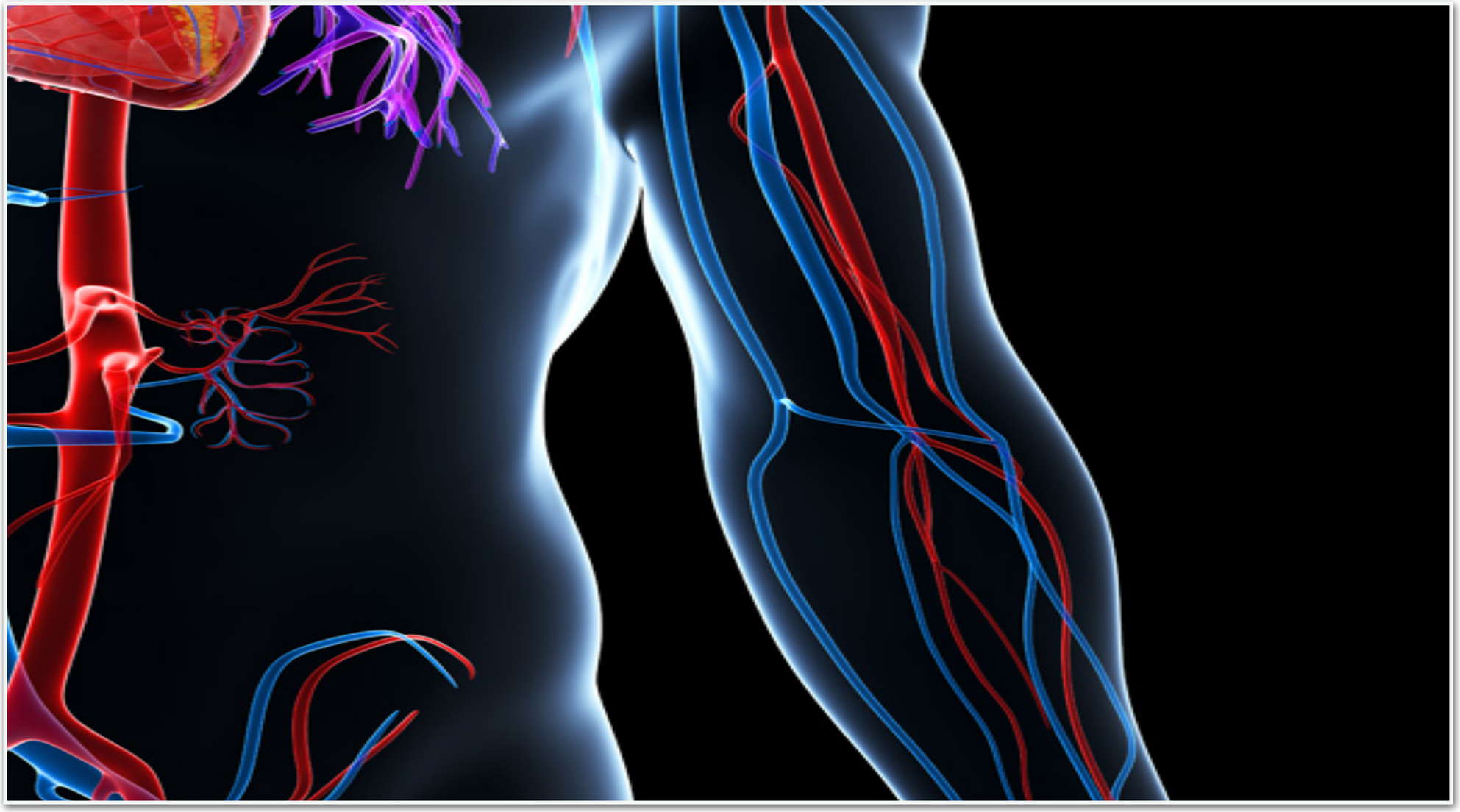
Vascular access and anticoagulation



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Vascular access outline

- Patient first : ESKD Life-Plan
- Type of vascular access
- Arteriovenous (AV) access planning
- Vessel preservation
- AV access cannulation
- AV access monitoring
- AV access complication

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ESKD life-plan and vascular access choice

- Reasonable that each patient with progressive CKD and/or with an eGFR 15-20 mL/min/1.73m2 or already on kidney replacement therapy should have individualised ESKD Life-Plan that is regular reviewed, updated, and documented on their medical record (Expert Opinion)

- Reasonable to conduct an annual review and update of each patients's individualized ESKD Life-Plan together with their health care team. (Expert Opinion)

- In addition to regular monitoring, a minimum quaterly overall review and update of each patient's vascular access functionality, complication risks, and potential future dialysis access options be done together with their health care team. (Expert Opinion)

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ESKD Life-Plan

- Strategy start in the predialysis period to ESKD
- Continuum of care model
- Maximize ESKD **modality choices** and **utilization** for a specific patient lifespan
  - Medical situation
  - Functional status
  - Logistics

Dialysis access

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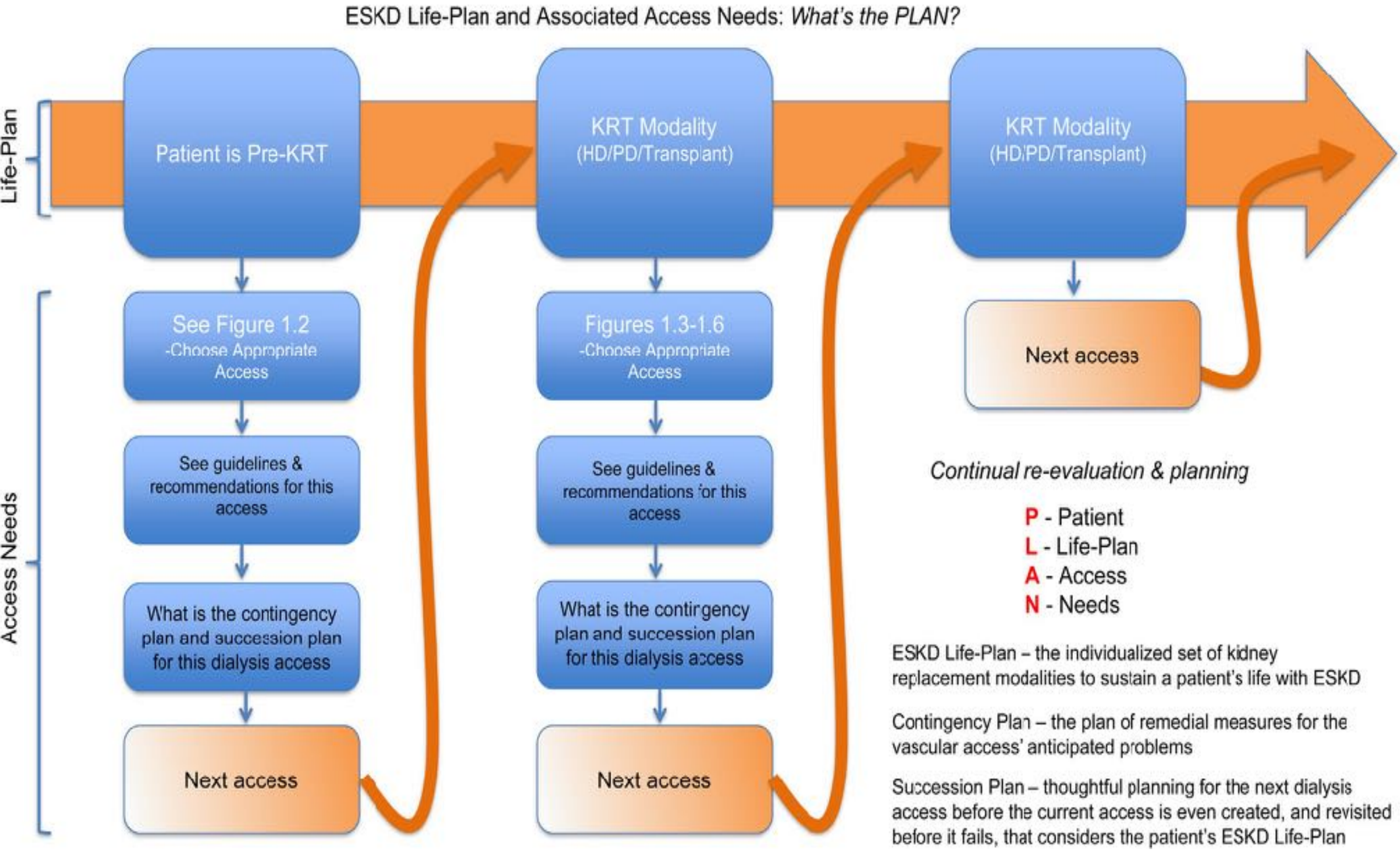
Right access, Right time, Right patient



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The Pre-KRT Patient Being Considered for Hemodialysis

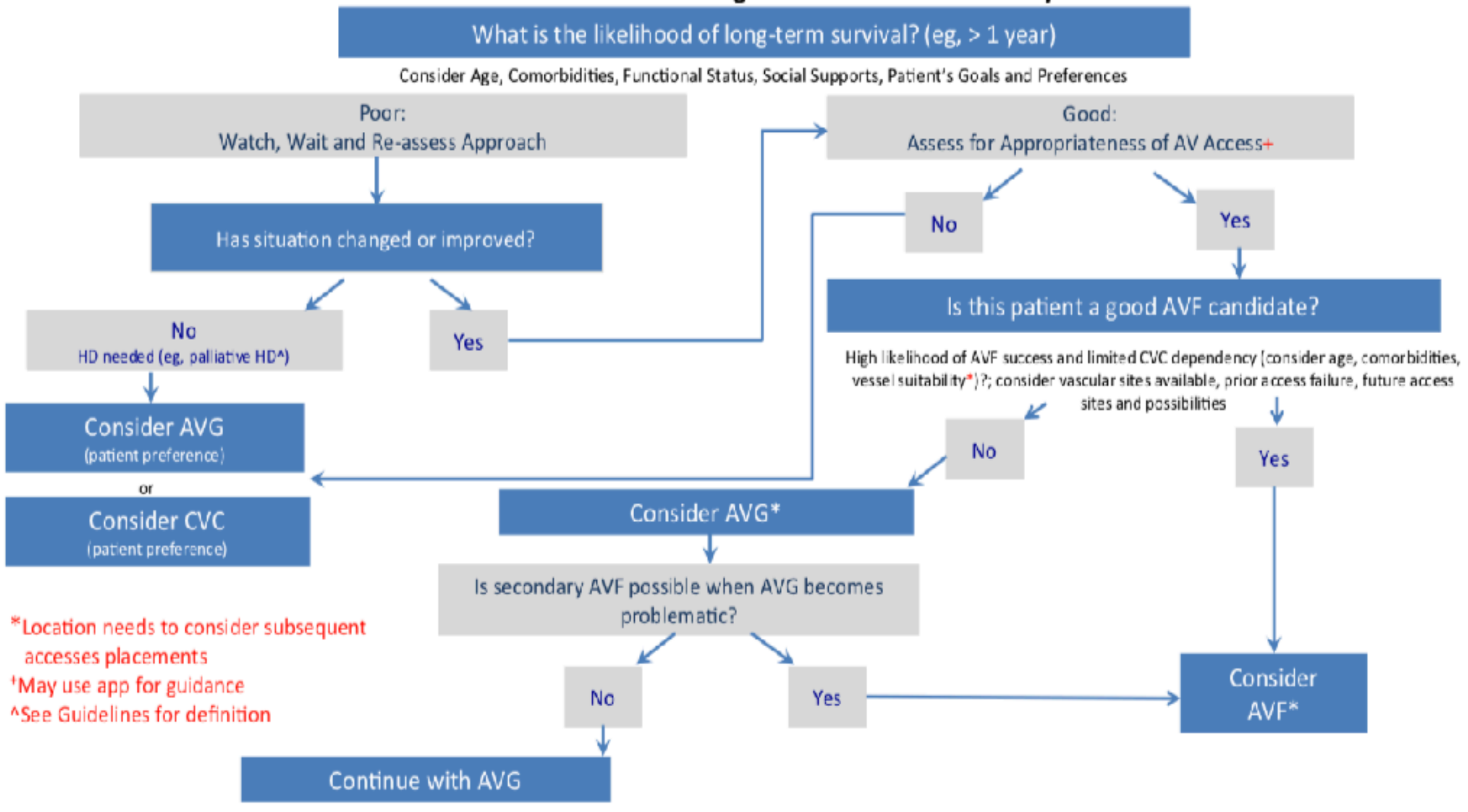

Figure 1.2. The pre-KRT patient being considered for hemodialysis. Abbreviations: AV, arteriovenous; AVF, arteriovenous fistula; CVC, central venous catheter; HD, hemodialysis; KRT, kidney renal replacement therapy; PD, peritoneal dialysis.

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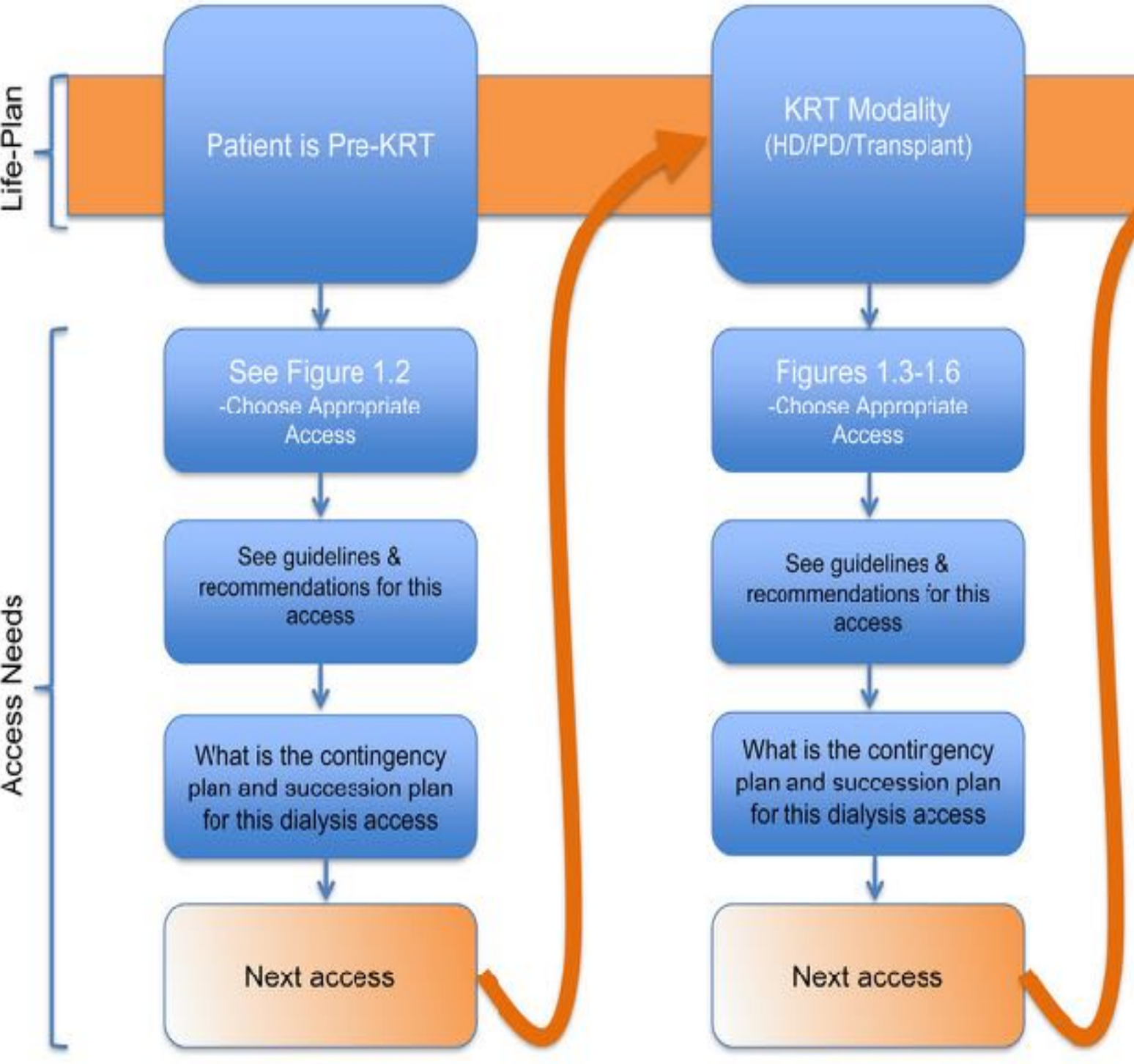
ESKD Life-Plan and Associated Access Needs: *What's the PLAN?*



Continual re-evaluation & planning

P - Patient
L - Life-Plan
A - Access
N - Needs

ESKD Life-Plan – the individualized set of kidney replacement modalities to sustain a patient's life with ESKD

Contingency Plan – the plan of remedial measures for the vascular access' anticipated problems

Succession Plan – thoughtful planning for the next dialysis access before the current access is even created, and revisited before it fails, that considers the patient's ESKD Life-Plan

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The Patient Is Already on Hemodialysis With a CVC

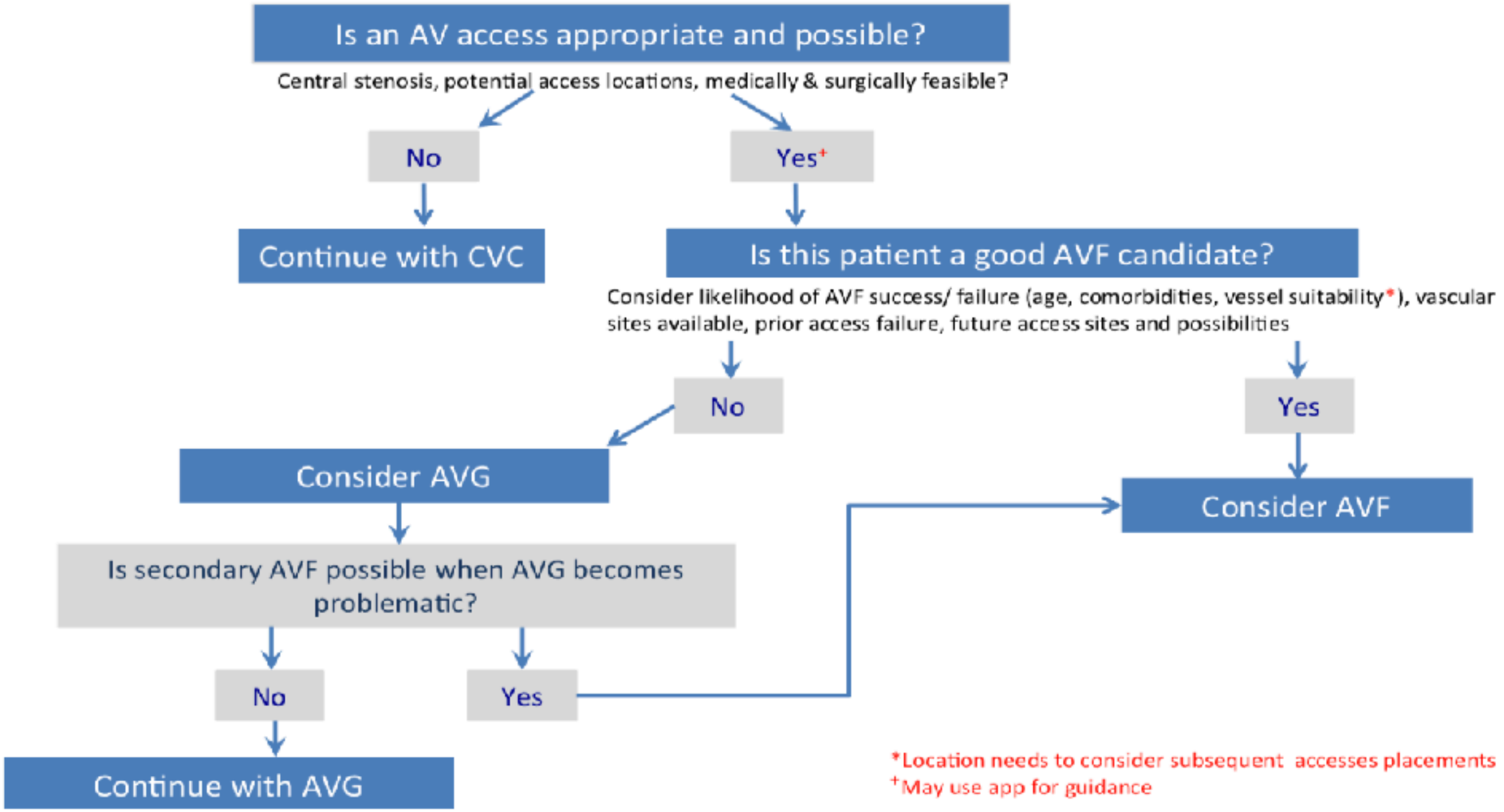

Figure 1.3. The patient is already on hemodialysis with a CVC. Abbreviations: AV, arteriovenous; CVC, central venous catheter.

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The Patient Is Already on Hemodialysis With a Failing AV Access

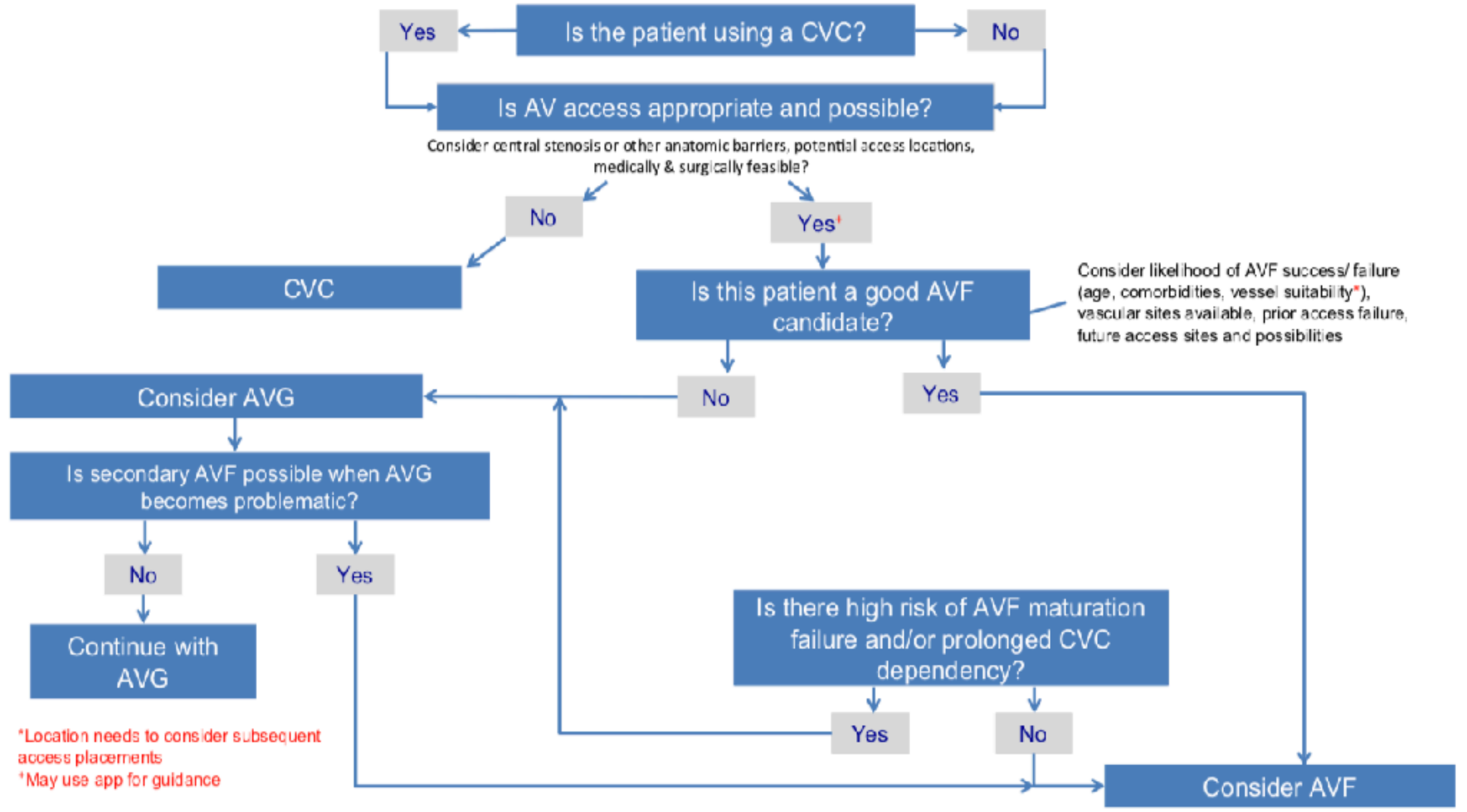

Figure 1.4. The patient is already on hemodialysis with a failing AV access. Abbreviations: AV, arteriovenous; AVF, arteriovenous fistula; CVC, central venous catheter.

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The Peritoneal Dialysis Patient is Being Considered for HD (See Table 6.1)

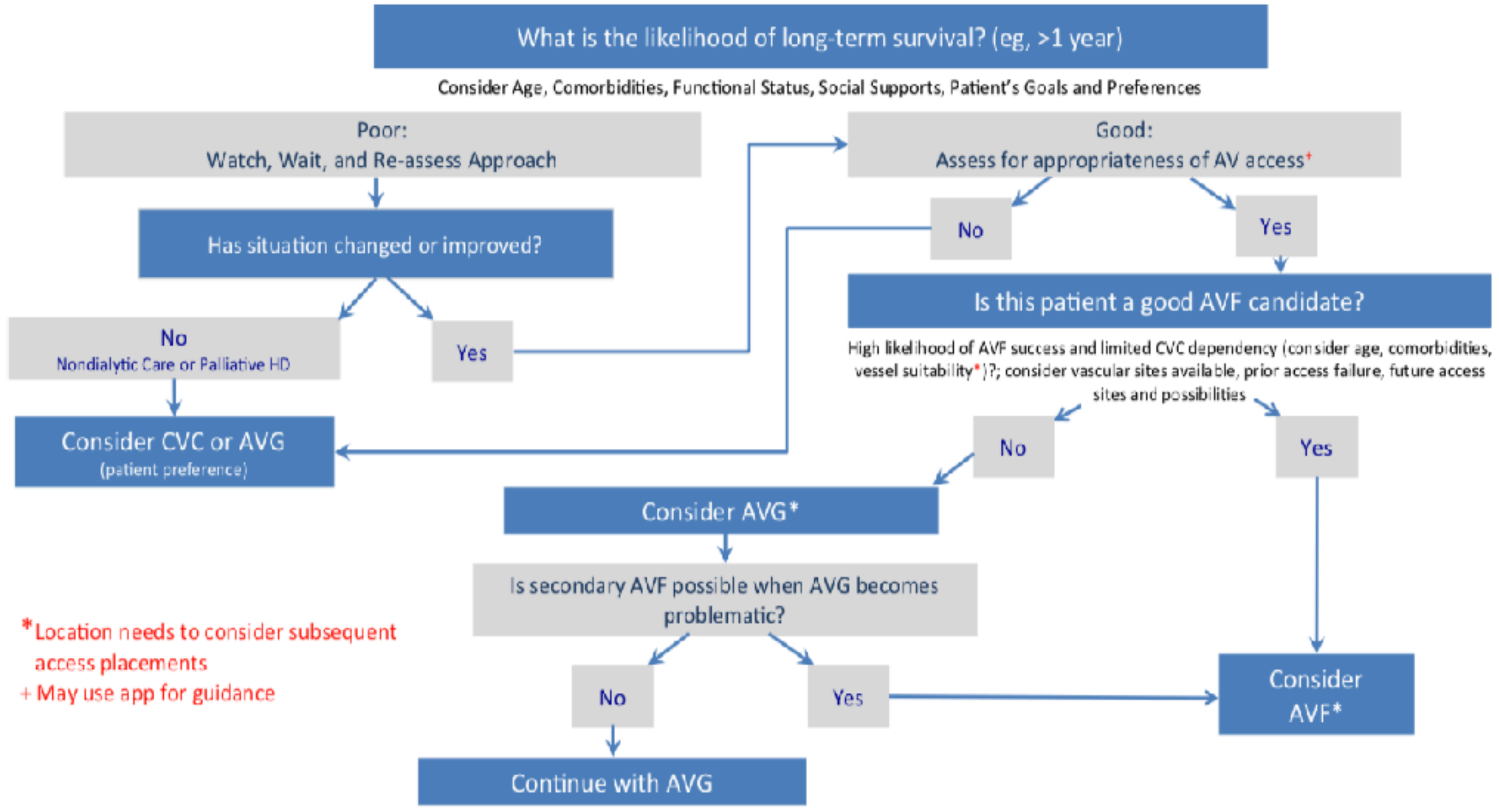

Figure 1.5. The peritoneal dialysis patient is being considered for HD. Abbreviations: AV, Arteriovenous; AVF, Arteriovenous fistula; CVC, Central venous catheter; HD, hemodialysis.

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The Transplant Patient Being Considered for HD#

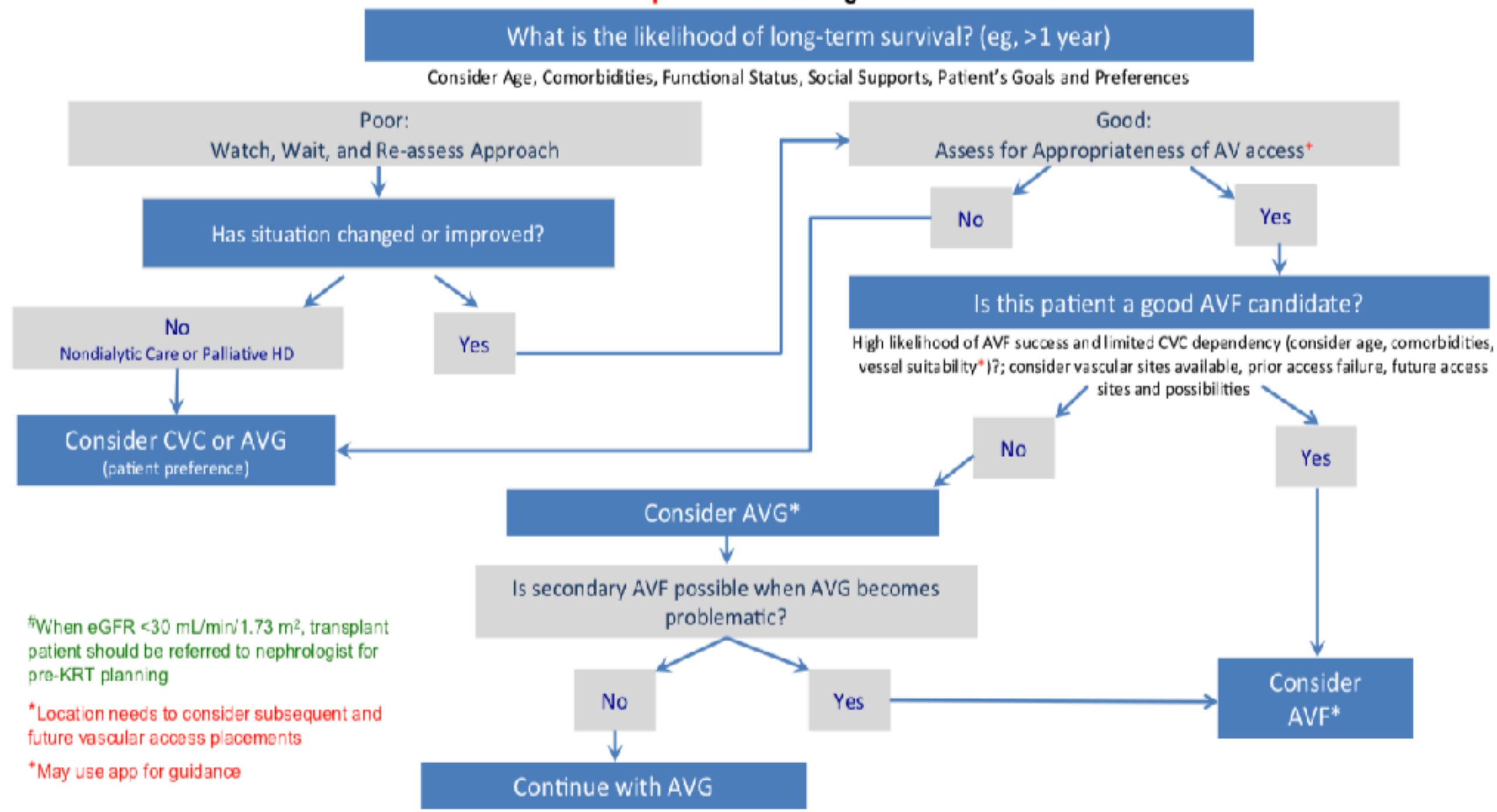

Figure 1.6. The transplant patient is being considered for HD. Abbreviations: AV, arteriovenous; AVF, arteriovenous fistula; CVC, central venous catheter; eGFR, estimated glomerular filtration rate; HD, hemodialysis; RRT, renal replacement therapy.

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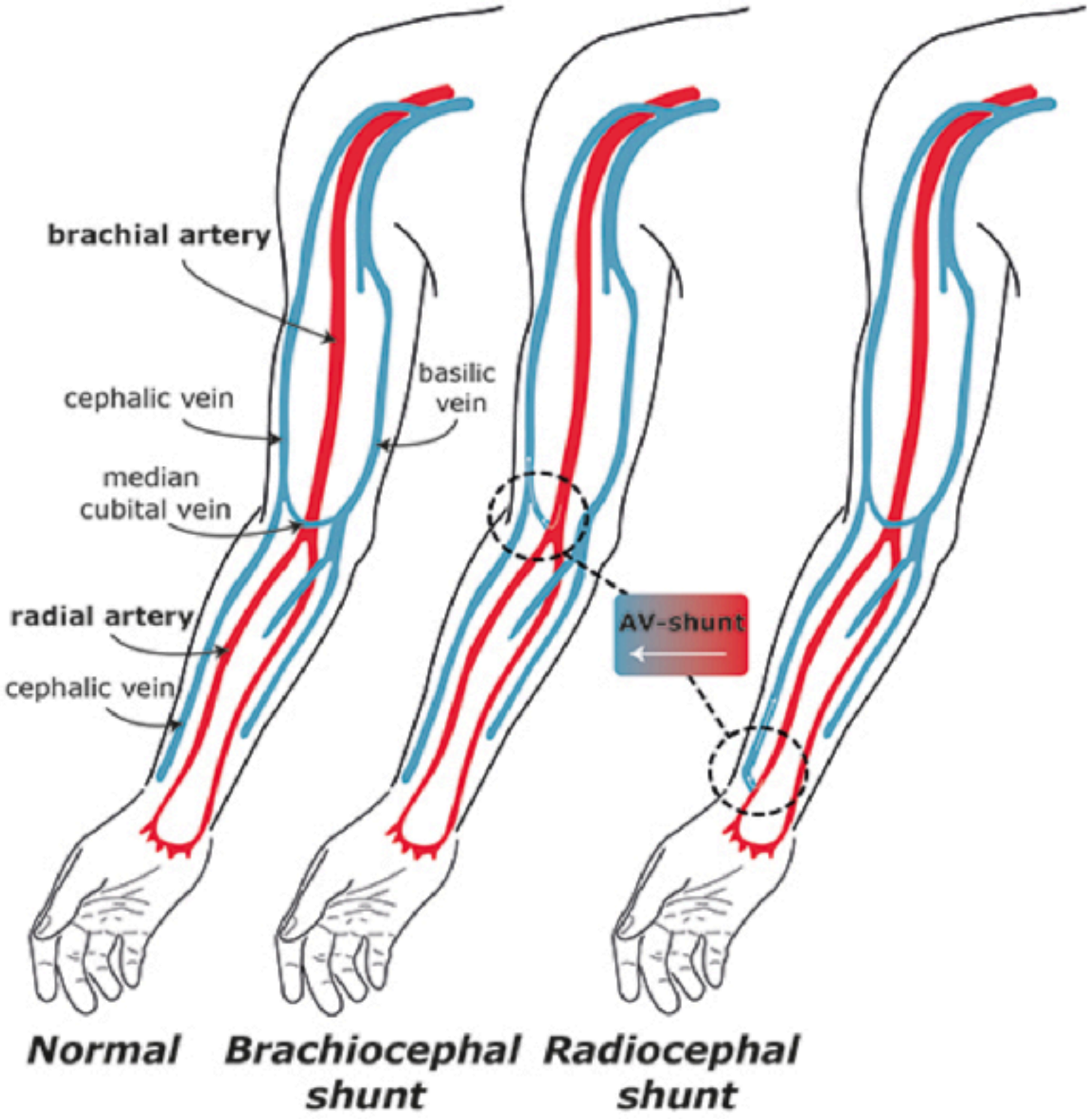
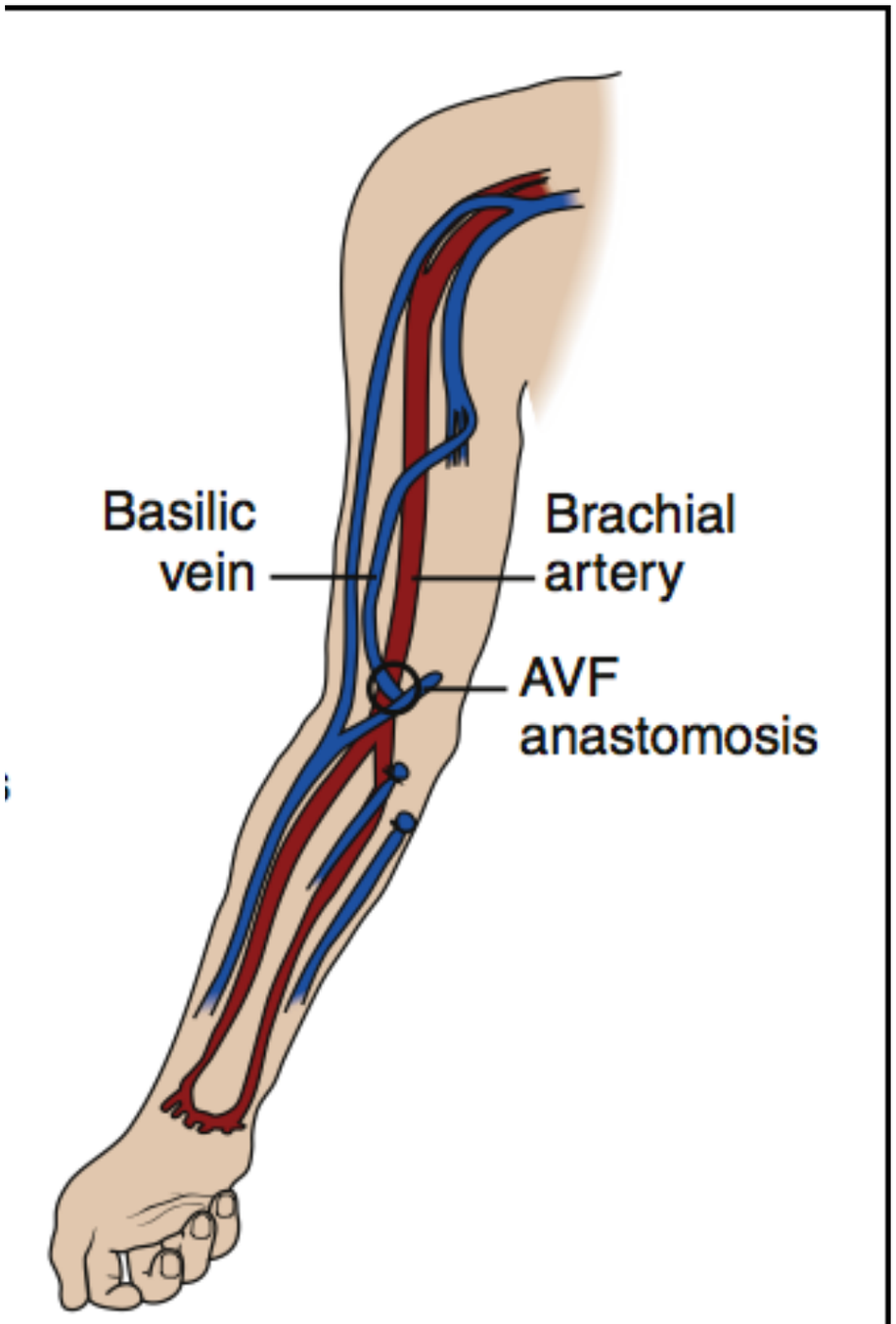
Type of vascular access

- Arteriovenous fistula (AVF)
- Arteriovenous graft : (AVG)
  - e-PTFE = expanded polytetrafluoroethylene (6 mm wall)
  - Nonautogenous saphenous vein
  - Bovine carotid artery biological grafts
- Cuffed/tunnelled hemodialysis catheter (DLC: double lumen catheter)

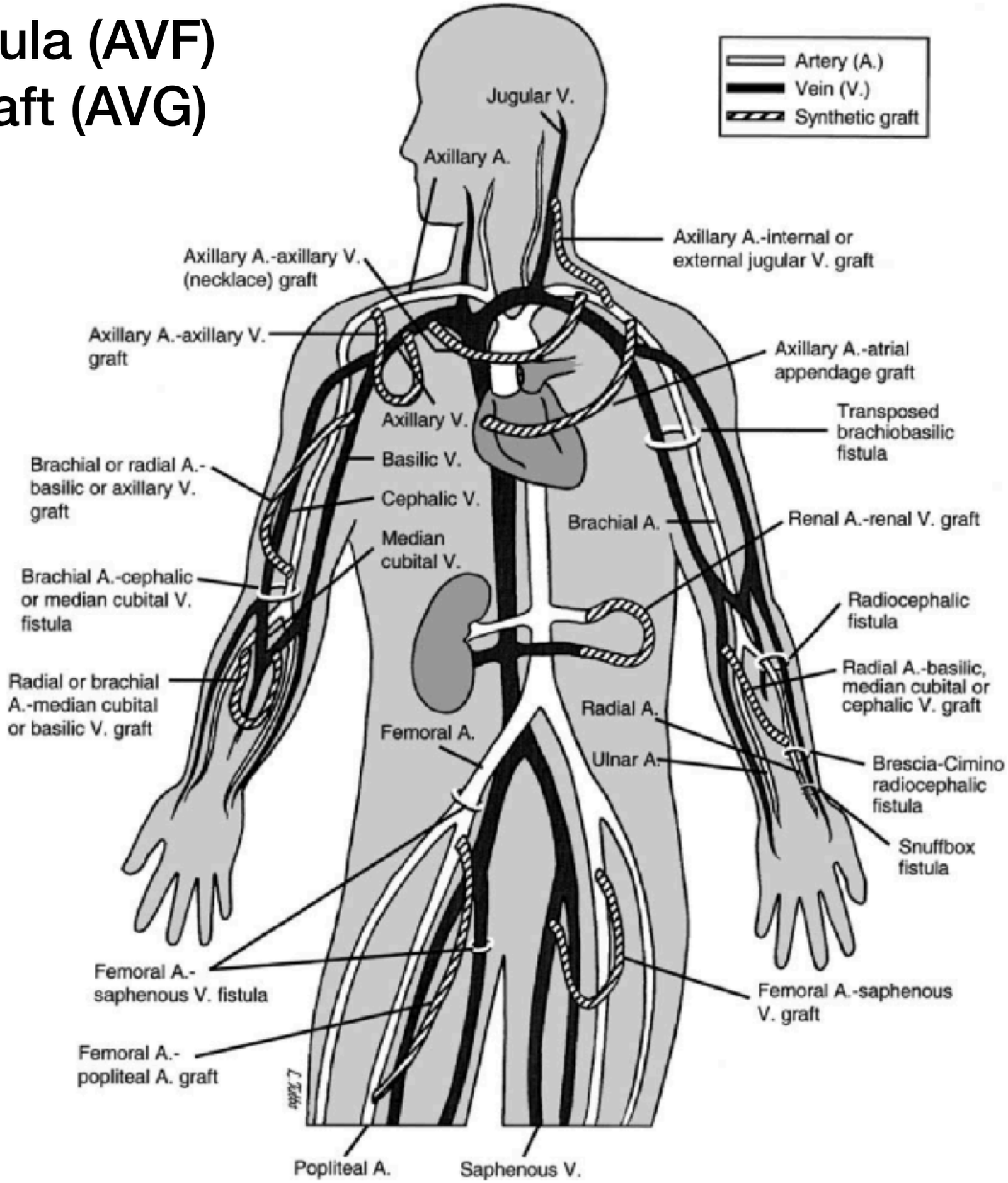
Arteriovenous fistula (AVF)



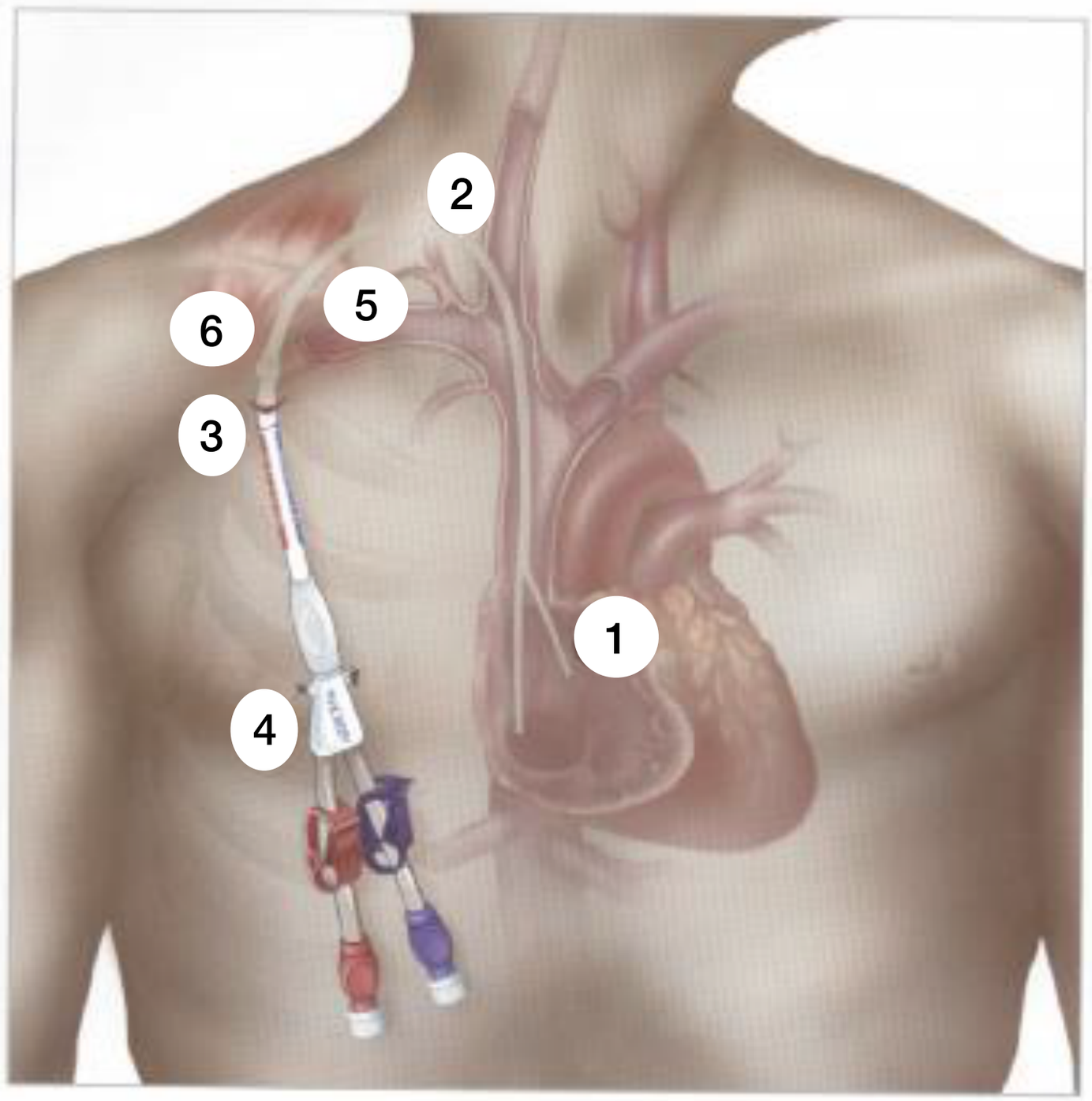


Brachiobasilic with transpostion

Arteriovenous fistula (AVF)
Arteriovenous Graft (AVG)



Tunneled/cuffed HD catheter



1. **Tip : Right atrium**
2. **Venotomy site: Rt IJ vein**
3. **Exit site**
4. **Hub**
5. **Tunnel : “2” to “3”**
6. **Cuff : above “3”**

Type of vascular access

	HD catheter	AVG	AVF
start use	immediate	1-3 wks	6-8 wks
primary failure	Less	less	More
survival	short	intermediate	Long
obstruction	More	intermediate	Less
infection	More	intermediate	Less

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Vascular Access Indication

- reasonable to have an AV access (AVF or AVG) in a patient requiring HD, when consistent with their ESKD Life-Plan and overall goals of care. (Expert Opinion)

- an AV access (AVF or AVG) in preference to a CVC in most incident and prevalent HD patients due to the lower infection risk associated with AV access use. (Conditional Recommendation, Low Quality of Evidence)

- if sufficient time and patient circumstances are favorable for a mature, usable AVF, such a functioning AVF is preferred to an AVG in incident HD patients due to fewer longterm vascular access events (eg, thrombosis, loss of primary patency, interventions) associated with unassisted AVF use. (Conditional Recommendation, Low Quality of Evidence)

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Mortality AVF/AVG versus CVC among Incident patients

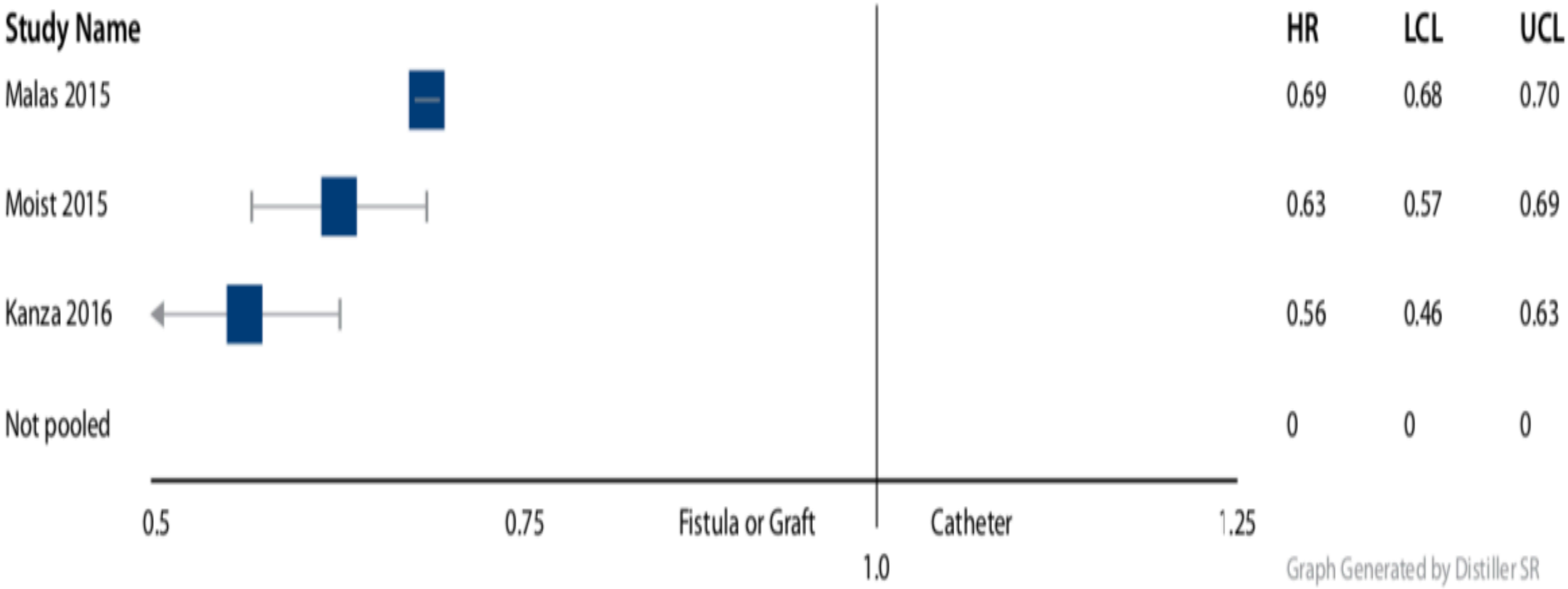

Figure 2.1. Hazard ratio for mortality with AVF or AVG versus catheter among incident HD patients. When HRs were reported as catheter versus AVF/AVG, ratios were inverted for consistency within display. Data were not pooled but are presented here for display only. Plot was made using DistillerSR Forest Plot Generator from Evidence Partners. Abbreviations: AVF, arteriovenous fistula; AVG, arteriovenous graft; HR, hazard ratio; LCL, lower confidence limit; UCL, upper confidence limit.

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CVC: indications for Use

- Short term duration:
  - AVF or AVG created but not ready for use and dialysis is required
  - Acute transplant rejection or other complications requiring dialysis
  - PD patient with complication that require time-limited peritoneal rest or resolution of complication (eg, pleural leak)
  - Patient has a living donor transplant confirmed with an operation date in the near future (eg. < 90 days) but required dialysis
  - AVF or AVG complication such as major infiltration injury or cellulitis that results in temporary nonuse until problem is resolved

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CVC: indications for Use

- Long-term or indefinite duration:
  - Multiple prior failed AV accesses with no available options
  - Valid patient preference whereby use of an AV access would severely limit QOL or achievement of life goals and after the patient has been properly informed of patient-specific risks and benefits of other potential and reasonable access options for the patient
  - Limit life expectancy
  - Absence of AV access creation options due to a combination of inflow artery and outflow vein problem or in infants/children with prohibitively diminutive vessels
  - Special medical circumstances

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Vascular access for incident HD patients

- most incident HD patients starting dialysis with a CVC should convert to either an AVF or AVG, if possible, to reduce their risk of infection/bacteremia, infection-related hospitalizations, and adverse consequences. (Conditional Recommendation, Very Low-Moderate Quality of Evidence)

- reasonable to use tunneled CVC in preference to nontunneled CVC due to the lower infection risk with tunneled CVC. (Expert Opinion)

- reasonable to use non- tunneled internal jugular CVC only for temporary purposes for a limited time period **(<2 weeks or per individual facility policy)** to limit infection risk. (Expert Opinion)

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Vessel location by distal to proximal sites

Vessel Location/ Cannulation Location	AVF	AVG
Forearm/ forearm	Snuffbox or distal radiocephalic forearm radial or ulnar basilic	Forearm loop
Forearm/upper arm	Proximal radiocephalic, antecubital vessel-perforator combinations	
Upper arm/ upper arm	Brachiocephalic	Upper arm straight
	Brachiobasilic	Upper arm loop
	Other brachial or basilic combinations	

- Distal first to proximal next approach
- Always preserve the integrity of vessels for future vascular access options
- Nondominant extremity in preference to dominant

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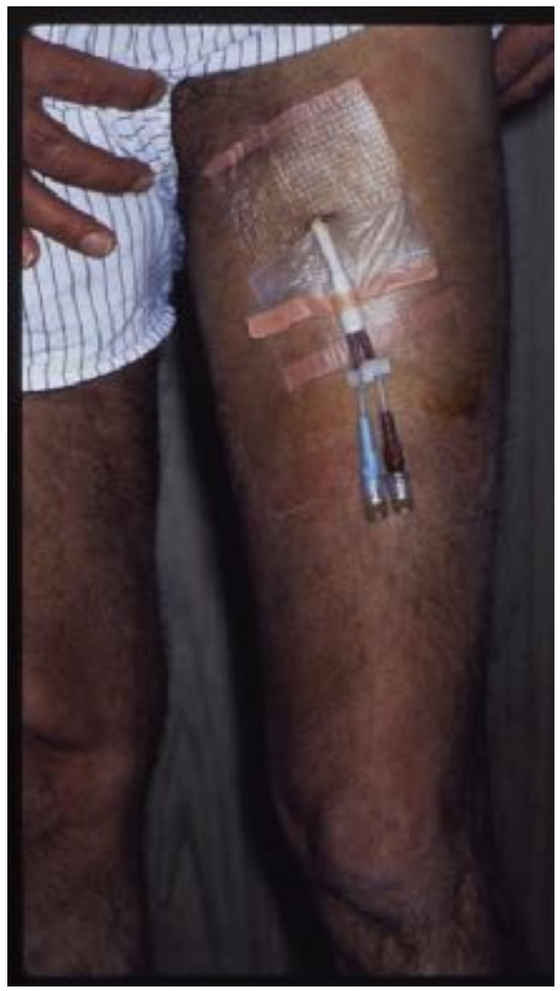
CVC location

1. Internal jugular
2. External jugular
3. Femoral
4. Subclavian
5. Lumbar

Rt side > Lt side
side without pathology



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AV access planning

- Timing : when to prepare for placing and vessel preservation

- Preoperative evaluation
  - History and examination

- Patient education

- AV access cannulation

การเตรียมหลอดเลือดเพื่อใช้ในการฟอกเลือดและการเฝ้าติดตาม

- 2.2 ควรหลีกเลี่ยงการวัดความดันโลหิต เจาะเลือด ให้สารน้ำ ฉีดยา หรือใส่สายสวน ที่หลอดเลือดบริเวณแขนซึ่งได้กำหนดไว้สำหรับทำหลอดเลือดชนิดถาวรสำหรับการฟอกเลือดในผู้ป่วยโรคไตเรื้อรังตั้งแต่ระยะที่ 4 ขึ้นไปที่เลือกการฟอกเลือดด้วยเครื่องไตเทียม (+/IV)

- avoidance of peripherally inserted catheters and unnecessary venipunctures, for patients on dialysis or with CKD where dialysis access is expected in the future (CKD G3 -G5). (Expert Opinion)
  - Artery or vein damage include
    - Radial artery access for coronary intervention
    - Venous cardiovascular implantable electronic devices : consider epicardial/leadless pacing

ข้อแนะนำเวชปฏิบัติการฟอกเลือดด้วยเครื่องไตเทียม พ.ศ.2557

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คำแนะนำสำหรับการดูแลผู้ป่วยโรคไตเรื้อรังก่อนการบำบัดทดแทนไต พ.ศ.2565 (ฉบับปรับปรุงเพิ่มเติม)

- ผู้ป่วยโรคไตเรื้อรังระยะที่ 4 ขึ้นไป ควรได้รับความรู้และคำแนะนำทางเลือก วิธีการรักษา ค่าใช้จ่าย สิทธิประโยชน์ต่างๆ รวมทั้งข้อดีและข้อด้อยของการบำบัดทดแทนไต ครอบคลุมการฟอกเลือดด้วยเครื่องไตเทียม การล้างไตทางช่องท้อง การปลูกถ่ายไตก่อนการเริ่มฟอกไต การปลูกถ่ายไต และการรักษาแบบประคับประคอง (1,B)

- ผู้ป่วยโรคไตเรื้อรังที่ตัดสินใจเลือกการฟอกเลือดด้วยเครื่องไตเทียม ควรได้รับการเตรียมเส้นเลือดถาวรใช้สำหรับฟอกเลือดชนิด AVF หรือ AVG ให้พร้อมใช้เมื่อเริ่มการฟอกเลือด ทั้งนี้ระยะเวลาการเตรียมขึ้นกับอัตราการกรองของไตขณะนั้นและอัตราการเสื่อมของไต ภายใต้ดุลยพินิจของอายุรแพทย์โรคไตและศัลยแพทย์หลอดเลือด(1,B)

- ผู้ป่วยโรคไตเรื้อรังที่ได้รับการเตรียมเส้นเลือดถาวร ทีมสหสาขาควรให้คำแนะนำเรื่องการบริหารเส้นเลือดหลังการผ่าตัดและติดตามความสมบูรณ์ของเส้นเลือด (1,B)

การเตรียมหลอดเลือดเพื่อใช้ในการฟอกเลือดและการเฝ้าติดตาม

- 2.1 ผู้ป่วยที่เลือกรับการฟอกเลือดด้วยเครื่องไตเทียมควรได้รับการเตรียมเพื่อทำหลอดเลือดชนิดถาวรสำหรับการฟอกเลือดล่วงหน้าอย่างน้อย 3 เดือน สำหรับ arteriovenous fistula (AVF) และ 4-6 สัปดาห์สำหรับ arteriovenous graft (AVG) ยกเว้น graft บางชนิด อาจเริ่มใช้ได้ทันทีหลังผ่าตัด (++/III)

- Non-dialysis CKD patients
  - eGFR 15-20 ml/min.
  - earlier referral should occur in patient with unstable and/or rapid rates of eGFR decline (> 10/min/ year) (expert opinion
- Dialysis patient
  - HD patient with recurrent vascular access problem (recurrent need for CVC use and/or ≥3 corrective interventions/6 months

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Preparation for permanent HD access

- 1.3 Patients should have a functional permanent access at initiation of dialysis therapy.

- 1.3.1 A fistula should be placed at least 6 months before anticipated start of HD treatments. (B)

- 1.3.2 A graft should, in most cases, be placed at least 3 to 6 weeks before the anticipated start of HD therapy. Some newer graft materials may be cannulated immediately after placement. (B)

  - AVG (e-PTFE) should not be cannulated before 2 wks

  - AVG (PU) should not be cannulated before 24 hr

KDOQI guideline 2006

Preoparation for permanent HD access

- 1.4 Evaluations that should be performed before placement of a permanent HD access include
- 1.4.1 History and physical examination, (B)
- 1.4.2 Duplex ultrasound of the upper-extremity arteries and veins, (B)
- 1.4.3 Central vein evaluation in the appropriate patient known to have a previous catheter or pacemaker. (A)

KDOQI guideline 2006

Consideration	Relevance
Patient History	
History of previous CVC	Previous placement of a CVC is associated with central venous stenosis.
Dominant arm	To minimize negative impact on quality of life, use of the nondominant arm is preferred.
History of pacemaker use	There is a correlation between pacemaker use and central venous stenosis.
History of severe CHF	Accesses may alter hemodynamics and cardiac output.
History of arterial or venous peripheral catheter	Previous placement of an arterial or venous peripheral catheter may have damaged target vasculature.
History of diabetes mellitus	Diabetes mellitus is associated with damage to vasculature necessary for internal accesses.
History of anticoagulant therapy or any coagulation disorder	Abnormal coagulation may cause clotting or problems with hemostasis of accesses.
Presence of comorbid conditions, such as malignancy or coronary artery disease, that limit patient's life expectancy	Morbidity associated with placement and maintenance of certain accesses may not justify their use in some patients.
History of vascular access	Previously failed vascular accesses will limit available sites for accesses; the cause of a previous failure may influence planned access if the cause is still present.
History of heart valve disease or prosthesis	Rate of infection associated with specific access types should be considered.
History of previous arm, neck, or chest surgery/trauma	Vascular damage associated with previous surgery or trauma may limit viable access sites.
Anticipated kidney transplant from living donor	Catheter access may be sufficient.

Physical Examination

Physical Examination of Arterial System	
Character of peripheral pulses, supplemented by hand-held Doppler evaluation when indicated	An adequate arterial system is needed for access; the quality of the arterial system will influence the choice of access site.
Results of Allen test	Abnormal arterial flow pattern to the hand may contraindicate the creation of a radial-cephalic fistula.
Bilateral upper extremity blood pressures	Pressures determine suitability of arterial access in upper extremities.
Physical Examination of Venous System	
Evaluation for edema	Edema indicates venous outflow problems that may limit usefulness of the associated potential access site or extremity for access placement.
Assessment of arm size comparability	Differential arm size may indicate inadequate veins or venous obstruction which should influence choice of access site.
Examination for collateral veins	Collateral veins are indicative of venous obstruction.
Tourniquet venous palpation with vein mapping	Palpation and mapping allow selection of ideal veins for access.
Examination for evidence of previous central or peripheral venous catheterization	Use of CVCs is associated with central venous stenosis; previous placement of venous catheters may have damaged target vasculature necessary for access.
Examination for evidence of arm, chest, or neck surgery/trauma	Vascular damage associated with previous surgery or trauma may limit access sites.
Cardiovascular Evaluation	
Examination for evidence of heart failure	Accesses may alter cardiac output.

Imaging studies

- Doppler ultrasonography
  - measure flow velocity, inner diameter of artery and vein
- Venography : evaluate central vein
- Arteriography : diminished or absent pulse, > 20 mmHg in MAP between 2 arms

Patient education

All patients should be taught how to:

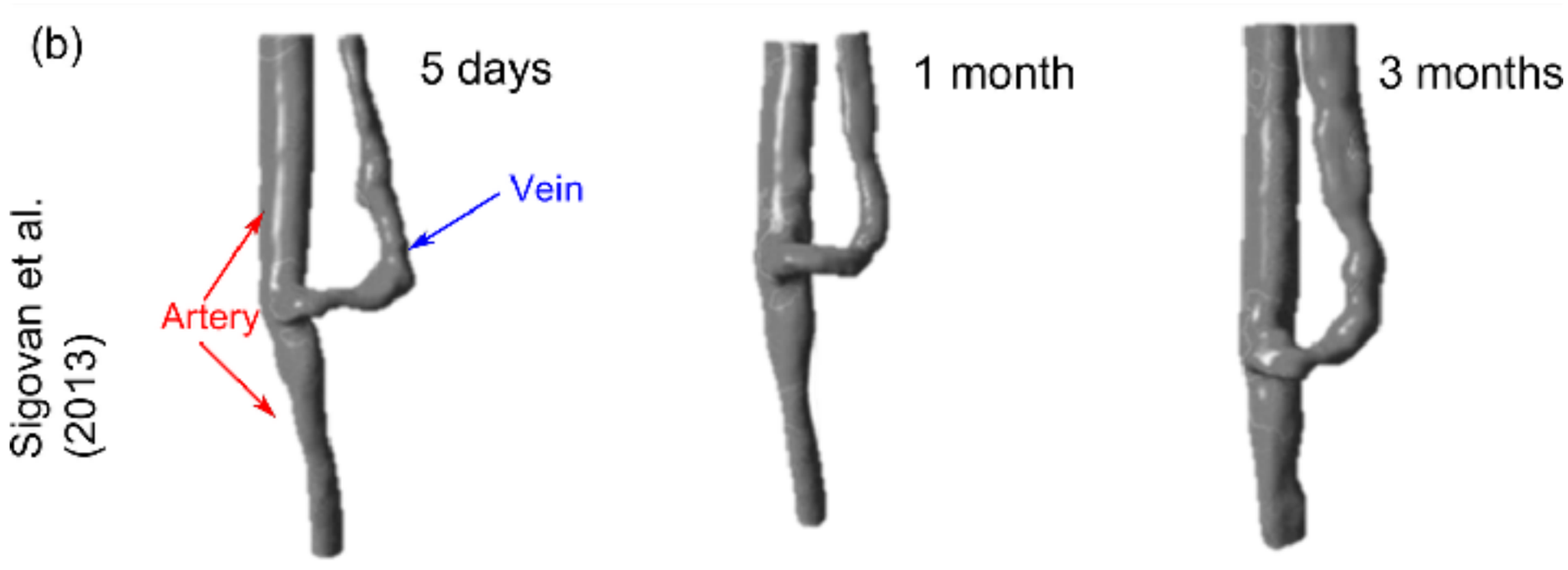
a. Compress a bleeding access;
b. Wash skin over access with soap and water daily and before HD;
c. Recognize signs and symptoms of infection;
d. Select proper methods for exercising fistula arm with some resistance to venous flow;
e. Palpate for thrill/pulse daily and after any episodes of hypotension, dizziness, or lightheadedness;
f. Listen for bruit with ear opposite access if they cannot palpate for any reason.

All patients should know to:

a. Avoid carrying heavy items draped over the access arm or wearing occlusive clothing;
b. Avoid sleeping on the access arm;
c. Insist that staff rotate cannulation sites each treatment;
d. Ensure that staff are using proper techniques in preparing skin prior to cannulation and wearing masks for all access connections;
e. Report any signs and symptoms of infection or absence of bruit/thrill to dialysis personnel immediately.

AV access cannulations

- Mature AV fistula : Rule of 6s
  - 6 mm in diameter
  - < 6 mm below the skin
  - access blood flow at least 600 mL/min
  - 6 cm. length in straight segment for cannulation



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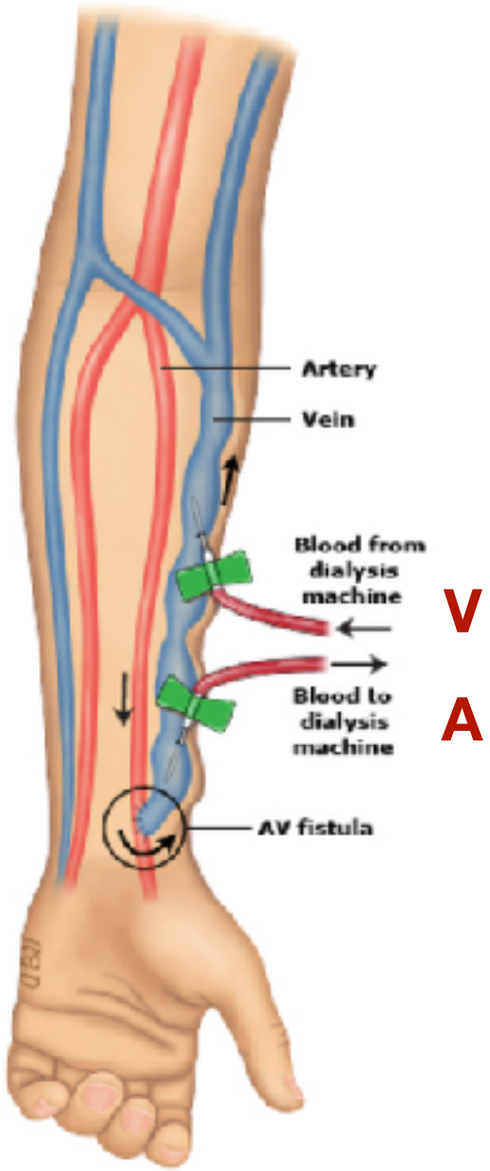
AV access cannulations

- Needle size
  - Initial use: 17 gauge (BFR <250 ml/min

    16 gauge (BFR <350 ml/min)
  - Mature access : > 15 gauge (BFR > 350 ml/min)
- Position and rotation
  - Arterial needle (upstream)
    - > 3 cm from arterial anastomosis site
    - point upstream or down stream
  - Venous needle (downstream)
    - 5 cm. from arterial needle
    - point downstream



prolong bleeding > 20 mins
increased intra-access pressure

AV access complication

- AVF or AVG
  - Dysfunction
    - Early : non-maturation
    - Late : stenosis and thrombosis (Flow dysfunction)
  - Others:
    - infection
    - aneurysm and bleeding
    - deep AVF
    - hand ischemia
    - high flow related heart failure
    - hand and arm edema

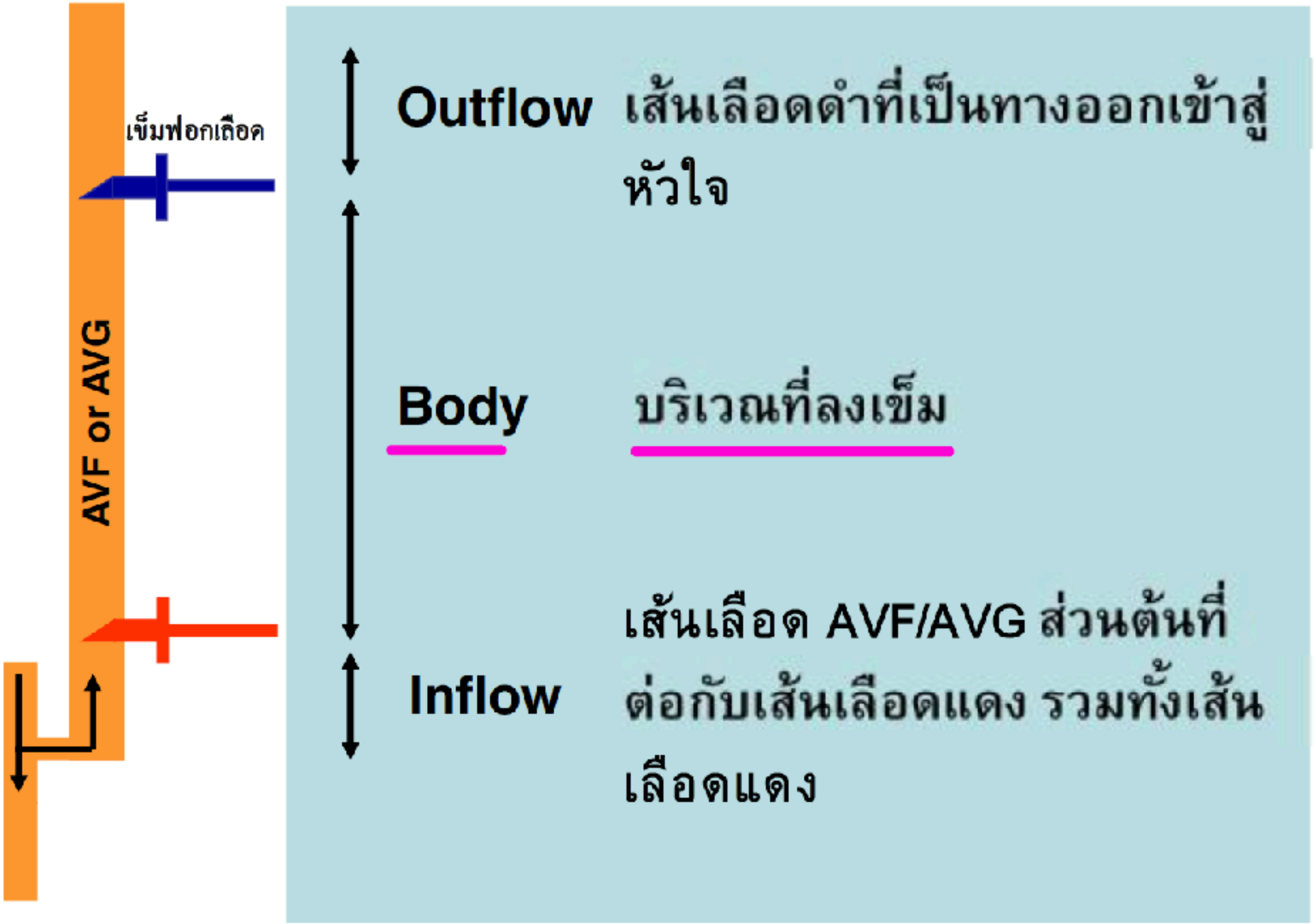
- HD catheter
  - Dysfunction
  - Infection

- Stenosis
  - Inflow stenosis
  - Outflow stenosis
  - Inflow and outflow stenosis
  - Central stenosis
    - Look for collateral vein

Vascular access monitoring

- Physical examination :inspection, palpitation, auscultation
- Vascular access surveillance :
    - static venous dialysis pressure
    - dynamic venous dialysis pressure
    - access flow
    - access recirculation
    - fistulogram

Physical examination



Clinical feature for the problem

- Arm swelling
- Difficulty cannulating access
- Prolong bleeding after needle withdrawal
- Hematoma formation
- Inadequate BFR
- Decrease Kt/V
- Persistent arm edema
- Aspiration of clots

  - Decrease target blood pump flow or speed
    - Low inflow to AVF or AVG
    - Outflow obstruction : high venous pressure

Physical Examination

Inspection	Vascular access scar site, infection/inflammation, hematoma, sign of ischemia (steal syndrome), aneurysm, arm elevation test, collaterals (central vein stenosis)
Palpitation pulse thrill	Feel for intravascular pressure along the veins;examine for segmental difference in quality Feel for elevated/low skin temperature;check the quality of pulsation along arteries and veins Check for pain caused by finger pressure
Auscultation bruit	Check for the presence of typical low-frequency bruit with systolic and diastolic components Examine for abnormal high-frequency bruit produced by turbulence due to stenosis.

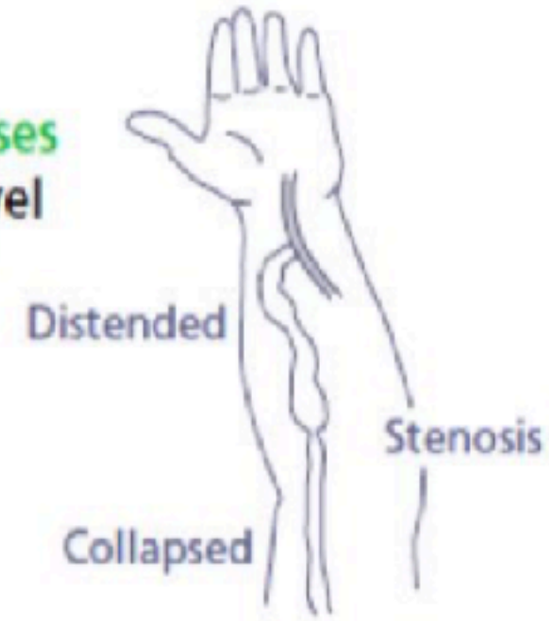
Arm Elevation Test

Upper Arm AVF

The AVF outflow vein **partially collapses** when the arm is raised above the level of the heart. It may feel "flabby" when palpated.

Lower Arm AVF

The AVF outflow vein **collapses** when the arm is raised above the level of the heart.



Click on the diagram to see a video on the Arm Elevation Test.

Upper Arm AVF

The AVF outflow vein **does not partially collapse** or become "flabby" after being raised above the level of the heart.

Lower Arm AVF

The AVF outflow vein **does not collapse** after being raised above the level of the heart.

Good to go!

Click here for other resources.

Contact expert clinician if any "stop" signs noted.

ESRD NCC
SEEKING, SHARING, SPREADING
IMPROVING PATIENT OUTCOMES
NETWORK COORDINATING CENTER

www.esrdncc.org

This material was prepared by the End-Stage Renal Disease Network Coordinating Center (NCC), under contract with the Centers for Medicare & Medicaid Services (CMS), an agency of the U.S. Department of Health and Human Services. The contents presented do not necessarily reflect CMS policy. CMS Contract Number: HHSM-500-2013-NW002C.

arteriovenous FISTULAFIRST
AVF — The first choice for hemodialysis

Physical Examination

Inspection

Vascular access scar site, infection/inflammation, hematoma, sign of ischemia (steal syndrome), aneurysm, arm elevation test, collaterals (central vein stenosis)

Palpitation

pulse
thrill

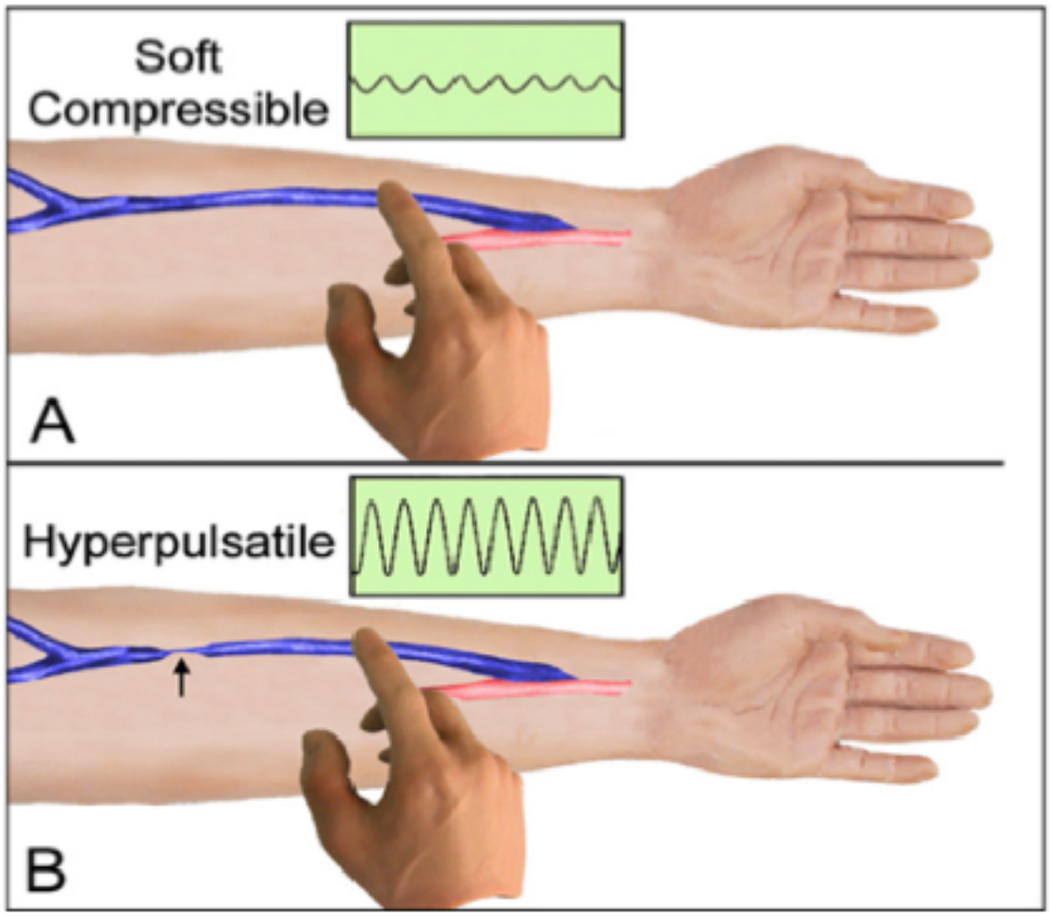
Feel for intravascular pressure along the veins;examine for segmental difference in quality
Feel for elevated/low skin temperature;check the quality of pulsation along arteries and veins
Check for pain caused by finger pressure

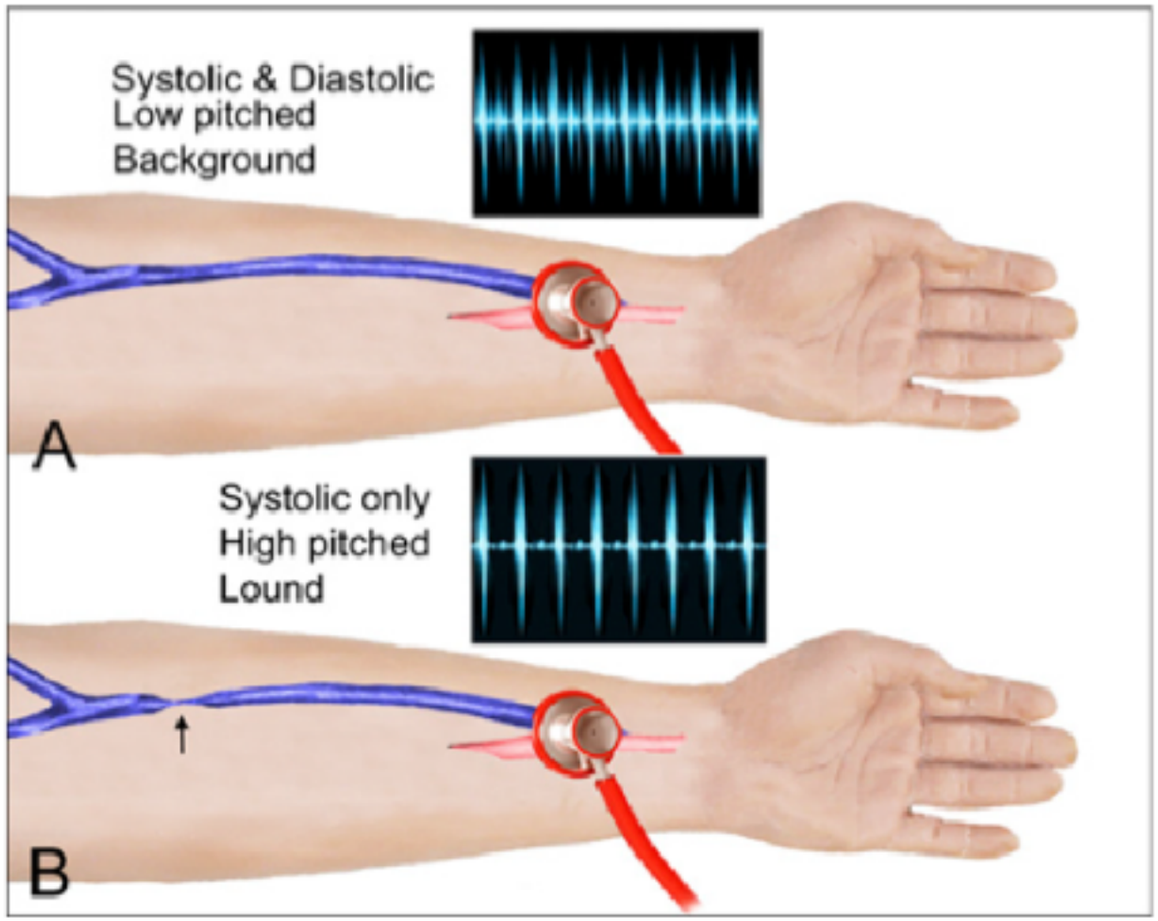
Auscultation

bruit

Check for the presence of typical low-frequency bruit with systolic and diastolic components
Examine for abnormal high-frequency bruit produced by turbulence due to stenosis.

AV access stenosis



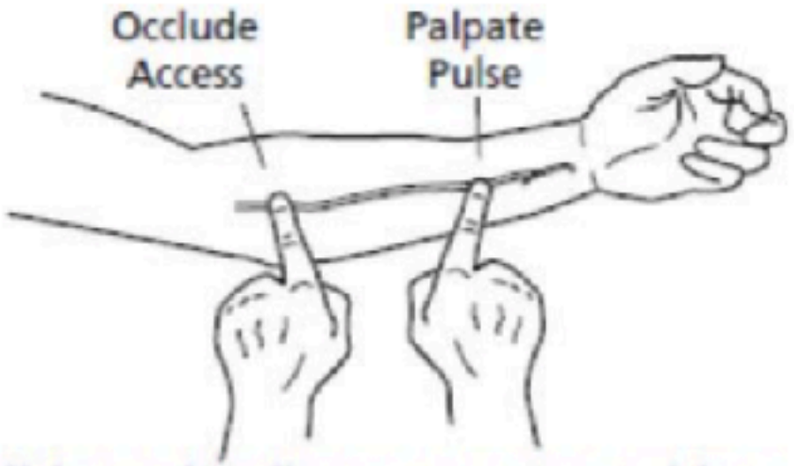


Outflow stenosis

Augmentation Test

Place your fingers on the out-going vein, feel the pulse, press down until no blood is flowing through the access. Keep your finger on the vein and feel for the pulse on the lower part of the access.

Pulse should be "strong and bounding" and may cause your finger to rise and fall with each beat.



Click on the diagram to see a video on the Augmentation Test.

Pulse does not become more forceful or "strong and bounding".

GO

Good to go!

Click here for printable instructions.

STOP

Contact expert clinician if any "stop" signs noted.

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arteriovenous FISTULA FIRST
AVF — The first choice for hemodialysis

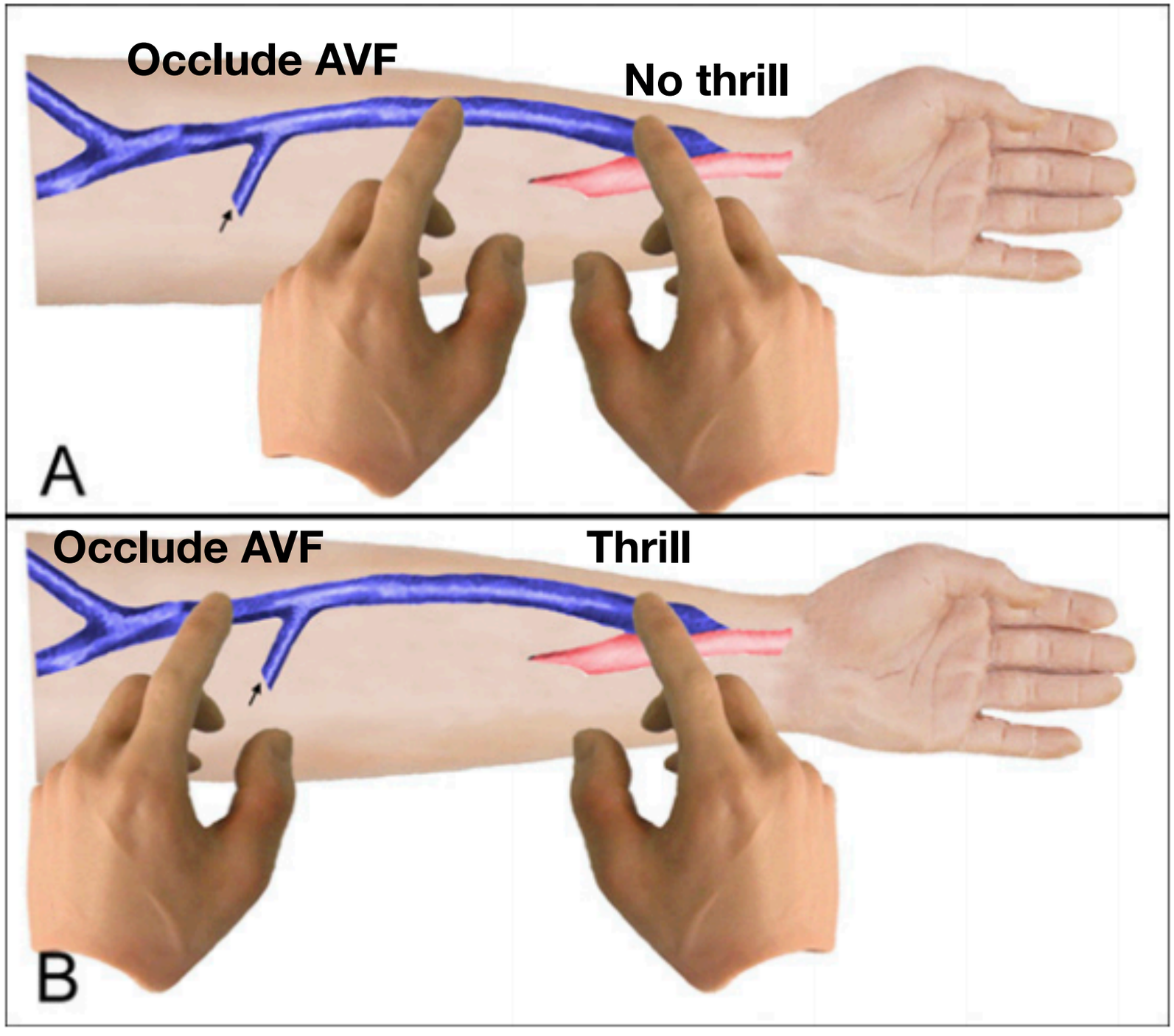
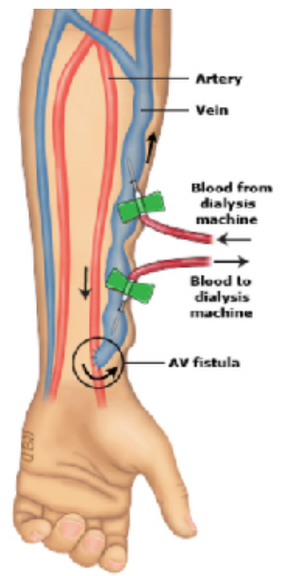


Figure 10. | **Sequential occlusion test**. (A) With occlusion at this point, the thrill will disappear. (B) With occlusion at this point, the thrill will persist because of the side branch.

Parameter	Normal	Inflow Stenosis	Outflow Stenosis	Coexisting Inflow and Outflow
Pulse	Soft,easily compressible	Hypopulsation	Hyperpulsation	Soft,easily compressible
Thrill	Continuous	Discontinuous	High pitched, louder, then discontinuous	Discontinuous (usually absent)
Augmentation Test	Normal	Poor augmentation	Good augmentation	Poor augmentation
Arm Elevation Test(fistula only)	Normal collapse	Normal or accentuated collapse	No collapse	No collapse
Clinical Features	No prolong bleeding or difficultly in cannulation	Difficulty in cannulation and an increase in negative arterial pressure	Prolonged bleeding and high venous pressure	
Access Flow	Normal	Decreased	Decreased	Decreased

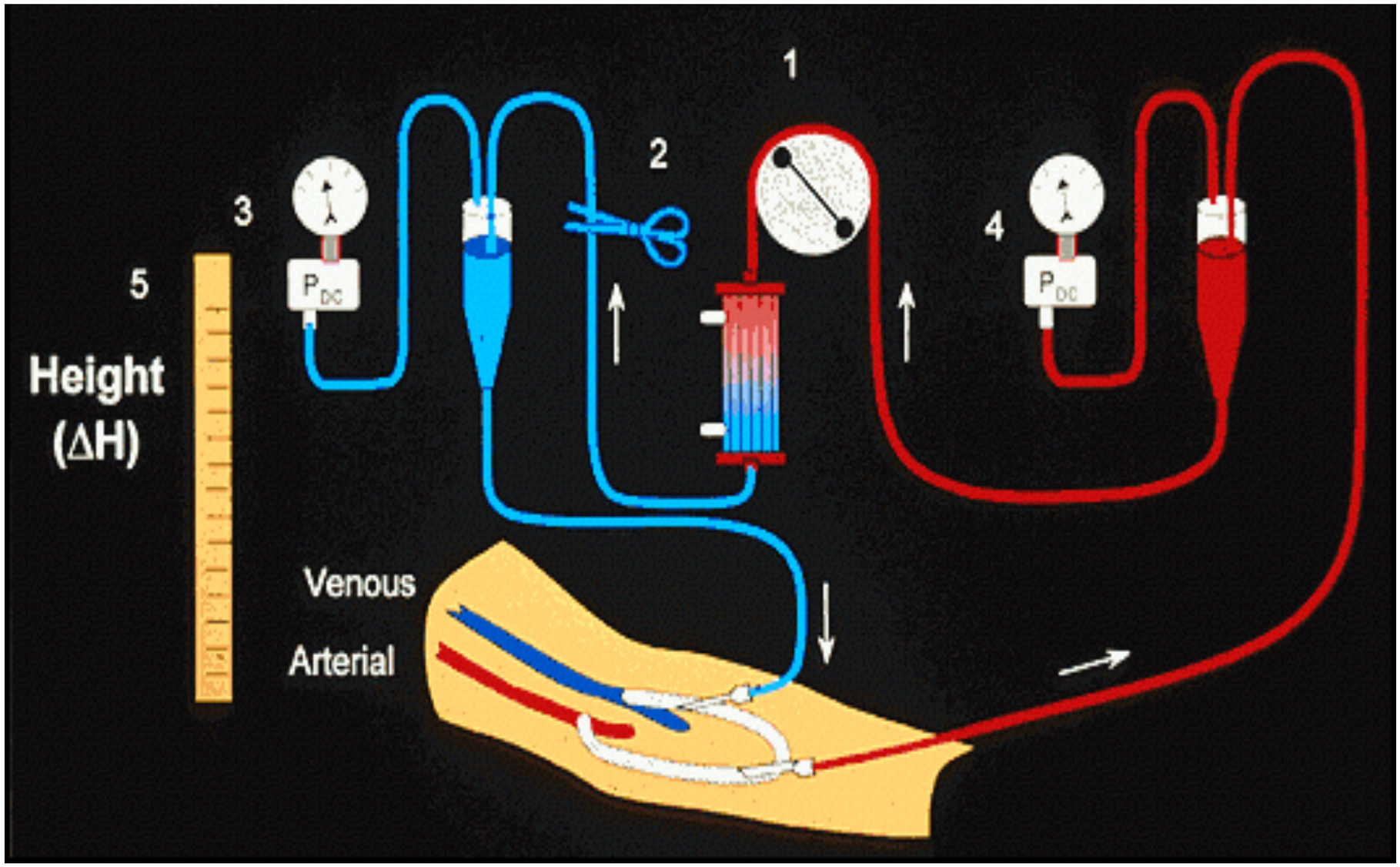
Vascular access surveillance:

- static venous dialysis pressure
- dynamic venous dialysis pressure
- access flow
- access recirculation
- fistulogram

Static venous dialysis pressure

Arterial PIA = (arterial IAP + arterial Poffset – arterial P0) / MAP

Venous PIA = (venous IAP + venous Poffset – venous P0) / MAP



PIA = intra-access pressure, in AV graft: PIA usually < 50% of MAP

Need for intervention

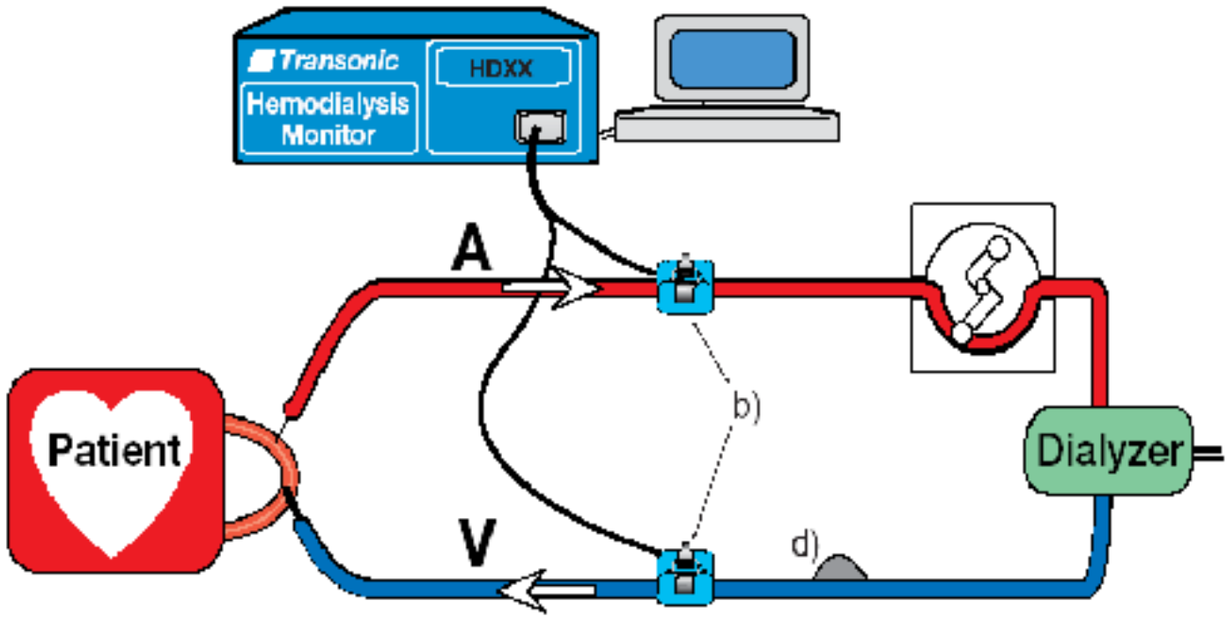
- A Venous segment static pressure (mean pressure) ratio
    - AVG or fistula : greater than 0.5
- An arterial segment static pressure ratio
    - AVG : greater than 0.75

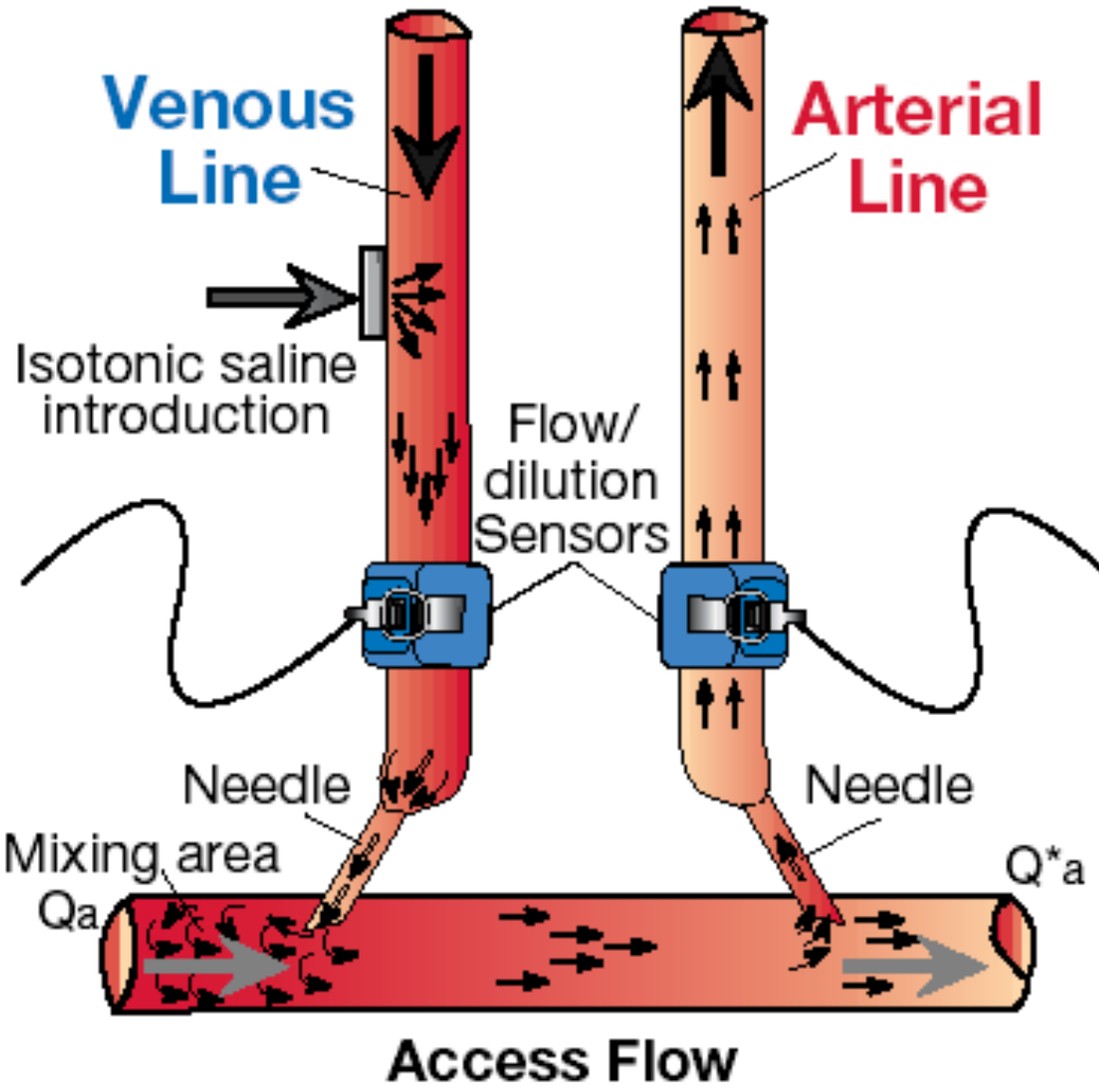
Kdoqi guideline 2006

Dynamic venous dialysis pressure

- Measure at blood flow rate of 200-225 ml/min (higher rate -> predictive value from excessive turbulence)
- > 150 mmHg – highly predictive of venous stenosis
- sensitivity 86%, specificity 93%

Access flow : Ultrasound (saline) dilution





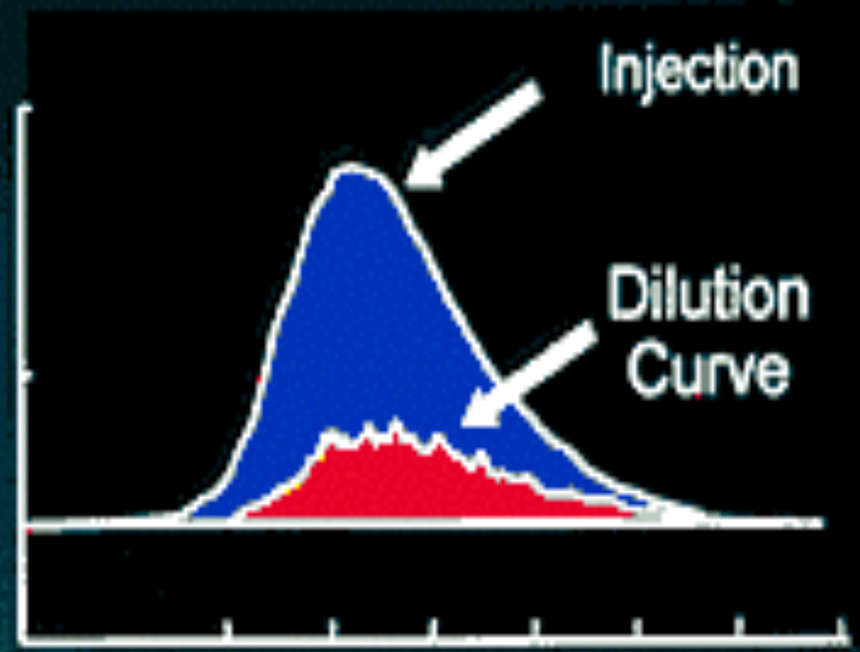
Measuring Access Flow

Indicator Dilution (Fick principle)

Flow = Amount injected / AUC

$= Q_B [(AUC_{inj} / AUC_{dil}) - 1)$

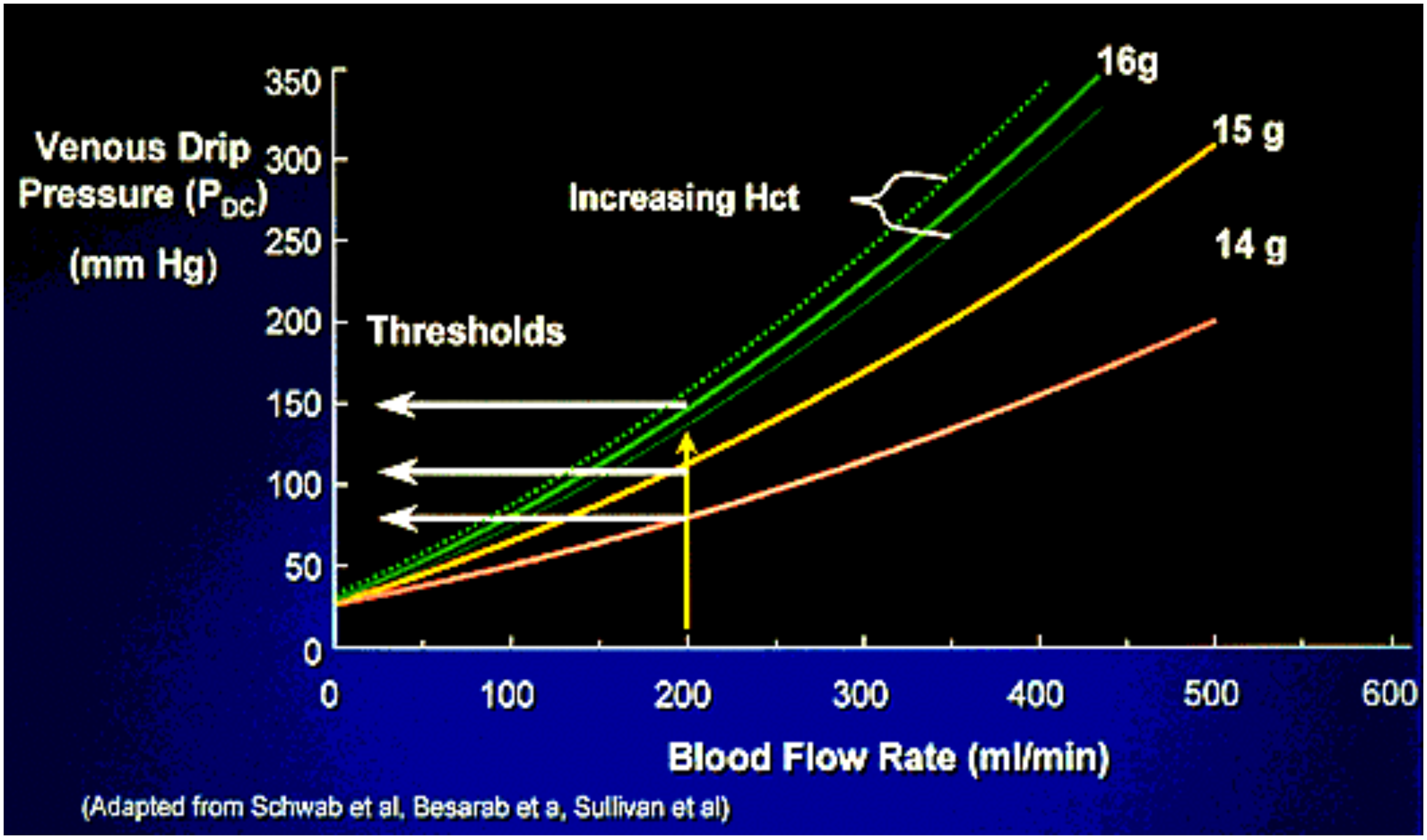
$= Q_B (1-r)/r$



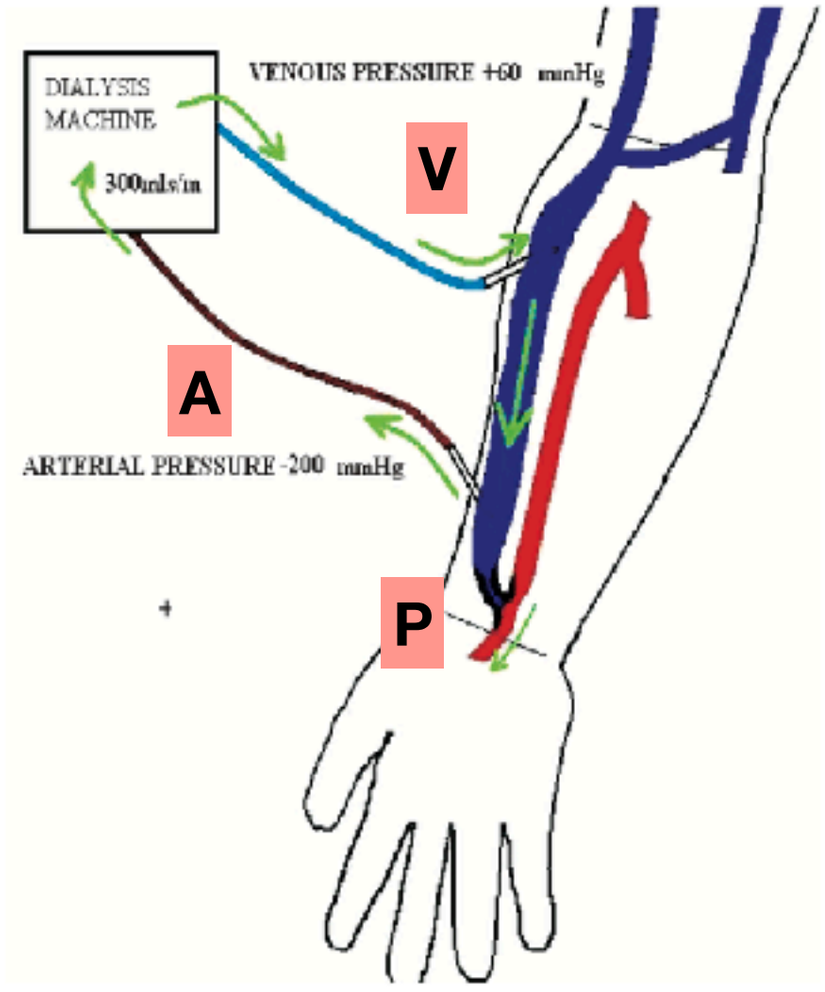
System Requirements:

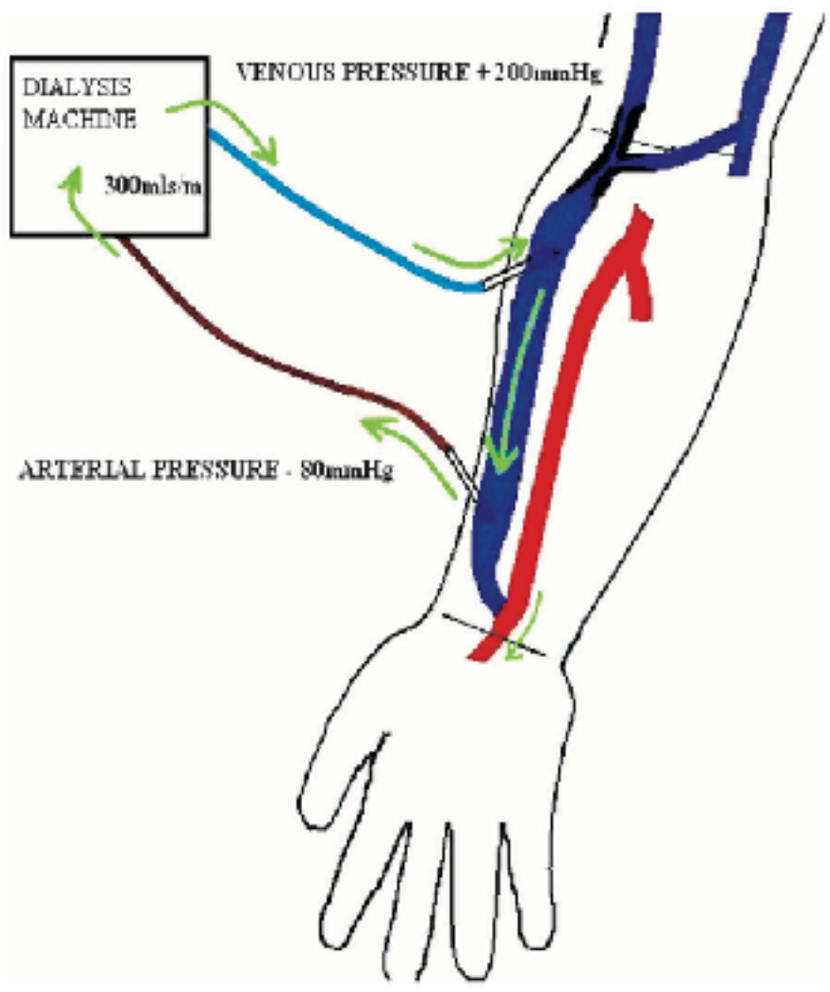
- **Good mixing of indicator with flowing stream**
  - turbulence desired
  - needle for injection oriented facing the flow
- **Detector placed downstream from injection where mixing is complete**
  - needles should be separated at least 4 cm, preferably 6 cm
- **Accurate measurement of Qb**
- **Ultrafiltration shut off (flow equal in both sensors)**

Dynamic venous dialysis pressure



Access recirculation





Percent recirculation = [(P-A)/(P-V)] x 100

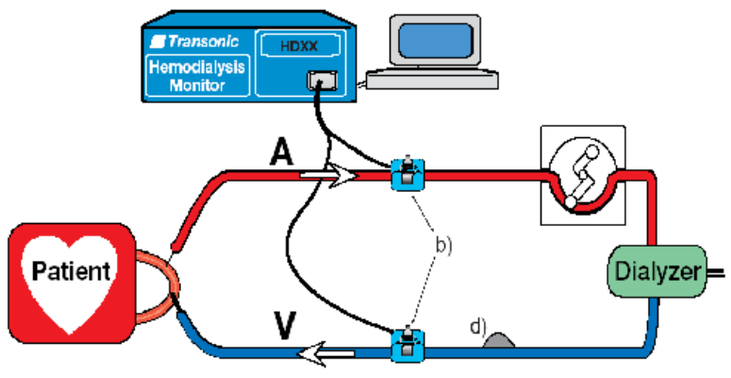
No recirculation : P=A, % recirculation = 0
Recirculation : P>A, % recirculation ≠ 0

Delivered Kt/V below prescribed Kt/V despite adequate prescription

Access recirculation

- Urea-based method :
  - Two needle urea-based method > 10%
  - Three-needle method > 15-20%
- Non urea-based (ultrasound dilution) method
  - ultrasound saline dilution method : >5%
  - thermal dilution : > 15%

Should be prompt investigate



Refer for evaluation

- Persistent abnormalities in any of the monitoring or survillance parameters
- A venous segment static pressure > 0.5 in AVF/AVG
- An arterial segment static pressure > 0.75 in AVG
- Access flow < 600 ml/min; AVG
- Access flow < 400-500 ml/min ; AVF

Imaging of vascular access

- Doppler ultrasound: detecting stenosis, mapping aneurysm
- Magnetic resonance angiography (MRA) : see both venous and artery in the upper extremities circulation
- Fistulogram : Gold standard

KDOQI
KIDNEY DISEASE OUTCOMES QUALITY INITIATIVE
National Kidney Foundation

Surveillance to Facilitate Patency

- There is inadequate evidence for KDOQI to make a recommendation on routine AVF, AVG surveillance by measuring access blood flow, pressure monitoring, or imaging for stenosis, that is additional to routine clinical monitoring, to improve access patency.

- Not recommend pre-emptive angioplasty of AVFs, AVGs with stenosis, not associated with clinical indicators, to improve access patency. (Conditional Recommendation, Moderate Quality of Evidence)

- Reasonable for patients with consistently persistent clinical indicators and underlying AV access stenosis to undergo preemptive angioplasty of their AV access to reduce the risk of thrombosis and AV access loss. (Expert Opinion)

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Am J Kidney Dis. 2020 Apr;75(4S2):S1-S164

KDOQI
KIDNEY DISEASE OUTCOMES QUALITY INITIATIVE
National Kidney Foundation

Clinical indicators (signs and symptoms) suggesting underlying clinically significant lesion during access monitoring

Procedure	Clinical Indicators	
Physical examination or check	• Ipsilateral extremity edema	354,365
	• Alterations in the pulse, with a weak or resistant pulse, difficult to compress, in the area of stenosis	378
	• Abnormal thrill (weak and/or discontinuous) with only a systolic component in the region of stenosis	239
	• Abnormal bruit (high pitched with a systolic component in the area of stenosis)	360
	• Failure of the fistula to collapse when the arm is elevated (outflow stenosis) and lack of pulse augmentation (inflow stenosis)	267
	• Excessive collapse of the venous segment upon arm elevation	
Dialysis	• New difficulty with cannulation when previously not a problem	379
	• Aspiration of clots	239
	• Inability to achieve the target dialysis blood flow	360
	• Prolonged bleeding beyond usual for that patient from the needle puncture sites for 3 consecutive dialysis sessions	
	• Unexplained (>0.2 units) decrease in the delivered dialysis dose (Kt/V) on a constant dialysis prescription without prolongation of dialysis duration	

Am J Kidney Dis. 2020 Apr;75(4S2):S1-S164

Treatment

- percutaneous balloon angioplasty : stenosis
  - high recurrent rate for stenosis, might need repeat angioplasty
- endovascular stents : stenosis, pseudoaneurysm
- presence of accessory vein: obliteration procedure (ligation, shut down, coil insertion)
- Surgical revision

Fistula thrombosis

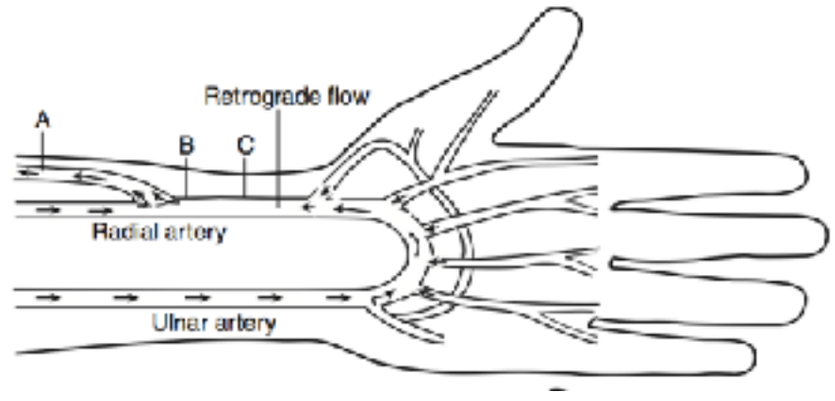
Risk factors:

- arterial stenosis
- fistula compression
- hematoma formation from cannulation injury
- hypovolemia
- hypotension
- hypercoagulable states

Management

- Surgical thrombectomy
  - Success rate 90%
  - Low complication rate
- Thrombolysis
  - Urokinase, streptokinase
  - Pulse spray technique (success rate > 90%, 50% patency at 1 year)
- Mechanical disruption : percutaneous method
  - Mechanical disruption have greater long-term patency
  - Major concern : pulmonary embolism

Steal syndrome



- Compromise the perfusion of the extremities distal to anastomosis
- Risk factors
  - Advanced age
  - Female sex
  - DM
  - Peripheral vascular disease
  - Large outflow conduits
  - Multiple prior permanent access procedures
  - Distal brachial artery-based procedures
  - Prior episode of AV access steal
- Pain, coldness, and paresthesias of distal extremity, especially during dialysis

KDOQI
KIDNEY DISEASE OUTCOMES QUALITY INITIATIVE
National Kidney Foundation

Strategies to reduced the incidence of AV access steal

- Assessment of arterial inflow imaging with correction of inflow stenoses

- Correct inflow stenosis or use contralateral extremity

- Avoid distal brachial artery-based procedures

- Avoid large conduits

Am J Kidney Dis. 2020 Apr;75(4S2):S1-S164

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Signs and symptoms of steal

Grade	Severity	Clinical Presentation	Treatment
0	None	None	None
1	Mild	Cool extremity with few symptoms	None
2	Moderate	Intermittent symptoms during dialysis, claudication	Intervention sometimes
3	Severe	Ischemic rest pain, tissue loss	Intervention mandatory

Note: Based on the Society for Vascular Surgery Reporting Standards for AV access steal.[487]

Am J Kidney Dis. 2020 Apr;75(4S2):S1-S164

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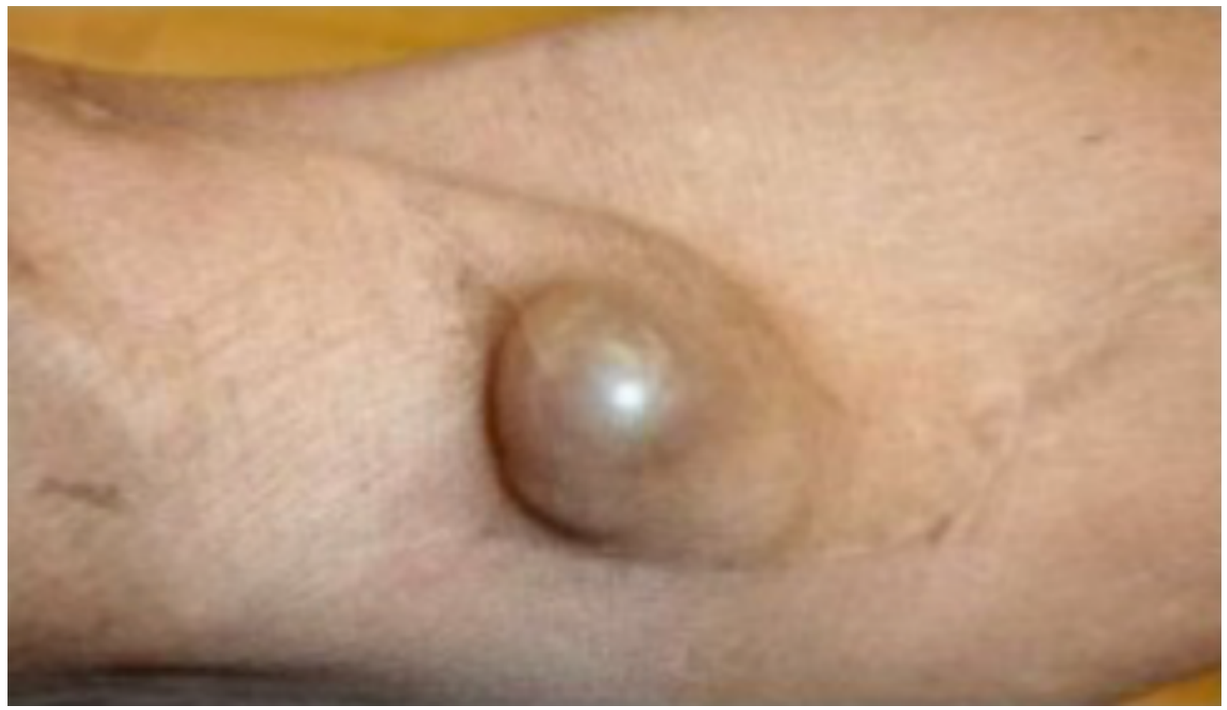
Treatment

- Ligation (if symptom are severe, limb loss at risk, or no other option available)
- Correction of arterial inflow stenosis
- Flow limiting or banding
- Proximalization of arterial inflow
- Revision using distal inflow (RUDI)
- Distal revascularization–interval ligation (DRIL)

Am J Kidney Dis. 2020 Apr;75(4S2):S1-S164

Unstable aneurysm (impending rupture)

- Thin, shiny skin
- Prolonged leaking
- Ulceration
- Rapid enlargement



Risk for erosion with haemorrhage, AV access dysfunction, pain, cannulation difficulties

AV aneurysm : indications for revision/repair

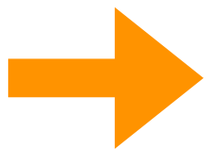
- Symptomatic, large or rapidly expanding AV access aneurysm/pseudoaneurysm
- Anastomotic aneurysm/pseudoaneurysm
- open surgical treatment > stent graft
- Avoid cannulation of the access through a pseudoaneurysm

Am J Kidney Dis. 2020 Apr;75(4S2):S1-S164

Anticoagulation

Factor Favoring Clotting of the circuit	Sign of clot in the circuit
Low blood flow	Extremely dark blood
High hematocrits	Shadow or black streaks in the dialyse
High UF rate	Foaming with subsequent clot formation in drip chambers and venous trap
Dialysis access recirculation	Rapid filling of transducer monitors with blood
Intradialytic blood and blood product transfusion	“Teetering”
Intradialytic lipid infusion	Presence of clot at the inflow dialyzer header
Use of drip chamber (air exposure, foam formation, turbulence)	Change of the arterial and venous pressure reading

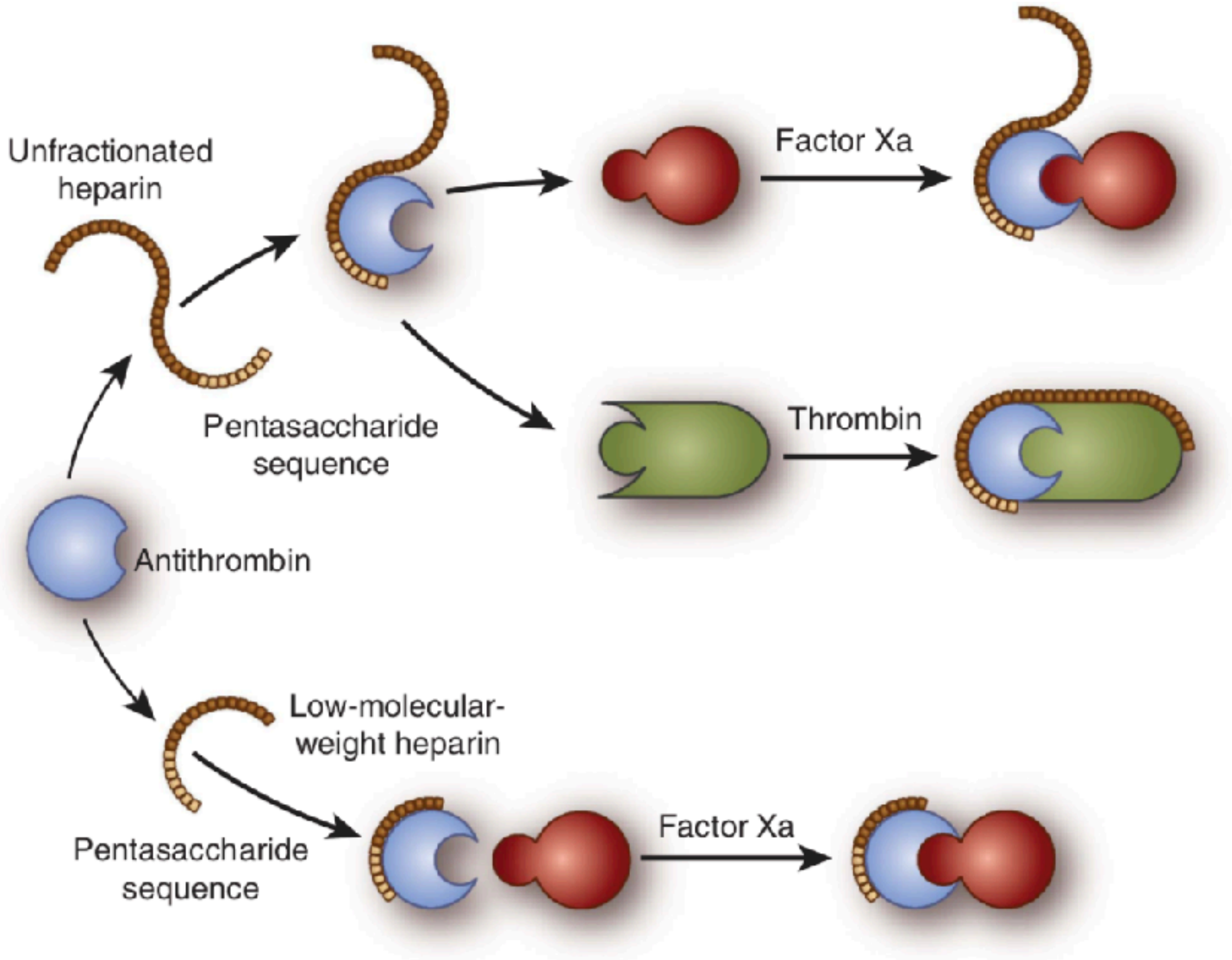
No anticoagulant :
dialyzer clotting rate during 3-4 hr : 5-10%



100-180 ml blood loss
(dialyzer+blood line)

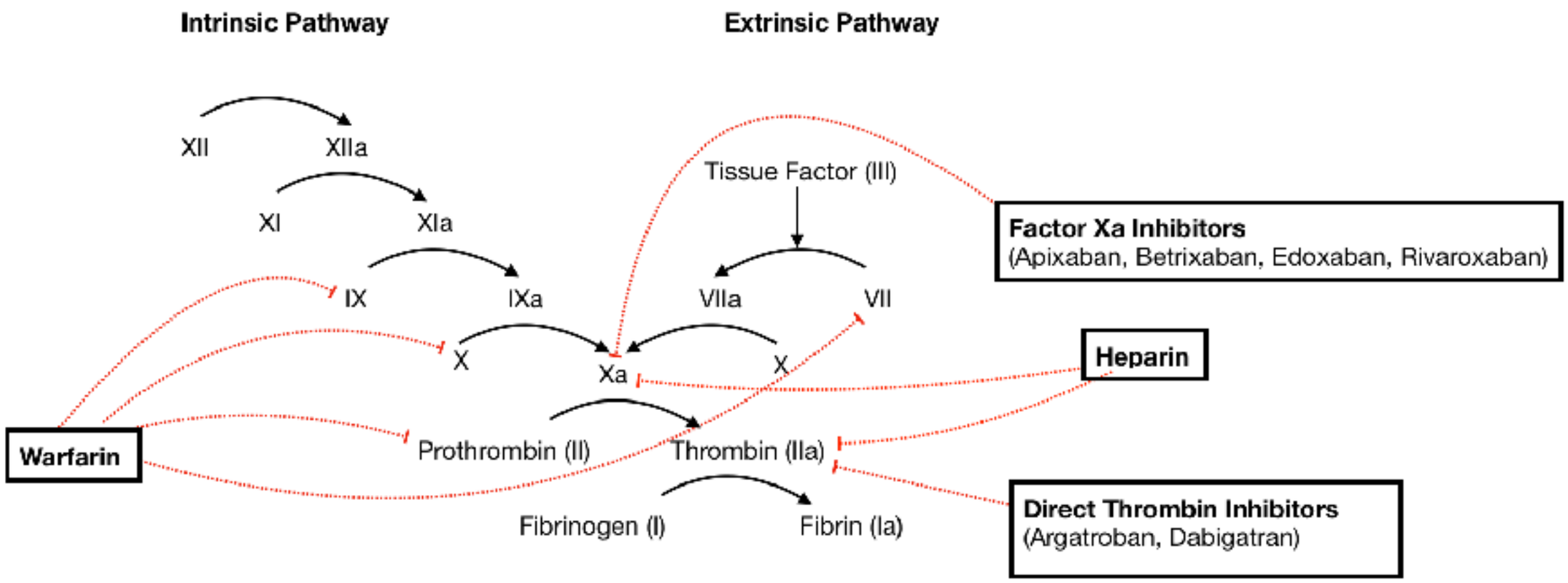
Reuse dialyzer : proper anticoagulation during dialysis maintain reuse fiber volume

Mechanism of action of anticoagulants



Kidney International 84(3):433-6

Heparin



- Size: 15,000 Da
- Half-life in dialysis patient: 50 minutes (range 30 mins- 2 hrs)
- Risk of systemic bleeding
  - High risk with GI lesion, recent surgery, pericarditis, thrombocytopenia : 25-50%
  - De novo bleeding: CNS, retroperitoneum, mediastinum

Heparin prescription

<table>
<tr><th colspan="4">Routine heparin prescription</th><th>Tight heparin prescription</th></tr>
<tr><td colspan="2">Constant-infusion method</td><td colspan="2">Single-dose only or
Repeated-bolus method</td><td rowspan="4">Slight risk for bleeding
Bleeding risk is chronic and prolonged

Baseline clotting time
↓
Initial bolus dose 750 IU
↓
check clotting time after 3 mins
Supplement bolus
keep clotting time at goal
↓
Start infusion 600 IU per hr
↓
Monitor clotting time every 30 mins
↓
Adjust dose to keep clotting time at goal</td></tr>
<tr><td>Initial bolus dose</td><td>Infusion dose</td><td>Initial bolus dose</td><td>Subsequent repeated boluses</td></tr>
<tr><td>2000-4000 IU
25-50 IU/kg</td><td>500-1,500 IU/hr</td><td>4000 IU</td><td>1000-2000 IU
bolus if needed</td></tr>
<tr><td colspan="4">No dose adjustment if BW 50-90 kg</td></tr>
<tr><td></td><td>Adjust
500 IU/hr</td><td colspan="2">Adjust
500-1000 IU</td></tr>
<tr><td colspan="5">AVF, AVG: stop heparin infusion 1 hr prior to the end of dialysis
Venous catheter: continue to the end of dialysis</td></tr>
</table>

Handbook of dialysis, 5 th edition

Heparin prescription

Routine heparin prescription				Tight heparin prescription
Constant-infusion method		Single-dose only or Repeated-bolus method		Slight risk for bleeding Bleeding risk is chronic and prolonged
Initial bolus dose	Infusion dose	Initial bolus dose	Subsequent repeated boluses	Baseline clotting time ↓ Initial bolus dose 750 IU ↓ check clotting time after 3 mins Supplement bolus keep clotting time at goal ↓ Start infusion 600 IU per hr Adjust dose to keep clotting time at goal
2000-4000 IU 25-50 IU/kg	500-1,500 IU/hr	4000 IU	1000-2000 IU bolus if needed	
	500 IU/hr		500-1000 IU	

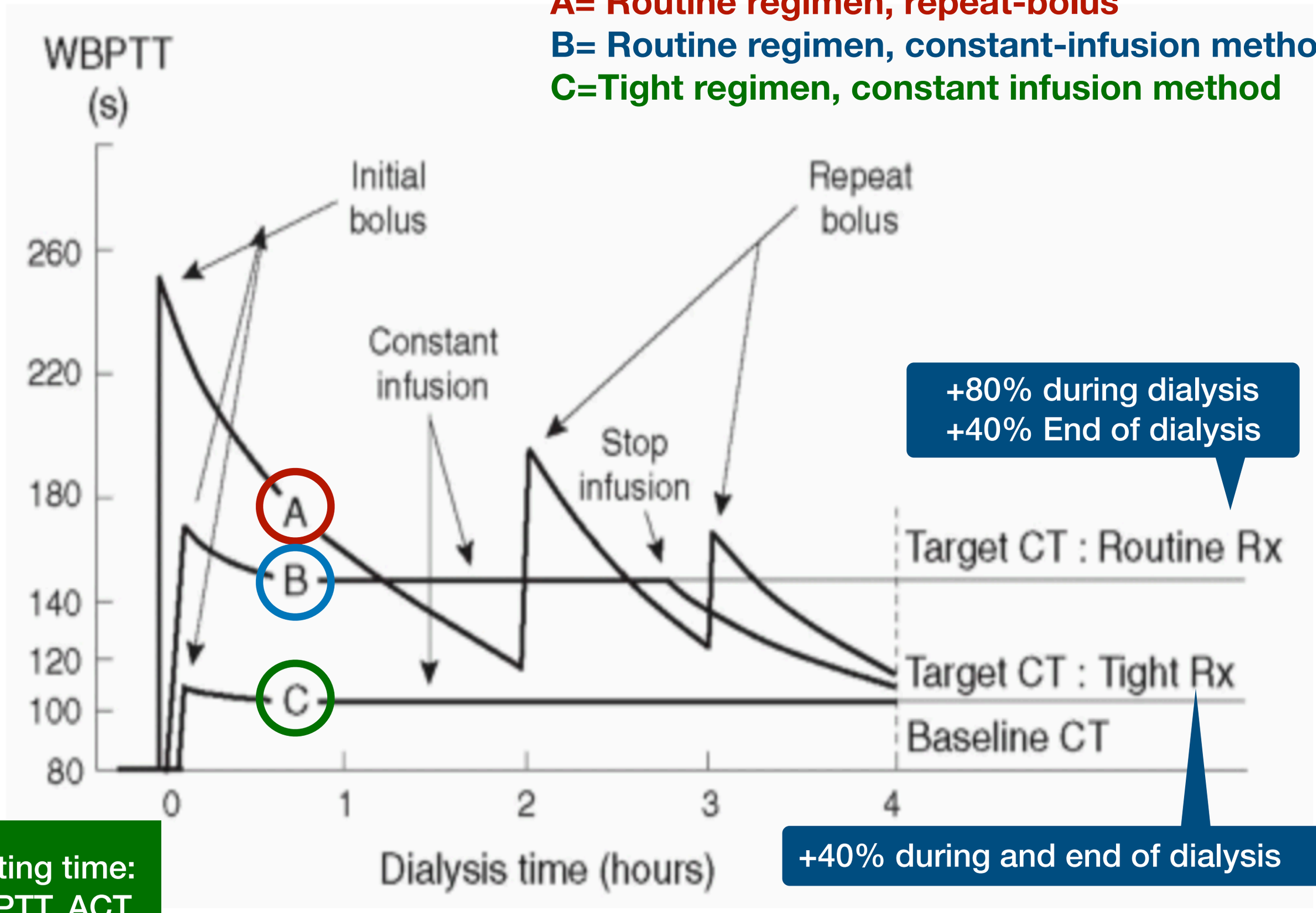
Adjusted Loading dose = Loading dose (Desired △ ACT LD/Observed △ ACT LD)
Adjusted Infusion Rate = Infusion rate (Desired △ ACT INF/Observed △ ACT INF)

Reduced initial bolus dose of UFH in
- Extremely uremic patients
- Patient with prolonged baseline clotting time
- Short-session dialysis

Handbook of dialysis, 5 th edition

Heparin regimens on clotting time

A= Routine regimen, repeat-bolus
B= Routine regimen, constant-infusion method
C=Tight regimen, constant infusion method



+80% during dialysis
+40% End of dialysis

+40% during and end of dialysis

Clotting time:
WBPTT, ACT

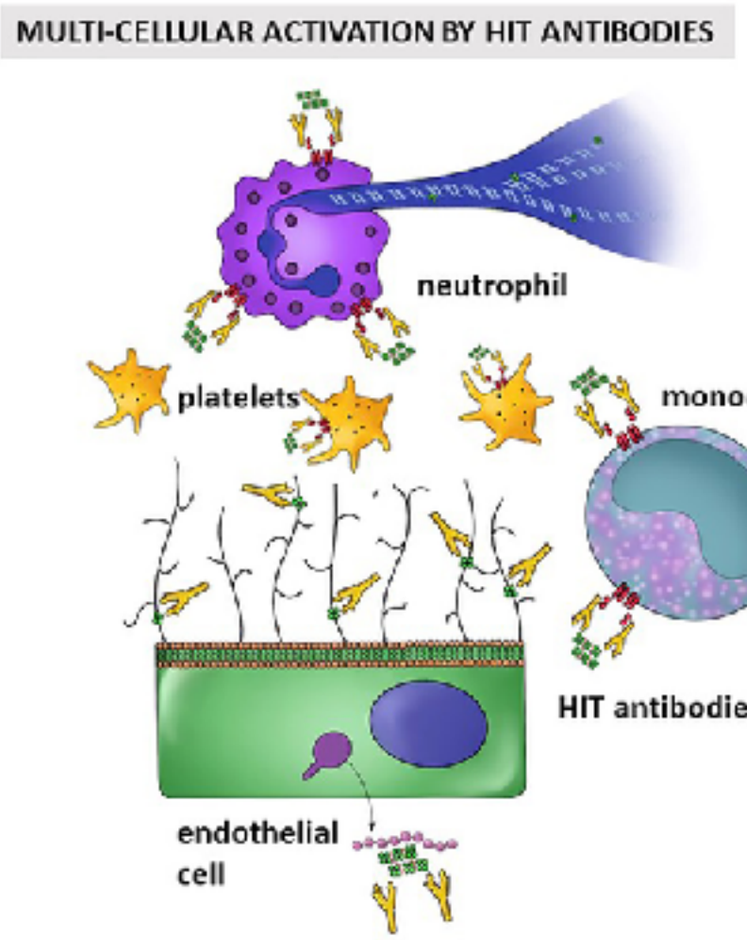
Handbook of dialysis, 5 th edition

Heparin associated complication

- Heparin-induced thrombocytopenia
- Lipids: increase TG, lower HDL
- Pruritus: local itching at injection site, systemic itching and allergic reaction
- Anaphylactiod reactions : immediate type 1 hypersensitivity
- Hyperkalemia : suppression of aldosterone synthesis, UFH>LMWH
- Osteoporosis : suppress osteoblast formation and activate osteoclast

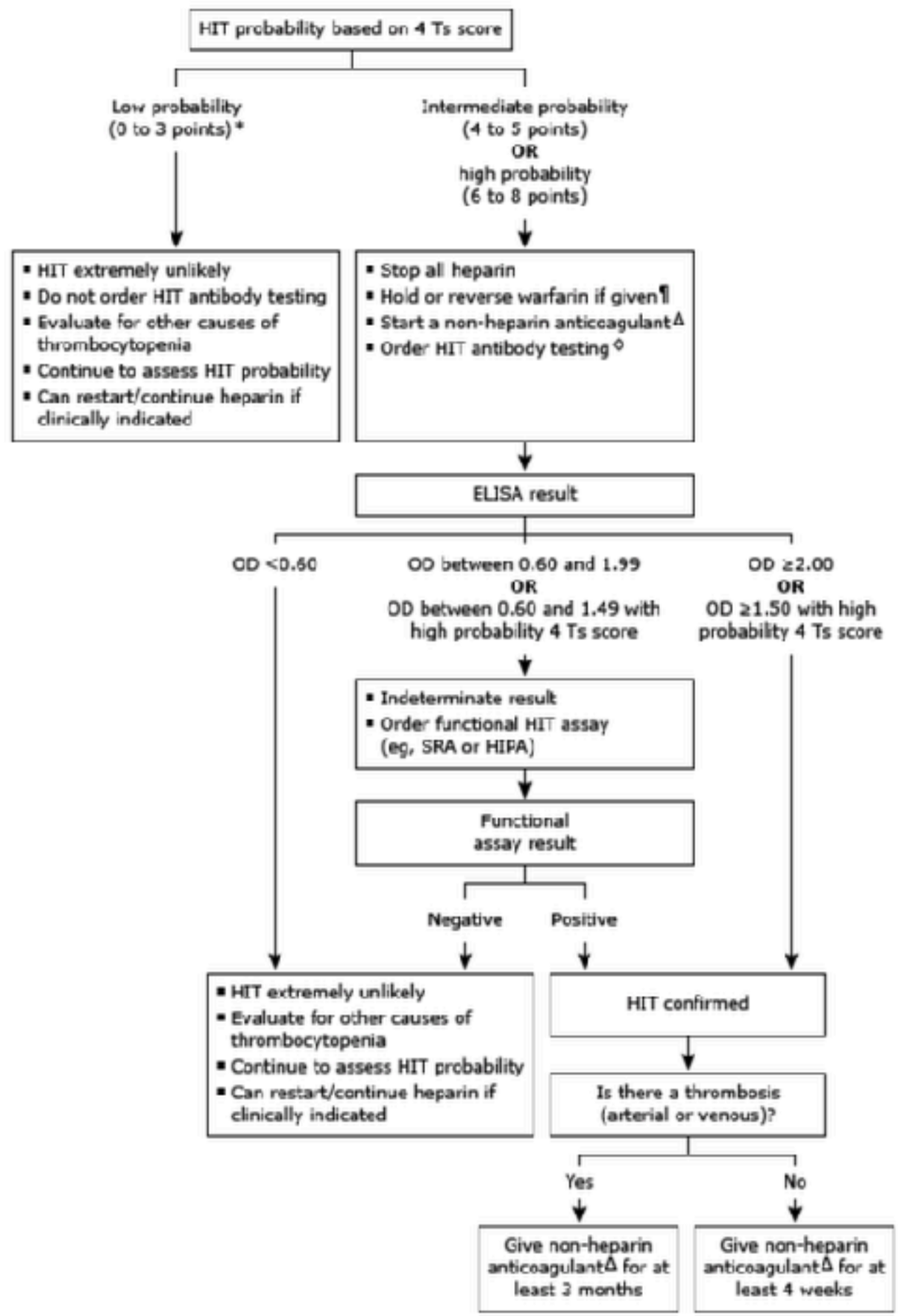
Heparin-induced thrombocytopenia (HIT)

	Type 1	Type 2
Frequency	10-20%	1-3%
Timing of onset	1-4 days	5-10 days after start heparin
Nadir platelet count	100,000 / microL	Usually > 20,000 /microL Median nadir 60,000/microL
Antibody mediated	No	Yes
Thromboembolic sequelae	None	30-80%
Hemorrhagic sequelae	None	Rare
Management	Observe	Cessation of heparin, alternative non heparin anticoagulation to prevent thrombosis



J Am Coll Cardiol 1998; 31:1449

4 Ts score parameters:	
Thrombocytopenia:	
▪ PLT decrease >50% **AND** nadir ≥20,000/microL **AND** no surgery within preceding 3 days	2 points
▪ PLT decrease >50% **BUT** surgery within preceding 3 days **OR** any combination of PLT fall and nadir that does not fit criteria for 2 or 0 points (eg, 30 to 50% fall or nadir 10,000 to 19,000/microL)	1 point
▪ PLT decrease <30% **OR** nadir <10,000/microL	0 points
Timing of onset after heparin exposure:	
▪ 5 to 10 days **OR** 1 day if exposure within past 5 to 30 days	2 points
▪ Probable 5 to 10 days (eg, missing PLT counts) **OR** >10 days **OR** <1 day if exposure within past 31 to 100 days	1 point
▪ ≤4 days without exposure within past 100 days	0 points
Thrombosis or other clinical sequelae:	
▪ Confirmed new thrombosis, skin necrosis, anaphylactoid reaction, or adrenal hemorrhage	2 points
▪ Suspected, progressive, or recurrent thrombosis, skin erythema	1 point
▪ None	0 points
Other cause for thrombocytopenia:	
▪ None	2 points
▪ Possible (eg, sepsis)	1 point
▪ Probable (eg, DIC, medication, within 72 hours of surgery)	0 points
Interpretation:	
0 to 3 points – Low probability (<1%)	
4 to 5 points – Intermediate probability (approximately 10%)	
6 to 8 points – High probability (approximately 50%)	



Uptodate 2021

J Thromb Haemost 2006; 4:759.

KDIGO 2012

- 5.3.4 In a patient with heparin-induced thrombocytopenia **(HIT)**, **all heparin must be stopped** and we recommend using **direct thrombin inhibitors (such as argatroban) or Factor Xa inhibitors (such as danaparoid or fondaparinux)** rather than other or no anticoagulation during RRT (1A)

- 5.3.4.1 In a patient with HIT who does not have severe liver failure, we suggest using **argatroban** rather than other thrombin or factor Xa inhibitors during RRT (2C)

Argatroban

- Direct thrombin inhibitor: argatroban, lepirudin, bivalirudin
- Metabolised by the liver
- High protein binding: Not significantly cleared during high-flux hemodialysis or hemodiafiltration
- Dose
  - Initial bolus 250 mcg/kg → infusion 2 mcg/kg/min or 6-15 mg/hr
  - Titrate to achieved APPTratio of 2-2.5
  - Stop infusion 20-30 mins prior to the end of the dialysis session

Murray, Kidney Int.2004;66;2446

Low molecular weight heparin (LMWH)

- MW 4000-6000 Da
- Dose : single dose at the start of dialysis

Name	Molecular weight (Da)	Anti-Xa/IIa activity ratio	Average dialysis bolus dose
Enoxaparin	4,200	3.8	0.5-0.8 mg/kg
Tinzaparin	4,500	1.9	1,500-1,800 IU

- Reduce risk of HIT, less hypertriglyceride
- Complication: anaphylactic reactions to bolus LMWH

Safety and Efficacy of Low Molecular Weight Heparins for Hemodialysis in Patients with End-Stage Renal Failure: A Meta-analysis of Randomized Trials

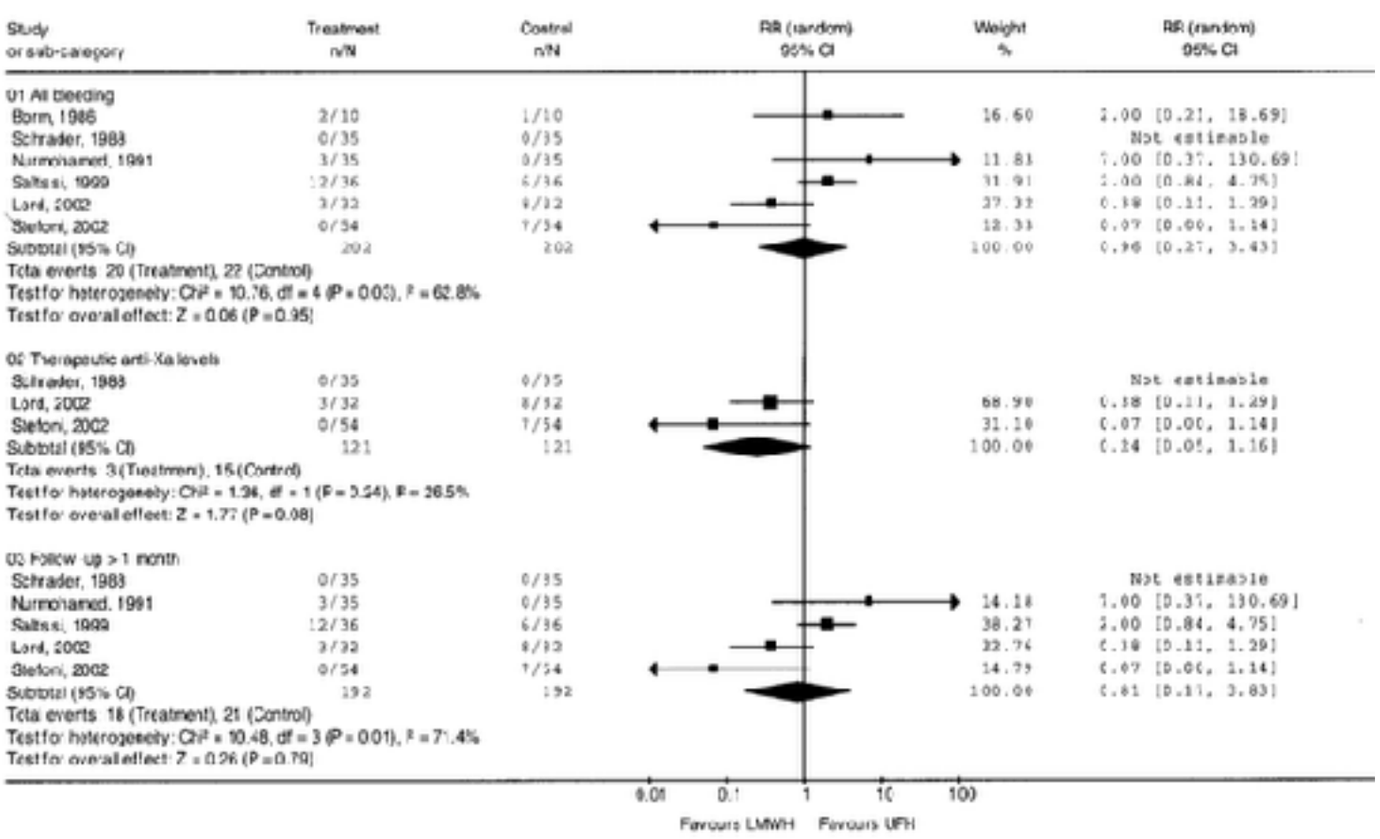


Figure 2. Individual study and summary relative risks for bleeding.

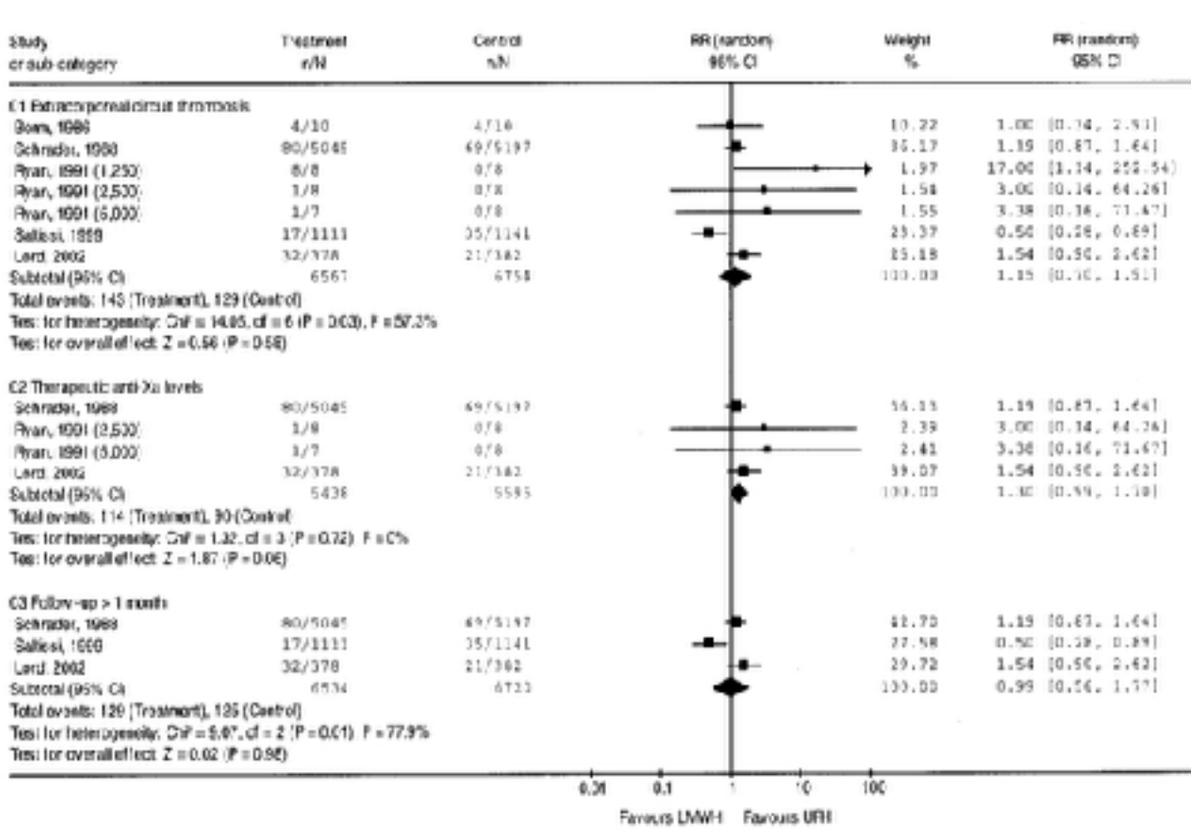


Figure 4. Individual study and summary relative risks for extracorporeal circuit thrombosis.

No significant difference in **bleeding** events or **thrombosis** of the extracorporeal circuit

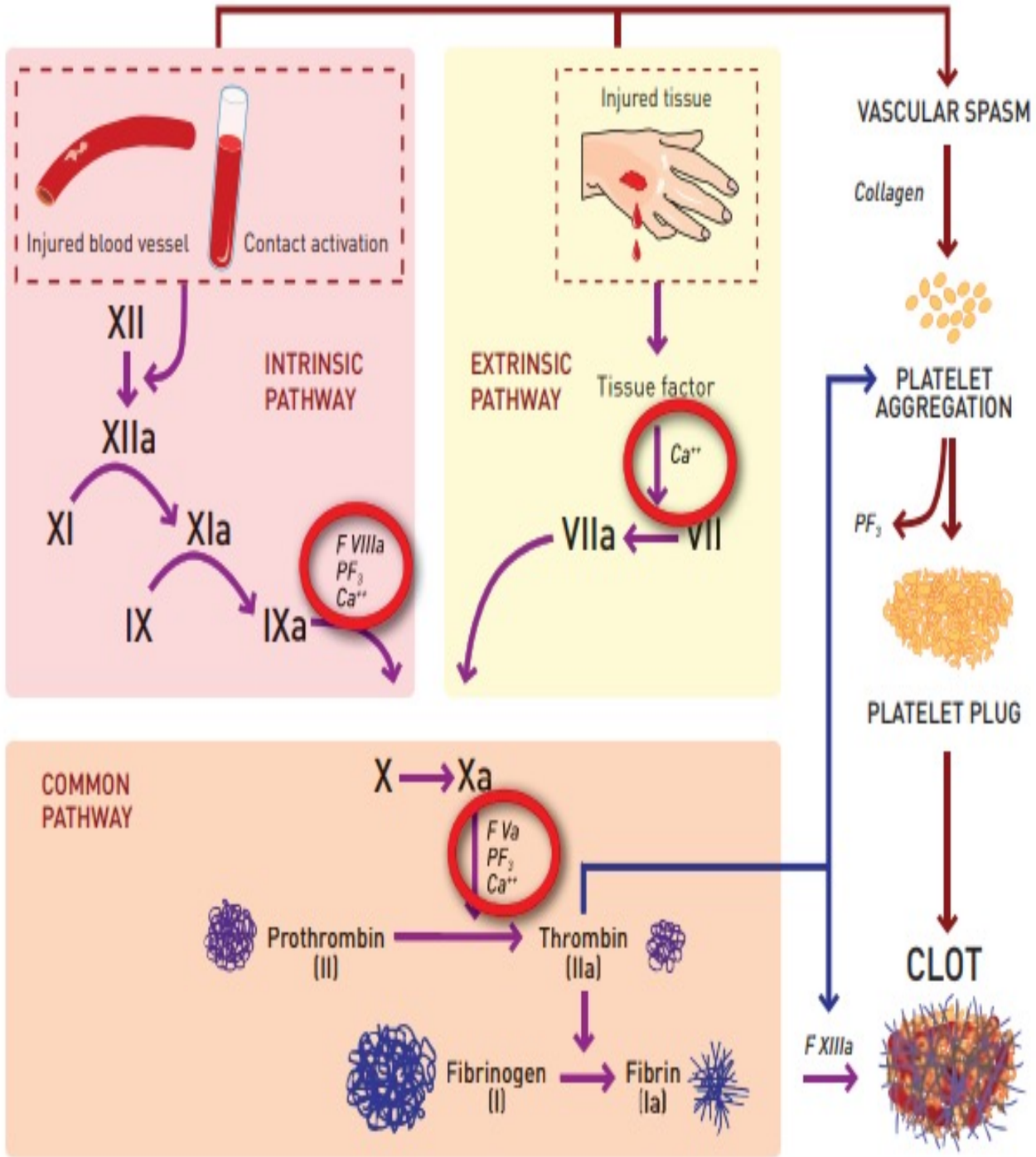
J Am Soc Nephrol 15:3192-3206, 2004

Heparinoids

- Danaparoid
    - Mixture of 84% heparin, 12% derma tan, 4% chondroitin sulphate, inhibit factor Xa
    - Monitor factor Xa
    - Cross-react with HIT antibodies up to 10% of cases
- Fondaparinux
    - Synthetic pentasaccharides, not cross-react with HIT Ab
    - Predialysis dose 2.5-5 mg, long half-life of 15 hr
    - Predialysis anti-Xa of ≤0.2 IU/mL

Citrate

- **Anti-hemostatic** : chelating ionized calcium-key cofactor of clotting cascade



- **Anti-inflammatory** :
  - reduced activation of WBCs and platelets
  - protective effect against Endothelial-cell inflammation and dysfunction
  - decrease signal molecule in several cellular

process related to inflammation and balance of oxidative species

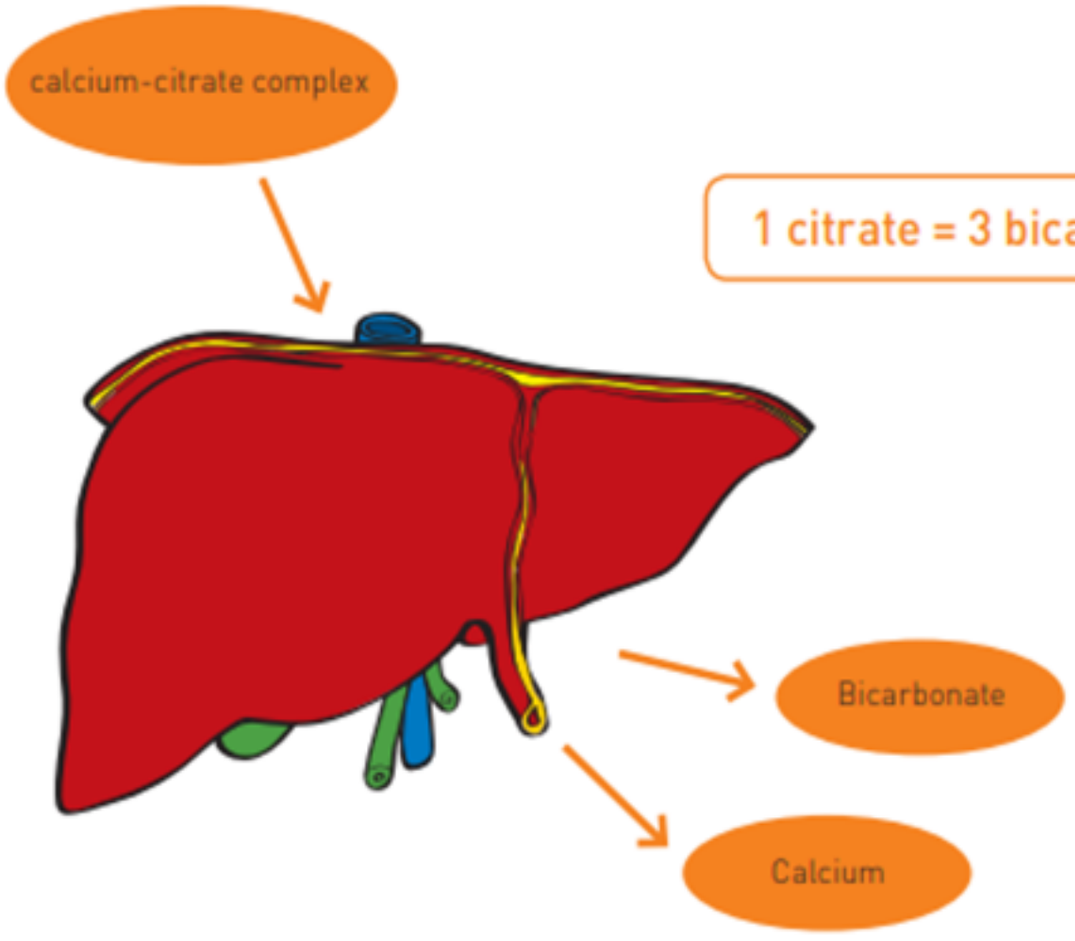
Levels of citrate and ionized calcium return to normal values within 30 minutes of discontinuing a citrate infusion

Am J Kidney Dis. 2000 May;35(5):802-11

Citrate metabolism

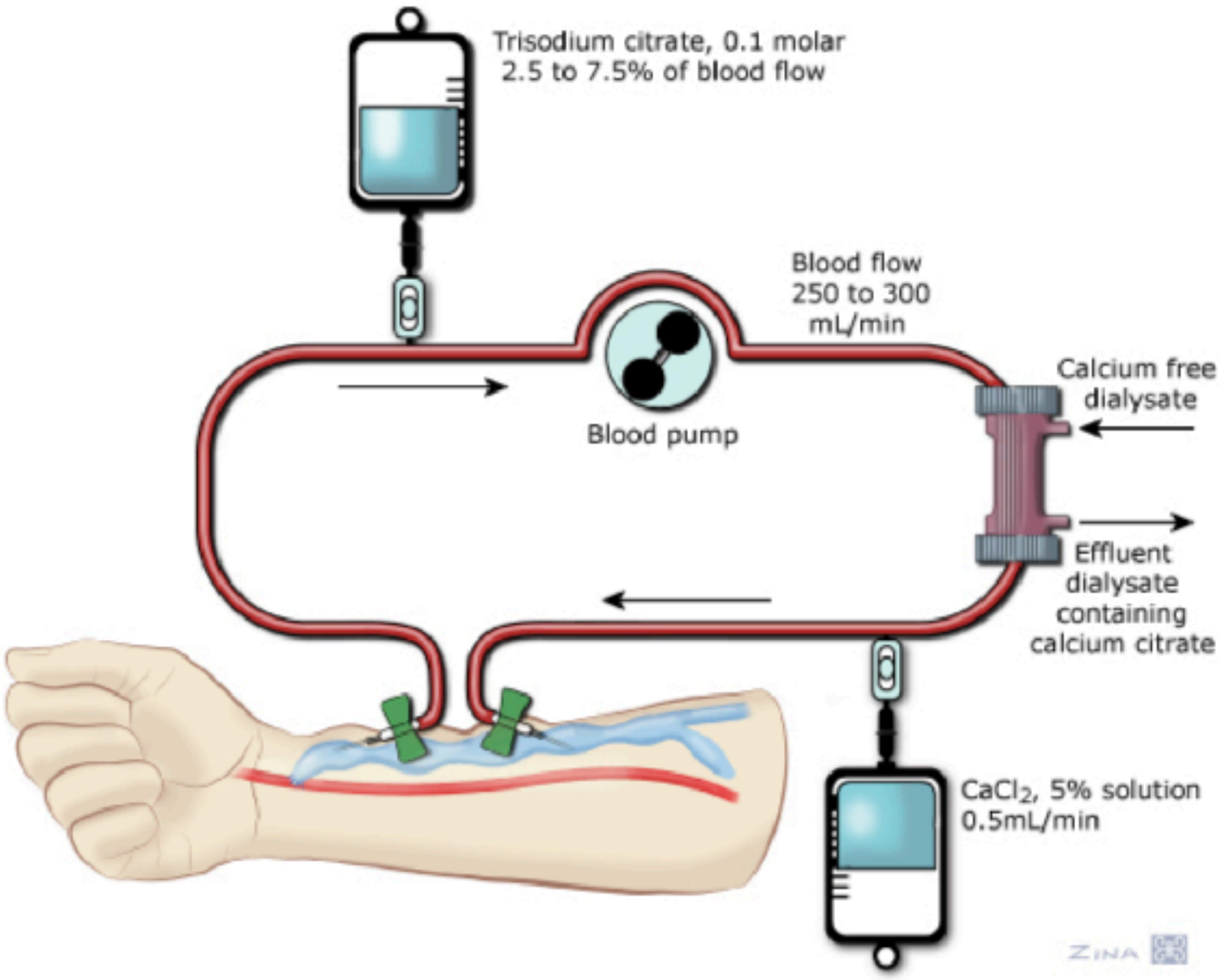
$Na_3citrate + 3\ H_2CO_3 \longleftrightarrow$ Citric acid $(C_6H_8O_7) + 3NaHCO_3$

Citric acid $+ O_2 \longleftrightarrow 3H_2CO_3 + H_2O + 3CO_2 + 4H_2O + 6CO_2$



- Rapidly metabolized through aerobic pathway of the Krebs cycle (tricarboxylic acid cycle) in the liver > skeletal muscle,kidney
- 1 mmol citrate provide 0.59 kcal
- Citrate protocol: citrate load 11-20 mmol/hr energy 150-280 kcal/24 hr

Regional citrate anticoagulation



- Trisodium citrate 0.1 mol, 2.5-7.5% blood flow
- Post hemodialysis machine 5% CaCl2 IV rate 0.5 ml/min
- Need Ca free dialyse
- Need low HCO2 dialyse
- Need monitor iCa

Complication: hypocalcemia, metabolic alkalosis, hypernatremia

Uptodate 2021

Dialysis Intervention for treatment of AKI

5.3.2 For patients without an increased bleeding risk or impaired coagulation and not already receiving effective systemic anticoagulation, we suggest the following:

5.3.2.1 For anticoagulation in intermittent RRT, we recommend using either unfractuionated or low-molecular weight heparin, rather than other anticoagulants. (1C)

5.3.2.2 For anticoagulation in **CRRT**, we suggest using **regional citrate anticoagulation** rather than heparin in patients who do not have contraindication for citrate. (2B)

Kidney International Supplement (2012) 2, 8-12

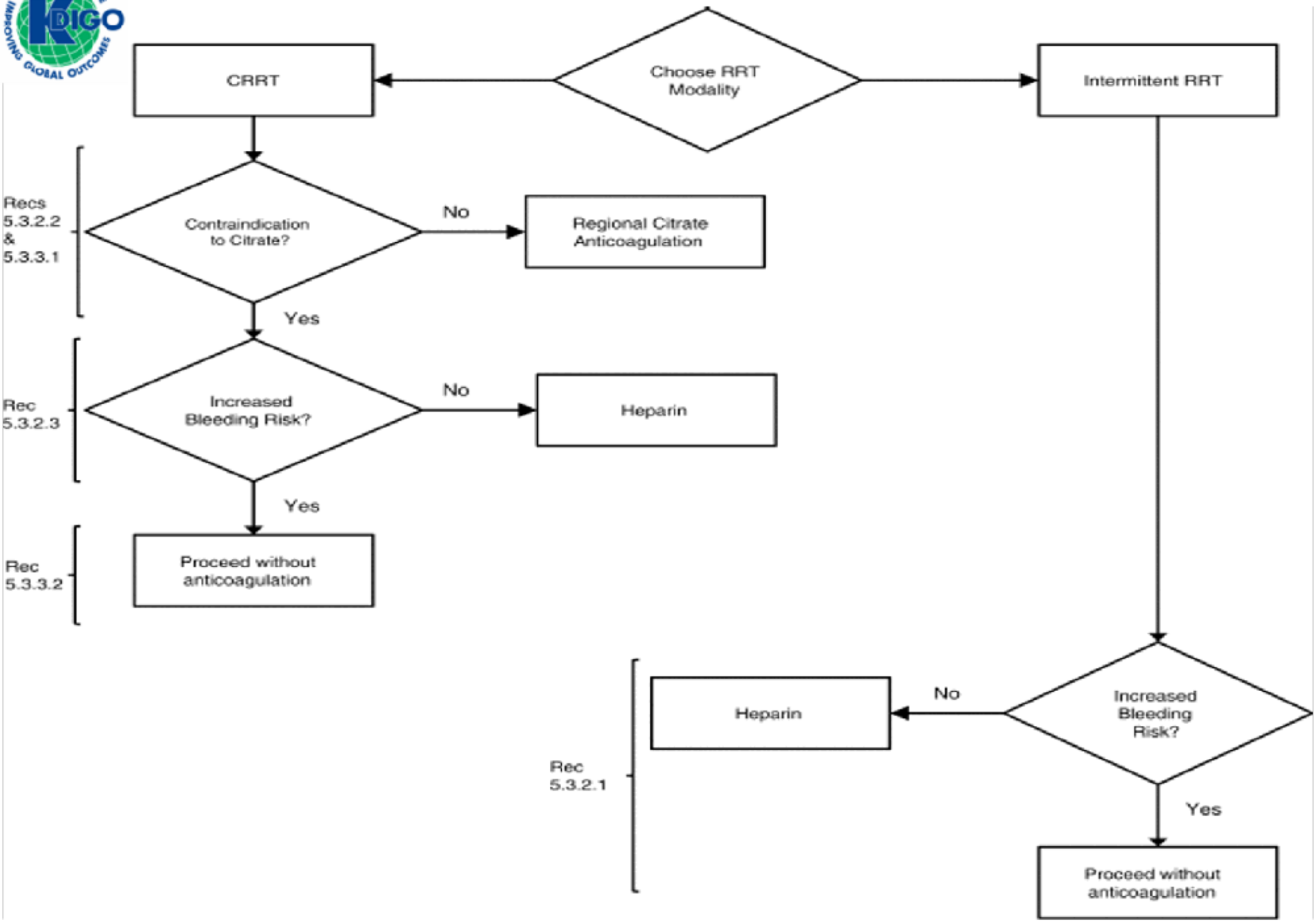
Dialysis Intervention for treatment of AKI

5.3.3: For patients with increased bleeding risk who are not receiving anticoagulation, we suggest the following for anticoagulation during RRT:

5.3.3.1: We suggest using regional citrate anticoagulation, rather than no anticoagulation, during CRRT in a patient without contraindications for citrate. (2C)

5.3.3.2: We suggest avoiding regional heparinization during CRRT in a patient with increased risk of bleeding. (2C)

Kidney International Supplement (2012) 2, 8-12



Kidney International Supplement (2012) 2, 89-115

CRRT dose

- Heparin protocol
  - Heparin in priming and rinsing solution
    - Heparin IV bolus 2000-5000 IU via venous line
    - Infusion 500-1000 IU/hr in arterial blood line
    - Keep aPTT 45-60 secs, PTT ratio 1.5-2

Handbook of dialysis, 5 th edition

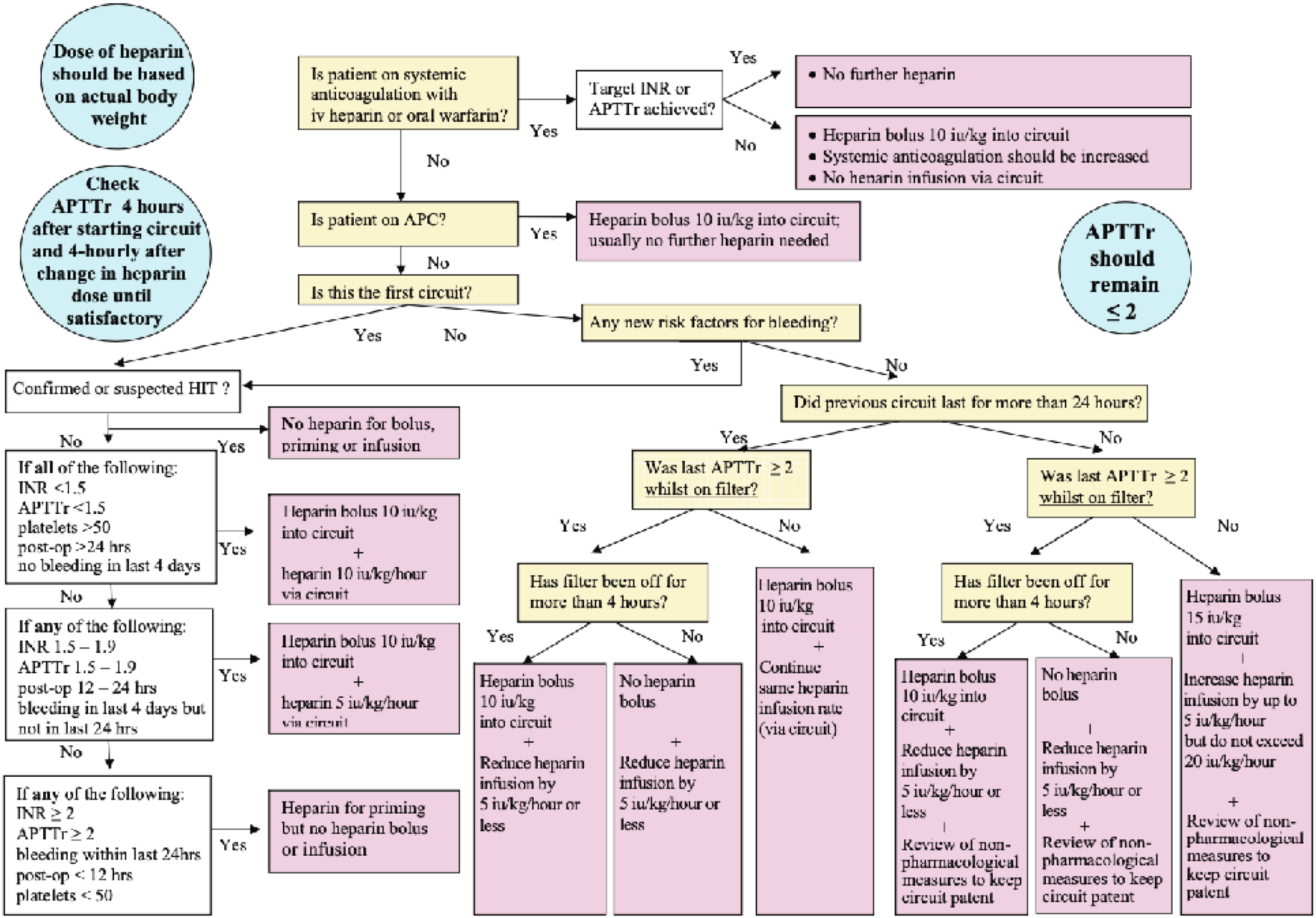
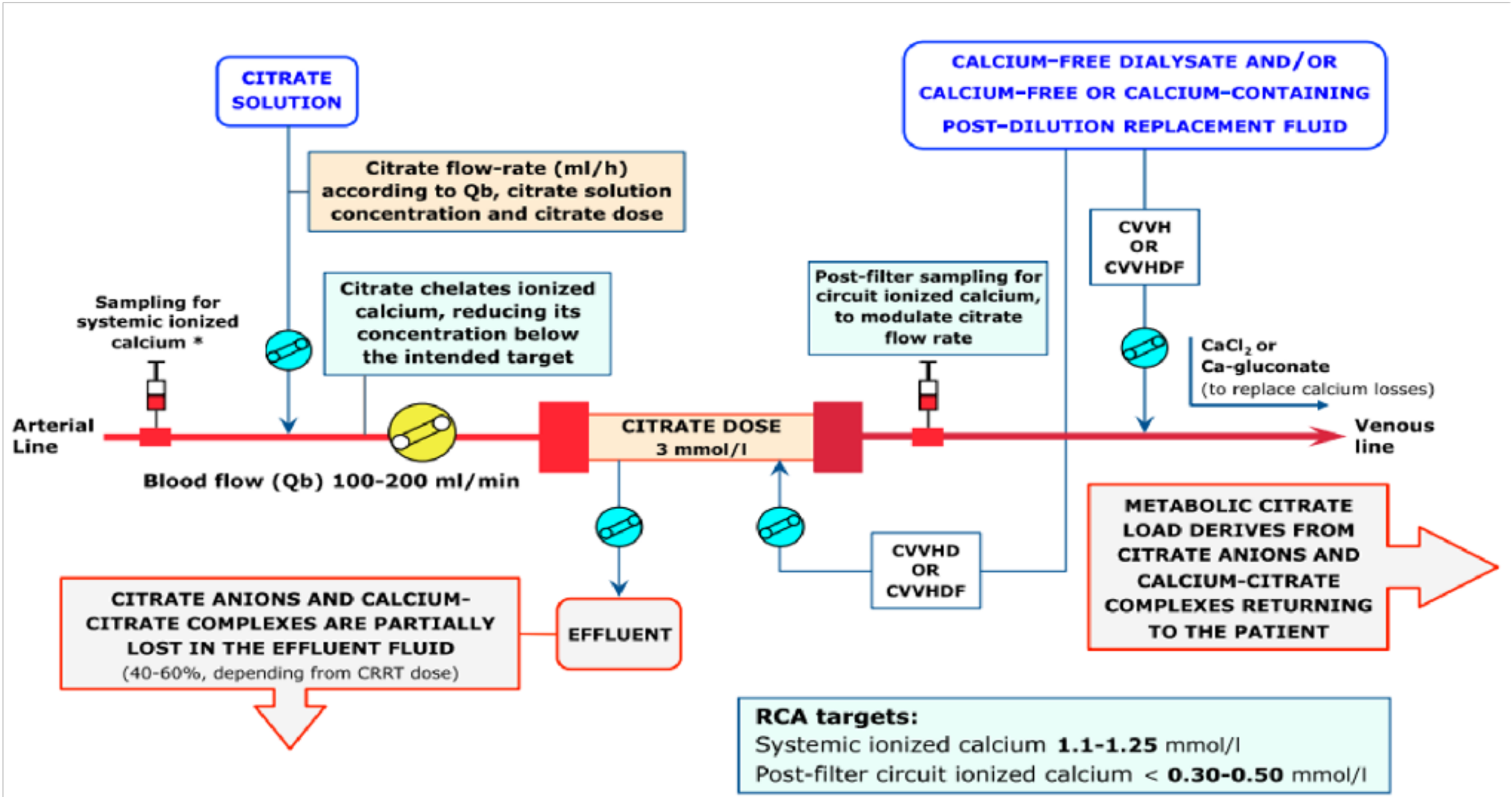


Figure 1. Algorithm for heparin anticoagulation during continuous renal replacement therapy. Algorithm is based on using 10,000 iu heparin in 40 ml of 0.9% NaCl. APC, activated protein C; APTTr, activated partial thromboplastin time ratio; CRRT, continuous renal replacement

Critical Care 2010, 14:419

RCA in CRRT



Clin J Am Soc Nephrol 9: 2173–2188, December, 2014

ค่าในเลือดที่ต้องการเก็บตรวจ	ความถี่ในการติดตาม	วัตถุประสงค์
Circuit ionized calcium (postfilter)	ภายใน 1 ชม.หลังจากเริ่มและติดตามทุก 6-8 ชม.	เพื่อปรับ dose ของ citrate
Systemic ionized calcium	ก่อนเริ่มทำ RRT ภายใน 1 ชม.หลังจากเริ่มและติดตามทุก 4-6 ชม.	Set initial calcium infusion rate ประเมินให้อยู่ใน physiologic range และเพื่อปรับ calcium infusion rate
Systemic total calcium	อย่างน้อยทุก 12-24 ชม.พร้อมกับ systemic iCa	คำนวณ systemic Total Ca: iCa ถ้า ratio ≥2.5 เป็น citrate accumulation (KDIGO 2.1)
ABG และ serum HCO3	ก่อนเริ่มทำ RRT ภายใน 1 ชม.หลังจากเริ่มและติดตามทุก 4-6 ชม.	ติดตามภาวะ metabolic acidosis หรือ alkalosis
Magnesium	อย่างน้อย ทุก 24 ชม.	เพื่อปรับการให้ magnesium เสริม
Serum sodium	อย่างน้อย ทุก 24 ชม.	ประเมินความถูกต้องของ RCA solutions
Serum lactate	ก่อนเริ่มทำ RRT อย่างน้อย ทุก 6-12 ชม.หรือตามอาการผู้ป่วย	ประเมินความเสี่ยงต่อการเกิด citrate accumulation ≥ 3.4 mmol/L

Complication	Mechanism	Preventive measures
Metabolic alkalosis	Excess buffer load • High citrate delivery • Inadequate matching of citrate/HCO3 in dialysate/replacement fluid	• Decrease citrate infusion rate - reduce BFR, reduce target citrate dose • Increase citrate and HCO3 loss - increase dialysate/replacement fluid rate • Reduce HCO3 in dialysate/replacement fluid • Limit exogenous buffer (acetate in TPN, citrate in blood product)
Metabolic acidosis	Inadequate citrate metabolism (citrate accumulation) **Rising anion gap, worsening metabolic acidosis** **Falling systemic iCa** **Escalating Ca infusion requirement** **Systemic Total Ca : iCa ratio >2.5:1**	Reduce/stop citrate infusion Increase citrate loss : increase dialysate/RF Switch to standard HCO3 in dialysate/RF Start HCO3 systemic infusion
	Inadequate buffer supply	Increase citrate delivery - Increase citrate rate, increase target citrate dose Reduce citrate/HCO3 loss - Reduce dialysate/replacement fluid rate Increase HCO3 in dialysate/RF Start HCO3 systemic infusion

Anticoagulant	Advantage	Disadvantage
Heparin (unfractionated)	Wide availability Large experience Short half-life Antagonist available Monitoring with routine tests (aPTT or ACT) Low costs	Narrow therapeutic index-risk of bleeding Unpredictable kinetics- monitoring required HIT Heparin resistance
Low-molecular weight heparin	More predictable kinetics -weight-based dosing -No monitoring required -Single predialysis dose may be sufficient in IHD -Reduced risk of HIT	-Risk of accumulation in kidney failure -Monitoring requires non routine test (anti-Factor Xa) -Different drugs not interchangeable -Incomplete reversal by protamine -More expensive than unfractionated heparin
Citrate	Strict regional anticoagulation - Reduced bleeding risk	-Risk of accidental overdose with potentially fatal consequences -Insufficient citrate metabolism in patients with reduced liver function and shock states resulting in accumulation with metabolic acidosis and hypocalcemia - acidosis, alkalosis, hypernatremia, hypocalcemia, hypercalcemia -increase complexity, requires strict protocol

Kidney International Supplement (2012) 2, 89-115

Thank you