



## ORIGINAL ARTICLE

# End-stage vascular access failure: can we define and can we classify?

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## Abstract

**Background:** Renal replacement therapy using dialysis has evolved dramatically over recent years with an improvement in patient survival. With this increased longevity, a cohort of patients are in the precarious position of having exhausted the standard routes of vascular access. The extent of this problem of failed access or 'desperate measures' access is difficult to determine, as there are no uniform definitions or classification allowing standardization and few studies have been performed. The aim of this study is to propose a classification of end-stage vascular access (VA) failure and subsequently test its applicability in a dialysis population.

**Methods:** Using anatomical stratification, a simple hierarchical classification is proposed. This has been applied to a large dialysis population and in particular to patients referred to the complex access clinic dedicated to patients identified as having exhausted standard VA options and also those dialysing on permanent central venous catheters (CVC).

**Results:** A simple classification is proposed based on a progressive anatomical grading of (I) standard upper arm options exhausted, (II) femoral options exhausted and (III) other options exhausted. These are further subdivided anatomically to allow ease of classification. When applied to a complex group of patients ( $n = 145$ ) referred to a dedicated complex access clinic, 21 patients were Class I, 26 Class II and 2 Class III. Ninety-six patients did not fall into the classification despite being referred as permanent CVC.

**Conclusions:** The numbers of patients who have exhausted definitive access options will continue to increase. This simple classification allows the scope of the problem and proposed solutions to be identified. Furthermore, these solutions can be studied and treatments compared in a standardized fashion. The classification may also be applied if patients have the option of transplantation where iliac vessel preservation is desirable and prioritization policies may be instituted.

**Key words:** catheter, classification, graft, haemodialysis, vascular access

## Introduction

Dialysis patients are surviving longer due to advances in nephrological care leaving those who are not fortunate enough to receive

a transplant on long-term dialysis. In most cases of prolonged renal replacement, haemodialysis will be the main modality [1]. A critical factor in outcome for haemodialysis patients is

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definitive vascular access (VA) either in the form of an arteriovenous fistula (AVF) or an arteriovenous graft (AVG). Autologous AVFs are the preferred choice for superior long-term outcomes, better infection resistance and fewer interventions [2]. AVGs, despite increased intervention rates, may offer equivalent outcomes to AVFs over the short term [3]. Central venous catheters (CVC) in contrast have poor patency, higher infection rates and are associated with complications including central venous stenosis. However, in some patients under careful care and regular monitoring, the tunneled catheter may remain patent and infection free for long periods of time, but this is not predictable.

A small percentage of patients will maintain autologous AVFs long term, but for many patients a sequence of fistula and/or graft formations with subsequent interventions and ultimate failures will eventually result in standard options being exhausted. The criteria determining this point are ill defined and vary between surgeons and units. Technology has increased in recent years with more surgical and radiological options available; however, evidence is not robust for many of these options [4]. The predominant determinant of VA success is the ability to find adequate venous drainage with suitable arterial inflow that can adapt to support an AVF.

Despite the increasing prevalence of haemodialysis patients with complex access issues, there remains no consensus on the definition of VA failure or end-stage vascular access. An extreme definition of VA failure would be whereby 'all potential routes of access have been utilized and haemodialysis is no longer achievable'. Thankfully this is a rare occurrence as treatment becomes palliative. This binary approach to access failure neglects the complex group of patients in whom access is challenging but still possible.

We have sought to define a classification system-based anatomically to reflect the degree of severity of access failure. We have defined end-stage access failure as occurring when bilateral venous occlusion or severe stenosis that renders standard upper limb access options non-viable. This may initially be seen as 'pre-failure' by many but as a workable classification, as well as the inferior outcomes of all subsequent options this definition is a useful one [5].

There are challenges with designing a practically applicable classification as variations in local expertise may have an impact on the possible solutions available, but for the purposes of defining access failure any patients with central stenosis should be classed as end stage. This may seem illogical as an autologous option may be possible even if central stenoses exist. This is however the approach taken in many disease processes, renal failure being an example. End-stage renal failure (CKD5) is not redefined, because someone has the option of a transplant. The potential solution does not define the problem and as such the anatomical lesion is the main variable to be classified.

A further confounder is that the nature of exhausted access options may be relative to the patient's situation, for example a young patient with transplant options may prefer a hemodialysis reliable outflow device (HeRO) to a loop thigh graft despite having no iliac stenosis. Another example may be avoidance of loop thigh grafts in the morbidly obese or debilitated. This classification aims to encompass these challenges; however, it may underestimate non-anatomical issues.

The introduction of alternative options in upper body central venous stenosis such as the HeRO device does not remove the requirement for a classification but reinforce the need. As stated above local expertise may be able to provide a straightforward HeRO device and avoid more exotic complex solutions. To be able to distinguish which patients should have a HeRO or a

thigh graft requires some form of stratification as recent studies have shown equivalence for both solutions but have not defined the nature of the patients' lesions [5].

For more exotic 'desperate measures' options such as femoral vein transpositions [6], necklace grafts and other creative grafts [7] and arterial loop grafts [8], the need for a classification is also desirable to be able to compare outcomes.

## Methods

### Defining VA failure—a systematic review

Searches of Pubmed central, Medline and the Cochrane Library were performed using the following specific search terms: vascular access, AVG, arteriovenous fistula, central venous stenosis and classification to identify articles in English language published prior to 31 March 2015, dealing primarily with the VA failure. In addition, the references cited in selected articles were reviewed for any further relevant available studies. All studies of vascular classification were eligible for inclusion.

We included randomized trials, observational studies and review articles. The systematic review was performed in accordance with PRISMA [3]. Therefore, all included studies were assessed for inclusion on the basis of their topic, type of study, method, number of patients included and availability of their original results.

### Proposed classification

A simple classification for end-stage VA failure is proposed based on anatomical sites. This follows a simple sequential broad categorization:

1. No upper limb VA option
2. No Lower limb VA option
3. No options at any site

These can be further subdivided into the site of occlusion/stenosis. Stenosis was defined as greater than 50% [with a left (L) and right (R) classification];

1. No upper limb VA option
  - (a) Axillary vein stenosis
  - (b) Subclavian vein stenosis
  - (c) Brachiocephalic/innominate vein stenosis
  - (d) SVC stenosis
  - (e) Arterial insufficiency
2. No Lower limb VA option
  - (a) Iliac stenosis
  - (b) IVC stenosis
  - (c) Arterial insufficiency
3. No options at any site
  - (a) CVC via a non-standard site (e.g. translumbar, transhepatic, other)
  - (b) No access options and treatment withdrawal

Laterality can be added to this classification to further delineate the issue. An example would be a right brachiocephalic stenosis and a left axillary stenosis. This would be classified as type 1 access failure but could be sub-classified as 1a(L)1b(R). For audit the purposes, the most central (proximal) venous lesion (i.e. nearest the heart) could be used. In this case, it would be 1b VA failure.

Another example would be a patient dialysing via a groin line placed through an iliac stenosis with bilateral iliac stenosis. This patient would be classified as 2a VA failure. A unilateral iliac stenosis would not classify as a type 2 access failure since

contralateral options exist but would be likely to be a type 1 access failure as they require a groin option. A patient with a transhepatic line due to SVC and IVC stenosis would classify as 3a access failure.

### Testing the classification

This classification was applied to a cohort of patients within a large dialysis population deemed to have exhausted standard access options. These patients were either all referred to the complex access clinic or were classified as 'permanent lines' in a contemporaneous database.

Two observers (M.F. and N.I.) separately classified the patients based on records and imaging. Where discrepancy occurred, consensus was reached with a third observer (J.A.).

### Results

Three hundred and eighty-eight articles and abstracts were identified using our search strategy. After screening the contents of the abstract, five full-text articles underwent assessment for eligibility and quality inspection of methodology. Following the assessment, no articles were found to be eligible for the review.

Consecutive patients attending a specialist complex access clinic ( $n = 97$ ) were stratified according to the proposed system. In addition to capturing those patients who had not been referred to the complex clinic, all dialysis patients who were noted to be on a permanent line ( $n = 48$ ) were also assessed. From this cohort of patients ( $n = 145$ ), it was found that many of those patients had a standard option that either had not been considered or had been refused by the patient and therefore were not in end-stage VA failure.

The remainder ( $n = 54$ ) were suitable for further classification. Of these patients, failure was limited to the upper limb in 26 patients, both upper and lower limbs in 26 patients and 2 patients had no options at all and were dialysed through a non-conventional CVC site (Table 1).

Within subgroup analysis, options available to those patients classified as Category 1 included subclavian and brachiocephalic segments with only two patients shown to have SVC stenosis (1a = 4, 1b = 6, 1c = 9, 1d = 2). Arterial insufficiency was the cause of failure in five patients (1e = 5) (Table 2).

Within those classified as Category 2 (including those where upper limb options are exhausted since the classification is hierarchical), the majority of reasons were for vascular insufficiency ( $n = 16$ ). Iliac and venous stenosis prevalence were similar (2a = 5, 2b = 5, 2c = 16).

Fortunately, few patients had exhausted both upper and lower limb options and only two patients were dialysing via a lumbar line (3a = 2). No patients in this cohort were withdrawn due to lack of access options.

**Table 1.** End-stage vascular access failure categories in a group of patients on permanent CVCs

Classification	N/A	1	2	3
(n)	91	26	26	2

Category 1, no upper limb options; Category 2, no lower limb options; Category 3, no options at any site.

**Table 2.** Sub-classification of exhausted vascular access

Sub-classification	1a	1b	1c	1d	1e	2a	2b	2c	3a	3b
(n)	4	6	9	2	5	5	5	16	2	0

There was only a single disagreement between observers which was resolved with the use of a third observer.

### Discussion

In many dialysis programmes, there will be patients who are considered to have exhausted definitive access options and are maintaining dialysis on a CVC. These patients can be classified as end-stage VA. As this group is disparate and comparisons for outcomes are difficult, it is proposed that a classification system be used.

We have devised a systematic hierarchical classification of VA failure which is based on the concept that leg options are generally considered only when simple and complex upper limb options are not possible and that direct central venous cannulation options, for example translumbar CVC, are reserved for the most desperate. This approach is reflected by clinical guidelines [9]. This classification system is not intended as a prescriptive management pathway for patients with progressive VA failure, but as a tool to aid classification and to assist in standardizing terminology for practice and research. End-stage VA failure does not necessarily occur in a stepwise fashion which makes the search for a standardized management algorithm futile. For example, a patient dialysing through a complex upper limb graft may have no lower limb options due to arterial disease and thus could progress from Group 1 to Group 3 exhausted VA upon loss of graft patency.

We believe that VA failure classification is required to assess the options that are attempted on patients with failed access as well as for the study of the natural history of access failure. No other classifications exist and studies are difficult to interpret without some standardization. This is especially important in multidisciplinary team meetings as it helps surgeons, radiologists and nephrologists have a common classification.

Debate may exist regarding what options are available and whether this is true end-stage VA failure or simply a more challenging situation. The choice between a subclavian neck graft and a HeRO may be offset by a loop thigh graft and standardized reporting to allow meaningful comparisons is overdue.

The classification is limited by the exclusion of non-anatomical reasons for VA exhaustion, for example age, frailty, obesity or patient choice for favouring a CVC over a graft. It is important to separate these two groups of anatomically exhausted and non-anatomically exhausted VA since they require different clinical management strategies and this separation allows more valid comparisons to be made between research populations. Interestingly within the cohort of patients where this classification was verified, over half of the patients who had been declared out of access options did not have anatomical reasons.

A further area of clinical need is the stratification of patients for transplantation. Organ allocation based on urgent requirement could be explored and practice varies between countries, and it can be argued that patients with declining options for VA should be prioritized. This will help in multidisciplinary team discussions between nephrologists and surgeons. Without a classification, this is impossible and may also be counterproductive. Using this classification, it can be seen that patients in Group 2 would be candidates for prioritization, whereas those in Group 3 would not. Indeed, the highest priority could potentially be awarded to those progressing from Group 1 to 2 to maximize the benefit of preservation of venous reserve from trauma due to lower limb CVC usage. The concept of vein preservation for transplantation is not widely publicised or practised.

On review of the literature, there appears to be no current usable classifications to apply to vascular access.

## Conclusion

This simple proposed classification may be useful in both clinical and research settings. When applied to an initial validation set of patients with permanent CVCs, it was found to be easy to apply with minimal interobserver variation and demonstrated useful results. While this is a prevalent cohort in a single centre, a larger prospective multi-centre validation is required.

The ease of use and simplicity of reporting appear to suggest that this systematic hierarchical classification has value in patients with end-stage vascular access.

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## Conflicts of interest statement

None declared.

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