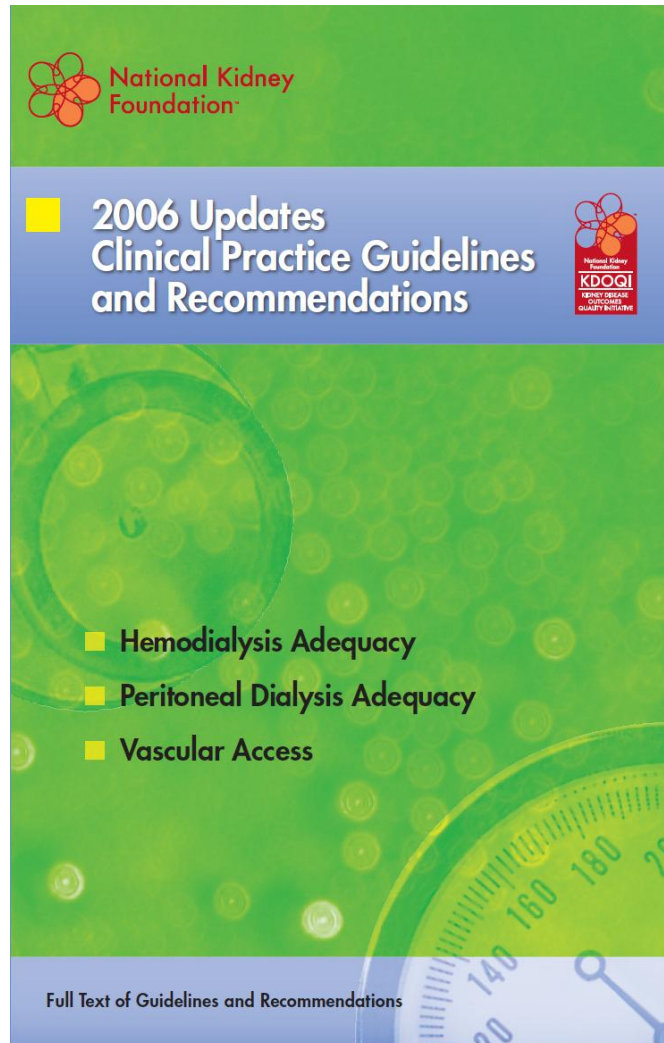


Hemodialysis(HD) access

Incheon St. Mary's Hospital
The Catholic University of Korea

Do Yeon Kim M.D, Ph.D

KDOQI guideline 2006, 2019 update



KDOQI®

KIDNEY DISEASE OUTCOMES QUALITY INITIATIVE

National Kidney Foundation

**KDOQI CLINICAL PRACTICE GUIDELINE FOR VASCULAR
ACCESS: 2019 UPDATE**



Charmaine E. Lok, Thomas S. Huber, Timmy Lee, Surendra Shenoy, Alexander S. Yevzlin, Kenneth Abreo, Michael Allon, Arif Asif, Brad C. Astor, Marc H. Glickman, Janet Graham, Louise M. Moist, Dheeraj K. Rajan, Cynthia Roberts, Tushar J. Vachharajani, and Rudolph P. Valentini



National
Kidney
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KDOQI CLINICAL PRACTICE GUIDELINE FOR VASCULAR ACCESS: 2018

AJKD SUBMISSION DRAFT
April 2019

- An important new concept introduced in this Vascular Access guideline update is that of the ***“ESKD Life Plan”***.
- ***This individualized and comprehensive map for dialysis modalities and vascular access for the lifetime of the patient*** is documented in this guideline, as well as the implementation tools for this guideline that will be developed by the National Kidney Foundation.

세 가지 access, 그리고 KDOQI 2019의 관점 변화

AVF · 자가 동정맥루

장기 개존율·감염률이 가장 좋음
약점은 성숙 실패와 긴 준비 기간

AVG · 인공혈관

빨리 사용 가능 (early-cannulation graft
aft는 24-72시간)
협착·혈전·감염이 더 잦음

Tunneled CVC

즉시 사용 가능
감염·central stenosis·사망 위험 증가 →
필요할 때만, 짧게

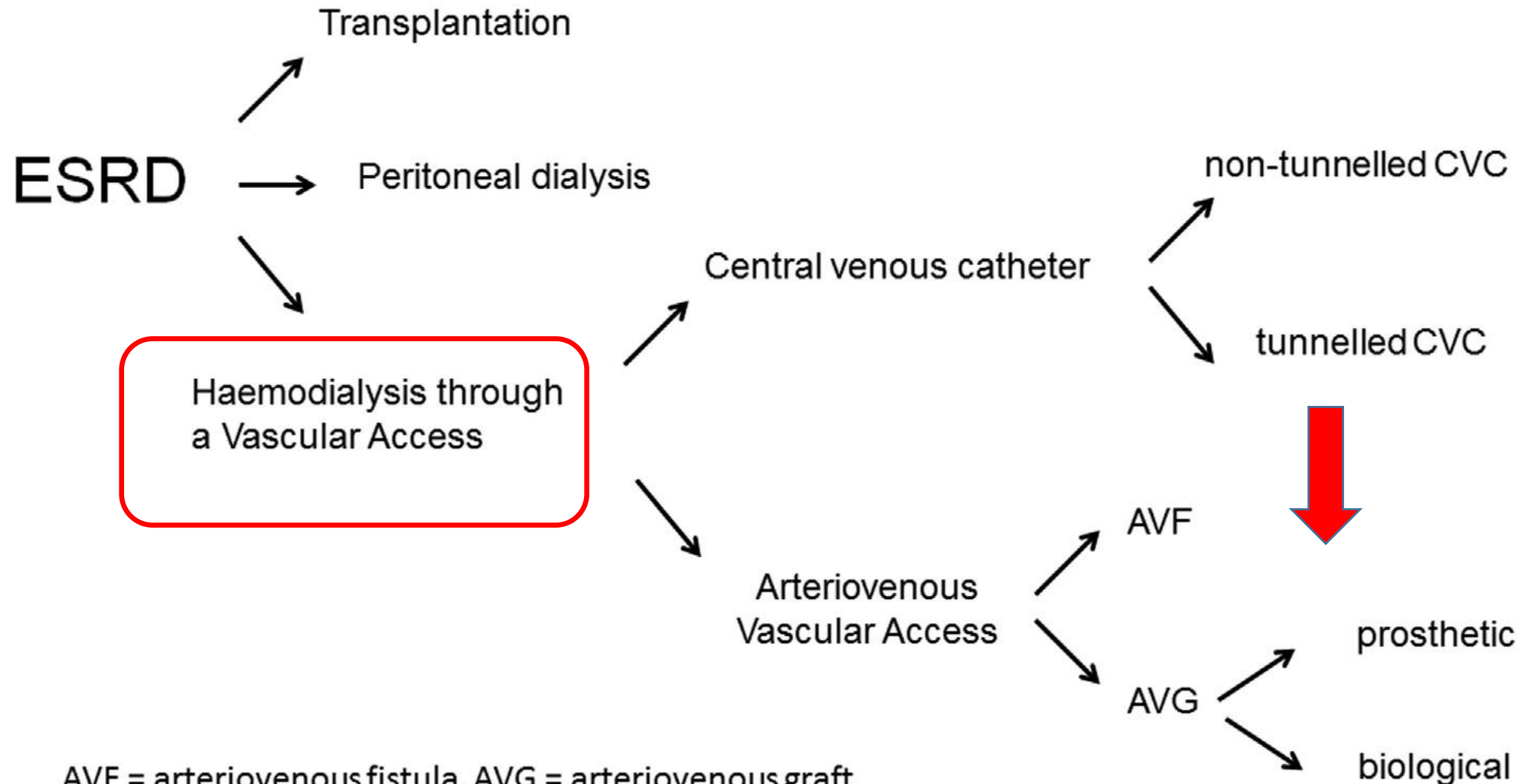
ESKD Life-Plan

환자의 평생 경로(CKD → 투석 → 이식·PD)를 먼저 그리고, 그 안에서 지금 필요한 access를 고른다. **Right access, right patient, right time, right reasons.**

Table 3. Classification of chronic kidney disease based on glomerular filtration rate (GFR).^{8–11}

Stage	Description	GFR mL/min/1.73 m ²
Stage 1	Kidney damage with normal or elevated GFR	90+
Stage 2	Kidney damage with mildly decreased GFR	60–89
Stage 3	Moderately decreased GFR	30–59
투석준비단계 → Stage 4	Severely decreased GFR	15–29
투석시작단계 → Stage 5	End stage renal disease (ESRD)	<15 or on dialysis

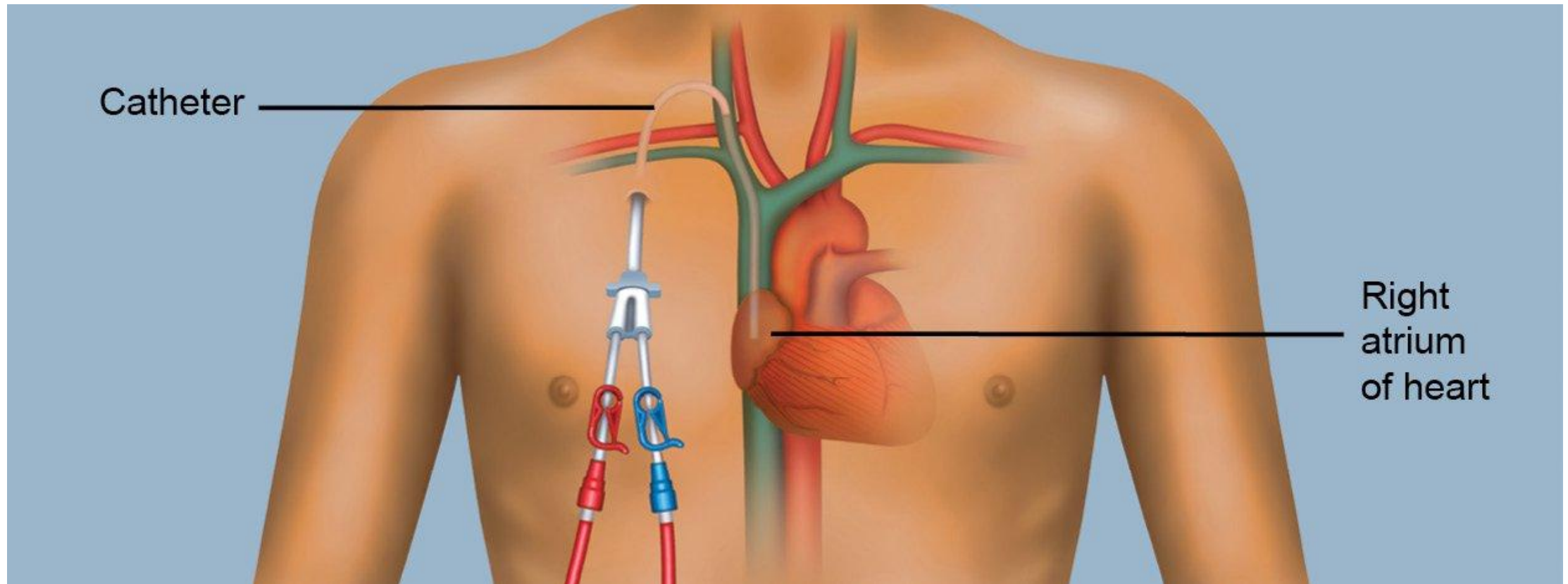
Treatment options for patients with ESRD

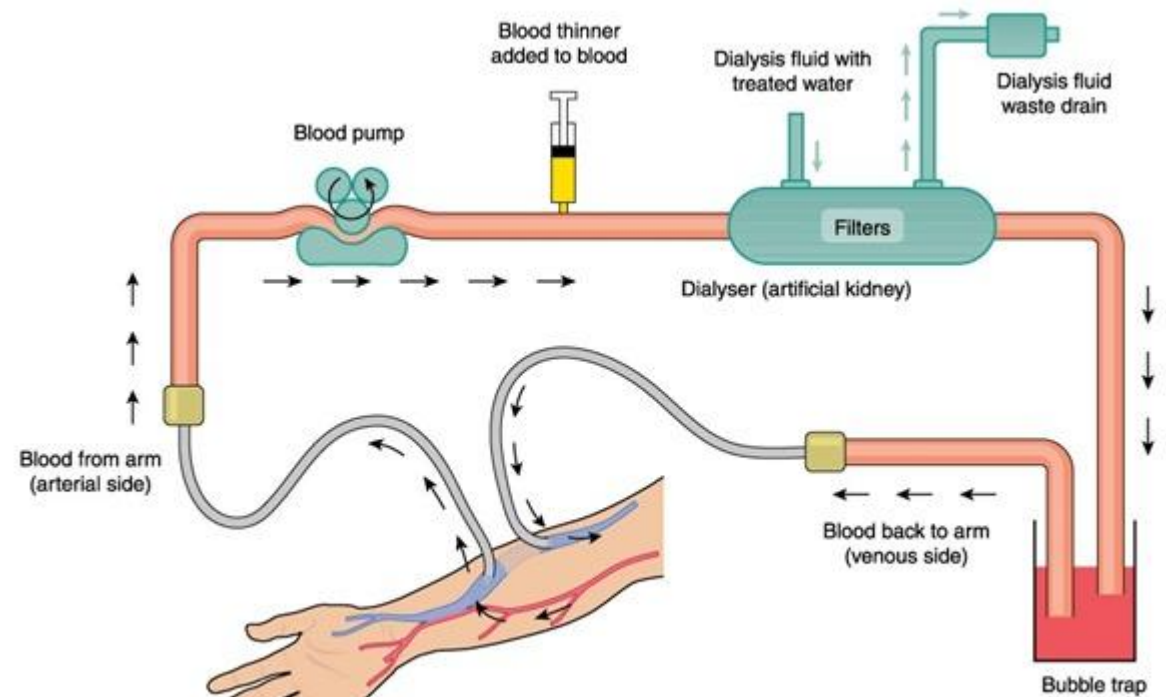
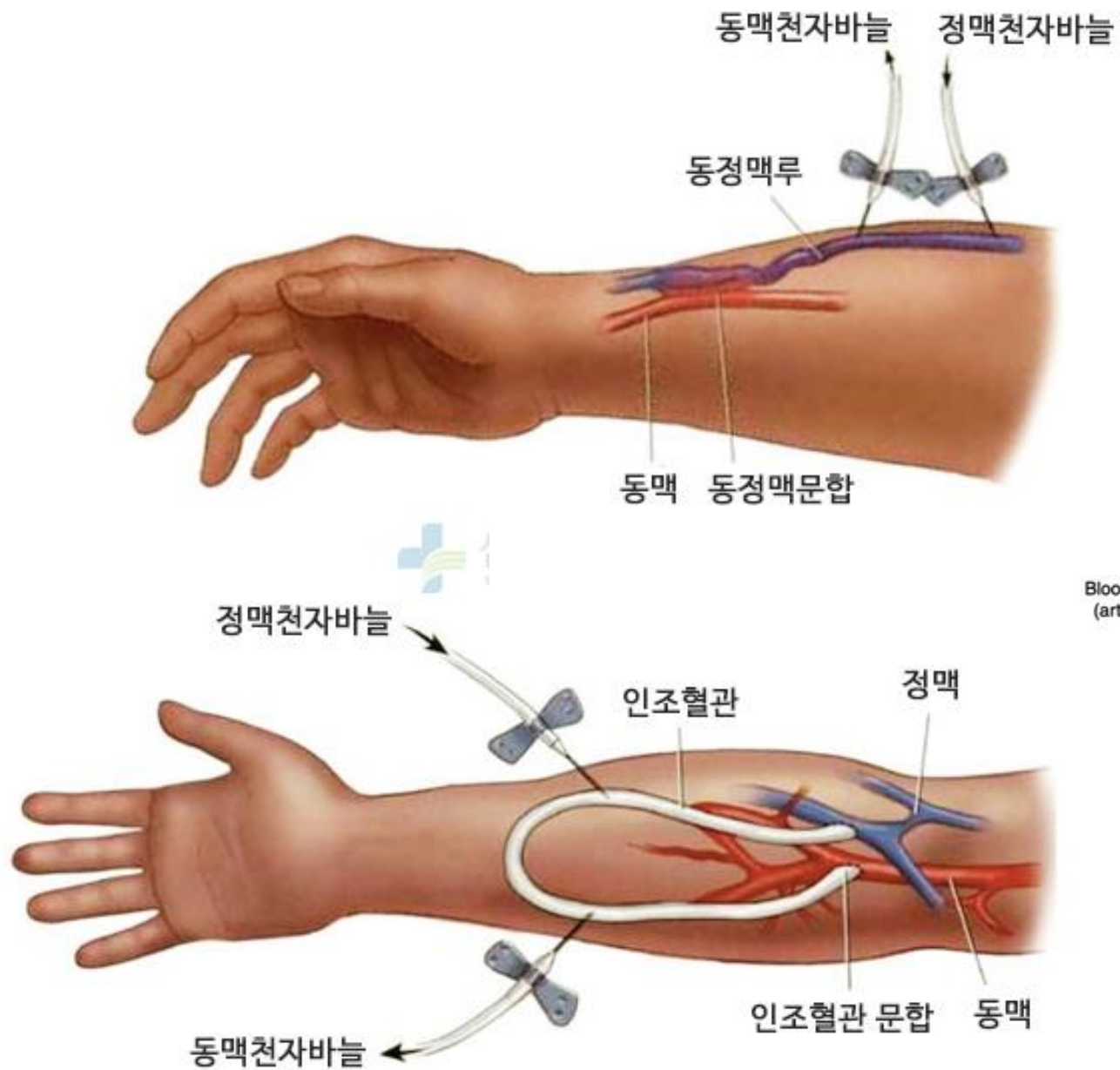


AVF = arteriovenous fistula, AVG = arteriovenous graft

ESRD = End stage renal disease, CVC = central venous catheter

Central venous catheter for HD





Vascular access(혈관접근)

- **For hemodialysis**
 - ; Blood flow at least 300ml/min, preferably 500ml/min.
- **Central venous catheters (CVC)**
 - ; Acute HD, or as bridging VA
- **Arterialization of a vein(AVF, arterio-venous fistula)**
 - ; Autogenous anastomosis between artery and vein
- **Interposition of a graft between an artery and a vein (AVGs, arteriovenous grafts)**
 - ; VA using a prosthetic graft

Advantages and Disadvantages of CVC for HD

Advantages	Disadvantages
• Universally applicable • Variety sites for placement • Immediately available for use • Low cost	• Thrombosis • Infection • Central venous stenosis or occlusion • Low patient satisfaction • Lower blood flow rate, long dialysis time ➔ <i>Risk of morbidity & mortality</i>

투석혈관접근 과정

신장내과
협진

문진 및 초음파검사를
통한 혈관 및 수술방법
결정
(수술 부위, 자가 or 인
조혈관, 손목 or 상완...,
AVF or AVG, basilic
vein transposition...)

수술시행(국소 or
부위마취...)
(Flow check,
thrill, bruit...)

투석가능여부
확인 후 투석시
작
(상처확인,
Maturation여부,
협착부위유무 등
등..)

병력과 진찰에서 찾아야 할 것

병력

- 우세손, 직업·생활
- 이전 CVC·PICC, pacemaker/ICD lead
- 심부전·LVEF, 판막 질환
- 당뇨·PAOD — steal 위험
- 이식 예정 시기, 기대여명

이학적 검사

- 양팔 혈압 차이 (>20 mmHg면 근위부 동맥 협착 의심)
- 요골·척골 맥박, Allen test
- Tourniquet으로 표재정맥 확인
- 팔·얼굴 부종, 흉벽 결순환 정맥 → central stenosis 단서

Vein preservation — CKD 환자는 비우세팔 정맥을 아낀다: 채혈·정맥주사는 손등으로, PICC는 피한다.

Choice of type of vascular access

- **Ideal VA**

- ; Resistant to infection and thrombosis, minimum adverse events

- **First option** : *Distal autogenous AVF* in the non dominant arm.

- Lower incidence of postoperative complications and fewer endovascular and surgical revision for AVF failure

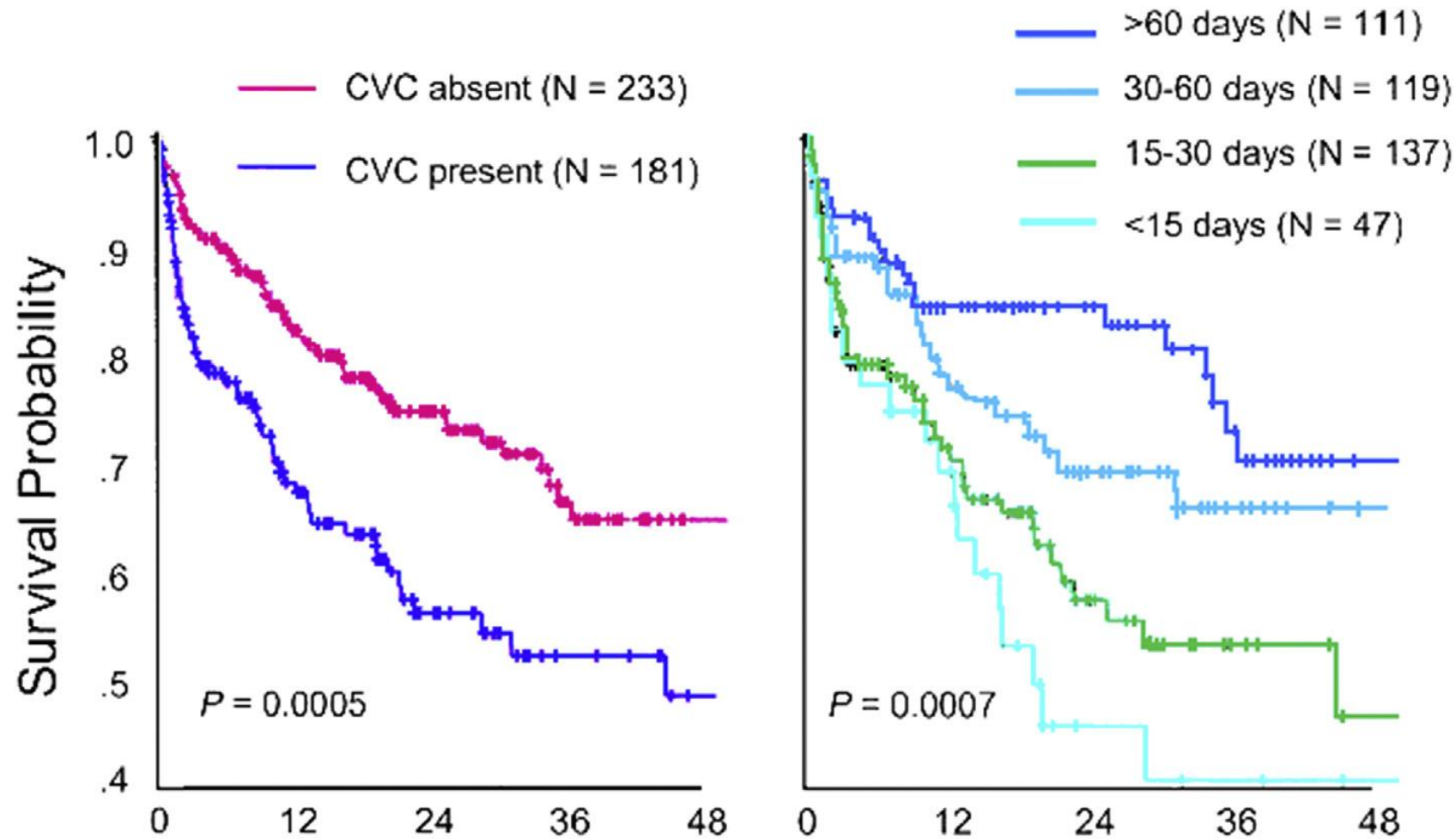
- **Next options** : *Prosthetic AVG* and *CVC(central venous catheter)*

- Higher morbidity and mortality in CVCs(infection...)

Time of referral for VA surgery

- Importance for the outcome of the VA.
- Early referral → More well functional autogenous AVFs
- Late referral → non-maturation and need for a CVC
- **Poor long term risk factors of AVF**
 - HD initiation with CVC, long AVF maturation time
 - Cardiovascular disease
 - Early cannulation

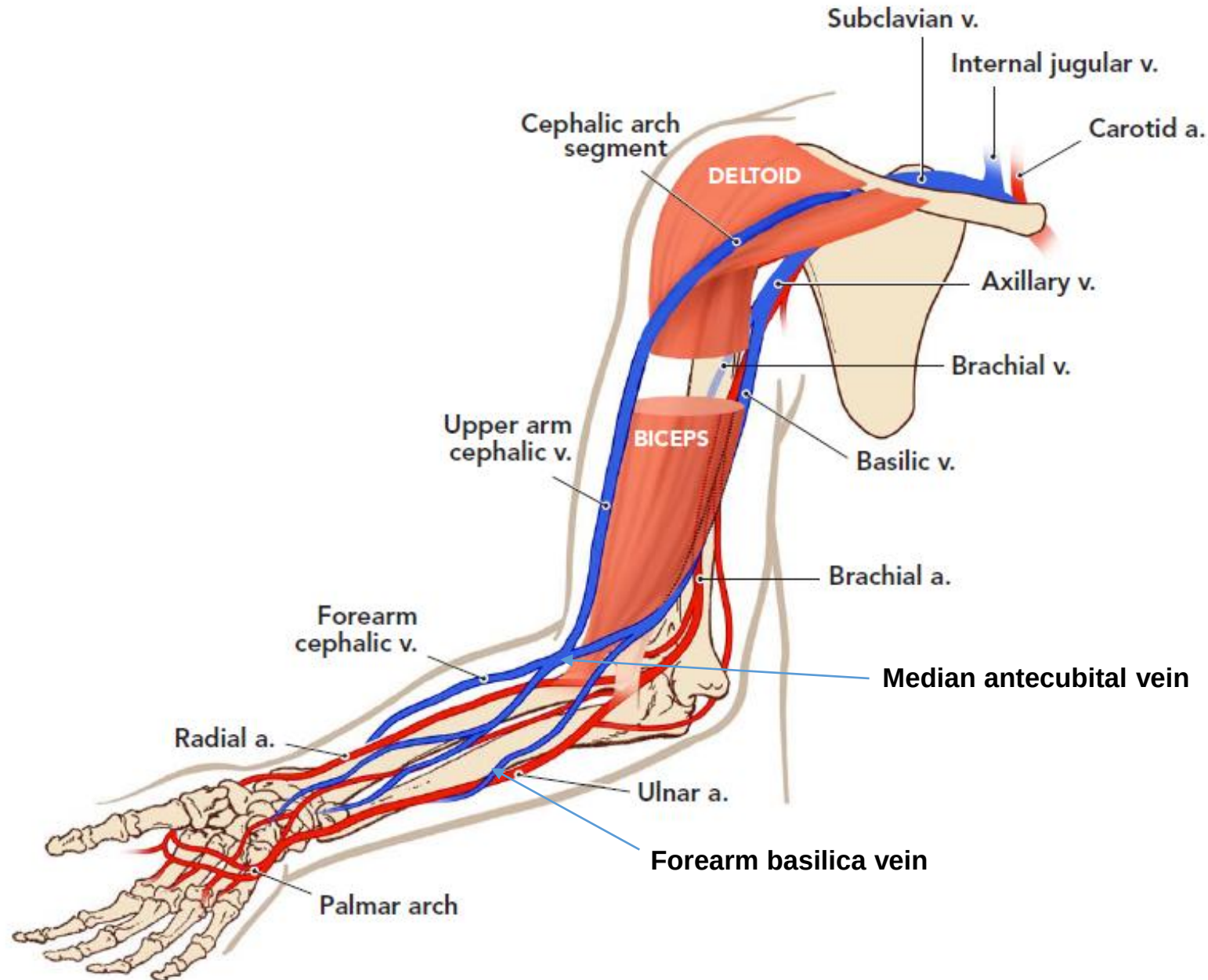
Kaplan-Meier curves of time to AVF failure



Months from first cannulation

J Am Soc Nephrol 2004;15:204 e9. Ravani et al.

Anatomy of Upper Extremity Vessels



Duplex mapping: 흔히 쓰는 기준

정맥 내경 (tourniquet 후)

$\geq 2.0-2.5$ mm

중심까지 연속성, 협착·혈전 없음

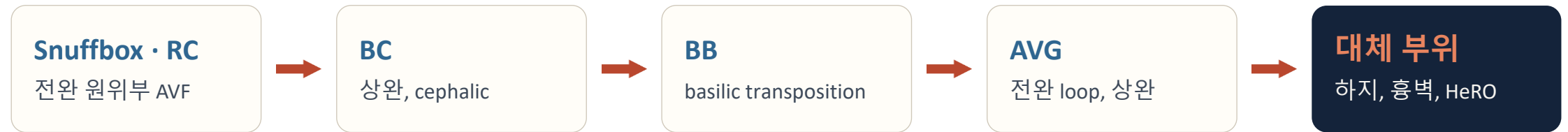
동맥 내경

≥ 2.0 mm

석회화, 삼상파형, 충혈 반응 확인

- 정맥 깊이가 6 mm를 넘으면 superficialization·transposition을 미리 계획
- Access 실패 고위험군(고령, 당뇨, 여성, 비만, 이전 실패)에서 특히 권장
- KDOQI 2019는 절대 cutoff를 두지 않는다 — 수치는 참고, 결정은 개별화

부위 선택: 원위부에서 근위부로



원위부부터

실패해도 근위부 옵션이 남는다

비우세팔부터

단, central vein·CIED가 있는 쪽은 피한다

자가정맥부터

단, 성숙 가능성·기대여명이 낮으면 AVG가 더 나을 수 있다

상지 AVF 세 가지 비교

AVF	장점	단점	수술 팁
RC(radiocephalic) Brescia-Cimino	근위부 보존, steal·고유량 위험 낮음	성숙 실패가 가장 흔함 (고령·당뇨·여성)	요골동맥 상태가 관건, snuffbox도 대안
BC(brachio-cephalic)	성숙률 높고 천자 쉬움	Steal, cephalic arch 협착, 고유량	Brachial arteriotomy는 짧게 (대략 4-6 mm)
BB(Brachio-basilic)	깊어서 보존된 basilic 정맥 활용	Transposition 필요, 부종, MABC 신경 손상	1단계와 2단계 성적은 비슷, 가는 정맥은 2단계

Primary option for vascular access (1)

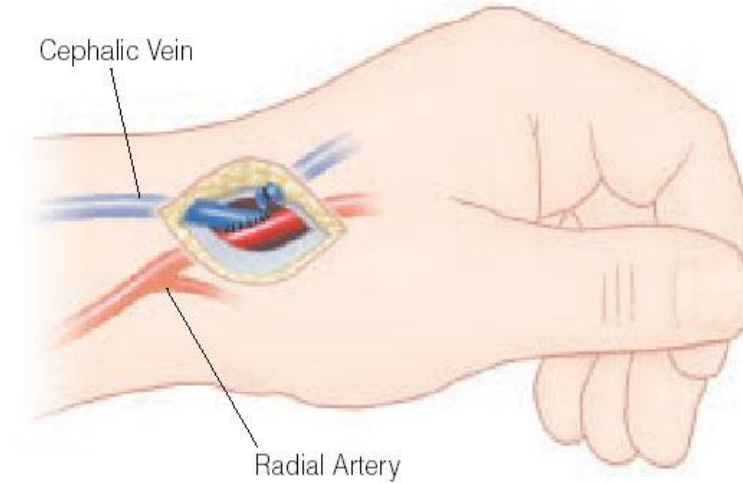
- **Autogenous arteriovenous fistula.**
- The first choice for VA creation : *Radiocephalic AVF (RCAVF)*
- **Advantages**
 - *Minimum of complications, revisions and hospital admissions*
- **Non-dominant arm**
- **A minimum internal vessel diameter**
 - *Radial artery and cephalic vein* : **2.0mm** using tourniquet
 - Successful fistula creation and maturation

Radiocephalic AVF (RCAVF)



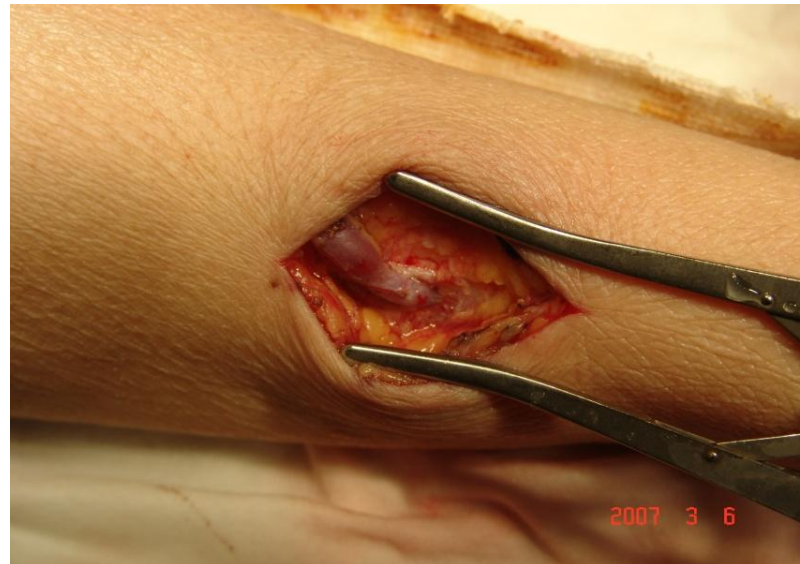
Brescia-Cimino (radiocephalic) fistula

: An autologous fistula constructed between the radial artery and the cephalic vein at the wrist.



Snuff-box fistula

: An autologous fistula constructed between a branch of the radial artery and an adjacent vein in the anatomic snuff box of the hand.



Disadvantages of AVF

- **Risk of early thrombosis and non-maturation**
 - Access failure
(**17%** mean early failure rate, up to 45%)
 - One year patency from **52% to 83%**
- **Old age** : Maturation failure

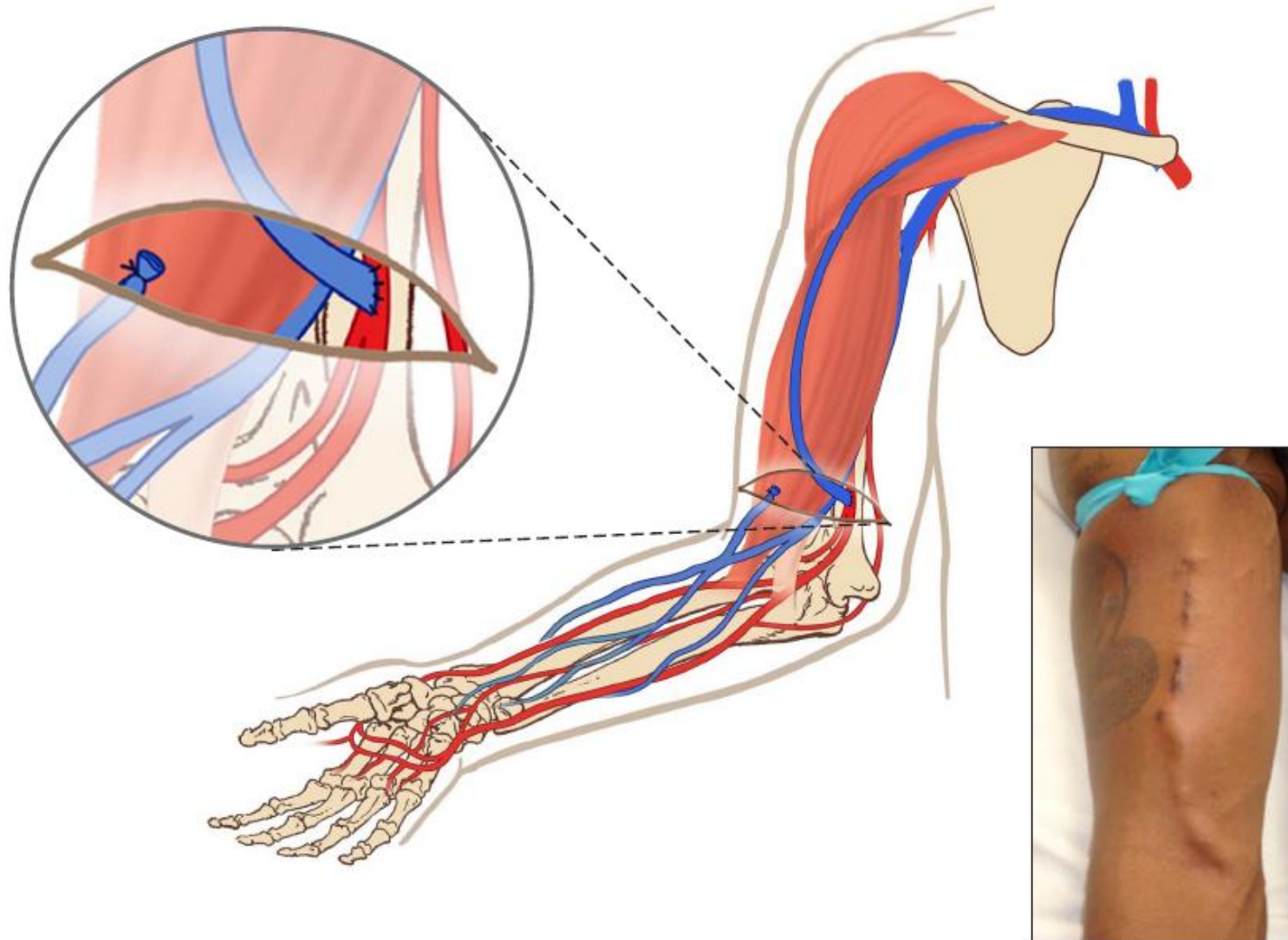
Table 5. Early failure and one year secondary patency rate of the radiocephalic AVF.

Reference	No. RCAVF	Early failure (%)	Secondary patency (%)
Silva et al. ⁵⁹	108	26	83
Golledge et al. ⁶⁰	107	18	69
Wolowczyk et al. ⁶¹	208	20	65
Gibson et al. ⁶²	130	23	56
Allon et al. ⁶³	139	46	42
Dixon et al. ⁶⁴	205	30	53
Ravani et al. ⁶⁵	197	5	71
Rooijens et al. ⁶⁶	86	41	52
Biuckians et al. ⁶⁷	80	37	63
Huijbregts et al. ⁵⁶	649	30	70

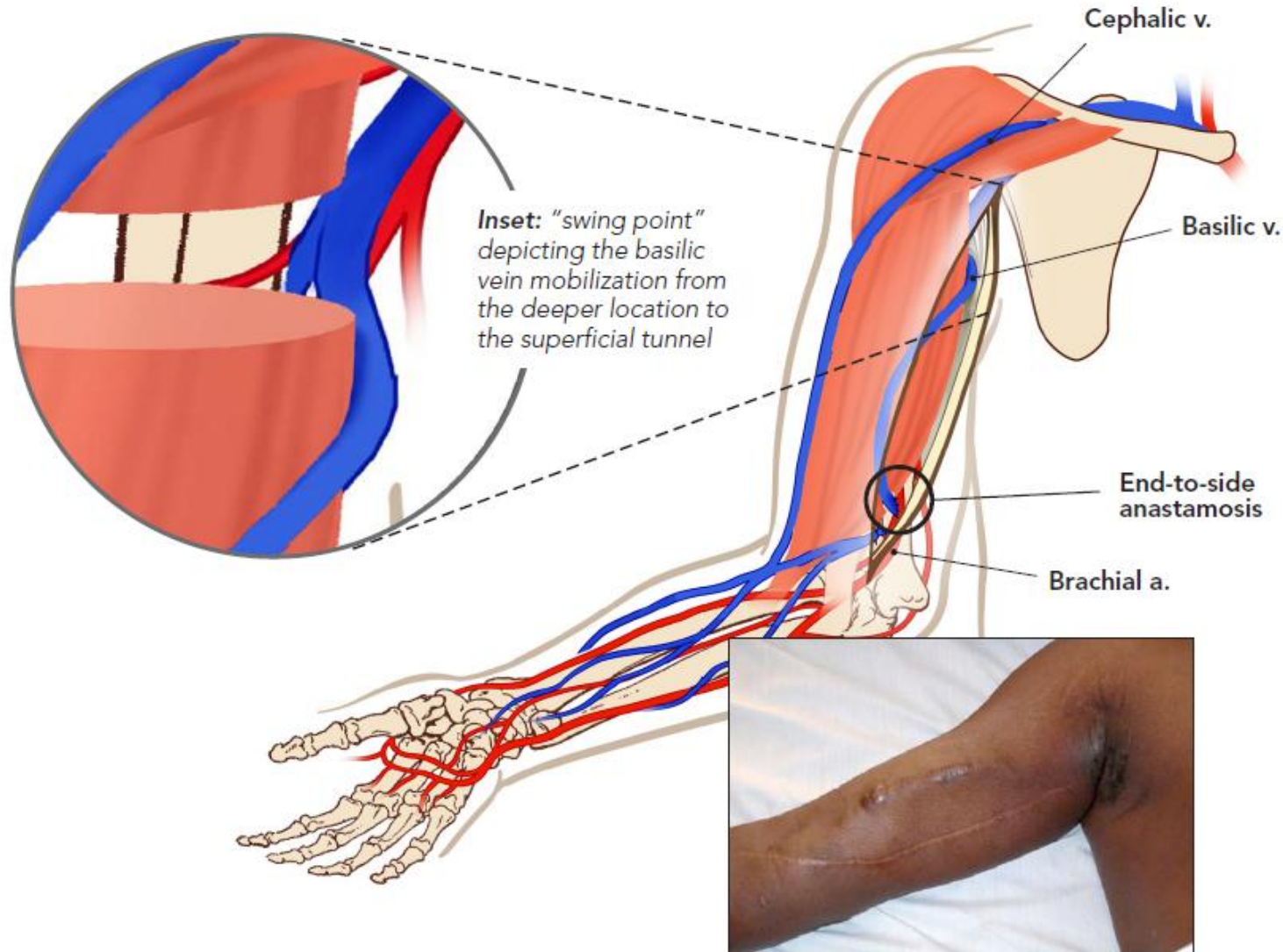
Primary option for vascular access (2)

- **Brachial artery based AVFs**
; BCAVF(brachiocephalic AVF) and BBAVF(Brachiobasilic AVF)
- **High access flow**
- **Good one year patency**
- **Low incidence of thrombosis** (0.2 events per patient/year) and **infection** (2%)
- **Reduced distal arterial perfusion and cardiac overload**
→ Risk of Steal syndrome ↑
- **Basilic vein transposition (BVT)** (upper or forearm)

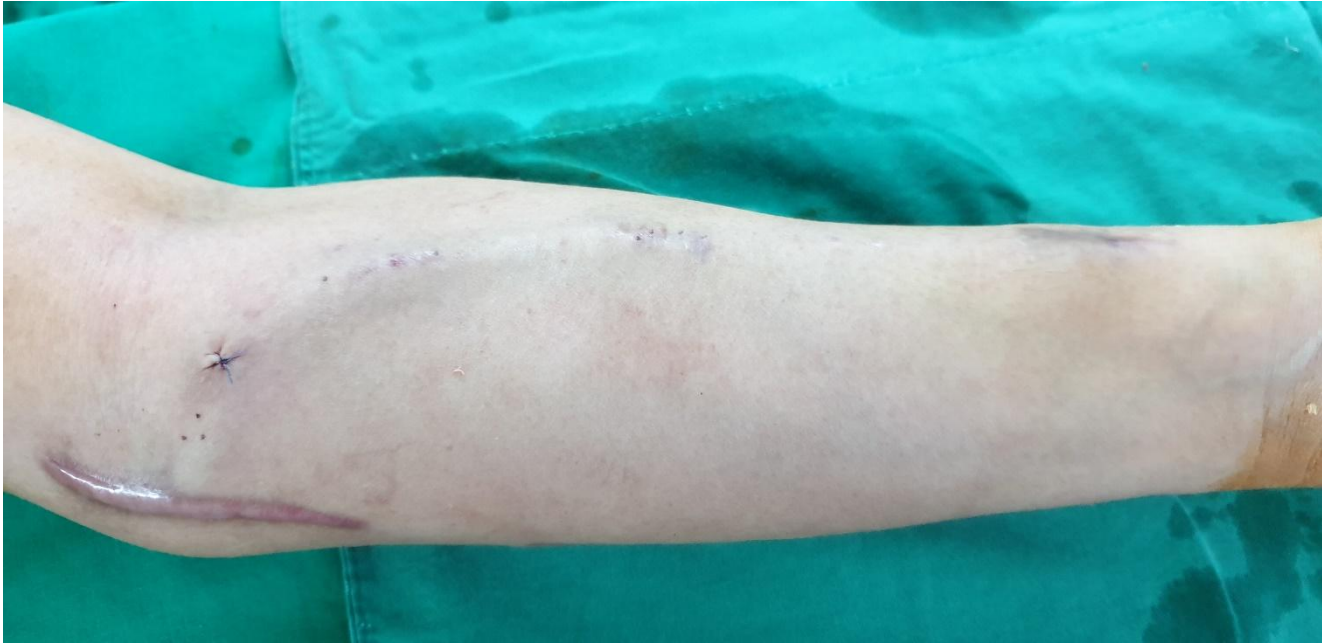
Brachiocephalic AVF(BCAVF)



Transposed Basilic Vein AVF(BBAVF)



Forearm basilica vein transposition



Variables and outcome of AVF

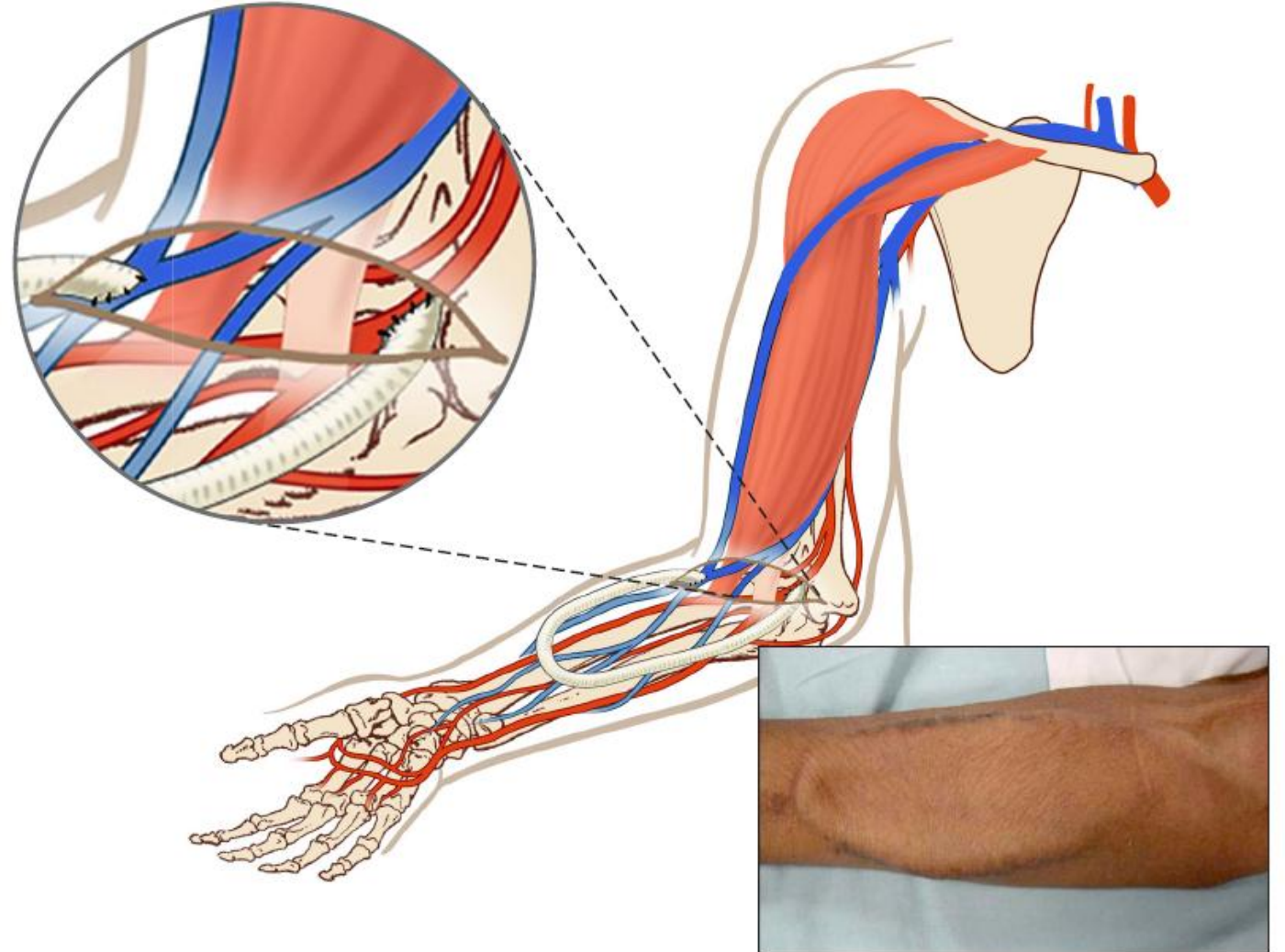
- **Age**(>65 years old)
- **DM**
- **Female**(smaller vessels, poor maturation and low long-term patency, more revision and AVG)
- **PAOD**
- **Obesity (BMI > 35)**
- **CCB, aspirin, ACEi** ; Better AVF, AVG patency
- **Anastomosis length** : Donor artery size ↓ → failure ↑

Secondary options for vascular access

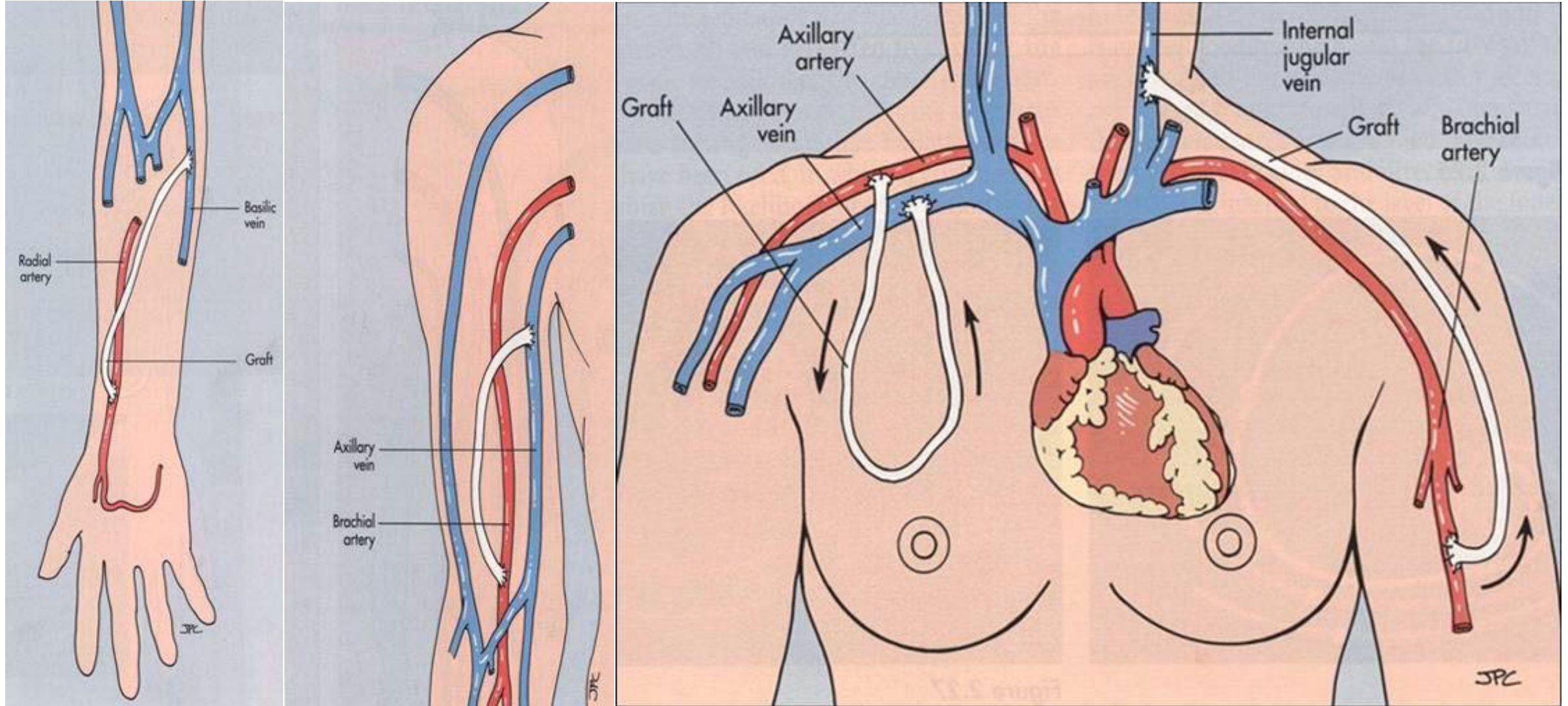
- **AVG VA with**
 - 4-6mm tapered or 6mm PTFE(polytetrafluoroethylene) graft
 - Biological material (ovine graft/Omniflow)
- **AVG**
 - Primary patency ; 1yr (40~50%), 2yr(20~30%)
 - Neointimal proliferation
 - Multiple intervention (outcome ↑)
 - Infection risk
 - Elderly patients may benefit : high rate of primary AVF failure
- **Minimum outflow vein diameter : 4mm**

Forearm Loop AVG

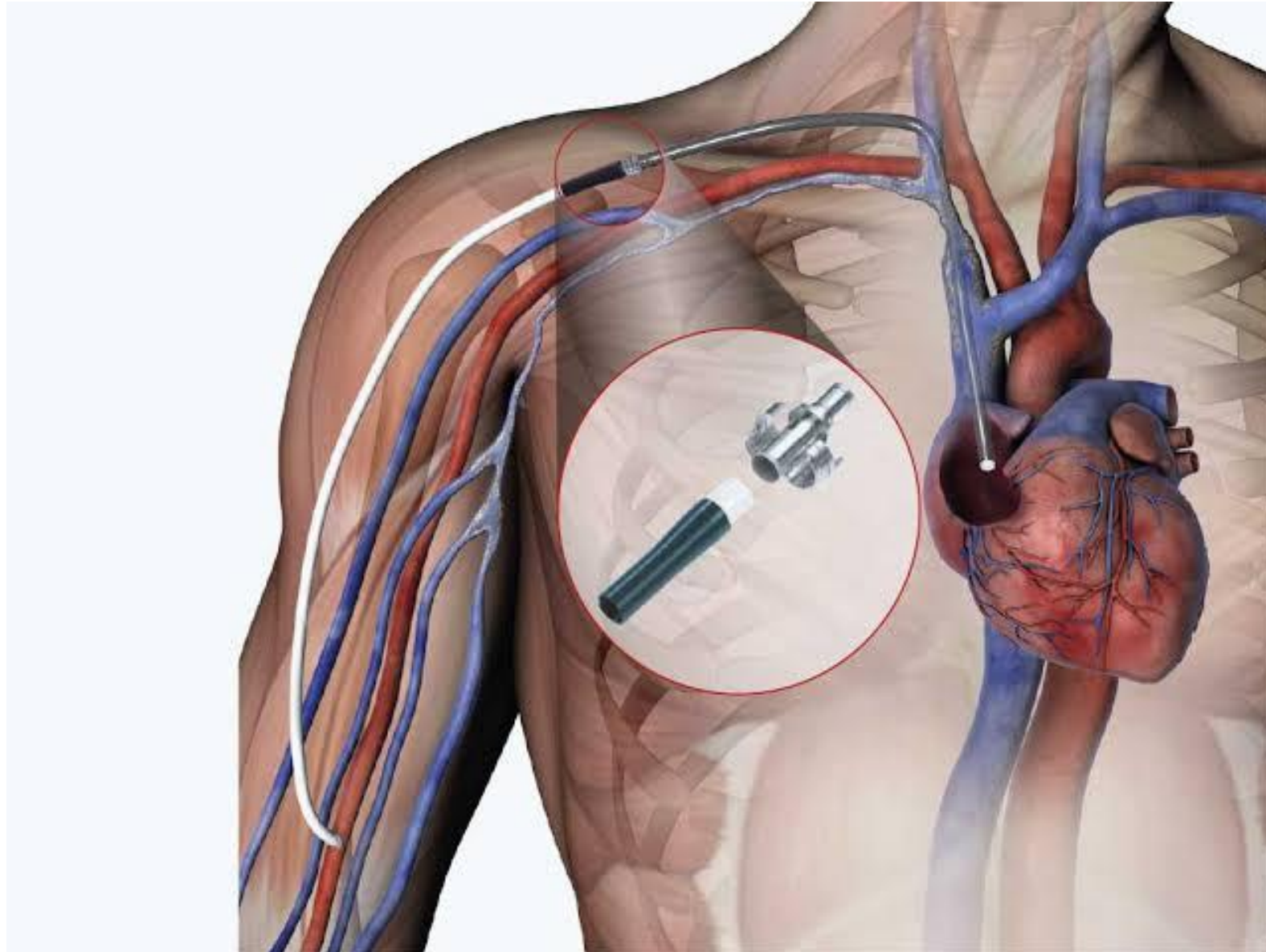
- **Anastomosis site**
: Brachial artery
to antecubital vein
to cephalic vein
to basilica vein
to brachial vein



Other AV Grafts



HeRO Graft



Pre-operative assessment

- **History and physical examination**
- **Duplex ultrasound(DUS)**
- **Digital subtraction angiography (DSA)**

History and physical examination

- **Hand dominance**
- **Previous vascular access**
 - ; Central venous catheters, peripherally inserted central catheter, pacemaker, defibrillator)
- **Upper and lower extremity venous thrombosis, hand ischemia**
- **Pulmonary hypertension or heart disease**
- **Skin conditions** : Dryness, redness and infection.
- **Upper arm swelling** (Central vein stenosis)
- **Hemiplegia** (Create VA on the paralytic side).
- **Contracture of the elbow joint**

Duplex ultrasound sonography

- **Venous mapping** (depth of vessels and VA sites)
; Measure artery and vein diameters and stenotic lesions
- **Evaluation of maturation**(flow and diameter check)
- **The first line imaging method in suspected VA dysfunction after VA creation**
(eg. Stenosis or thrombosis)

Digital subtraction angiography

- Helpful in only a small group of selected patients
- **Significant peripheral vascular disease and suspected proximal arterial stenosis**
- **Previous CVCs** additional preoperative imaging of the central veins should be performed.
(eg. Venography or intravascular ultrasound)

Preoperative check points

- Technical aspects

- **Venous preservation**
; Save the forearm veins
- **Arm exercise** ; Improve artery and vein diameters
- **Preoperative or perioperative hydration**
; Improve AVF patency
- **Preoperative antiplatelet agents**
; Incomplete evidence but reduce VA thrombosis
- **Preoperative physical examination**
; Upper limb pulse, superficial vein check in warm room

Perioperative check points

- Technical aspects

- **Prophylactic antibiotics**
; Cephalosporin, amoxycillin/clavulanic acid or a glycopeptide
- **Anesthesia** : Local or regional anesthesia
- **Perioperative anticoagulation (heparin)**
; Postoperative hemorrhage and no effect on patency
; Local instillation of heparinized saline or ringer's solution into vessels
- **Arteriovenous fistula configuration**
; End to side (vein to artery) anastomosis

Meta-analysis of Heparin use

Table III. Results of randomized controlled trials of systemic heparin use in arteriovenous fistula (AVF) surgery. Stouffer's Z method results indicate combined significance levels weighted for number of participants

<i>First author</i>	<i>Patients</i>	<i>Bleeding rate increased</i>	<i>P</i>	<i>Patency rate increased</i>	<i>P</i>
D'Ayala (2008) ⁴⁴	115	Yes	.008	No	.79
Ravari H (2008) ⁴⁵	198	No	.175	Yes	.046
Bhomi K (2008) ⁴⁶	50	Yes	<.01	No	.46
Stouffer Z method (combined <i>P</i>)		Yes	<.001	No	.1458

Summary of surgical techniques (1)

- AVF ; *Most distal site possible*
- **Proximal AVFs** : Lower initial failure & better patency
→ Steal syndrome ↑ , less comfortable
- **Arterial & venous diameters** : more than 2 mm
- **Non-dominant arm**
- **Pacemaker or CVC** : Contralateral side

Summary of surgical techniques (2)

- **1st choice** : *RCAVF or Snuffbox*
- **2nd choice**
 - : Young patients
 - BCAVF or basilica vein transposition, AVG
 - : Old patients
 - BCAVF or AVG
- **The number of re-interventions** : Significantly higher in AVGs
- **Choice of graft** : 4-6mm tapered ePTFE graft, 6mm ePTFE graft
 - Can be use after 1~2 week (4 weeks)

Summary of surgical techniques (3)

- Should be a *palpable thrill* or, at least an *audible bruit*
- *The absence of a bruit* ; Something wrong
→ A good predictor of early AVF thrombosis or occlusion
- *Flow meter check*
 - ; Radio-cephalic fistula : about 300mL/min
 - ; AVG on brachial or BCAVF : 700~1000mL/min

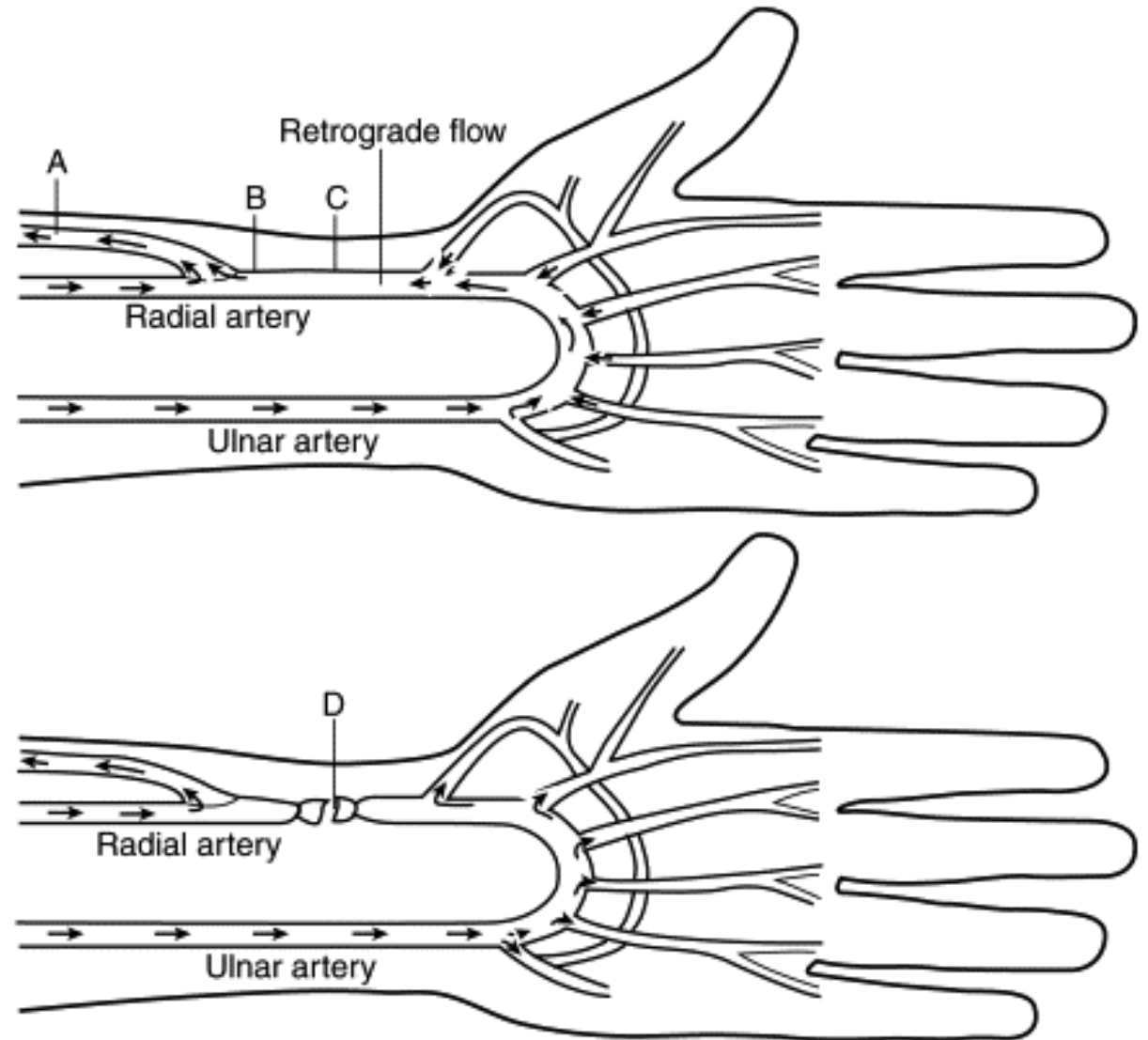
Peri-operative complications

- Hemorrhage
- Post-operative infection
- Non-infected fluid collections
- Vascular access induced limb ischemia : 4~9% (Stage 3, 4)
- Early thrombosis

AVF and Steal syndrome

VA induced ischemia

Stage 1	Slight coldness, numbness, pale skin, no pain
Stage 2	Loss of sensation, pain during HD or exercise
Stage 3	Rest pain
Stage 4	Tissue loss affecting the distal parts of the limb, usually the digits



Access maturation and care

- **AVF** : Preferably *4~6 weeks*
- **AVG** creation : *2~4 weeks*
- **Check points, "Rule of 6s "**
 - (1) Bruit and thrill
 - (2) Adequate venous diameter ; $> 6\text{mm}$
 - (3) Adequate depth ; $< 6\text{mm}$
 - (4) Adequate volume flow ; $> 600 \text{ ml/min}$

성숙 판정: Rule of 6s

600

혈류 mL/min 이상

6 mm

정맥 직경 이상

<6 mm

피부로부터 깊이

6주

이때까지 성숙 평가

수술 후 4-6주에 진찰과 duplex로 평가한다. 이 기준에 못 미치면 기다리지 말고 원인을 찾는다.

Management of maturation failure

- **The most common causes**

- ; Venous, arterial or anastomotic stenosis

- Intervention(balloon angioplasty, BAM), surgical revision

- ; Competing veins or large patent branches

- Branch ligation

- ; Excessive depth from the skin

- Superficialization

- **Hand-arm exercise**

Anticoagulation therapy

- **Reduce thrombosis but no long term benefits.**
- **Case by case....**
 - ; Aspirin, clopidogrel, cilostazol, warfarin, berasil
- **Omega-3 fatty acids** (fish oil) in improving VA function or maturation

Late vascular access complications

- True and false access aneurysm
- Infection
- Stenosis and recurrent stenosis
 - *Inflow arterial stenosis*
 - *Juxta-anastomotic stenosis*
 - *Venous outflow stenosis*
 - *Cephalic arch stenosis*
- Thrombosis
- Central venous stenosis
- VA induced limb ischemia and high flow VA
- Neuropathy
- Non-used vascular access

협착과 혈전: 어디에 생기고 어떻게 푸나

호발 부위

- RC AVF: juxta-anastomotic
- BC AVF: cephalic arch
- AVG: graft-vein 문합부
- 공통: central vein

치료

- PTA가 1차, 일부 RCT에서 DCB가 개존 향상
- AVG 정맥 문합부 협착, 재발·파열: covered stent
- 혈전: 수술적·혈관내 혈전제거 후 원인 협착 교정
- 반복 재발, 짧은 구간: 수술적 revision

감시(surveillance) — KDOQI 2019는 임상 모니터링(진찰, 투석 지표)을 기본으로 하고, 개존율을 높이기 위한 일상적 기기 surveillance는 권하지 않는다.

Central vein occlusion과 CIED lead

원인과 진단

- 이전 CVC (특히 subclavian), pacemaker·ICD lead
- 팔·얼굴·유방 부종, 흉벽 결순환 정맥
- 투석 중 정맥압 상승, 지혈 지연
- 진단은 venography — duplex로는 한계

처치와 예방

- 증상이 있을 때만 PTA ± stent — 무증상 협착은 치료하지 않음
- Lead가 있는 쪽 access는 피한다
- CIED가 필요하면 비경정맥(epicardial·leadless) 고려
- 우회: HeRO, 흉벽 graft, 드물게 흉강 내 우회

Access와 심장이 만날 때

고박출성 심부전

- Q_a 1.5–2 L/min 이상, 또는 Q_a/CO 20–30% 이상
- 상완 기반 access에서 흔함
- 심초음파로 확인
- Banding·RUDI로 혈류 감소, 필요하면 결찰

심장수술과의 충돌

- CABG radial conduit와 RC AVF가 같은 동맥을 두고 경쟁
- LIMA 이식 환자의 동측 access: coronary–subclavian steal 가능성(controversial)
- 신장이식 후 AVF 결찰: RCT에서 LV mass 감소

Radiocephalic AVF

- Local anesthesia
- Incision : Between radial artery and cephalic vein
- Cephalic vein dissection and dilatation
- Cephalic vein 의 dorsal branches 보다 proximal 부위를 이용
- Arteriotomy : 8-11mm
- 8-0 prolene, continuous running suture
- Post anastomosis dilatation : manual method, branch ligation

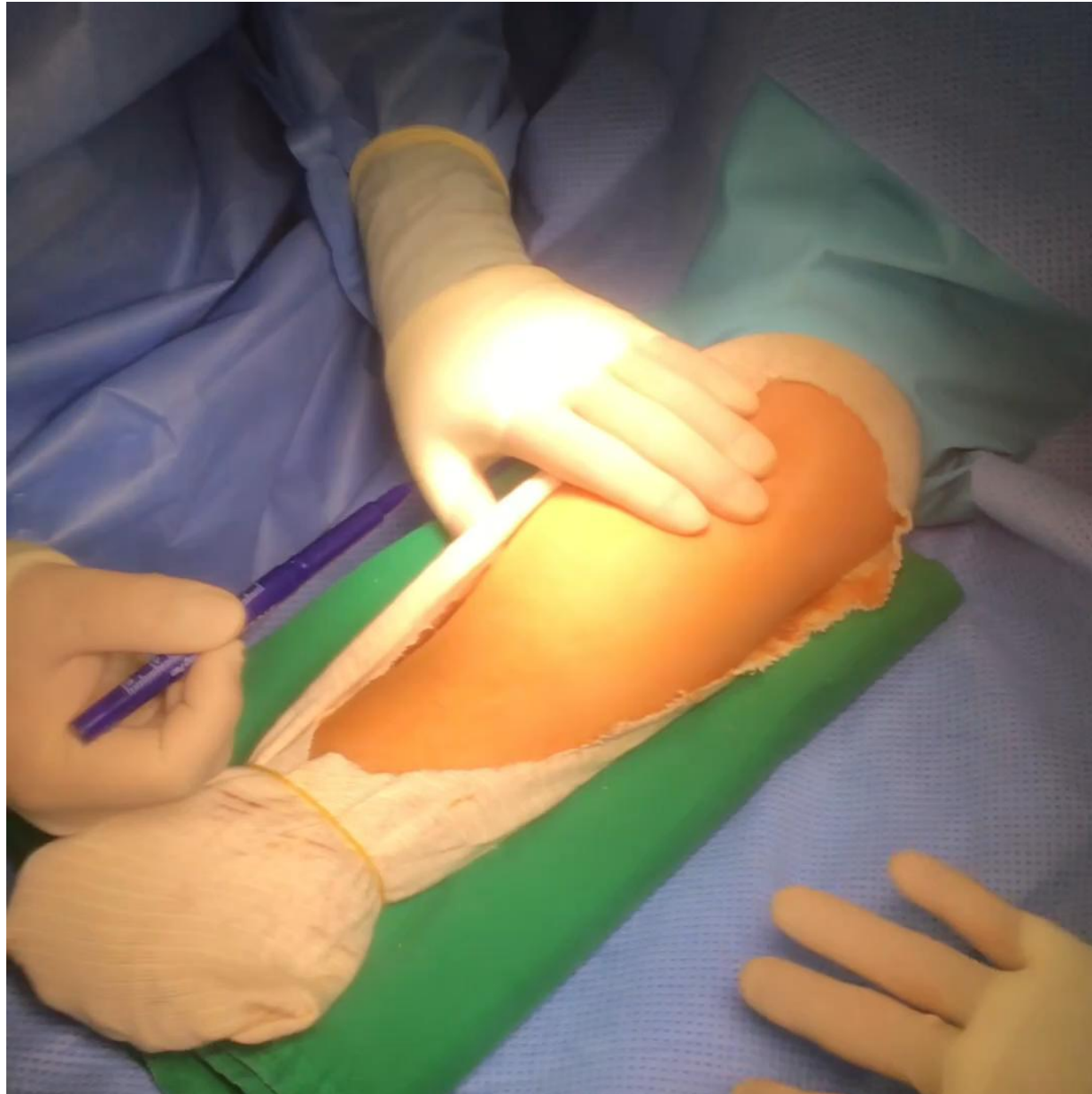
RCAVF Video Clip



AVG with loop graft

- Local anesthesia
- Incision : Between brachial artery and antecubital vein at cubital fossa
- Graft : ePTFE 4-6mm tapered size, thin wall, thick wall
- Venotomy and vein anastomosis 7-0 prolene
- Arteriotomy and artery anastomosis 7-0 prolene
- Post anastomosis dilatation : manual method

Brachio-antecubital AVG Video Clip



Brachiobasiliac AVF c basilic vein transposition

Brachiobasilic AV Fistula with Basilic Vein Transposition



경청해 주셔서 감사합니다.