M. Midia_Quality Improvement Guidelines for Percutaneous Image Guided Management of The Thrombosed or Dysfunctional Dialysis Circuit
9-15-15

Quality Improvement Guidelines for PERCUTANEOUS IMAGE GUIDED MANAGEMENT OF THE THROMBOSED OR DYSFUNCTIONAL DIALYSIS CIRCUIT

Standards of Practice Committee

Revisions Committee

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SIR Standards of Practice Committee  
Quality Improvement Document Template  

Percutaneous Image Guided Management of The Thrombosed or Dysfunctional Dialysis Circuit

Preamble

The membership of the Society of Interventional Radiology (SIR) Standards of Practice Committee represents experts in a broad spectrum of interventional procedures from both the private and academic sectors of medicine. Generally Standards of Practice Committee members dedicate the vast majority of their professional time to performing interventional procedures; as such they represent a valid broad expert constituency of the subject matter under consideration for standards production.

Technical documents specifying the exact consensus and literature review methodologies as well as the institutional affiliations and professional credentials of the authors of this document are available upon request from SIR, 3975 Fair Ridge Dr, Ste 400 North, Fairfax, VA 22033.

Methodology

SIR produces its Standards of Practice documents using the following process. Standards documents of relevance and timeliness are conceptualized by the Standards of Practice Committee members. A recognized expert is identified to serve as the principal author for the standard. Additional authors may be assigned dependent upon the magnitude of the project.

An in-depth literature search is performed using electronic medical literature databases. Then a critical review of peer-reviewed articles is performed with regards to the study methodology, results, and conclusions. The qualitative weight of these articles is assembled into an evidence table, which is used to write the document such that it contains evidence-based data with respect to content, rates, and thresholds.
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When the evidence of literature is weak, conflicting, or contradictory, consensus for the
parameter is reached by a minimum of 12 Standards of Practice Committee members using a
Modified Delphi Consensus Method (Appendix A, last two references). For purposes of
these documents consensus is defined as 80% Delphi participant agreement on a value or
parameter.

The draft document is critically reviewed by the Revisions Subcommittee members of the
Standards of Practice Committee, either by telephone conference calling or face-to-face
meeting. The finalized draft from the Committee is sent to the SIR membership for further
input/criticism during a 30-day comment period. These comments are discussed by the
Subcommittee, and appropriate revisions made to create the finished standards document.
Prior to its publication the document is endorsed by the SIR Executive Council.

INTRODUCTION

Percutaneous endovascular interventions have been widely used and proven as the standard of
care in the management of dysfunctional dialysis access and as an effective alternative when
compared to similar surgical interventions. This document is meant to provide an update on key
topics relevant to endovascular management of thrombosed or dysfunctional dialysis access
since the first SIR guidelines published in 2003. Review of this document will allow the reader
to become familiar with the benefits of the National Kidney Foundation Kidney Disease
Outcomes Quality Initiative (NKF-DOQI) guidelines as they relate to dialysis access. Moreover,
the current assessment of dialysis access using a spectrum of invasive and non-invasive tests, as
well as indications and contraindications to percutaneous intervention and their success and
complication threshold rates are reviewed and updated.

A well-functioning and reliable vascular access is a vital component in the optimal care of
hemodialysis-dependent patients with end stage renal disease (ESRD). Long-term hemodialysis
access is most commonly secured through the creation of an arteriovenous fistula (AVF) or an
arteriovenous graft (AVG). There are advantages and disadvantages for both types of
hemodialysis arteriovenous access. AVFs are usually given their higher cumulative patency rates
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and lower associated morbidity and mortality rates relative to AVGs [1-6]. However, up to 30%-60% of AVFs may fail to mature, or thrombose. [4-12].

There is a positive correlation between the duration and frequency of hemodialysis and patient morbidity and mortality [13]. All hemodialysis accesses inevitably fail with time. [13-15]. Restoration of thrombosed and dysfunctional hemodialysis access can be achieved with either image-guided percutaneous interventional procedures, surgery or a combination of these methods [13, 16]. Endovascular management has replaced open surgery as the primary treatment method of dysfunctional and thrombosed dialysis accesses where possible. [3,16-18].

Multidisciplinary care and maintenance of the hemodialysis circuit is critical in achieving optimal patient outcomes [19]. All interventions in hemodialysis patients should be planned and executed with the aim to preserve an individual patient’s finite useable arterial and venous segments for establishing future arteriovenous accesses. There are a number of percutaneous image guided interventions that are used in the management of dysfunctional hemodialysis access (AVGs and AVFs), which includes pharmacologic thrombolysis [20,21], mechanical thrombectomy [20-25], balloon angioplasty [26-28], stent or stent graft placement [29-32], and/or a combination of these methods [33].

To prevent adverse outcomes, NKF KDOQI guidelines suggest routine and regular performance of the following: a) monitoring the access with physical examinations; b) periodic surveillance using invasive and noninvasive methods to measure access blood flow (QA), dialysis venous pressure (VP) and access recirculation (AR); and c) diagnostic imaging (Doppler ultrasonography and fistulography) when an abnormality is detected. CT angiography or magnetic resonance angiography are occasionally indicated when there is suspicion for an arterial steal syndrome or an inflow lesion, depending on a patient’s allergy to contrast medium [13, 34]. However, the most efficient and beneficial surveillance strategies for reducing access thrombosis and increasing vascular access survival are still in debate [36-38]. The potential weaknesses of the aforementioned surveillance paradigm include: 1) lack of accurate and reliable screening methods to predict thrombosis, 2) questionable benefits and potential harms of the preventative interventions (for example, angioplasty promoting neointimal hyperplasia), and 3) concerns on the validity of clinical trial results and recommendations on specific thresholds for interventions [35-37, 39].

Patients are referred for further diagnostic work-up and therapeutic interventions if a trend is documented on subsequent assessments [35]. Endovascular management of a thrombosed or dysfunctional hemodialysis access is often performed on an outpatient basis. Thus assessment of patients prior to a procedure is necessary for identifying patients at high risk for complications.
and who would potentially require periprocedural admissions. [40, 41]. This may include
patients with aneurysmal dilatation of the dialysis circuit that may require thrombolysis for an
extended period of time. [41]. Physical examinations can be helpful in assessing access
dysfunction [35, 42-44]. Up to 90% of patients with an abnormal physical examination have a
significant abnormality on imaging [42-46]. Imaging of the AVF/AVG is a prerequisite in
performing dialysis access interventions and allows for further immediate assessment of a
treatment’s efficacy.

Imaging assessment of an access, which includes the use of Doppler ultrasonography and/or
fistulography, should include the arterial inflow, anastomosis and the entire venous outflow tract down
to the cavoatrial junction”. Doppler ultrasonography is an accurate tool in identifying the presence,
location, and severity of access stenosis but it is not sensitive and specific enough to reliably
quantify access flow [47, 48]. Doppler ultrasound is also useful in determining causes of a non-
maturing AVF and could be used to guide endovascular interventions [49-51].

Fistulography facilitates detailed imaging of the entire hemodialysis circuit including the central
veins. Fistulography is commonly performed with iodinated contrast. Carbon dioxide (CO₂)
could be used when performing a fistulogram in patients with severe contrast allergy or those
with residual renal function. However, CO₂ fistulography is less reliable in delineating the veins,
may overestimate the degree of a stenoses, and should be performed with caution as it may cause
arterial embolization and stroke [52]. Systemic and access site infection, particularly in patients
with thrombosed access, is a contraindication for fistulography [53, 54]. When hemodynamic
significance of stenosis is difficult to ascertain based on angiographic findings, a pull-back
pressure measurement could be obtained, although there is no consensus in the literature as to
what gradient indicates a hemodynamically significant venous stenosis [55].

Dialysis circuit blood flow measurements may be useful in providing more accurate quantitative
hemodynamic information [56, 57]. Blood flow measurement (Qa), has close correlation with
inflow stenoses in AVFs, however, its role in AVGs is controversial, as a decline in access flow
could be minimal until a high degree of stenosis develops.[55]. Many Q thresholds have been
proposed in the screening for AVF dysfunction [58]. KDOQI Guidelines recommend AVF
intervention if Qa is lesser than 450-500 ml/min. A ratio of venous access pressure to mean
arterial pressure (VAPR) greater than 0.55 has been shown to be a reliable criterion for detection
of outflow stenoses in AVGs. VAPR may show lesser variation in an AVF while a stenosis is
developing because of collateral pathways that provide alternate routes to bypass significant
outflow stenoses. The role of new functional end points in assessing hemodialysis access
function such as resistive index and pressure drop coefficient is yet to be established [49, 57].
Thrombolysis, thrombectomy and balloon angioplasty are commonly used techniques in restoring hemodialysis circuit patency [22-25, 59]. Early identification and intervention of thrombosed hemodialysis circuits aiming to achieve patency in 24-48 hours when feasible is desired [85, 86]. Regardless of the technique used to restore patency, hemodialysis circuit thrombosis is associated with up to 70% rate of irreversible access failure within the first year of the intervention [60-62]. A newly established fistula, long segment outflow venous stenosis, multiple stenoses or occlusions, or being elderly or diabetic have been associated with reduced primary patency after angioplasty [63-66].

In certain cases, the use of a stent or stent graft placement is required to achieve patency in dialysis circuits [29-32, 67-70]. Potential indications for using stents and stent grafts as an alternative to surgery include treating refractory AVG circuit stenoses, central vein stenoses including cephalic arch stenosis, post angioplasty circuit ruptures and pseudoaneurysms. Stent placement may be advantageous over balloon angioplasty in achieving primary patency of dialysis circuit stenoses, particularly in treatment of graft-vein anastomotic and venous outflow stenoses. However, it is not clear if there is a significant benefit to using stent placement over angioplasty for treating AVF stenoses or establishing secondary access patency [71]. The benefits of using stent grafts in restoring hemodialysis circuit patency should be weighed against the risk of loss of useable arterial and venous segments for establishing future arteriovenous accesses, and other potential complications of stent grafts such as infection, stent kinking, stent crushing, and stent strut protrusion and migration. Up to 16% of stent-implanted AVGs are eventually surgically revised as a result of graft infection. [72-76].

Reduction of hemodialysis circuit patency is most commonly caused by venous intimal hyperplasia. Venous hyperplasia is initiated by injuries of the endothelial layer as a result of surgical trauma, hemodynamic shear stress vessel wall injury due to needle punctures (upstream events), all of which result by the cascade of inflammatory processes including leukocyte adhesion, migration of smooth muscle cells from the media to the intimal layer, and endothelial proliferation (downstream events) [77]. Despite advances in the understanding of the pathogenesis of neointimal hyperplasia, the role and efficacy of novel therapies and techniques (i.e. cutting balloon angioplasty, cryoplasty, drug eluding stents, systemic pharmacological agents, perivascular drug delivery, and cellular and gene therapies) in treating dysfunctional hemodialysis circuits are still evolving [2, 27, 59, 78-81].

Early detection and intervention for non-maturing AVFs could prevent early access failure. The majority of AVF failures are due to stenotic lesions in the access circuit that are often progressive. In addition, patients with early access failure are often committed to tunneled
dialysis catheters, which can result in complications such as central venous stenosis [82, 83]. Despite early intervention, the longevity of an immature AVF requiring two or more interventions is usually poor [84].

Surgical shunt revision should be considered in patients that require repetitive interventions in a short time interval (angioplasty is required more than two times within three months) if there are no contraindications, if access thrombosis occurs more than two times within a one month interval, or if a recurrent correctable lesion is identified [13, 88]. In patients with recurrent occlusions of hemodialysis vascular access, hypercoagulability testing should be considered [89].

Hemodialysis access dysfunction can result in distal hypoperfusion ischemia syndrome (DHIS), which may manifest as ischemia in the extremity harboring the access or heart failure. In these cases, decision to treat is based on the severity of the patient’s signs and symptoms. Arterial angioplasty and surgical revision can relieve ischemic symptoms resulting from the presence of an atherosclerotic stenosis in the arterial supply to the extremity. [90-92].

This guideline is written to be used in quality improvement programs to assess percutaneous management procedures for thrombosed or dysfunctional hemodialysis circuit. The most important processes of care are (1) patient selection, (2) performing the procedure, and 3) monitoring the patient. The outcome measures or indicators for these processes are indications, success rates, and complication rates. Outcome measures are assigned threshold levels.

DEFINITIONS

Mature or functional dialysis circuit: A dialysis circuit that (1) is functional when the flow is >600 ml/min or when the vein has a minimum diameter of 6 mm for arteriovenous fistulae (AVFs), (2) does not exceed a depth of 0.6 cm, (3) has margins that are clearly identifiable when a tourniquet is in place, and (4) 6 cm of access venous segment is accessible for cannulation [14]. The dialysis circuit should be evaluated for non-maturation 4-6 weeks after surgical creation if it does not meet the above criteria. [93, 94].

Thrombosed dialysis circuit: A hemodialysis circuit (fistula or graft) with thrombotic occlusion and lack of significant blood flow. Thrombus may extend into the outflow veins or inflow arteries. Thrombosed AVFs, especially those with aneurysmal dilatation, may harbor significantly larger amounts of thrombus compared to thrombosed AVGs and therefore could require admission for percutaneous intervention.
Dysfunctional dialysis circuit: (1) A hemodialysis circuit that has a hemodynamically significant stenosis, (2) a native fistula that fails to mature during an adequate time period (usually 4-6 weeks), or (3) a circuit that cannot be successfully punctured to perform dialysis (provide the minimum flow during dialysis). Dysfunctional dialysis circuits are clinically defined by variation in thrill/bruit, difficult cannulation, recirculation, excessive bleeding from the venipuncture site, and ultimately thrombosis. Dialysis circuit flow values suggesting a dysfunctional dialysis circuit include (1) flow rates <600 mL/min and <400-500 mL/min for AVFs and AVGs, respectively (or a decrease of more than 25%-33% from baseline normal flow rate), (2) AVGs or AVFs that have a venous static pressure ratio greater than 0.5-0.4, or (3) AVGs with an arterial segment static pressure ratio greater than 0.75. A venous pressure ratio of 0.4 has 91% sensitivity and 86% specificity for identifying AVG stenoses of at least 50% [88, 95-98].

Dialysis circuit recirculation: In a dysfunctional dialysis circuit, access recirculation (AR) occurs when blood from the venous port (dialyzed blood) reenters the dialyzer through the arterial port to support the extracorporeal blood flow rate set by the blood pump. [13]. The percentage of AR greater than 10% is accepted as abnormal. But any access recirculation should prompt an investigation [13, 36, 88]. In measuring AR, three separate measurements in succession are suggested to account for different variables such as the type of dialyzer machine, tubing size and needle gauge used for measuring recirculation. Apart from improper needle placement, the most common causes of access recirculation are the presence of high-grade venous stenosis, and inadequate arterial blood flow rate [14].

Arterial steal syndrome: Arterial steal syndrome is a misnomer and distal hypoperfusion ischemia syndrome (DHIS) is suggested as more appropriate for describing the underlying pathophysiology. Arterial steal or shunting is present in the majority of patients with upper limb hemodialysis access but only a minority of these patients develop symptoms of the syndrome [99]. DHIS is usually due to inflow problems but occasionally it can also be due to high flow through the fistula. DHIS can present as cardiac failure or ischemic symptoms in the fistula harboring extremity (i.e. paresthesias, pain, motor weakness, sensory loss, or tissue loss) [92].

Early versus late fistula failure: Early failure is defined as AVFs that were never usable or failed within three months of use. Late failure is defined as failure that occurred after a period of normal usage (usually accepted as greater than 3 month) [100].

Fistulogram: An angiogram used to visualize and evaluate a hemodialysis circuit, components of which include the arterial anastomosis site, the fistula or graft, and outflow veins, including the ipsilateral central veins, vena cava and the right atrium. Multiple orthogonal projections are Copyright © 2015 by the Society of Interventional Radiology. All rights reserved. No part of this publication covered by the copyright hereon may be reproduced or copied in any form or by any means - graphic, electronic, or mechanical, including photocopying, taping, or information storage and retrieval systems - without written permission of the publishers.
often helpful to better visualize lumen size and patency, and to characterize stenotic lesions. When hemodynamic indicators or clinical symptoms cannot be explained by fistulography, evaluation of the inflow arteries may be required.

**Functionally significant stenosis:** An anatomically significant stenosis with >50% reduction of normal vessel diameter (graft, inflow and outflow vessels) and accompanied by a hemodynamic or clinical abnormality[13], such as:

1. Change in physical examination characteristics of the thrill
2. Swelling in extremity harboring access
3. Clinical parameters such as prolonged bleeding after needle withdrawal
4. Inability to puncture the venous outflow and perform hemodialysis (excluding difficulty due to extrinsic hematoma or outflow vein that is buried too deep into the soft tissues and not necessarily due to a functionally significant stenosis)
5. Presence of collateral veins or developing venous aneurysm
6. Elevated venous pressures recorded during hemodialysis (static and dynamic pressures) or measured within the vascular access during a diagnostic study (static pressures)
7. Unexplained reduction in dialysis flow kinetics such as decreased intra-access blood flow at dialysis
8. Elevated negative arterial prepump pressures that prevent increases in blood flow to acceptable values.
9. Abnormal recirculation values

**Anatomic causes of dialysis circuit dysfunction:** Extrinsic or intrinsic abnormalities of the arterial inflow, or venous outflow that result in diminished access function. The great majority of anatomic causes are intrinsic to the graft or vessel. However, extrinsic compression can rarely contribute to dialysis circuit dysfunction (e.g., prosthetic graft kinking, pseudoaneurysm compression of the access, or compression from a periaccess hematoma). These abnormalities include:

1. Arterial (Inflow) problems
   a. Stenosis of the inflow artery to the access.
   b. Stenosis at the anastomotic site of an autogenous fistula or arterial anastomosis of synthetic graft.
   c. Stenosis at the peri-anastomotic segment of an autogenous fistula.
2. Access problems
   a. Stenosis of the graft or hypertrophied venous segment of an autogenous fistula.
3. Venous (Outflow) problems
   a. Venous anastomotic stenosis of prosthetic grafts.
b. Stenosis of the venous outflow, of access (from the venous-graft or arterial-venous anastomosis to the central veins).

c. Failure to mature. In the case of AVFs, multiple venous collaterals that divert blood flow away from the primary outflow vein can prevent the development of a hypertrophied outflow vein suitable for puncture [101, 102].

Note: While over 90% of access thromboses and dysfunction are due to underlying anatomic stenoses, occasionally an alternate process (e.g., low cardiac output, postdialysis hypotension, access site infection, dehydration, or a hypercoagulable state) can result in thrombosis of a prosthetic graft or autogenous fistula in the absence of an anatomic cause, or contribute to accelerated failure of the hemodialysis access [89]. Central venous stenoses are more often symptomatic in patients with AVGs compared with AVFs [98].

Endovascular management of thrombosed or dysfunctional dialysis circuits: The use of catheter-based endovascular techniques to restore or maintain adequate blood flow within the access to support effective hemodialysis.

Endovascular thrombus removal: The removal of occlusive thrombus from within the graft or native fistula, including the outflow veins and inflow arteries to restore blood flow to the circuit. Removal of thrombus may be accomplished by any of the various percutaneous endovascular methods, such as thrombolysis, aspiration thrombectomy, balloon thrombectomy, clot maceration, or mechanical thrombectomy.

Endovascular treatment of a stenoses: The restoration of the luminal diameter of the treated vascular segment to an acceptable size (anatomic success), and resolution of the functional abnormality as documented by monitoring, surveillance or diagnostic testing [14]. Stenosis may be treated with balloon angioplasty. In selected instances, stents or stent grafts may be required to improve luminal dimensions or repair a vascular injury. Preventive intervention may be warranted for an anatomical stenosis that is accompanied by hemodynamic or clinically abnormal findings [103, 104].

Anatomic success of a treated stenoses: For stenoses without thrombosis, anatomical success is defined as less than 30% residual diameter stenosis of the treated vascular segment. For thrombosed accesses, anatomical success is defined as restoration of flow combined with a less than 30% residual diameter stenosis for any significant underlying stenosis [104, 105].

Clinical success: Defined as the resumption of normal hemodialysis for a minimum of at least
one session following percutaneous intervention. After the treatment of either a thrombosed or
stenotic dialysis circuit, a continuous palpable thrill (no pulse) extending from the arterial
anastomosis can be used as an indicator of clinical success [104].

**Hemodynamic success**: Defined as the normalization of hemodynamic parameters. A reduction
of venous dialysis pressures to below predefined threshold values can be considered evidence of
hemodynamic success. Also a reduction of static intragraft systolic pressure/cuffed brachial
systolic pressure ratios to below predefined thresholds can be considered as evidence of
hemodynamic success [20]. The goal is to achieve a normalized systolic pressure ratio of less
than 0.5 in the arterial limb and 0.33 in venous limb of the graft [88]. However, it should be
recognized that there are currently no uniformly accepted criteria of percent reduction in pressure
or pressure ratio from pretreatment values to determine hemodynamic success [104].

**Procedural success**: Defined as anatomic success plus at least one indicator of hemodynamic or
clinical success [104].

**Post-intervention primary patency**: The interval of uninterrupted patency after endovascular
intervention within a dialysis circuit to thrombosis or repeated endovascular intervention. [104,
105].

**Post-intervention assisted primary patency**: The interval of patency after an endovascular
intervention until dialysis circuit thrombosis or a surgical intervention of the access circuit [104].
Endovascular intervention(s) on a previously treated lesion or a new arterial or venous outflow
stenosis/occlusion (excluding access thrombosis) are compatible with assisted primary patency.
Assisted primary patency ends with percutaneous thrombolysis/thrombectomy or surgical circuit
thrombectomy [104].

**Post-intervention secondary patency**: The interval of patency after a endovascular intervention
until the dialysis circuit is surgically declotted, revised or abandoned because of inability to treat
the original lesion, multidisciplinary team decision, interval renal transplant, or patient lost to
follow-up, etc. [104].

**Cumulative patency**: The total time the dialysis circuit remains patent (regardless of the number
of primary interventions and/or thrombectomies) during a given time period. Cumulative patency
begins at the time that the graft is first placed [13].

**Complications** can be stratified on the basis of outcome. *Major* complications result in:
admission to a hospital for therapy (for outpatient procedures), an unplanned increase in the level
of care, prolonged hospitalization, permanent adverse sequelae, or death. Minor complications result in no sequelae; they may require nominal therapy or a short hospital stay for observation (generally overnight). (See Appendix B). The complication rates and thresholds below refer to major complications unless otherwise specified.

Published complications rates and suggested thresholds are given in Tables 6-7. Major and minor complications occur in up to 18% of patients. Complication rates can be expected to be lower with management of non-thrombosed dialysis access.

INDICATIONS

The decision to treat a dialysis circuit with endovascular techniques is always made in light of the patient’s clinical presentation and comorbidities, the number of potential alternative access sites available, and the expertise of the treating medical team.

Indications for the treatment of non-thrombosed fistulae/grafts:

Stenosis without thrombosis that occurs in a dialysis circuit should be treated with endovascular techniques when:

1. Clinically or hemodynamically significant dialysis circuit abnormalities or distal ischemia symptoms are present. These abnormalities include reduction in flow, increase in pressure or access recirculation preempting adequate delivery of dialysis, abnormal physical exam findings or symptoms interfering with use of dialysis access; or

2. Stenosis of >50% of the lumen diameter in either venous outflow or arterial inflow (considered functionally significant, see Definitions) is present. Intervention is indicated if clinical and angiographic findings are both abnormal and concordant.

Indications for the treatment of thrombosed fistulae and grafts:

Stenosis(es) with thrombosis occurring in a dialysis circuit should be treated with endovascular techniques when:

1. Perianastomotic stenosis is present. In the setting of graft thrombosis these lesions should be initially treated with a combination of thrombolysis or thrombectomy and balloon angioplasty; or

2. Underlying venous stenosis is present. Thrombosis is associated with underlying venous stenosis in >85-90% of cases.

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Indications for the treatment of central vein stenosis:

Treatment of central vein stenosis is indicated when the stenosis is >50% of the lumen diameter or when the dialysis circuit is hemodynamically compromised or non-maturing. The decision to treat a central vein stenosis should be based primarily on clinical parameters, such as debilitating arm swelling or frequently failing accesses. Endovascular intervention with transluminal angioplasty is the first-line treatment of central vein stenosis [68].

Indications for the use of stents and stent grafts:

Stents or stent grafts should be considered for use with:

1. Failed angioplasty (refractory stenosis (es)) i.e., persistent stenosis and hemodynamically abnormal findings after angioplasty) despite the use of high pressure balloons with subsequent acute elastic recoil of the vein or over 50% residual stenosis after angioplasty for central venous stenoses (including cephalic arch stenoses); or
2. Stenosis that recurs twice within 3 months after previously successful angioplasty in patients that are not good surgical candidates due to comorbidities or inadequate alternative long-term access sites; or
3. Acute repair of angioplasty-induced venous rupture that cannot be controlled with balloon tamponade; or
4. Dialysis circuit pseudoaneurysm [13, 76].

Indication for the treatment of non-maturing AVFs:

AVFs that have failed to mature after an appropriate amount of time (e.g. > 2 months) may be treated with the following endovascular techniques:

1. Balloon angioplasty of afferent pre-anastomotic stenosis (es) to the maturing AVF;
2. Balloon angioplasty of the anastomosis to increase inflow to the maturing venous limb; or
3. Percutaneous embolization of small venous tributaries and ligation of the accessory veins that shunt flow away from the main maturing vein to increase flow through this segment. [106].

Indications for the treatment of dialysis DHIS:

1. Clinical symptoms or signs of arterial steal ipsilateral to a functional fistula or graft; or

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CONTRAINDICATIONS

Contraindications for endovascular treatment of dysfunctional dialysis circuit include:

**Absolute Contraindications**

1. Hemodialysis access graft infection or overlying cellulitis.
2. Thrombosed fistula with cannulation site ulceration.

**Relative Contraindications**

1. Severe contrast allergy.
2. Correctable coagulopathy.
3. Severe hyperkalemia, acidosis, or both.
5. Within one month of dialysis access creation.
6. Contraindications to thrombolytic therapy, such as recent stroke, major abdominal surgery, known central nervous system neoplasm, and so forth (for procedures to be performed with fibrinolytic therapy, etc.). A variety of mechanical techniques may be used as an alternative in this situation.
7. An enlarged/aneurysmal fistula with extensive thrombus burden. Instead, surgical thrombectomy or surgical revision is advised.
8. A thrombosed fistula with the presence of distal ischemia of ipsilateral extremity.
   Depending on the underlying etiology, both endovascular and surgical techniques can be performed to correct DHIS symptoms including transluminal angioplasty, banding, flow reduction, distal revascularization and interval ligation.
9. Significant right to left shunt.
10. Significantly reduced cardiopulmonary reserve (e.g., pulmonary hypertension, severe lung disease, cardiomyopathy, and right heart failure).
11. A clotted fistula with numerous in situ stents.
12. Repeated angioplasty and declotting in short time intervals (2-3 interventions in 1-3 months).

Silent pulmonary embolism is common in patients with thrombosed AVG after thrombolysis/thrombectomy [160]. However, the practice of repeated endovascular thrombolysis is safe and has not been shown to cause significant change in pulmonary arterial pressure, although, the long-term clinical relevance is yet to be determined [107, 108]. The
presence of a patent foramen ovale is not a contraindication for hemodialysis access
thrombolysis. However, although rare, devastating paradoxical systemic embolism can occur
following percutaneous interventions for dysfunctional dialysis access [109-111].

QUALITY IMPROVEMENT

Success and Patency Rates
Indicator thresholds may be used to evaluate the efficacy of quality improvement programs. The
tables below (1-5) reflect the clinical success rates, and primary and secondary patency rates
reported in the published literature.

Table 1. Clinical Success and Patency Rates for Management with Angioplasty
(27, 66, 112-126)

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<th>AVF</th>
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<tr>
<td></td>
<td>Reported Rates (%)</td>
<td>Suggested Thresholds (%)</td>
</tr>
<tr>
<td>Clinical Success</td>
<td>87-100 (96)</td>
<td>2011 ACIR-SIR: 85</td>
</tr>
</tbody>
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| Patency
| 3 mos Primary | 68-93 (82)            | 80                    | 24-91 (72)            | 70                    |
| 6 mos Primary | 25-85 (61)            | 2011 ACIR-SIR: 50     | 3-63 (49)             | NKF-KDOQI, 2006: 50, 2011 |
|                | 12 mos Primary        | 25-74 (49)            | 7-41 (37)             | ACR-SIR: 25, 2003 SIR: 40 |
|                | 24 mos Primary        | 17-40 (30)            |                       |                       |
|                | 3 mos Secondary       | 91-96 (94)            |                       |                       |
|                | 6 mos Secondary       | 80-97 (90)            |                       |                       |
|                | 12 mos Secondary      | 67-91 (84)            | 81*                   |                       |
|                | 24 mos Secondary      | 68-79 (71)            | 47*                   |                       |

Reported rates are presented as range (weighted average based on sample size of the study)
*Based on one study only [123]
Table 2. Clinical Success and Patency Rates for Management with Stent or Stent Graft Placement (30, 32, 67, 70, 73, 122, 127-132)

<table>
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<td>Reported Rates (%)</td>
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<td>Reported Rates (%)</td>
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<tr>
<td>Clinical Success</td>
<td>98*</td>
<td>90</td>
<td>88-100 (91)</td>
<td>90</td>
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<tr>
<td>Patency</td>
<td>3 mos Primary</td>
<td>80†</td>
<td>80</td>
<td>37-88 (70)</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>6 mos Primary</td>
<td>39-82 (62)</td>
<td>60</td>
<td>11-91 (50)</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>12 mos Primary</td>
<td>32‡</td>
<td>17-61 (41)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>24 mos Primary</td>
<td>27†</td>
<td>46-56 (56)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6 mos Secondary</td>
<td>72*</td>
<td>70</td>
<td>48-68 (56)</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>12 mos Secondary</td>
<td></td>
<td>32-81 (56)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Reported rates are presented as range (weighted average based on sample size of the study):
- *Based on one study only [30]; †Based on one study only [127]; ‡Based on one study only [133]; §Based on one study only [132].

Table 3. Clinical Success and Patency Rates for Management with Pharmacologic Thrombolysis/Mechanical Thrombectomy (24, 25, 115, 134-150)

<table>
<thead>
<tr>
<th></th>
<th>AVF</th>
<th></th>
<th></th>
<th>AVG</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Reported Rates (%)</td>
<td>Suggested Thresholds (%)</td>
<td></td>
<td>Reported Rates (%)</td>
</tr>
<tr>
<td>Clinical Success</td>
<td>76-95% (87%)</td>
<td>2011 ACR-SIR: 75%</td>
<td></td>
<td>62-95% (86%)</td>
<td>2011 ACR-SIR: 85%</td>
</tr>
<tr>
<td>Patency</td>
<td>3 mos Primary</td>
<td>60-86% (68%)</td>
<td>2011 ACR-SIR: 30%</td>
<td>15-65% (41%)</td>
<td>2011 ACR-SIR: 40%</td>
</tr>
<tr>
<td></td>
<td>6 mos primary</td>
<td>34-58% (42%)</td>
<td>30%</td>
<td>11-72% (48%)</td>
<td>2011 ACR-SIR: 20% (30%)</td>
</tr>
<tr>
<td></td>
<td>12 mos primary</td>
<td>9-49% (24%)</td>
<td>41%†</td>
<td>9-56% (44%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>24 mos primary</td>
<td>6-40% (13%)</td>
<td>30%</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3 mos secondary</td>
<td>87%*</td>
<td>85</td>
<td>80%†</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6 mos secondary</td>
<td>75-90% (78%)</td>
<td>75</td>
<td>72-96% (88%)</td>
<td>2011 ACR-SIR: 65%</td>
</tr>
<tr>
<td></td>
<td>12 mos secondary</td>
<td>50-87% (72%)</td>
<td>74-93% (84%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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24 mos secondary 29-79% (40%) 56%‡

Reported rates are presented as range (weighted average based on sample size of the study);
*Based on one study only [134]; ‡Based on one study only [85]; †Based on one study only [147].

Table 4. Clinical Success and Patency Rates for Management of Nonmaturing AVFs (82, 116, 151-155)

<table>
<thead>
<tr>
<th>Reported Rates (%)</th>
<th>Suggested Thresholds (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical Success</td>
<td>79-100 (89)</td>
</tr>
<tr>
<td>Patency</td>
<td>70</td>
</tr>
<tr>
<td>3 mos Primary</td>
<td>54-84 (65)</td>
</tr>
<tr>
<td>6 mos Primary</td>
<td>17-78 (43)</td>
</tr>
<tr>
<td>12 mos Primary</td>
<td>34-75 (58)</td>
</tr>
<tr>
<td>24 mos Primary</td>
<td>23-60 (47)</td>
</tr>
<tr>
<td>3 mos Secondary</td>
<td>82*</td>
</tr>
<tr>
<td>6 mos Secondary</td>
<td>76-79 (78)</td>
</tr>
<tr>
<td>12 mos Secondary</td>
<td>68-90 (79)</td>
</tr>
<tr>
<td>24 mos Secondary</td>
<td>53-82 (69)</td>
</tr>
</tbody>
</table>

Reported rates are presented as range (weighted average based on sample size of the study)
*Based on one study only [152]
The majority of procedures were PTA

Table 5. Clinical Success and Patency Rates of Accesses with Central Venous Stenoses (156-158)

<table>
<thead>
<tr>
<th>Angioplasty</th>
<th>Stent &amp; Stent Graft Placement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reported Rates (%)</td>
</tr>
<tr>
<td>Clinical Success</td>
<td>100*</td>
</tr>
<tr>
<td>Patency</td>
<td>90*</td>
</tr>
<tr>
<td>3 mos Primary</td>
<td>23-83 (63)</td>
</tr>
<tr>
<td>6 mos Primary</td>
<td>12-77 (55)</td>
</tr>
<tr>
<td>6 mos Secondary</td>
<td>100‡</td>
</tr>
</tbody>
</table>
Reported rates are presented as range (weighted average based on sample size of the study);
*Based on one study only [156]; ‡Based on one study only [157].

Complications
Complications are categorized into major and minor complications. Major and minor complications are defined according to the Society of Interventional Radiology (SIR) Standards of Practice Classifications [88]. Please note that the published rates are dependent on the patient selection of each study and are only reported for studies that differentiate major and minor complications based on SIR guideline definitions (28, 62, 115-116, 118-120, 159).
# Table 6. Major Complication Rates and Thresholds

<table>
<thead>
<tr>
<th></th>
<th>AVF</th>
<th></th>
<th></th>
<th>AVG</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reported Rates (%)</td>
<td>Suggested Threshold (%)</td>
<td>Complication Type</td>
<td>Reported Rates (%)</td>
<td>Suggested Threshold (%)</td>
<td>Complication Type</td>
</tr>
<tr>
<td>All interventions</td>
<td>0-4.6 (1.1)</td>
<td>6</td>
<td>See below</td>
<td>0-10.3 (6.5)</td>
<td>7</td>
<td>See below</td>
</tr>
<tr>
<td>Angioplasty</td>
<td>0-4.6 (1.1)</td>
<td></td>
<td>Venous perforation, puncture site hematoma, pseudoneurysm, vessel rupture at angioplasty site, rupture and loss of AVF, stent migration to right atrium, ulnar nerve palsy</td>
<td>N/A</td>
<td></td>
<td>N/A</td>
</tr>
<tr>
<td>Stent and/or stent graft</td>
<td>0*</td>
<td>None</td>
<td></td>
<td>0*</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Thrombolysis/Thrombectomy</td>
<td>N/A</td>
<td>--</td>
<td>N/A</td>
<td>6-10.3 (7.9)</td>
<td></td>
<td>Bleeding (puncture and distal sites), broken nonretrievable occlusive balloon segment, arterial emboli, PTA rupture, significant extravasation, graft-related pseudoneurysm requiring surgical repair, infection of vascular access graft requiring surgical removal, angioplasty balloon fractured requiring surgical removal, sepsis and hypotension 29 days after procedure, cardiac arrhythmia leading to death, rupture of outflow brachial vein, arterial anastomosis during balloon application</td>
</tr>
</tbody>
</table>
 Reported rates are presented as range (weighted average based on sample size of the study); *Only based on one study [129]
Table 7. Minor Complication Rates and Thresholds

<table>
<thead>
<tr>
<th>AVF</th>
<th>Reported Rates (%)</th>
<th>Suggested Threshold (%)</th>
<th>Complication Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>All interventions</td>
<td>0-15 (2.3)</td>
<td>10</td>
<td>See below</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Puncture site psuedaneurysm, puncture site hematoma, avulsion of the balloon portion of the balloon catheter from shaft, vasovagal reaction, venous perforation, contrast extravasation</td>
</tr>
<tr>
<td>Angioplasty</td>
<td>0-7.8 (1.9)</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stent and/or stent graft</td>
<td>15*</td>
<td>15</td>
<td>Puncture site hematoma</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thrombolysis/Thrombectomy</td>
<td>N/A</td>
<td>--</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>AVG</th>
<th>Reported Rates (%)</th>
<th>Suggested Threshold (%)</th>
<th>Complication Type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.9-18.2</td>
<td>12</td>
<td>See below</td>
</tr>
<tr>
<td></td>
<td>(7.7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.9-18.2</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(8.2)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Reported rates are presented as range (weighted average based on sample size of the study); *Only based on one study [129]

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Appendix A

Consensus Methodology

Reported complication-specific rates in some cases reflect the aggregate of major and minor complications. Thresholds are derived from critical evaluation of the literature, evaluation of empirical data from Standards of Practice Committee members' practices, and, when available, the SIR HI-IQ™ System national database.

Consensus on statements in this document was obtained utilizing a modified Delphi technique. (1,2)

The Committee was unable to reach consensus on the following: ___________

References:

Appendix B

Society of Interventional Radiology
Standards of Practice Committee
Classification of Complications by Outcome

Minor Complications
A. No therapy, no consequence
B. Nominal therapy, no consequence; includes overnight admission for observation only.

Major Complications
C. Require therapy, minor hospitalization (<48 hours)
D. Require major therapy, unplanned increase in level of care, prolonged hospitalization (>48 hours).
E. Permanent adverse sequelae
F. Death.
Acknowledgments

Dr. Mehran Midia authored the first draft of this revised document and served as topic leader during the subsequent revisions of the draft. Dr. Sean R. Dariushnia is the chair of the Revision Subcommittee. Drs. T. Gregory Walker & James E. Silberzweig are co-chairs of the Standards of Practice Committee. Dr. Boris Nikolic is Councilor of the SIR Standards Division. All other authors are listed alphabetically. Other members of the Standards of Practice Committee and SIR who participated in the development of this revised clinical practice guideline are (listed alphabetically):

SIR Disclaimer

The clinical practice guidelines of the Society of Interventional Radiology attempt to define practice principles that generally should assist in producing high quality medical care. These guidelines are voluntary and are not rules. A physician may deviate from these guidelines, as necessitated by the individual patient and available resources. These practice guidelines should not be deemed inclusive of all proper methods of care or exclusive of other methods of care that are reasonably directed towards the same result. Other sources of information may be used in conjunction with these principles to produce a process leading to high quality medical care. The ultimate judgment regarding the conduct of any specific procedure or course of management must be made by the physician, who should consider all circumstances relevant to the individual clinical situation. Adherence to the SIR Quality Improvement Program will not assure a successful outcome in every situation. It is prudent to document the rationale for any deviation from the suggested practice guidelines in the department policies and procedure manual or in the patient’s medical record.
References


Percutaneous Image Guided Management of The Thrombosed or Dysfunctional Dialysis Circuit

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