9. Diagnosis and treatment of access-induced ischaemia

Guideline 9.1. Access-induced ischaemia should be detected by clinical investigation and the cause should be identified by both non-invasive imaging methods and angiography (Evidence level III).

Guideline 9.2. Enhancement of arterial inflow, access flow reduction and/or distal revascularization procedures are the therapeutic options. When the above methods fail, access ligation should be considered (Evidence level II).

Rationale

Access-induced upper extremity ischaemia is a serious complication that, when not treated in time may lead to major amputation [1] From published series, it can be estimated that the incidence of symptomatic ischaemia varies from 2% to 8% of the haemodialysis population [2,3]. Elderly patients, diabetics and patients with peripheral and/or coronary arterial obstructive disease are more prone for the development of access-induced ischaemia. In addition, previous ipsilateral vascular access increases the risk. Access-induced ischaemia occurs more often in proximally located fistulas [4]. These high-flow AVFs induce a steal phenomenon with lowering of distal perfusion pressures and, when collateral circulation is inadequate, symptoms may occur [5–8]. A grade 1–4 classification for access-induced ischaemia (grade 1: pale/blue and/or cold hand without pain, grade 2: pain during exercise and/or HD, grade 3: ischaemic pain at rest and grade 4: ulceration, necrosis and gangrene) can be used to outline the severity of the disease and this ranges from minor symptoms to finger necrosis. A number of these patients have increasing pain during dialysis treatment. For grade 1 and 2 ischaemia a conservative treatment is indicated, while with grade 3 and 4, interventional treatment is indicated [9].

Diagnosis of access-induced ischaemia

Physical examination, including observation and palpation of peripheral vessels, may be inadequate and misleading for the diagnosis of symptomatic ischaemia. Additional non-invasive testing with measurement of digital pressures and calculation of the digit-to-brachial index (DBI), transcutaneous oxygen determination, ultrasonography of forearm arteries and access blood flow measurement are important steps in the diagnosis and decision-making process [10,11]. Finally, angiography with visualization of the upper extremity arterial tree from the proximal subclavian artery to the distal palmar arches with and without AVF compression to enhance distal flow, is obligatory to outline the strategy for treatment and to determine whether interventional or surgical options are preferred [12].

Management of access-induced ischaemia

The options for treatment depend on the aetiology of the ischaemia: inflow arterial obstruction and/or distal arterial lesions are recanalized with small-calibre balloons and stent implantation [13–15], high-flow AVFs, as mainly observed in patients following successful renal transplantation are eligible to flow-reducing procedures like banding and distal arterial extension [16–18]. Steal in itself may be cured by ligation of the artery distal of the arteriovenous anastomosis [19]. In most patients it is necessary to add a saphenous vein graft bypass to the forearm arteries (DRIL ¼ distal revascularization þ interval ligation). The results of these procedures are usually good with relief of symptoms and preservation of the access site (Table 1) [20–27]. A simple alternative of the DRIL procedure is the PAVA (proximal arteriovenous anastomosis) technique, in which the AV anastomosis at the elbow is disconnected and moved to the axilla by means of a graft interposition [28,29]. Intra-operative digital pressure measurement or transcutaneous oxymetry ($TcPO_2$) is mandatory to guarantee an adequate surgical intervention with acceptable outcome. A digital-brachial pressure index >0.60 or $TcPO_2$ of >40 mm Hg is indicative of a sufficient distal hand perfusion [30–32]. The same DBI threshold may be also predictive for the development of ischaemia in predialysis patients receiving new vascular access [33–35]. In some patients, AVF ligation and change in renal replacement modality (to continuous ambulatory peritoneal dialysis ¼ CAPD) or transition to central venous catheter access, may be the only solution.

Prevention of access-induced ischaemia

An adequate preoperative evaluation and surgical technique are the keystones to avoid ischaemia. Physical examination of peripheral pulses, bruits, and measurement of bilateral arm blood pressures are essential for the work-up before AVF creation. Duplex ultrasonography is very useful in the assessment of not only superficial veins but also arteries. Preoperative measurement of digital pressures may be helpful to indicate patients at risk for ischemia. Patients with preoperative digit-to-brachial indices (DBI) <1.0 are more likely to develop steal, but there is no DBI threshold below which steal is inevitable. If there is any doubt concerning the status of the peripheral circulation, angiography or MRA is advised. Steal is more likely in patients undergoing brachial-based arteriovenous fistulae than in those receiving prosthetic grafts.

Table 1. Results of distal revascularization and interval ligation (DRIL) procedure for the treatment of access-induced ischemia

Author	No. of patients	Success in %	AVF patency (%)
Schanzer et al. [20]	14	93	82
Haimov et al. [21]	23	96	73
Katz et al. [22]	6	83	100
Berman et al. [23]	21	100	94
Lazarides et al. [3]	7	94	–
Stierli et al. [24]	6	100	100
Knox et al. [25]	52	90	83
Diehl et al. [26]	12	100	100
Sessa et al. [27]	18	73	94

Therefore, a limited length of the arteriovenous anastomosis of 10 mm in radial-cephalic and 5–7 mm in graft and/or brachial-cephalic/basilic AVFs, may contribute to the prevention of large volumes of blood shunting through the AVF. Either a ‘‘non-smooth’’ anastomosis (90° or 180° angle) adds to a greater anastomotic resistance and thus limitation of flow.

Recommendations for further research

Further search for pre-operative indicators that outline the risk on post-operative ischaemia may help to take adequate measures for prevention.

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