

EDUCATIONAL ARTICLE

Routine Surveillance in Vascular Access for Hemodialysis

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There is increasing evidence that surveillance of AV access for haemodialysis prevents access thrombosis and improves the quality of care. This article reviews the evidence for surveillance and the various strategies and techniques available for detection of the failing access.

Keywords: Vascular access; Haemodialysis; Graft surveillance; Thrombosis.

Introduction

The two basic components of a vascular access for hemodialysis that allow for its routine, uninterrupted use and to provide for optimal dialysis efficiency are high flow and durability. A functioning access is very important to the patient, dialysis center, and payors. Access dysfunction that increases intra-access pressures and decreases flow can lead to thrombosis of the fistula or graft. Thrombosis requires additional measures to restore patency, which are costly and time consuming and usually requires the introduction of a temporary central venous dialysis catheter, which has its own unique complications. These all lead to significantly reduced quality of life for patients with end-stage renal disease (ESRD).¹ Dysfunctioning but patent grafts or fistulas may also lead to extended dialysis treatment times and/or underdialysis. A recent study demonstrated that even seemingly minor decreases in the dialysis prescription led to significantly increased morbidity, increased hospitalization, length of stay and costs.²

This argues the need for structured, routine methods to identify access dysfunction prior to thrombosis. Prospective monitoring of AV fistulae and grafts may allow for earlier detection of anatomic lesions, which may then be corrected by an appropriate intervention.

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A number of methods have been used in the past to monitor access function including physical examination, direct and indirect flow measurements, intra-access resistance, intra-access pressure and access recirculation. As a result of the innate differences between AV fistulas and grafts, these tests may be more useful in one than the other (e.g. urea recirculation may be more applicable for autogenous fistulas).

Several assumptions need to be made when considering dialysis access surveillance. First, and most importantly, these studies need to be done routinely and serially. There have been many suggestions as to the appropriate timing, but the optimal interval is probably monthly.³ Secondly, the recorded observations must be readily available for future use in order to follow trends over time. Intervention should not be performed as a result of a single abnormal test, but serial measurements should be used to identify trends indicating deterioration of flow or increasing resistance over time. Triggers then need to be placed such that at a point in time the abnormalities are addressed by appropriate diagnostic testing and corrective intervention. It is also becoming clear that following intervention, functional testing of the access should be performed to verify that the intended improvement in access flow and decrease in access resistance has been achieved.

Flow Measurements

Direct and indirect flow measurements are common surveillance tools. Direct flow measurements can

be obtained using duplex ultrasound or magnetic resonance angiography (MRA) and used serially to detect those accesses at risk for dysfunction and thrombosis. Their routine use is limited by the need for expensive equipment so that their overall cost is high and unlikely to be offset by reimbursement. In addition, duplex ultrasound accuracy and reproducibility are very operator dependent. However, such studies provide a unique opportunity not only to measure flow, but also to delineate stenoses accurately.

Indirect flow can be quantified using in-line techniques at the time of dialysis, after needle placement. Several methods exist including the use of indicator dilution techniques such as ultrasound dilution,⁴ transcutaneous access flow rate,⁵ glucose dilution,⁶ timed ultrafiltration,⁷ ionic dialysis⁸ and differential conductivity.⁹

Ultrasound dilution techniques are currently the most commonly used: Ultrasound probes are placed on the dialysis lines and they are then reversed, creating recirculation. A saline bolus is injected into the venous line. The venous probe samples the concentration of the injected bolus, the arterial sensor measures the concentration of the bolus following dilution through the vascular access, and the classical indicator dilution equation is applied, resulting in a flow calculation of the access.

Pressure Measurements

Dynamic venous pressures (determined while the pump head is turning) are difficult to standardize, which limits their usefulness, whereas static venous pressures (routinely measured during each dialysis session prior to starting the dialysis pump) are simple and more frequently used. Normally, systemic pressure rapidly dissipates over the length of an AV graft or fistula. The presence of a stenosis within the inflow, the outflow or the access itself will alter this gradient so that changes in pressure at the arterial and venous ends of the access can be used for its detection. The ratio of intra-access pressure at the arterial end to mean arterial pressure (MAP) and the ratio of intraaccess pressure at the venous end to MAP can be calculated. With normal venous outflow, the venous/MAP ratio should be low, whereas with increasing stenosis, this ratio (along with the arterial ratio) will increase. A midgraft stenosis would cause an increasing pressure in the arterial side of the conduit while the venous ratio would remain low. In contrast, both ratios would be low in the presence of an arterial inflow stenosis. As always, single

readings should not influence decision-making, rather the data should be examined serially for changes or trends over time.

Physical Examination

Physical examination is an important yet often forgotten factor in following graft function over time. All members of the vascular access team, including physicians, nurses, technicians and patients themselves should be proficient at assessing vascular access. No special equipment or testing is required, which makes it one of the more attractive methods for monitoring graft function. Evidence of venous stenosis may include prominent collateral veins, edema, changes in the characteristics of the thrill/pulse, and prolonged bleeding from needle sites.¹⁰

Recirculation

Recirculation occurs when dialyzed blood travels back to the dialyzer without adequate mixing with the systemic circuit. This can be caused by a stenosis of the access outflow. Recirculation can be accurately and reproducibly measured by using ultrasound dilution or differential conductivity techniques. Calculated urea recirculation has also been used historically to identify graft outflow stenosis. However, urea recirculation is relatively insensitive and only renders a positive result at very low access flows. It is therefore not recommended for AV grafts, which require high flows to maintain patency. In contrast, it is a reasonable test in patients with native fistulas, which can remain patent at low flows.

Discussion

The basic assumption of access surveillance is that grafts and fistulas with high flow and low outflow resistance remain patent. With increasing venous outflow resistance, measured flows decrease and measured resistance increases. Intraaccess pressure ratios (both arterial and venous) also will rise in the setting of venous stenosis. Older studies report that 90% of graft thromboses occur as a result of venous outflow abnormalities.¹¹ This anatomic abnormality will be reflected in both flow decreases and resistance increases. Newer observations¹² suggest that arterial inflow abnormalities may be the cause of access dysfunction or thrombosis in a significantly higher percentage of cases than previously thought. While flows will decrease with arterial stenosis, resistance measurements may not be perturbed, leading to

a bias that flow measurements are preferable for access monitoring.

A surveillance program must first identify the baseline measurement of choice, and then follow it serially to identify trends over time. A graft will reach its baseline flow early following creation, whilst a fistula may take months to reach its baseline flow. Routine studies, probably monthly, need to be measured, recorded, and analyzed.

Many studies^{13–16} show that routine measurements can detect the access at risk for thrombosis, and allow for definitive study and treatment of the anatomic abnormality. There are no large randomized prospective studies that show definitive increases in the life span of a particular access with the use of surveillance. Some authors^{17–19} have argued that these techniques do not prolong prosthetic graft survival and may actually increase the costs of access maintenance as a result of the greater number of corrective procedures (primarily percutaneous transluminal angioplasty-PTA) performed. However, avoiding access thrombosis alone is beneficial as it requires urgent therapy (interventional or surgical), results in the loss of the optimal dialysis efficiency, requires the need for a temporary catheter (with a risk of further complications) and significantly increases costs. Importantly, access thrombosis is one of the dialysis patient's greatest worries.²⁰

For prosthetic vascular access grafts, older studies have shown that relative flow rates can predict the propensity for thrombosis.^{21,22} The higher the flow, the less likely the graft is prone to thrombosis. Grafts with flows greater than 800 ml/minute have a risk of thrombosis that is significantly less than those under 800 ml/minute. Studies that have looked at decreasing flow as a trend have shown an increasing probability of demonstrating anatomic lesions and subsequent thrombosis.^{6,23,24} Besarab¹⁴ and others^{15,25–27} have championed the use of venous pressures and intraaccess pressure monitoring, demonstrating that higher venous pressures and intraaccess pressures lead to an increased rate of access thrombosis. Those using newer techniques, such as ultrasound dilution, have also reinforced the concept of flow monitoring as an effective technique to measure access flow and predict impending thrombosis.²⁸

Because patency in AV fistulas can be maintained with significantly lower flows than in AV grafts, they require a different approach to surveillance. AV fistulas dissipate pressure downstream rapidly as a result of the many collateral outflow pathways. Therefore, intraaccess pressure ratios will be significantly less than a graft, and the use of these measurements may not be as valuable as with a prosthetic access.

The number of collateral veins in an AV fistula also render dynamic and static venous pressure monitoring less predictive of thrombosis.

It is therefore more important to consider relative changes with serial measurements over time with these accesses. Nevertheless, there is solid evidence^{29,30} to support preemptive interventional/surgical procedures to improve longitudinal survival in AV fistulas. Recirculation studies (e.g. urea recirculation) may be valuable in the AV fistula. It is the author's opinion that serial physical examinations in patients with AV fistulas can provide particularly important additional information.

When routine surveillance identifies the access at risk for thrombosis, the next step is to proceed to angiography for a definitive diagnosis and PTA or surgical repair. Duplex ultrasound has been advocated by some³¹ as an interim step, prior to angiography, as it may be as valuable for grading the stenosis as well as quantifying the current flow. There is an emerging concept that once an intervention has been performed, anatomic confirmation is not adequate and additional studies (e.g. duplex ultrasound) should be used to demonstrate a physiologic improvement in flow.^{31,32}

Summary

- Hemodialysis access has a high rate of dysfunction.
- Access thrombosis contributes to significant problems for clinicians, dialysis personnel, patients and payors.
- Access surveillance can identify those that develop anatomic abnormalities that place them at risk for thrombosis.
- There are many tools to use for surveillance monitoring at the disposal of carers. Dialysis units should choose the tool that best meets their needs and abilities, and to use it to produce serial measurements.
- Data should be carefully recorded, readily available and periodically analyzed to detect undesirable trends.
- Once trigger points are met, accesses should be definitively studied using duplex scanning and/or fistulography and appropriate revision performed by angioplasty or surgery.
- After correction of the problem, new baseline values should be obtained and surveillance once again instituted.
- Rigid application of these concepts will allow us to better care for our patients requiring hemodialysis.

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