

Early cannulation of native arteriovenous fistulas in hemodialysis.

Case reports and literature review

Canulación temprana de fístulas arteriovenosas nativas en hemodiálisis.

Serie de casos y revisión de la literatura

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Abstract

The native arteriovenous fistula (nAVF) is the ideal access in patients in hemodialysis, however, traditionally requires a period of maturation from its surgical construction that usually takes more than 8 weeks, exposing patients to a longer time with catheters; In this article, we describe 4 cases of early cannulation (<3 weeks) based on nursing staff expertise and ultrasound criteria.

Keywords: Vascular access, arteriovenous fistula, maturation, cannulation, renal insufficiency, ultrasound.

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Resumen

La fístula arteriovenosa nativa (FAVN) constituye el acceso ideal en los pacientes de hemodiálisis, sin embargo, necesita un periodo de maduración desde su construcción quirúrgica; en este periodo, que suele tardar más de 8 semanas, se expone a los pacientes a un tiempo mayor con catéteres. El presente artículo describe cuatro casos de canulación temprana (<3 semanas) que se llevaron a cabo con base en la experticia del personal de enfermería y algunos criterios ecográficos.

Palabras clave: acceso vascular, fístula arteriovenosa, maduración, canulación, insuficiencia renal crónica, ultrasonido.

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Introduction

Patients with end-stage chronic kidney disease on hemodialysis require adequate vascular access that guarantees an optimal blood flow and allows to obtain an appropriate dialysis; native arteriovenous fistula (nAVF) is considered the ideal access in this group of patients due to its high survival rate and lower risk of complications compared with other types of access such as grafts and catheters.¹ The use of nAVFs is also an indicator for measuring the performance and quality improvement in dialysis centers.²

Despite there are guidelines that recommend the use of nAVF,^{3,4} a very significant percentage of patients have a catheter as a vascular access. One

of the multiple reasons for this situation is the late initiation of cannulation of the nAVF, since important differences in the initiation of the first cannulation have been found worldwide: in Japan the mean time is 10 days; in Europe and New Zealand, 46 days, and in the United States, 82 days.⁵ This statistics in Colombia and Latin America is unknown.

Although nAVF is the ideal access, the optimal time to start its cannulation after its construction is relatively long and varies in different dialysis centers: from week 6 until week 10 or 12, depending, among many factors, on the expertise of the nursing staff and other aspects that have shown that 20-40% fail to mature,^{2,6-9} with which hemodialysis patients are exposed to a longer permanence of the catheter; this implies greater risks of associated morbidity and



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mortality.² Therefore, for a nAVF to be adequate to initiate its cannulation, which is known as “maturation” in dialysis centers, it must have physical characteristics that allow a continuous and safe puncture that guarantees an adequate dialysis.^{10,11}

Physical examination by palpation and visualization is the gold standard used in the majority of renal units worldwide, especially in Colombia, to determine when a nAVF can be cannulated to initiate hemodialysis; nevertheless, physical examination by an experienced cannulator predicts clinical maturation (ability to use the nAVF for hemodialysis) accurately by 70-80%,¹² however, this prediction may vary between nursing staffs at different centers depending on their expertise. Therefore, the timely and accurate evaluation of the maturation of this type of access is essential to minimize the prolonged time and the use of the catheter in the renal units.

In recent years, imaging aids such as ultrasound have become an excellent diagnostic tool to evaluate the nAVF and to facilitate its cannulation; moreover, they are non-invasive, easily accessible and inexpensive procedures. A postoperative ultrasound evaluation can provide objective measurements to predict the early use of the nAVF, and even to guide early interventions and evaluate those which are delayed in maturation.^{12,13}

For several years, some criteria based on the use of ultrasound have been proposed to assess the maturation of the nAVF; among these are those of the National Kidney Foundation/Diseases Outcomes Quality Initiative. The most commonly used worldwide are known as the rule of six, which indicates that a fistula is mature when it has a vein diameter > 6 mm, a maximum depth from the skin of the access of 6 mm, a time of construction > 6 weeks and a vascular access blood flow > 600 mL/min.³ Other criteria used are those of the University of Alabama at Birmingham, which require a diameter >4 mm (Figure 1) and a blood flow >500 mL/min.^{14,15}

With the idea of reducing the rate of catheters and encouraging the early use of the native fistula with the help of ultrasound, a series of cases of early

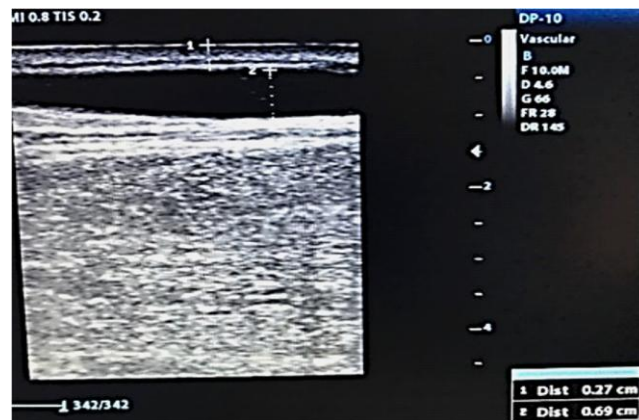


Figure 1. Ultrasound image of a native arteriovenous fistula with a distance from the skin of 0.27 cm and a vein diameter of 0.60 cm. Source. Document obtained during the conduct of the study.

cannulation of the nAVF using ultrasound criteria and the experience of the nursing staff are presented.

Materials and methods

To assess the inner diameter and the depth of the fistula from the skin, in the reported cases a Mindray DP-10 portable ultrasound machine (Figure 2) with a linear transducer was used. Since a Duplex was not available, blood flow was not measured.

The cannulation of the nAVF was performed by expert nursing personnel (known as master cannulators), with high experience and certified for



DP-10
Ultrasound system

Figure 2. Mindray DP 10 portable ultrasound system used to take ultrasound scans. Source: Document obtained during the conduct of the study.

these procedures; needles No.17 French (the smaller gauge available) were used in the three first cannulations and No. 15 in the fourth.

The procedure was explained to the patients, along with the pros and cons.

Case presentation

We present the cases of 4 patients who received hemodialysis through an indwelling catheter and whose nAVF was constructed between 2 and 3 weeks before.

Case 1

A 55-year-old male patient with humeral-cephalic arteriovenous fistula (HCAVF) constructed 22 days before (construction date: 01-12-2017, cannulation date: 23-12-2017, inner diameter: 0.4 cm by ultrasound), in whom it was evidenced a catheter dysfunction due to inadequate flow through it, which could not be improved with adequate heparinization and lavage (Figure 3)



Figure 3. Ultrasound scan of native arteriovenous fistula Patient 1. Source. Document obtained during the conduct of the study.

Case 2

A 48-year-old male patient with nAVF constructed 24 days before (construction date: 29-12-2017, cannulation date: 22-01-2018, venous trajectory diameter: 0.41 cm), who presented accidental dislodgement of the catheter retainer in more than

80% of its length, so it was decided to remove it. An attempt was made to avoid the implantation of a new catheter, so ultrasound was used to verify the largest diameter of the venous trajectory and decide if the fistula could be cannulated (Figure 4).



Figure 4. Ultrasound scan of native arteriovenous fistula Patient 2. Source. Document obtained during the conduct of the study.

Case 3

A 56-year-old male patient with radial-cephalic fistula in the left upper limb constructed 15 days before (construction date: 05-10-2018, cannulation date: 20-10-2018). On day 15 of its construction, the nAVF had a depth of 0.36 cm and a venous trajectory diameter of 0.44cm, so it was cannulated (Figure 5).

Case 4

A 54-year-old male patient with HCAVF constructed 16 days before (construction date: 08-10-2018, cannulation date: 24-10-2018, venous trajectory diameter: 0.69 cm) (Figure 6).

Results and discussion

We present 4 cases of male patients who did not suffer from diabetes, who were cannulated with a 17 French needle in their first three hemodialysis sessions without presenting infiltration or hematomas and with a 15 French needle in the fourth session; the pump flow increased from 250 to 300 mL/minute.



Figure 5. Cannulated radial-cephalic fistula. Source. Document obtained during the conduct of the study.



Figure 6. Ultrasound scan of native arteriovenous fistula Patient 4. Source. Document obtained during the conduct of the study.

In the first two cases the cannulations of the nAVF were performed at 22 and 24 days of construction due to catheter dysfunction, while in

the other two cases the cannulation was early and was carried out at 16 days of construction upon the initiative and mutual agreement of the nursing staff (Table 1).

While it is true that clinical practice guidelines for hemodialysis recommend a rate lower than 10% at day 90, worldwide there are figures that estimate that 81% of patients start hemodialysis through a catheter.¹

In clinical practice in dialysis centers, especially in the Western Hemisphere, they have been using the recommendations of the K-DOQI Guidelines,³ which suggest to wait at least 4 to 6 weeks for the first cannulation, but in clinical practice this time is extended until 8-10 weeks according to expert opinion; in this way the dependence of the patient to the catheter is prolonged with the inherent risks that this implies.¹⁶

Tabla 1. Características de los pacientes y de la canulación durante las 3 primeras sesiones de hemodialisis.

Patient	Age (Years)	Gender	Type of fistula	Date of construction	Date of first cannulation	Days after construction	Needle used in the 3 initial sessions	Pump flow in the 3 initial sessions	Complications
1	55	Male	Humeral cephalic fistula	01-12-2017	23-12-2018	22	15 Fr	250 mL/min	None
2	48	Male	Humeral cephalic fistula	29-12-2017	22-01-2018	23	15 Fr	250 mL/min	None
3	56	Male	Left radial-cephalic fistula	05-10-2018	20-10-2018	15	15 Fr	250 mL/min	None
4	54	Male	Right radial-cephalic fistula	08-10-2018	24-10-2018	16	15 Fr	250 mL/min	None

Fr: French

Source: Own elaboration.

An arteriovenous fistula is clinically mature when it is cannulable with two large gauge needles, when it provides sufficient blood flow for adequate dialysis and when an arbitrary time to start cannulation has been chosen for safety after 8 weeks.¹²

The maturation of the fistula is a complex process of vascular remodeling that requires dilation of the vessels and a marked increase in the blood flow rates in the feeding artery and in the draining vein with the respective structural changes in the walls of the vessels.¹⁷ However, there are studies that demonstrate that there is no difference in the failure rate of nAVFs when they are cannulable between days 14 and 28 versus cannulation between days 43 and 84 after their construction, provided that they are clinically and radiologically mature.¹⁸

Likewise, there are different radiological guidelines to initiate cannulation when the diameter of the venous tract is greater than 4, 5 or 6 mm; however, it has been evidenced that with a diameter > 4 mm, cannulation of the vein using a 17 French needle is already feasible after 14 days of construction. In this sense, the blood flow, the diameter, and the depth of the nAVF predict clinical maturation.¹⁹

The cannulation of a fistula between days 14 and 28 is feasible and helps avoid the implantation of a new catheter; this decision should be based on an adequate clinical assessment by the nursing, nephrology and vascular surgery staff, furthermore, it is suggested to complement it with ultrasound assistance, which includes the measurement of the diameter of the fistula and, if Doppler is available,

the measurement of blood flow, with which high rates of conversion of the catheter to nAVF are achieved.¹⁹

In contrast, early cannulation of the nAVFs before 14 days of constructed has been associated with a greater increase of primary failure of the fistula in the long term, which negatively impacts the survival of the nAVFs.¹⁸

Early cannulation (before three or four weeks after its construction), is not without risks such as infiltration, thrombosis and loss of access, it will not only constitute a waste of time and investment in the construction of the access, especially in countries such as ours, where the health resources are limited, and in addition, it could negatively affect the patient's perception regarding a new reconstruction procedure.²⁰

Despite these risks, the benefit of early cannulation is a reduced amount of time with a catheter, which means less time a patient is exposed to the risk of associated infections and a lower risk of venous access thrombosis when removing the catheter.²⁰ Taking into account the different practices in different countries such as Japan, where the nAVFs are cannulated 10 days after construction,²¹ at the beginning of 2020 we published and suggested a classification according to the time of cannulation or the nAVF after the construction, which is described in [Table 2](#).²²

Table 2. Time classification of the nAV fistula according to the first cannulation.

- Premature cannulation before 14 days (2 weeks)
- Early cannulation between 15 and 28 days (2 and 4 weeks)
- Late cannulation after 28 days (after 4 weeks)

This classification is based exclusively on the cannulation time of native Arteriovenous Fistulas and could be used as a basis to carry out different comparative and prospective studies to evaluate the safety of cannulation according to time. Likewise, main areas of research are required to identify clinically useful predictive factors in order to ensure successful cannulation of the fistula, as well as to understand the pathophysiology of its maturation.

The *Primum non nocere* principle, attributed to Hippocrates²³ and understood in English as “first, do no harm”, has been widely accepted to guide patient care in medical practice and must be taken into account in all aspects of medical practice; therefore, in any medical intervention the risks must be weighed against the benefits it implies. In this sense, vascular access has been rightly referred to as the lifeline of the dialysis patient, and any intervention to create a nAVF or start its cannulation leads to benefits, but there are risks with its creation and use. The knowledge and experience in cannulation by the staff of the renal units along with the use of imaging tools such as ultrasonography improves the success of the procedure and the long-term survival of native fistulas and of the patients themselves.

Conclusion

The purpose of this series is not to promulgate the indiscriminate criterion of early cannulation, especially between the weeks 2 and 4 after the fistula is constructed, nor to put at risk the viability of the nAVF; However, it can be concluded that, despite the limitations of the sample due to the small number of patients and based on the different published studies, with adequate clinical judgment of the nursing staff taking into account an appropriate thrill and/or superficial venous dilation and with the help of ultrasonographic criteria (diameter > 4 mm) it is possible to predict the maturation of a nAVF in order to successfully initiate its early cannulation and avoid the implantation of a catheter or the prolongation of the use thereof.

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Conflict of interest

None declared by the authors.

Ethical responsibilities

Protection of people and animals

The authors declare that no experiments were performed on human beings or animals for this research.

Right of privacy and informed consent

The authors declare that patient data do not appear in this article.

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Contribution of the authors

Ignacio Villanueva and Mauricio Ruiz M: Attention of cases, literature review and writing of the article.

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