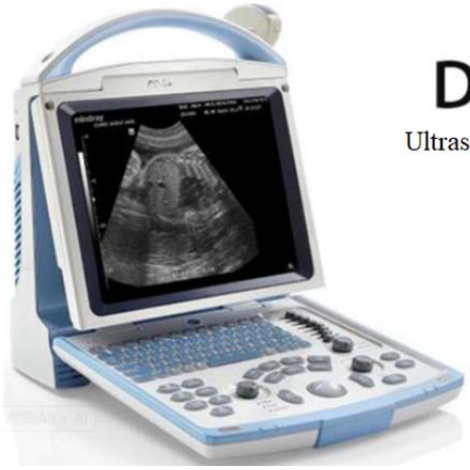

Figure 4. Mindray DP 10 portable ultrasound scanner used for ultrasound examinations.
Source: Document obtained during the study.

The first AVF, due to its depth, was not easily cannulated and the last two, due to their trajectories, were not visible, in addition, the trill was very diminished and they were also not easily cannulated. Given the characteristics of the cases, it was decided to use ultrasound guidance to facilitate cannulation of the native AVFs, for which a Mindray DP 10 portable ultrasound machine was used (**Figure 4**).

It is important to emphasize that both the medical and nursing staff should have knowledge of the anatomy of the vessels of the upper limb and the type of native fistulas that can occur in this extremity, which are shown in **Figure 5** and **6**.

For cases such as patient 1, with humerobasilic AVF, this type of fistula is the second option for performing an AVF when the subject's anatomy does not allow one to be performed at the wrist[7]. They are technically simple, have a low failure rate and generally require a second surgery that requires superficialization of the venous trajectory. In addition, they have different designs depending on the configuration of the patient's veins.

In patient 2, with a humero cephalic arteriovenous fistula, which had been constructed for 4 months and in which, despite this time, the native AVF had not achieved a visible dilatation to be able to be cannulated due to its depth, when the ultrasound was performed, it was observed to be at a depth of 1.03 cm, something very unusual in this type of fistula where the cephalic trajectory is very superficial. Sometimes these situations could suggest or be considered a failure of maturation, which is a major problem. Thus, early failure is defined as an AVF that cannot be used for dialysis or that fails within 3 months of use[8,9], and which also did not correspond to the situation of this patient, since ultrasound could visualize an adequate course and diameter of the vein. Generally, the AVF that has failed to mature has an anatomical problem of some kind that can be identified by physical examination and confirmed by imaging.

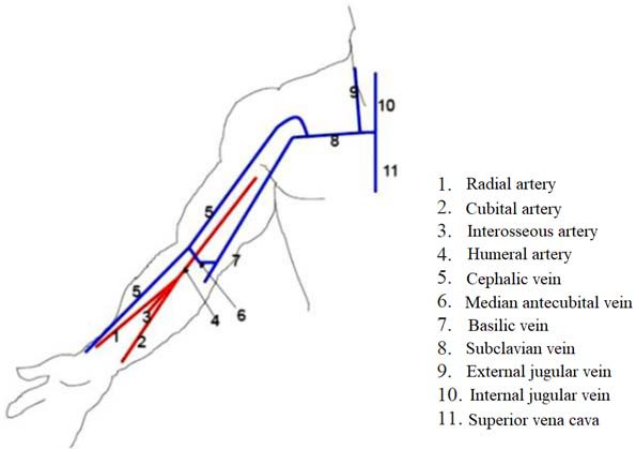

Figure 5. Vascular anatomy of the upper limb.
Source: Taken from Jiménez-Almonacid[6].

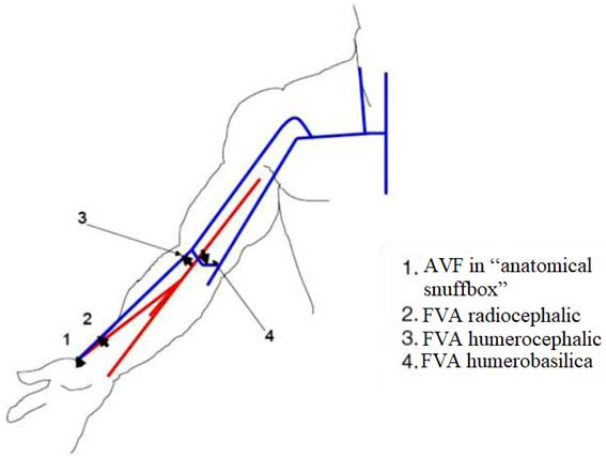

Figure 6. Autologous arteriovenous fistulas in the arm.
Source: Taken from Jiménez Almonacid[6].

3. Results

In the cases of HB fistula and HC fistula, using ultrasound as a guide, cannulation of the venous tract was performed without difficulty and without complications, generating satisfaction and greater safety on the part of the nursing staff and the patients. In patient 3, the radiocephalic fistula did not reach adequate maturation and the largest diameter of the minor fistula was 0.4 cm, so it was decided to postpone cannulation and continue with maturation exercises and ultrasound follow-up. At 9 weeks, adequate dilatation of the venous segment was ob-

served (>0.4 cm), and cannulation of the fistula was achieved.

4. Discussion

Hemodialysis catheter users have higher risks of death, infection and cardiovascular events compared to patients with a usable fistula, who have the lowest risk[5].

As of May 2016, 62.7% of prevalent hemodialysis patients in the U.S. were using an AVF according to data from the United States Renal Data System[10] (**Figure 7**).

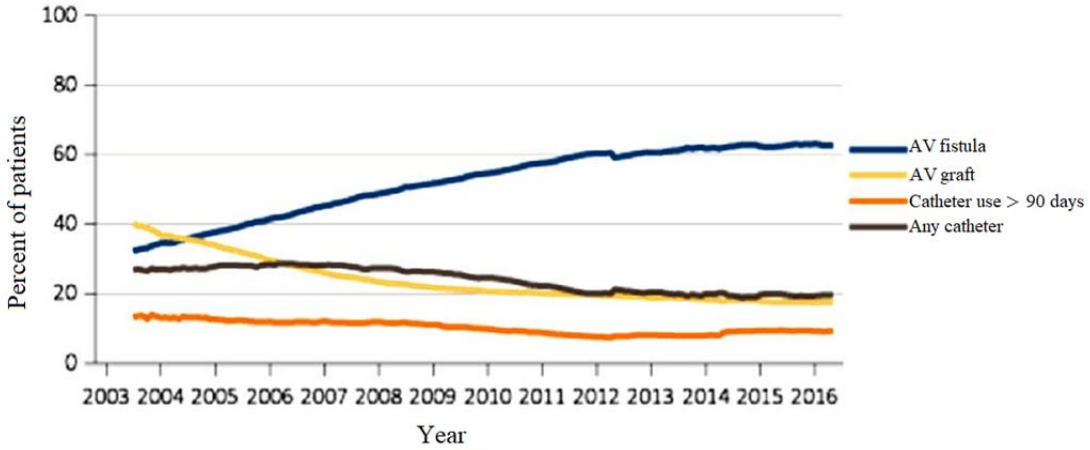

Figure 7. Data on hemodialysis in patients with arteriovenous fistulas.
Source: United States Renal Data System.

In Colombia, as of 2016, according to data from the High Cost Account, 72.8% of hemodialysis patients have an AVF[11]. As in other countries, here the recommendation is that catheter use in chronic hemodialysis patients (>3 months) should be <10%[12]. Worldwide, hemodialysis clinical practice guidelines recommend native AVF as the first vascular access option, which would lead to lower morbidity and mortality compared to grafts and catheters[13].

The low rates of fistula use have led to worldwide initiatives such as the First Catheter Last (FFCL) del Workgroup Coalition in the United States or DaVita Cath Away program (out catheter), both aimed at achieving the clinical and organizational changes necessary to increase the number and use of fistulas in renal units[7].

In consideration of these findings related to the use of AVF in dialysis, any measures taken with the aim of preserving them and increasing their half-life are very valuable.

Initial cannulation failures are one of the most common reasons why patients reject the creation of permanent vascular access; fear of fistula due to pain and hematoma is another situation that interferes with their acceptance[14]. It should also be mentioned that patients who require multiple cannulation attempts or who experience infiltration, hemorrhage or hematoma formation generate increased levels of dissatisfaction, as well as an increase in the cost of medical care due to the need for additional diagnostic tests and interventions[15].

Ultrasound could play several roles, including earlier use of AVF due to a lower frequency of puncture-associated complications, successful use of difficult-to-cannulate AVF, and training for self-cannulation in case of home hemodialysis as in North American and European countries. The first cannulation of the vascular access is also a determining factor in the successful and continued use of the fistula[16].

The concept of AVF maturity is related to the physical characteristics that allow continued puncture and guarantee adequate dialysis. There are guidelines and recommendations as to when to consider a fistula mature, the most widely used through clinical guidelines is known as *the rule of 6*—6 weeks of construction, length of at least 6 cm, blood flow of 600 cc/min, diameter >0.6 cm and depth of approximately 0.6 cm (ideally between 0.5 and 1 cm from the skin surface)[5,10] (**Figure 8**).

If an AVF meets *the rule of 6*, it is considered

ready to initiate cannulation; however, the quality of evidence for the above values is weak and does not always predict an adequate scenario for this procedure. An internal diameter >0.4 cm is often used to determine when to initiate AVF use, which, combined with a minimum flow volume of 500 ml/min, predicts a high level of fistula usability. The latter should also be accessible and 1 cm from the skin surface, ideally 0.5 cm with a straight segment 6–10 cm in length[17-19].

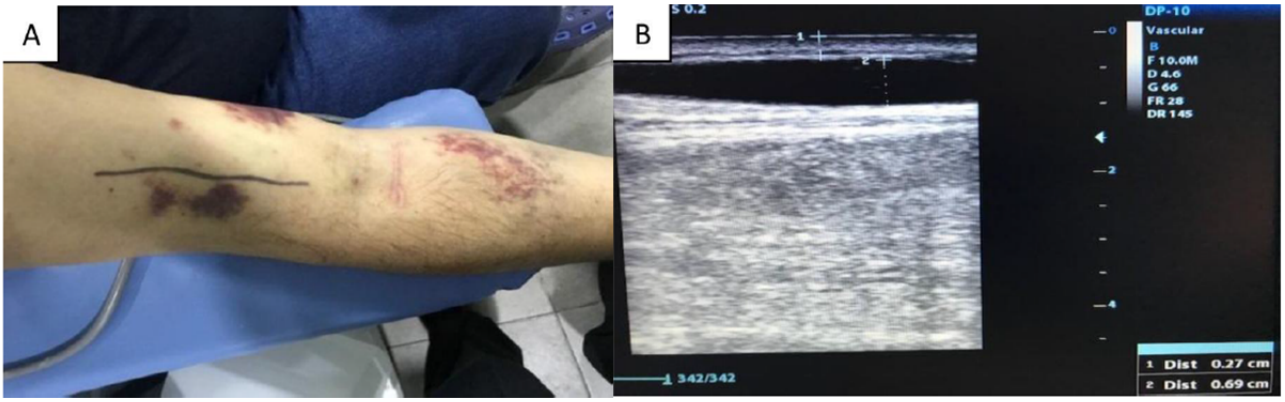

Figure 8. (A) Mapped arteriovenous fistula. It can be used as a reference source for the cannulator; **(B)** ultrasound of arteriovenous fistula at 8 weeks of construction. Depth of 0.27 cm and diameter of 0.69 cm is observed.
Source: Document obtained during the performance of the study.

Ultrasonography was introduced in the early 1970s and since then has been used in numerous clinical situations. Apart from being an inexpensive procedure, it does not require contrast medium and can be performed with portable equipment that is easy to move around[20].

The average increase in the age of dialysis patients, leading to greater and more complex comorbidity, and the pressure for early cannulation of a new AVF are risk factors for puncture-related blood infiltration[15,21], which carries with it the risk of requiring a new catheter to provide continuity of dialysis while the complication is resolved. Therefore, with an aging dialysis unit population and an increasing number of constricted AVFs, it is inevitable that difficult access will become an increasingly common problem. This has led to the observation that simply creating more AVFs in new patients will not be sufficient to significantly reduce central venous catheter dependence unless other aspects of practice also change to improve the time to successful fistula use[22].

It is clear that the pace of work and time constraints faced by nurses in dialysis units do not allow for every cannulation to be performed under ultrasound guidance, therefore, the blind cannulation technique guided by trill palpation will continue to be the common day-to-day practice.

However, the use of ultrasound-guided cannulation is proposed in “difficult cases”, which may include coagulation disorder, a new AVF in an elderly patient, an AVF with a history of multiple cannulation attempts, a small caliber vessel, the presence of an adjacent artery or nerve, or a vessel whose cannulation on the first attempt is critical or whose depth of the AVF from the skin surface may exceed the usual recommendation (<0.6 cm), particularly in obese patients. In these situations, complications are more likely with the use of the blind technique[2].

5. Conclusions

The pace of work and time constraints faced by nurses in dialysis units do not allow every cannulation to be performed under ultrasound guidance, therefore, the blind cannulation technique guided by trill palpation will remain the most common day-to-day practice in hemodialysis units. However, ultrasound-guided cannulation is proposed in “difficult cases”, which may include elderly patients, coagulation disorder, AVF with a history of multiple cannulation attempts, small caliber vessels, an adjacent artery or nerve, a vessel where the first attempt cannulation is critical because its depth exceeds the usual recommendation (<0.6 cm) or, particularly, obese patients where complications are more likely with the blind technique.

To date, direct evidence on the benefits of ul-

trasound-guided AVF cannulation is limited to case reports where its use is reported to reduce the number of failed cannulation attempts and vessel wall damage[3,16]. Randomized clinical trials to examine the benefits of ultrasound-guided cannulation in dialysis have not been completed and are needed.

Conflict of interest

The authors declare that they have no conflict of interest.

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