Vascular access: care and monitoring of function

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Introduction

Without an adequate vascular access, haemodialysis efficiency is reduced, which results in increased morbidity and mortality [1]. Once the last access possibility has been exhausted, the patient is faced with a life-threatening condition. Access-related problems are responsible for ~ 50% of the hospitalizations of haemodialysis patients [2]. Hence, the quality of vascular access is not only a medical but also a socio-economic issue.

From the moment that the first access is created, an ongoing process is often started that will end with the loss of all access possibilities if the patient survives long enough. A careful approach will postpone this moment and will help to sustain life and quality of life longer than if access systems are constructed and monitored carelessly. The ideal access should provide adequate blood flow for an indefinite time, so that dialysis delivery is maximized upon each cannulation.

Complications such as thrombosis, infection and haemorrhage should be absent. Today, such an ideal access does not exist.

The most frequently applied access possibilities are the Cimino–Brescia (arteriovenous; AV) fistula and the polytetrafluoroethylene (PTFE) graft. The purpose of this comment is to indicate which specific measures help to provide the optimum survival of access.

The native arterio-venous fistula

In 1966, Brescia et al. [3] first described the classical radiocephalic, AV fistula, which consists of endogenous vessel material, covered by natural endothelium. As a consequence, infectious and thrombotic complications are less preponderant than with alternative access systems that are composed of foreign material. Ideally, the AV fistula is constructed in the lower arm. Alternatively, similar more proximal constructions can be created if the quality of distal vessels is unsatisfactory. In diabetics, older patients and patients with severe atheromatous disease, the elbow and upper arm may be the preferred location.

Early measures and timely referral

Because the creation of Cimino–Brescia fistulas needs patent arteries and veins, timely referral to the

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nephrologist is a prerequisite. From the moment a patient is expected to progress to renal replacement therapy, one arm should be preserved for the future creation of a vascular access system. The non-dominant arm is preferred, if the quality of the vessels is adequate. The planning strategy implies that the selected arm is not used for venous puncture, with the exception of the veins at the back of the hand, which can still be used for blood collection. This strategy should, if possible, be followed, even with patients expected to start peritoneal dialysis or undergo kidney transplantation, because they might require transfer to haemodialysis later. The patient should be made aware of this decision so that he/she can actively participate in the prevention of undesired venous punctures. Along the same line of thought, peritoneal dialysis might be preferred as a primary dialytic treatment strategy [4] because renal replacement therapy can be provided for a substantial period of time without wasting vascular access possibilities.

Unfortunately, ~30% of dialysis patients are referred to the nephrologist in the final months preceding dialysis treatment (late referral) [5]. The chance to have a patent vascular access system at the start of dialysis is negatively correlated with the number of previous consultations with the nephrologist [6,7]. Both the start of dialysis using a central venous catheter and the premature puncture of an access system, both of which are common with late referral, are independently correlated with the development of access failure [8]. Patients who have been known to the nephrologist during the phase of progression of renal failure have a greater chance of having a patent fistula at the start of dialysis than unknown patients, or known patients with an unanticipated progression of renal failure [9]. Nevertheless, even among patients who had been seen by a nephrologist at least 1 month prior to the start of haemodialysis, 27% started dialysis on a catheter [10]. Hence, even in patients with timely referral, the timing of access creation can be improved.

**Synthetic grafts for vascular access**

Next to central catheters, PTFE grafts are the most frequent alternative to the Cimino–Brescia fistula. These grafts consist of artificial material (Goretex®), which is inserted in an attempt to bridge the distance between endogenous arteries and veins. Although PTFE grafts ‘mature’ faster than endogenous fistulas, at least 3 weeks are needed before the first puncture to allow endothelialization of the internal wall. Puncture should not be repeated systematically at the same location, because this tends to destroy the endothelial layer.

PTFE grafts, which are composed of foreign material, are subjected to a high risk of thrombotic and infectious complications. Survival of PTFE grafts is substantially lower than that of AV fistulas [11]. The use of PTFE grafts should be restricted to a minimum, but until recently PTFE grafts have remained popular as the first choice in many areas of the world [12]. The welcome trend to use PTFE grafts less frequently is unfortunately counterbalanced by the more frequent use of central venous catheters [13]. According to the HEMO study, AV fistulas are less frequently available in female and older patients, and in the presence of vascular disease [14].

**Vascular access thrombosis and infection**

Both AV fistulas and PTFE grafts are most frequently lost because of thrombotic events, which are mainly related to mechanical damage to the vascular wall and to abnormal flow patterns, with shear-stress-related damage to the endothelium [15]. The most frequent direct cause of late access thrombosis is severe venous stenosis [16].

Many of the conditions that predispose a patient to vascular disease, such as diabetes mellitus, increasing age, enhanced thrombogenicity, inflammation, dyslipidaemia and hyperhomocysteinaemia, also predispose them to the loss of the vascular access system [8,11,17–20], although for homocysteine the relation with fistula loss was not confirmed unequivocally [21,22]. Anticardiolipin antibodies are registered more frequently in patients with grafts [23], and are related to a greater odds ratio for access thrombosis [23,24]. It is, however, impossible to discern from these studies whether the antibodies are the cause or the consequence of access problems.

The question should be raised of whether an intensive surveillance of the access system for signs of venous stenosis could not be a strategy to detect the tendency to succumb to thrombotic complications early, so that the access can be corrected before it is conclusively lost. The timely detection of venous stenosis of the access system resulted in a substantial reduction of the number of declot procedures and in a substantially longer graft survival [25,26]. Sometimes access problems could be predicted from simple clinical signs such as prolonged bleeding after cannula withdrawal and/or a change in the bruit over the access by auscultation. These data underscore the importance of clinical follow-up of access systems. It could be argued that these parameters are only found if the stenosis is advanced, and that more sophisticated methods should be used to allow early detection. In the study by May et al., however, only the most severe degrees of stenosis were related to access failure [16].

Access systems carry not only a risk of thrombosis, but also of infection, especially if they consist of foreign material. Infection may occasionally even occur in graft material that has been left in place, although it is no longer used as an access system [27]. Infectious endocarditis is a life-threatening infectious complication, which is observed particularly in access systems composed of exogenous artificial material, such as PTFE grafts and central vein catheters [28]. The tip of soft indwelling catheters is positioned in the atrium, close to the cardiac valves. Therefore, these access systems carry a special risk of endocarditis.
Unexplained infectious problems in patients with these access systems should always prompt careful scrutiny for access infection and endocarditis. In the future, infectious complications might be prevented by specific treatment of catheters, such as antibiotic bonding [29] or silver impregnation [30], but unequivocal proof of the usefulness of this approach has, to the best of our knowledge, not yet been provided.

Early detection of failing vascular access

In several studies, blood flow was markedly lower in failing access systems [16,31,32]. To measure blood flow, specific apparatus (Trasonic system) is necessary, which is based on the ultrasound dilution technique and the inversion of the inlet and outlet dialyser blood lines [33]. The blood flow rates of access systems prone to thrombosis overlap considerably with the flow rates in the non-thrombosing systems, however [16]. Hence, it remains unclear which cut-off value should be selected for the prediction of access problems. In addition, most of the above-mentioned data were collected in patients with PTFE grafts. In general, average blood flows are markedly lower in AV fistulae, despite a lower risk of thrombosis. Therefore, similar studies should be undertaken in large patient populations and AV fistulas before this line of thought can be extrapolated. Other parameters, such as venous or arterial pressures and recirculation, lacked statistical power [16].

Next to the Trasonic system, blood flows can also be measured by Doppler ultrasonography. Although flow measurements by the Trasonic system and Doppler are significantly correlated [16], individual values do not correspond to each other in a convincing fashion. The external shape of fistulae is more irregular than that of grafts, which makes it more difficult to position the Doppler system correctly to allow a reliable flow measurement. On the other hand, Doppler might be a relevant method to predict graft stenosis [34].

Therapeutic strategies

Surgical revision remains the gold standard for the treatment of access stenosis [35]. The most reliable alternative corrective therapy is angioplasty, without or with stenting. This maneuver helps to postpone the definitive loss of a vascular segment for access use. On the other hand, the potential damage to the endothelium that lines the access system is not negligible.

Aspirin, dipyridamole, low-molecular-weight heparin, ticlopidine and clopidogrel might all prevent thrombosis. A number of in vitro and in vivo studies point to a beneficial effect of dipyridamole on smooth muscle proliferation and access stenosis [36,37]. Aspirin, however, was found to have a deleterious impact [37,38]. In other studies, however, a positive clinical effect of aspirin was demonstrated, either in conjunction with AV shunts or with Cimino-Brescia fistulae [39–42]. Controlled, long-term, recent clinical studies focusing on AV fistulas, however, are lacking.

Several possibilities are available for the correction of thrombosis: thrombolysis, thrombectomy, thrombectomy plus revision, and the creation of a new vascular access. Thrombectomy results in the lowest subsequent access survival [43]. Thrombolysis is contra-indicated in patients with a recent cerebrovascular accident, recent polytrauma and coagulation disturbances. Complications include bleeding and allergic reactions. The creation of a new vascular access implies the loss of a segment of vessels of the arm for future access. Hence, thrombectomy plus revision seems to be the most attractive possibility.

Conclusion

Vascular access problems remain the Achilles heel of modern haemodialysis. Indwelling catheters cause significant morbidity. Native fistulae function longer and better than PTFE grafts. PTFE grafts fail because of myo-intimal hyperplasia causing venous stenosis, which frequently also lies at the origin of thrombosis of the AV fistula. Screening tests can detect venous stenosis, which in turn predicts thrombosis. Prophylactic angioplasty can prolong access survival but its long-term effects have not been well established.

References


