Anatomy and Physiology of Vascular Access

Advanced Course in Vascular Access 2019

Convenor: Professor Kittipan Rerkasem

2 – 3 May 2019, Chiang Mai, Thailand

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Native Fistula ~~First~~ **Only**

- Native AVF 80% IN EUROPE
  90% IN JAPAN
- Native AVF ≈ 60% IN THE USA !!
- Westmead Renal Unit >95% Native AVF*

*** Fistulas created by our unit**

The Native Hemodialysis Access Fistula is

a Pathology,

a Disease,

Created surgically,

for therapeutic reasons!

The Native Hemodialysis Fistula

- Changes throughout it’s lifetime
- Generally keeps growing
- It can be too big, too small or just right!
- There is no “normal”

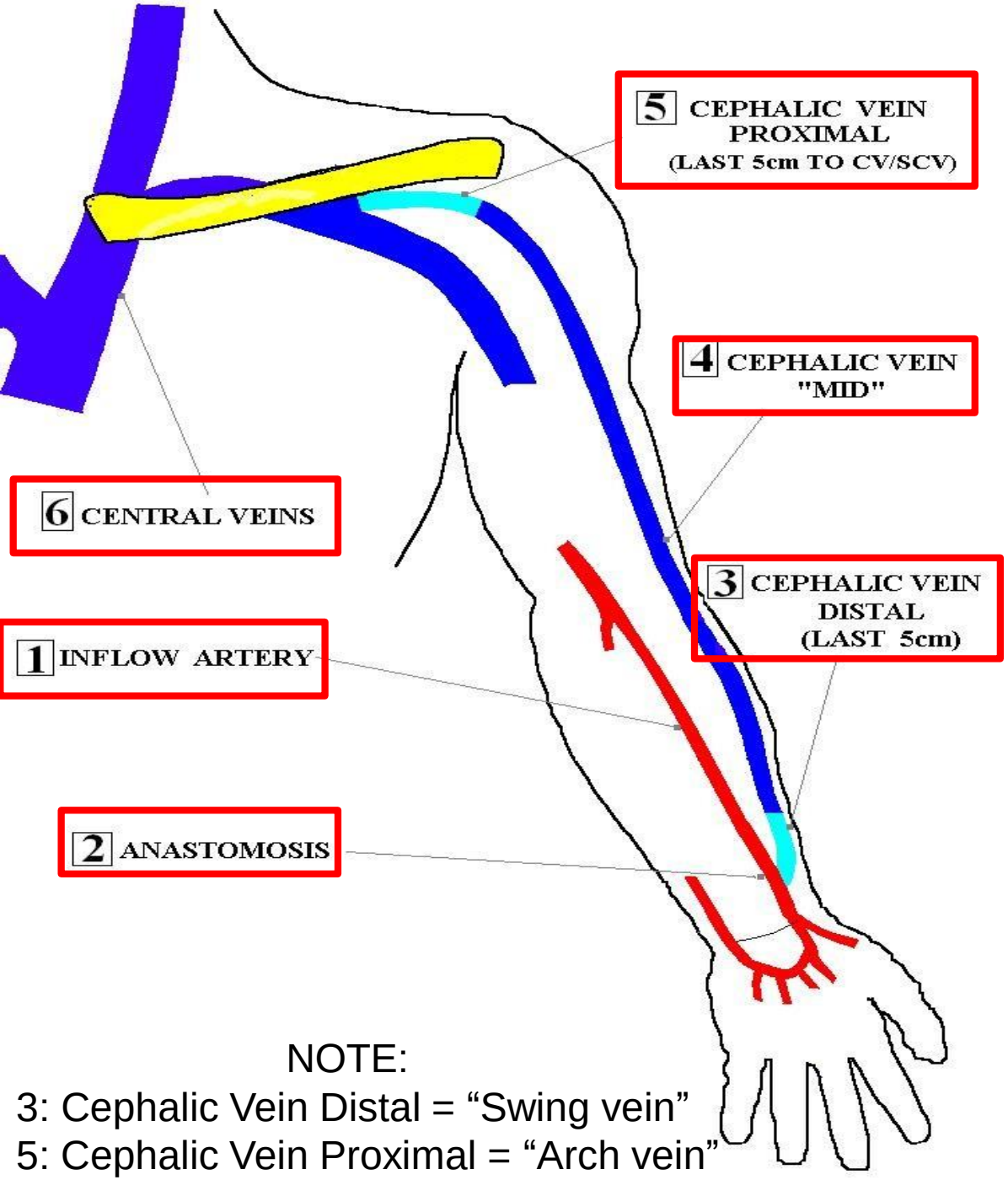
ANATOMY

Nomenclature

- Standardised to RC AVF
- Independently described by:

CLARK et al

SWINNEN et al

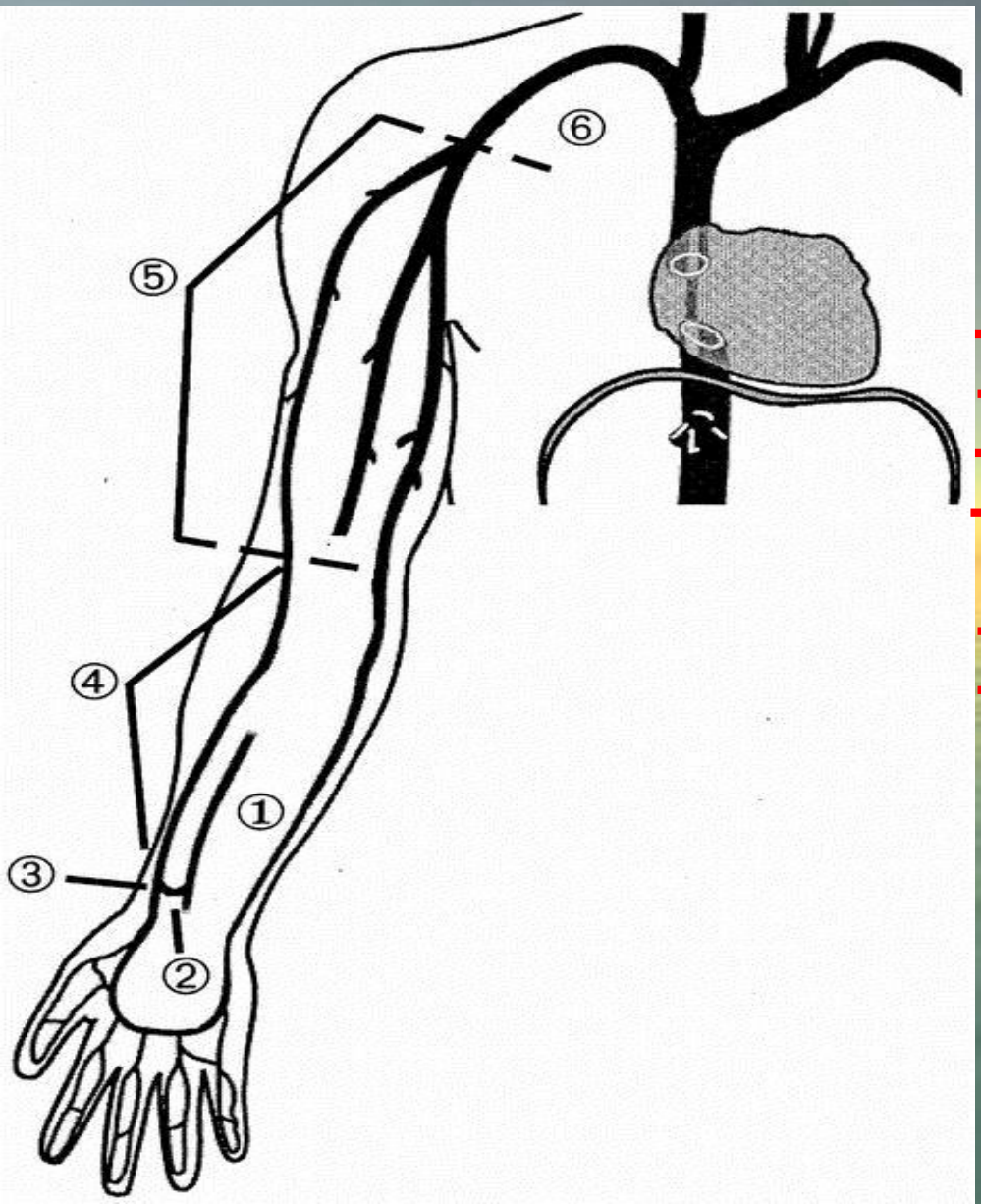


NOTE:
3: Cephalic Vein Distal = “Swing vein”
5: Cephalic Vein Proximal = “Arch vein”

DIVISION OF FISTULA CIRCUIT INTO 6 ZONES

J SWINNEN 2000

DIVISION OF FISTULA CIRCUIT INTO 6 ZONES - CLARK ET AL 2002



LOCATION OF 109 STENOSES WITHIN DYSFUNCTIONAL NATIVE RADIOCEPHALIC FISTULAE.

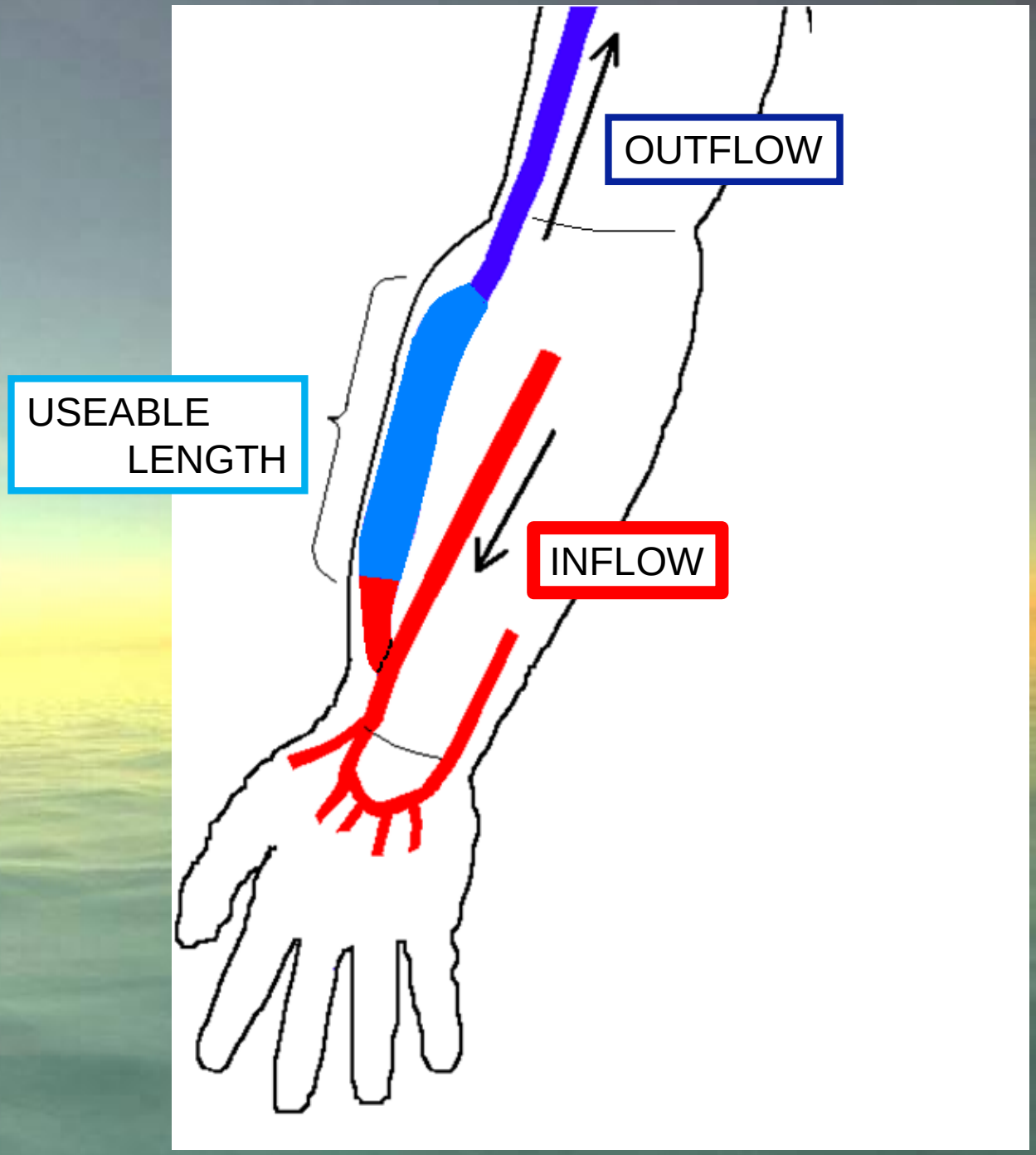
- **1 = NATIVE ARTERY**
- **2 = ANASTOMOSIS**
- **3 = INITIAL 2cm OF FISTULA**
- **4 = VENOUS OUTFLOW > 2cm FROM ANASTOMOSIS**
- **5 = DISTAL OUTFLOW**
- **6 = CENTRAL VEINS**

Clark TW J Vasc Interv Radiol 2002; 13:51-59

All Fistulas

have

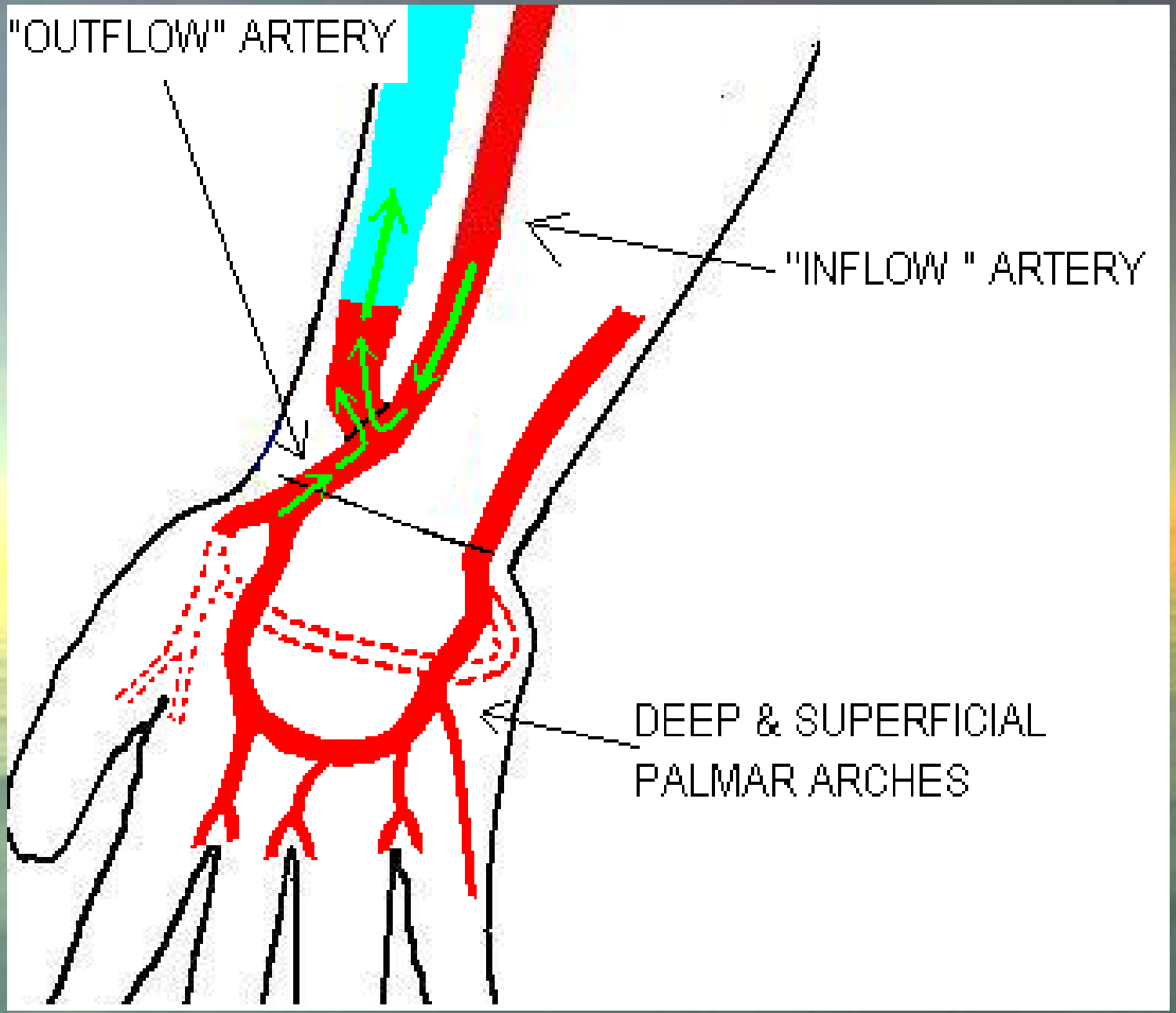
3 Components


OUTFLOW
USEABLE
LENGTH
INFLOW

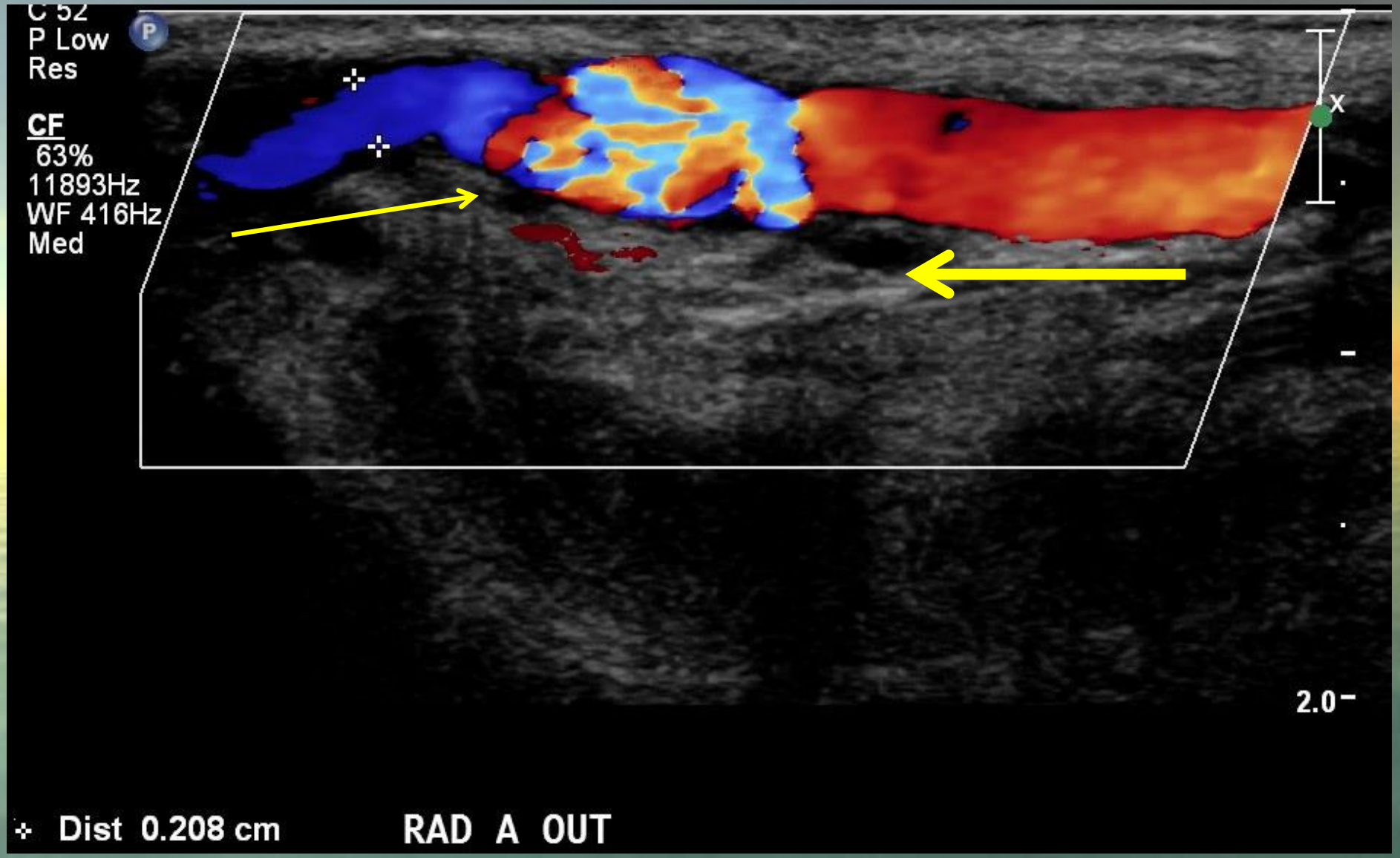
1.Inflow

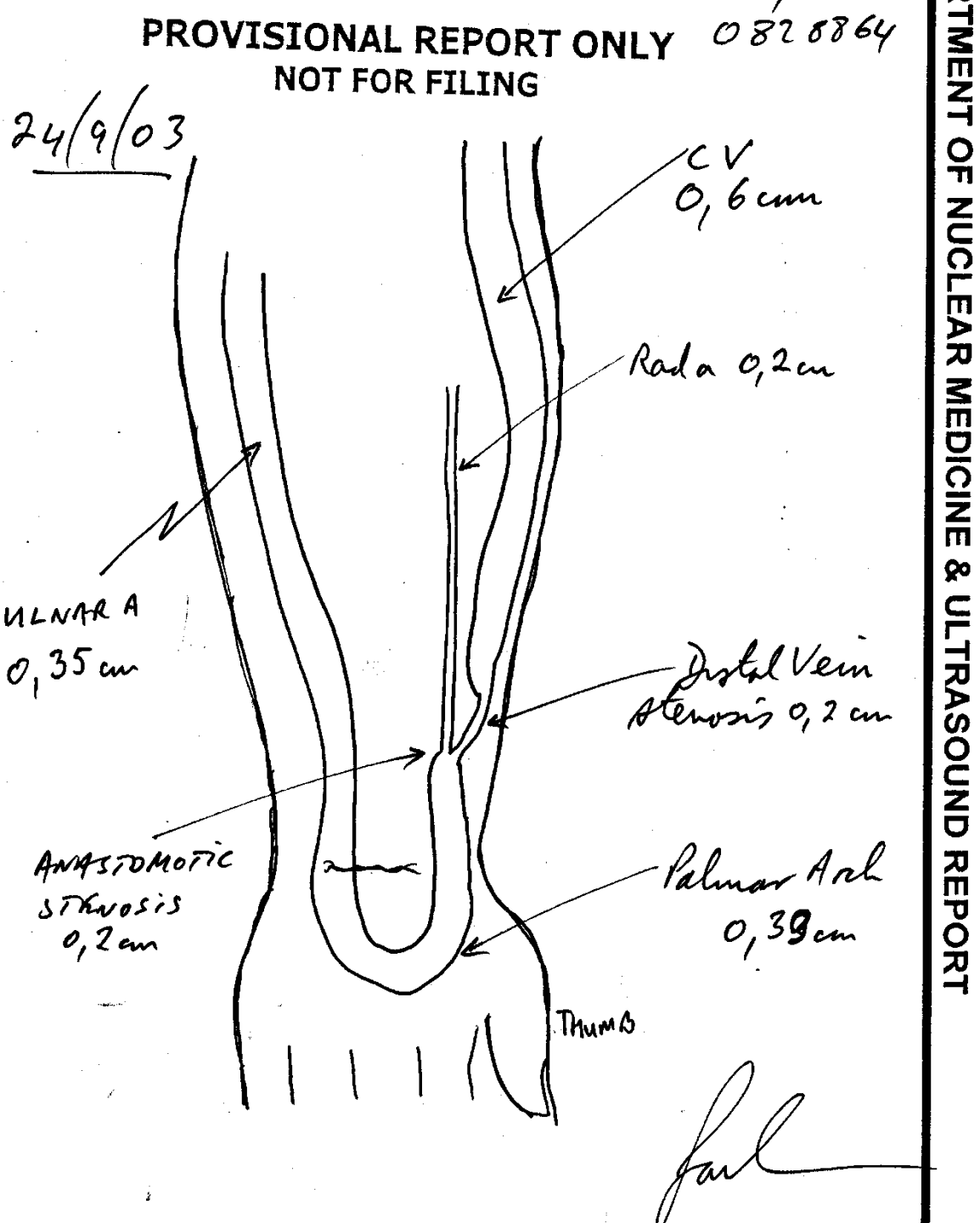
- Subclavian A
- Brachial A
- Radial A

- Ulnar A / Palmar Arch


"OUTFLOW" ARTERY
"INFLOW " ARTERY
DEEP & SUPERFICIAL
PALMAR ARCHES

Normal Radio-cephalic AVF

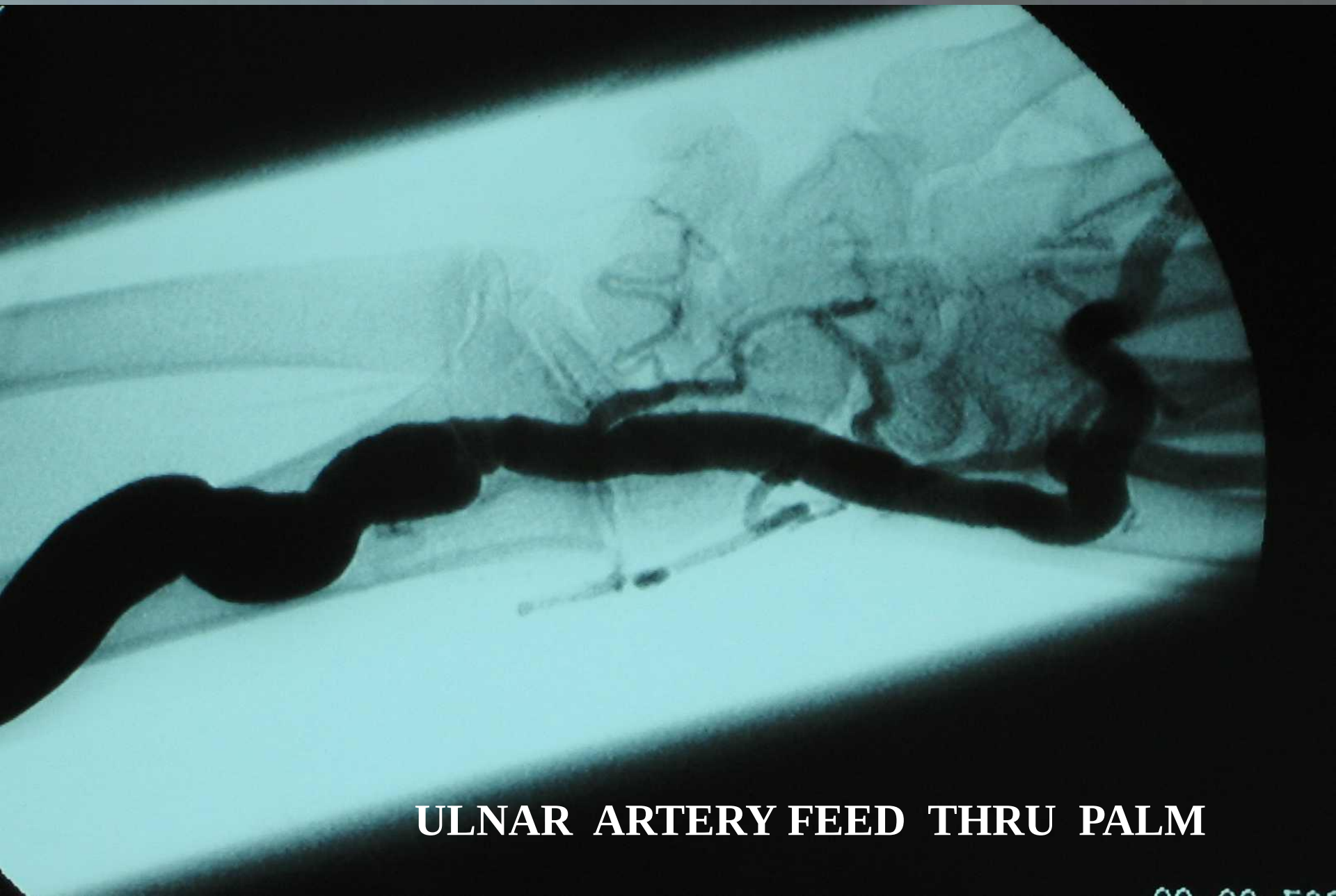




Ulnar Inflow Artery

AVF fed by reverse flow thru Palmar Arch

Ulnar Inflow Artery



Anatomical Vs Functional Inflow

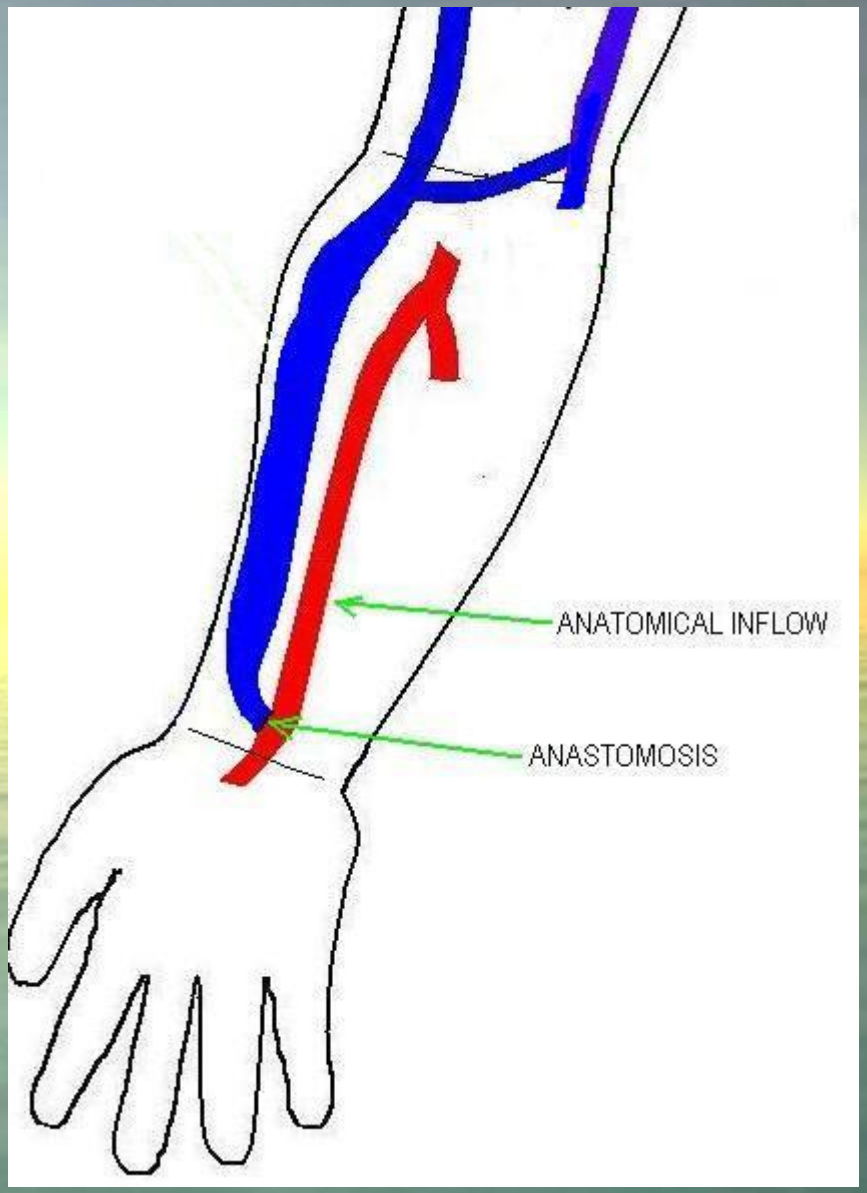
Anatomical inflow (radial artery)

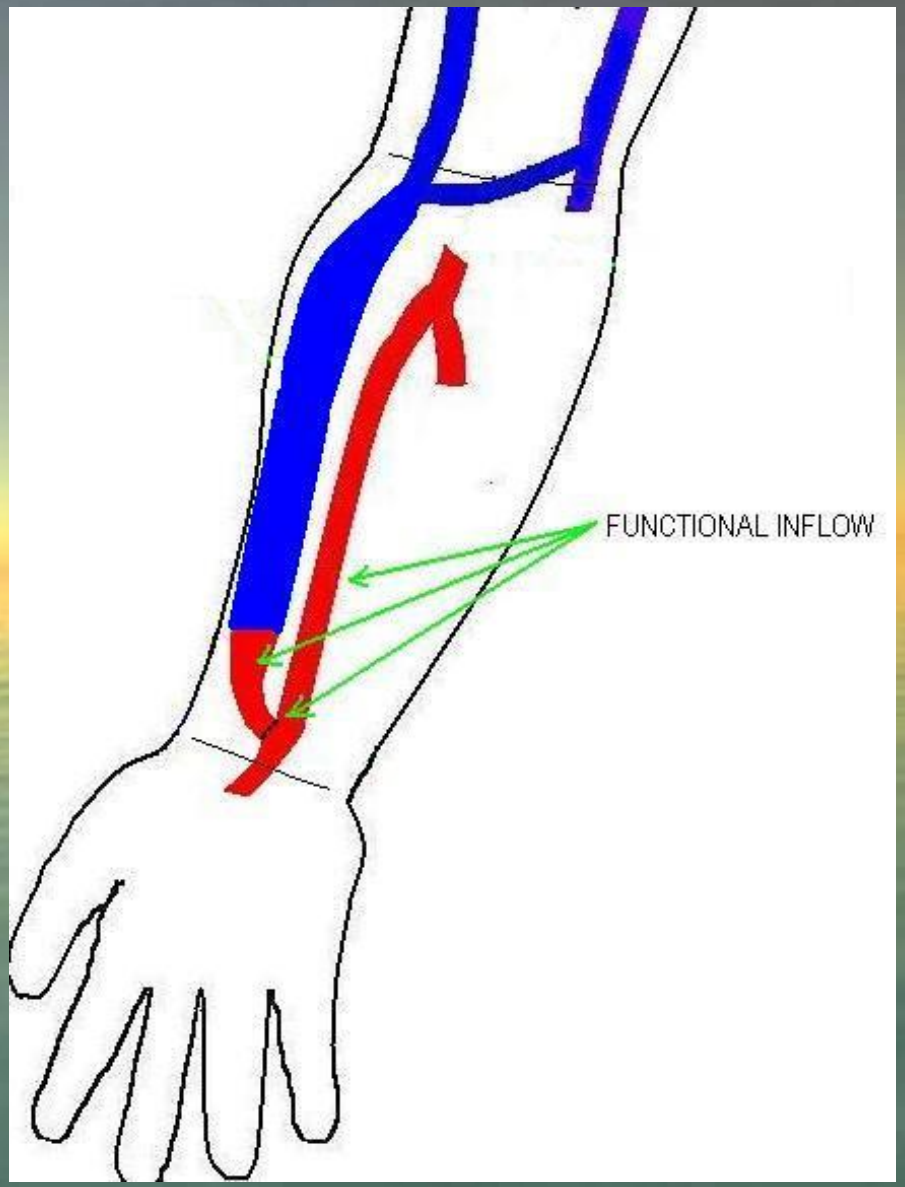
and the

Functional inflow (Radial a, Anastomosis Swing vein)

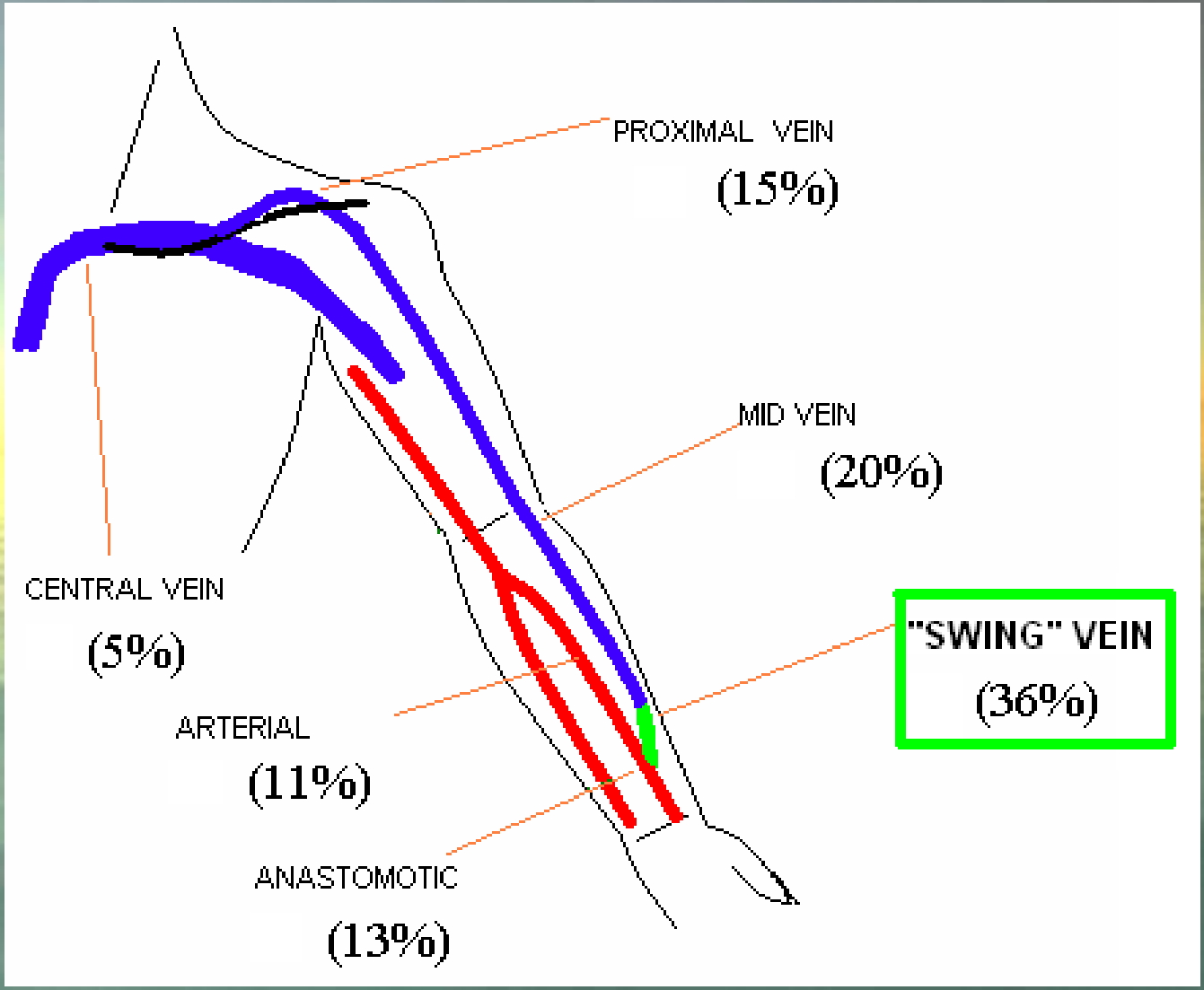
NB 30% of fistula stenoses occur in this area !

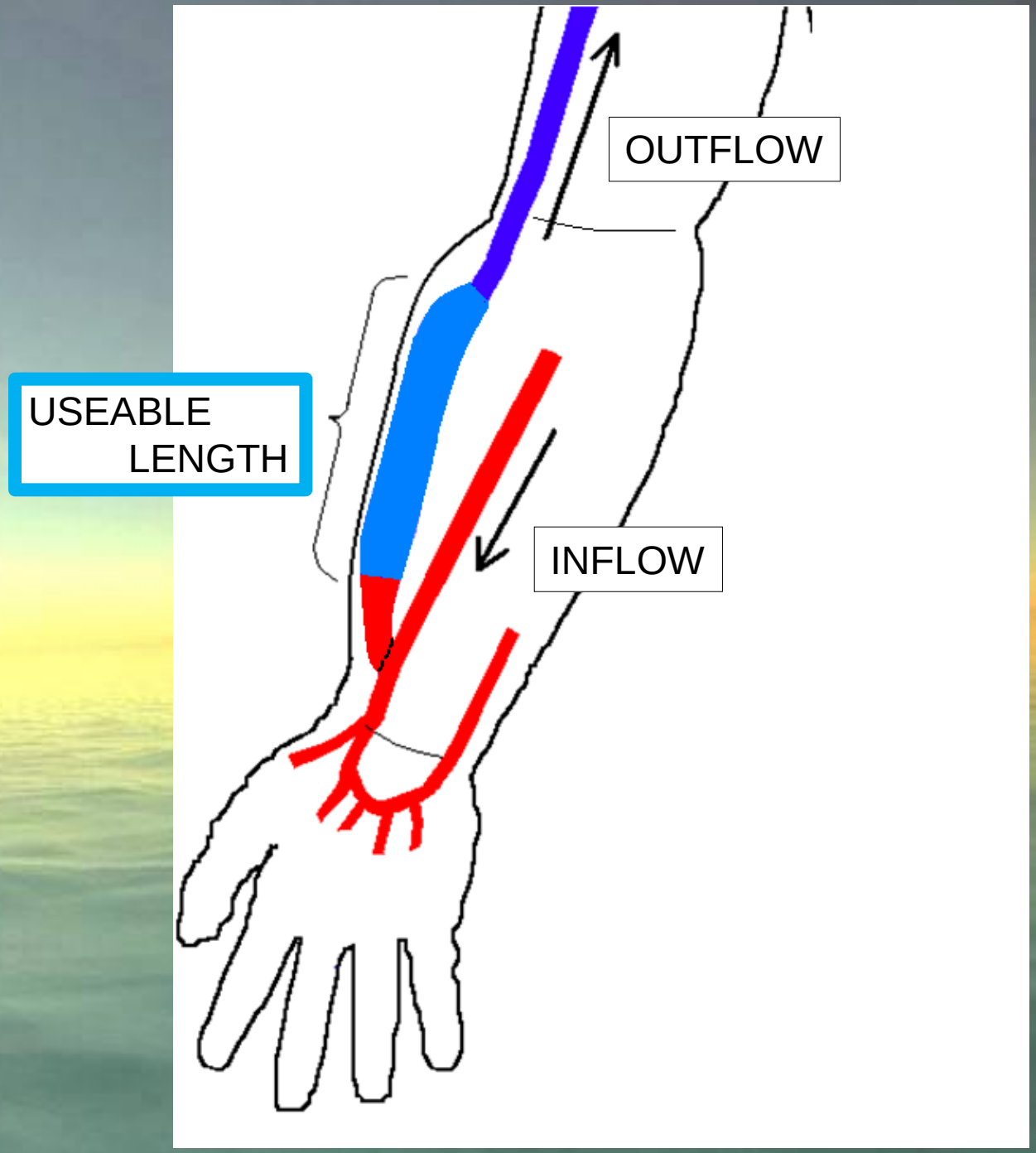
Anatomical Vs Functional Inflow





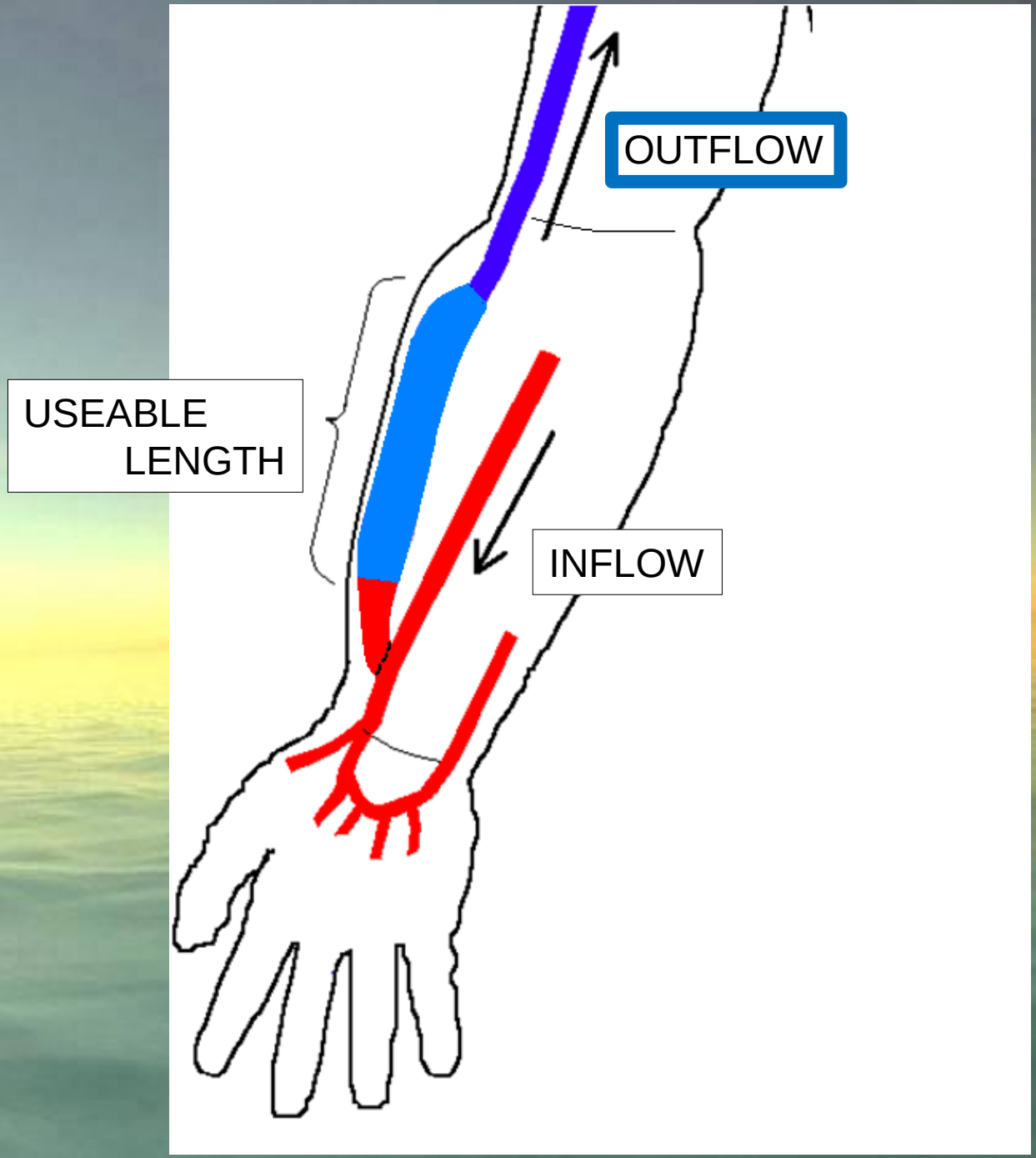
Distal Cephalic Vein: “Swing Vein”




OUTFLOW
USEABLE
LENGTH
INFLOW

2. Useable Length

- Site of needling (Rule of 6's)
- > 6 cm of "Useable Segment" for needling
- < 6 mm deep
- > 6 mm in diameter
- > 600 mls/min Fistula Flow (Qa)
- Straight & Accessible

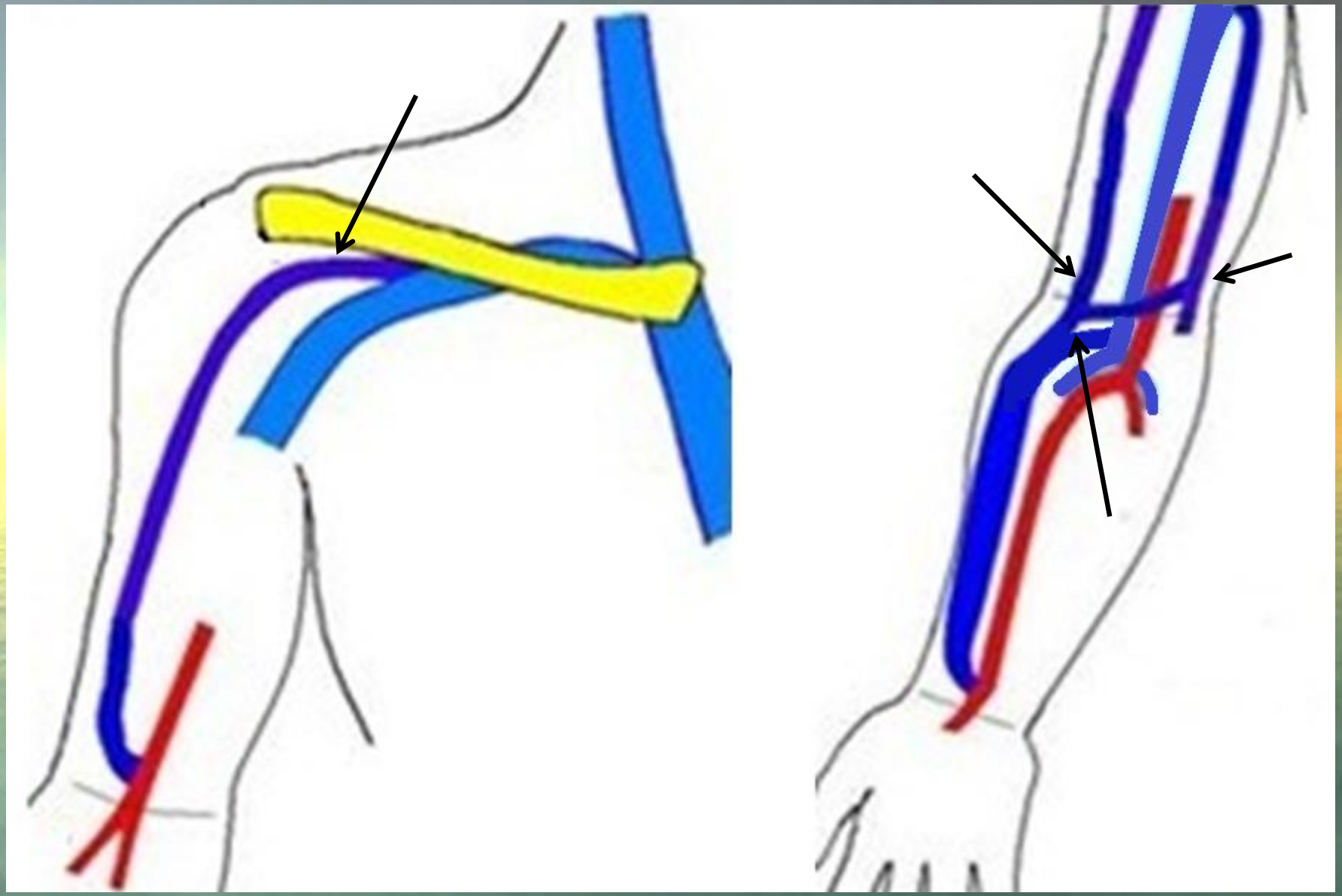

OUTFLOW
USEABLE
LENGTH
INFLOW

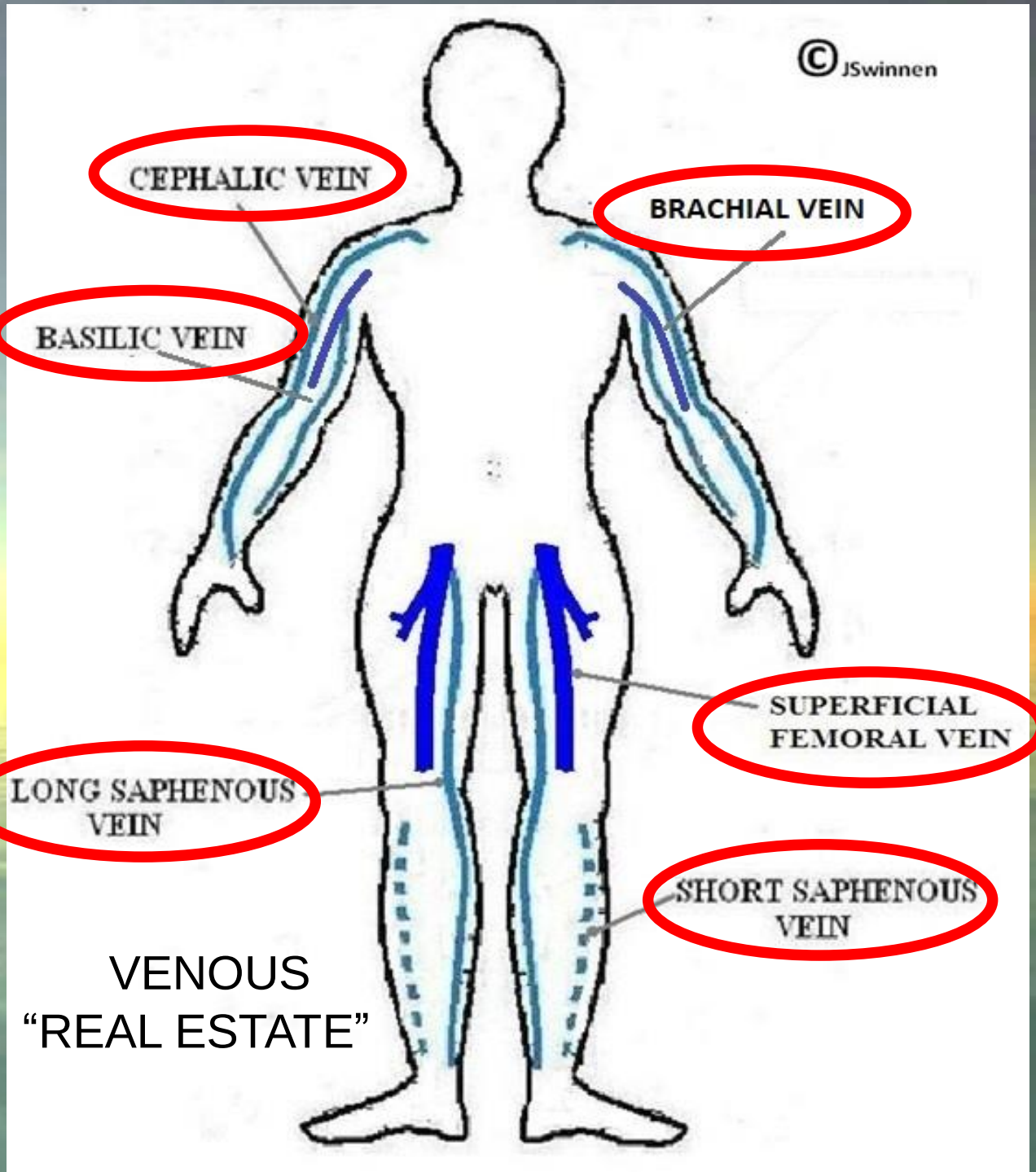
3. Outflow

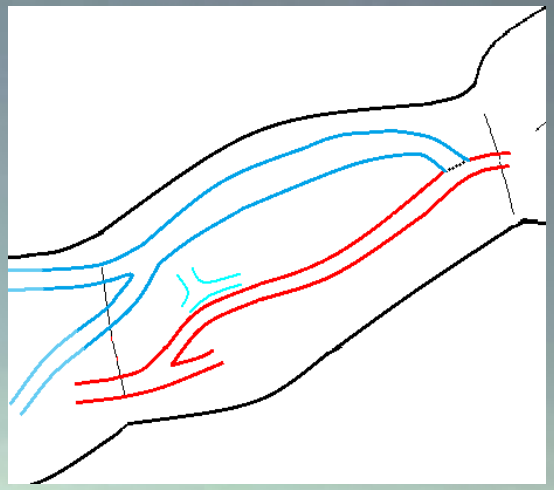
- Important variable between different fistulas
- Outflow stenoses the hardest to treat
- RC AVF has the best outflow configuration*

* The Radio-Cephalic Fistula is **by far** the best Native Fistula !!!

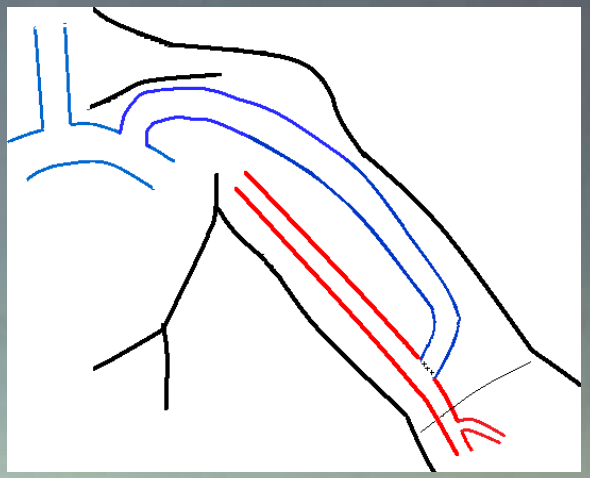
OUTFLOW **RC** vs **BC** AVF



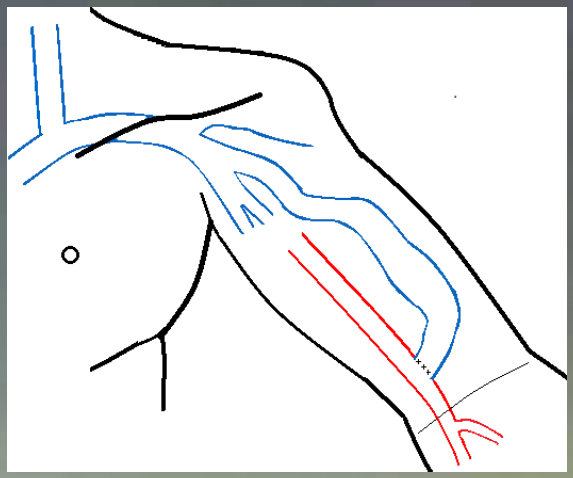

©JSwinnen
CEPHALIC VEIN
BRACHIAL VEIN
BASILIC VEIN
SUPERFICIAL FEMORAL VEIN
LONG SAPHENOUS VEIN
SHORT SAPHENOUS VEIN
VENOUS
"REAL ESTATE"



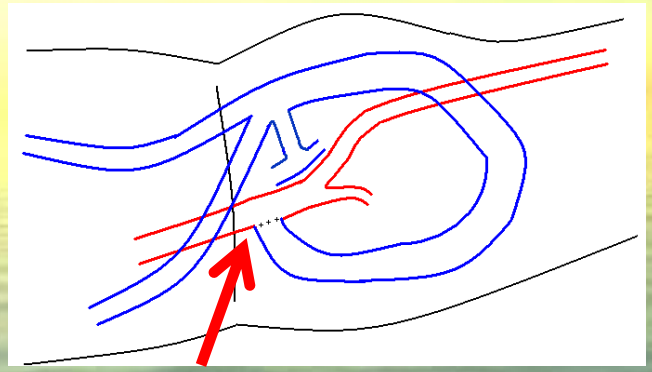
Radio-Cephalic



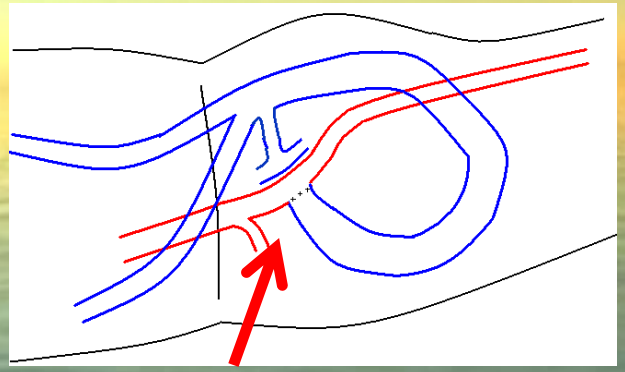
Brachio-Cephalic



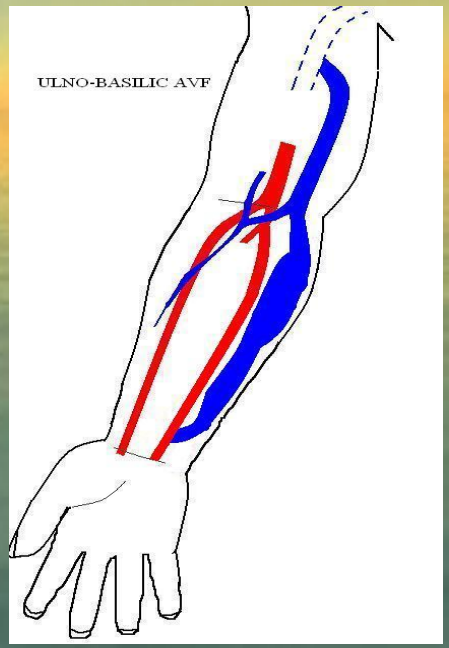
Brachio-Basilic



Loop Forearm RC

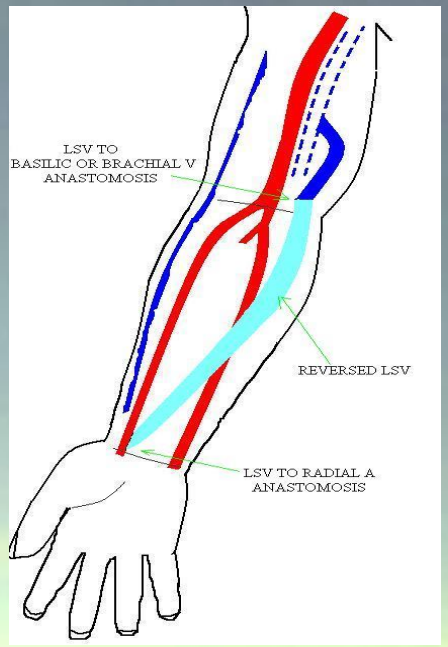


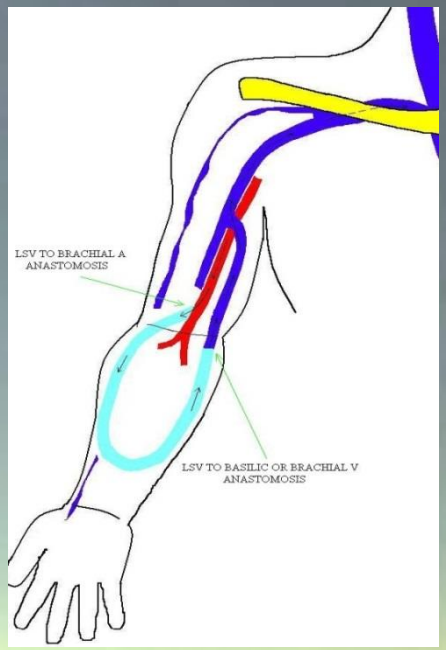
Loop Forearm BC



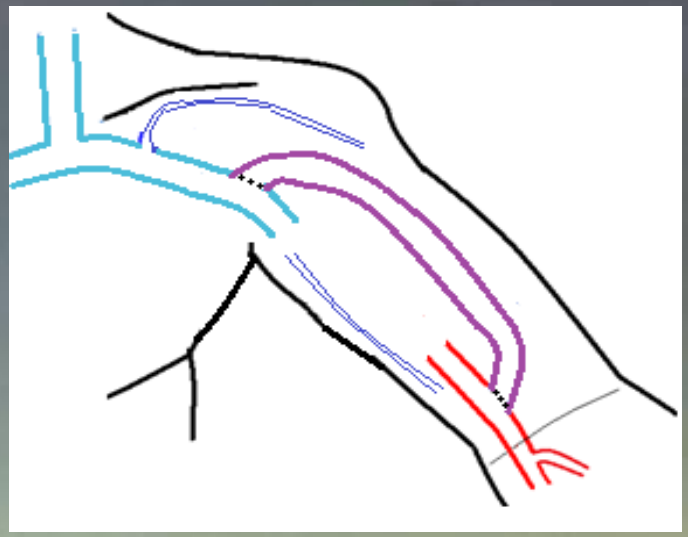
Ulno-Basilic

Native Fistula Configurations

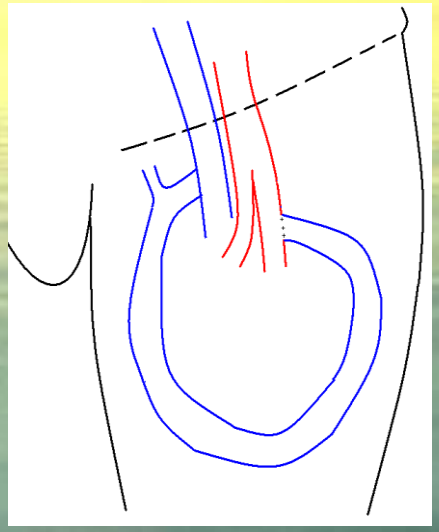




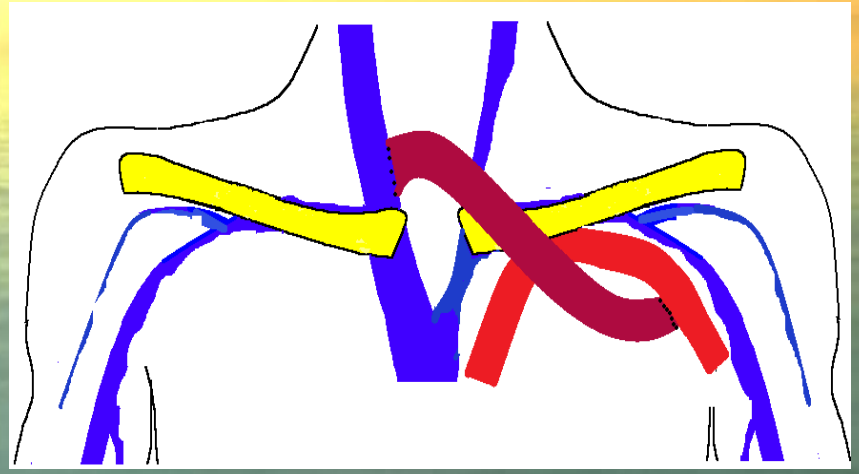
LSV Forearm Straight & Looped



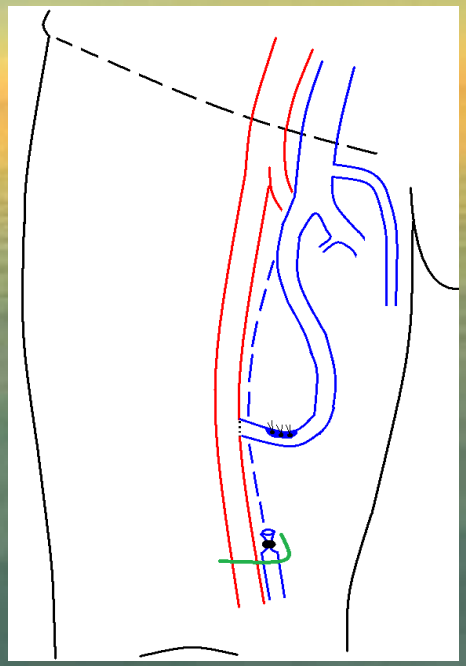
Transposed DFV Brachio-Axillary



LSV InSitu Thigh



Transposed DFV Axillo-Jugular



Thigh DFV

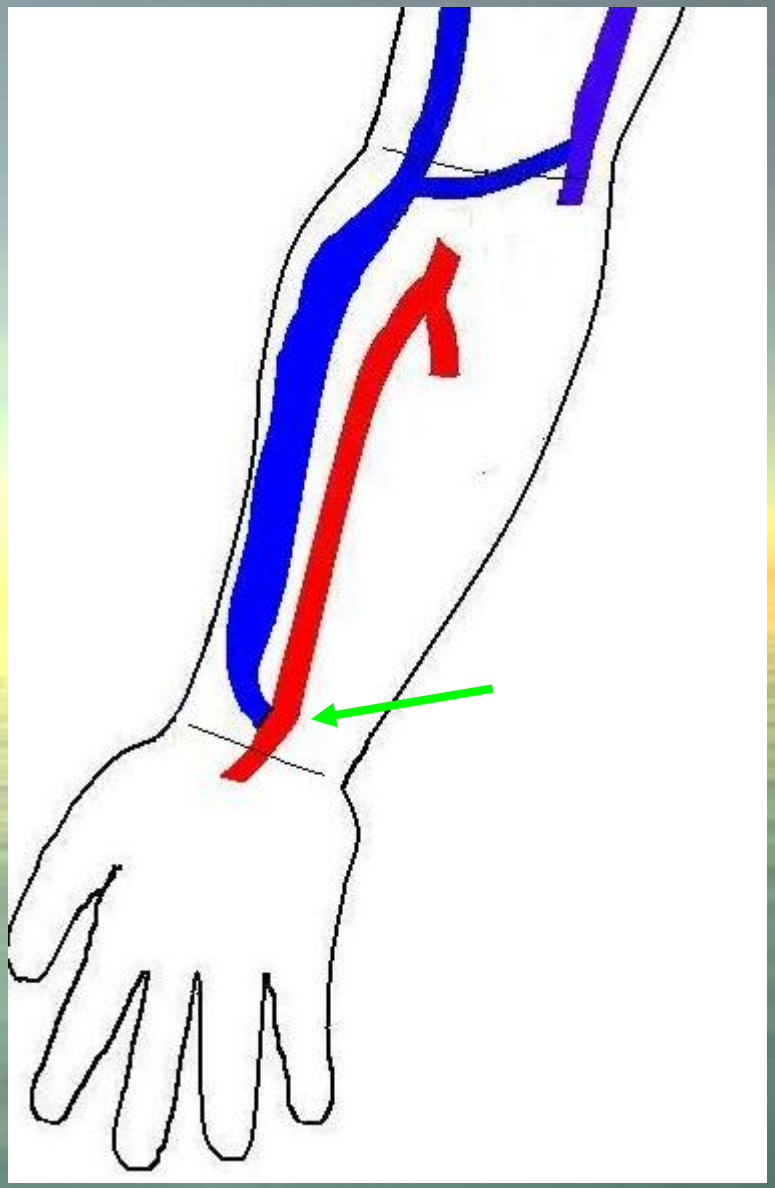
Distal Radio-Cephalic Fistula

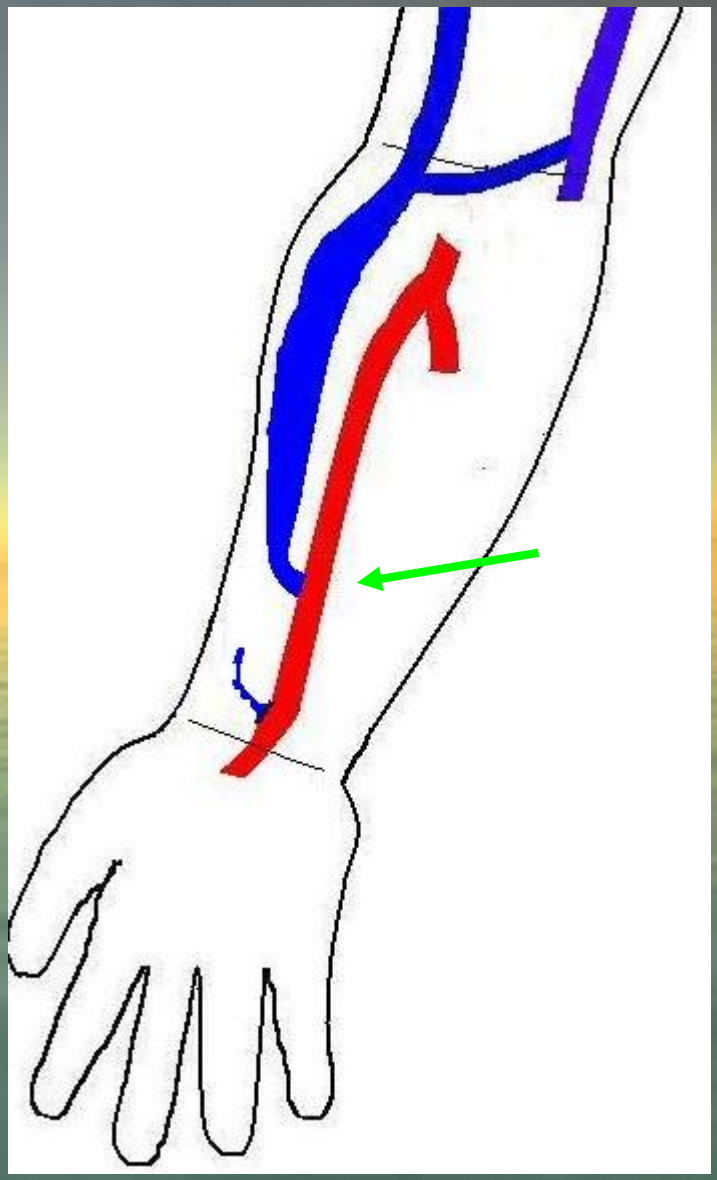
Distal Radio-Cephalic Fistula

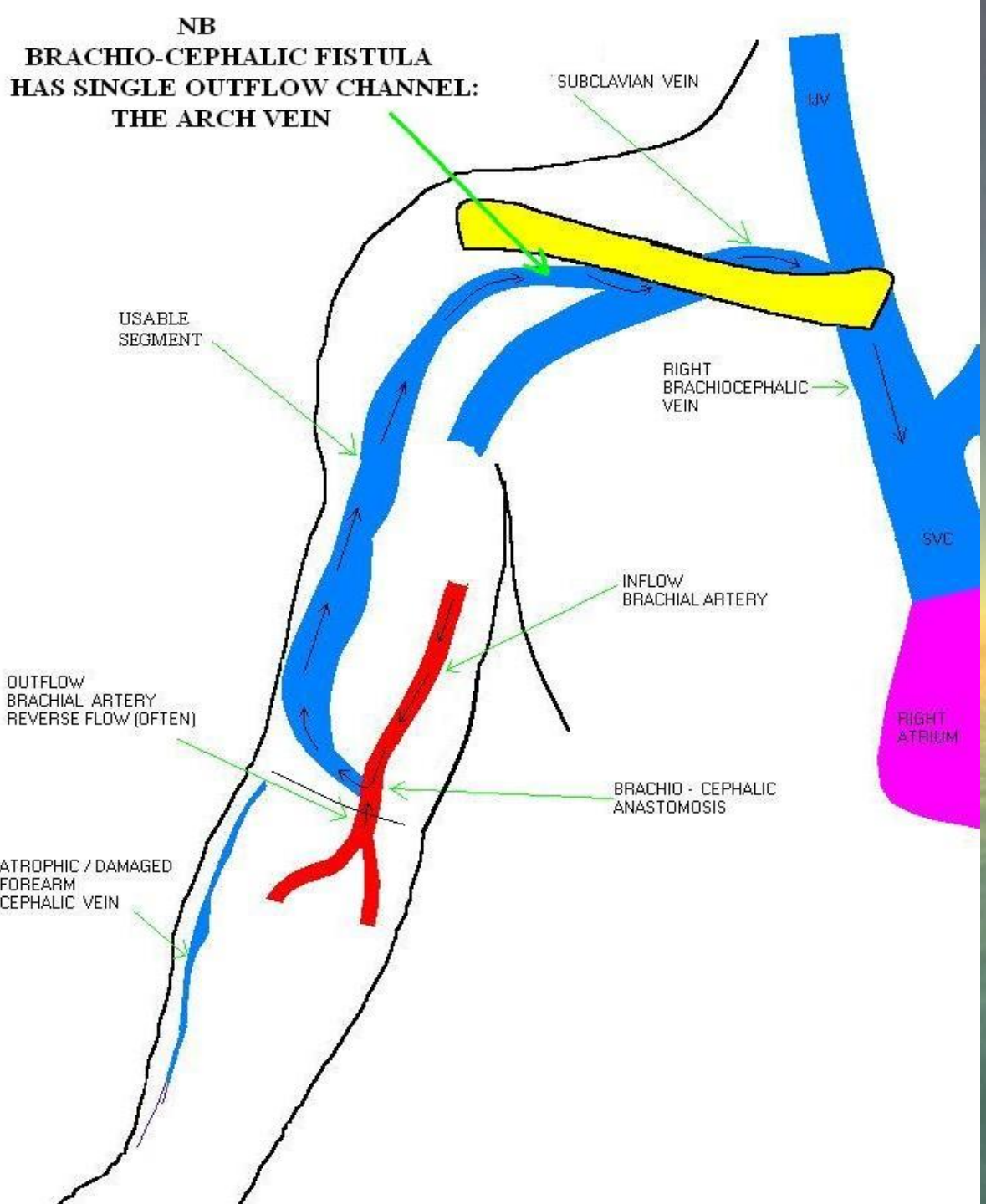
- Best outflow configuration (Triple)
- Giant Fistula / High Output State rare
- Most convenient access
- Significant steal very uncommon
- Radial artery fully expendable
- Endovascular revision very safe!

“Triple Outflow” Radio-Cephalic Fistula

Proximalised RC Fistula

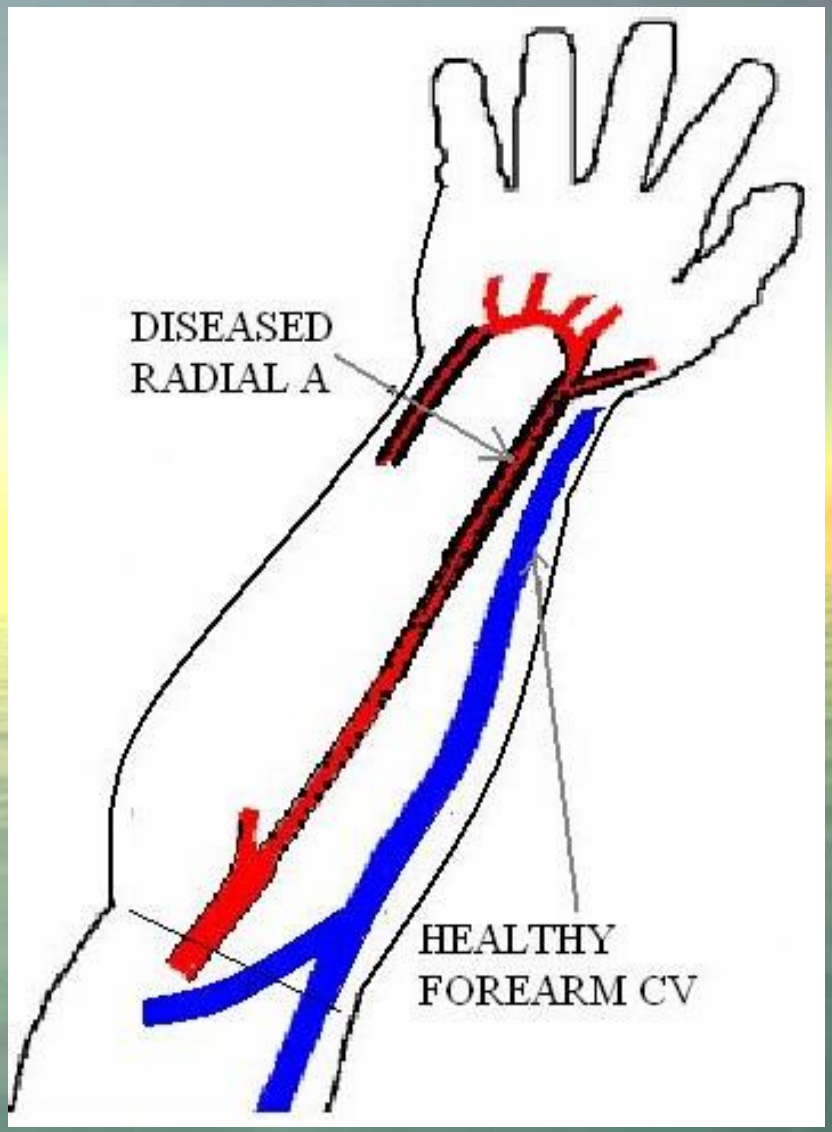


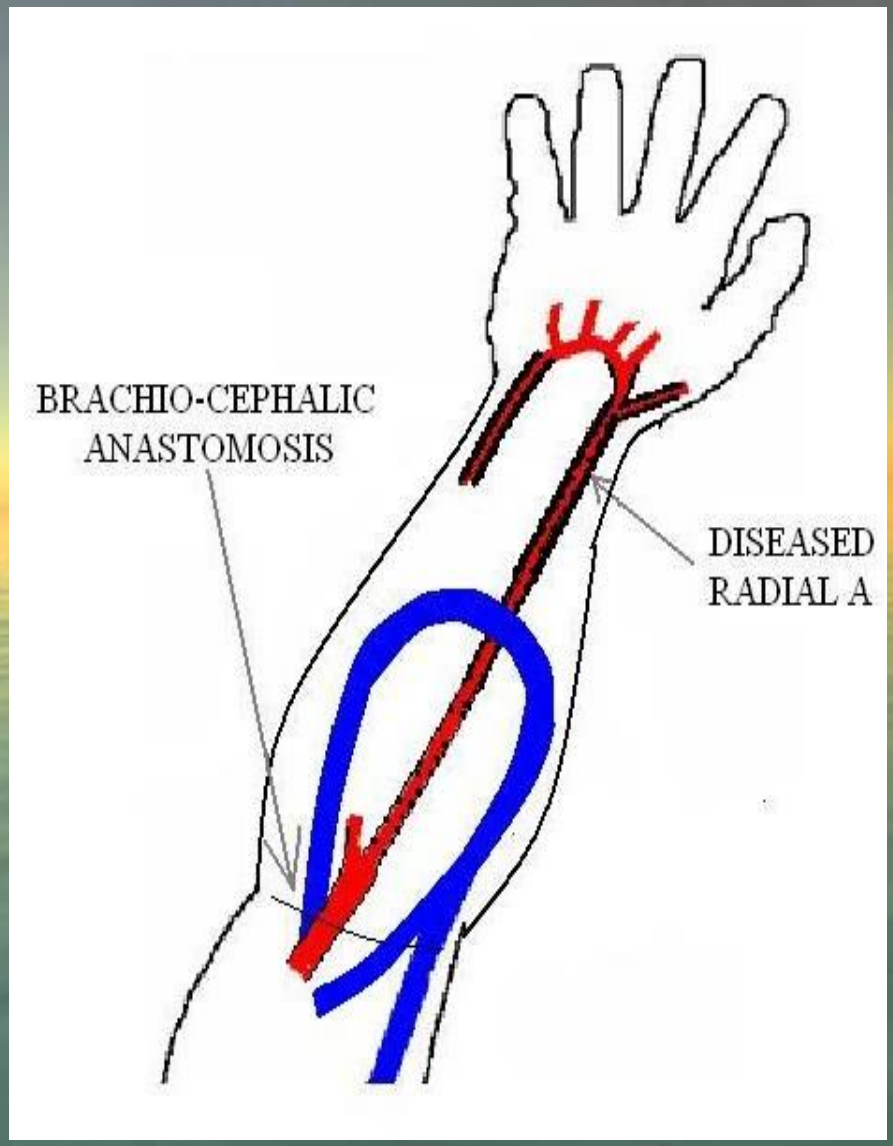




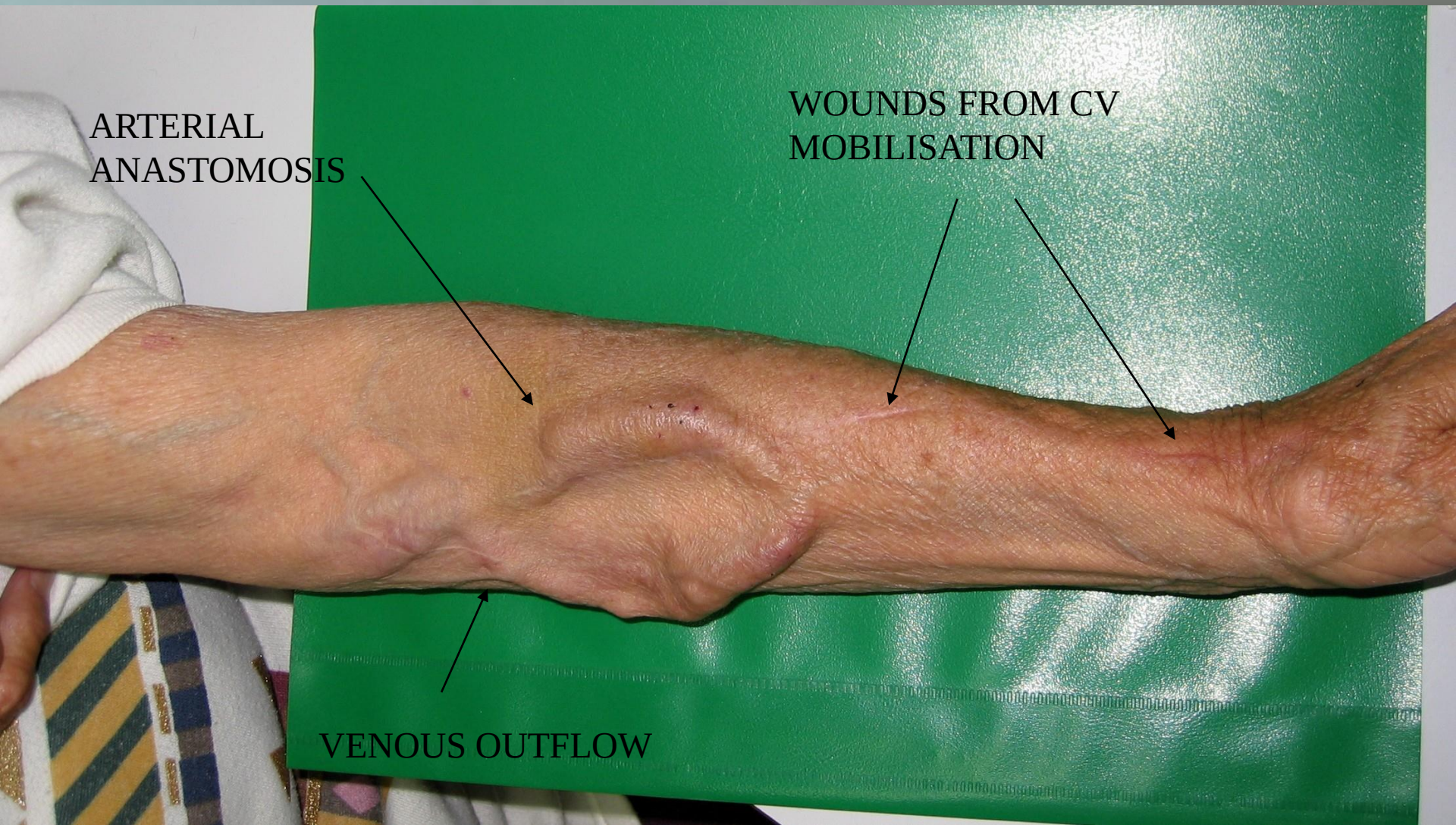
Other Native AVF:
Brachio-cephalic AVF

“Loop Forearm BC AVF”

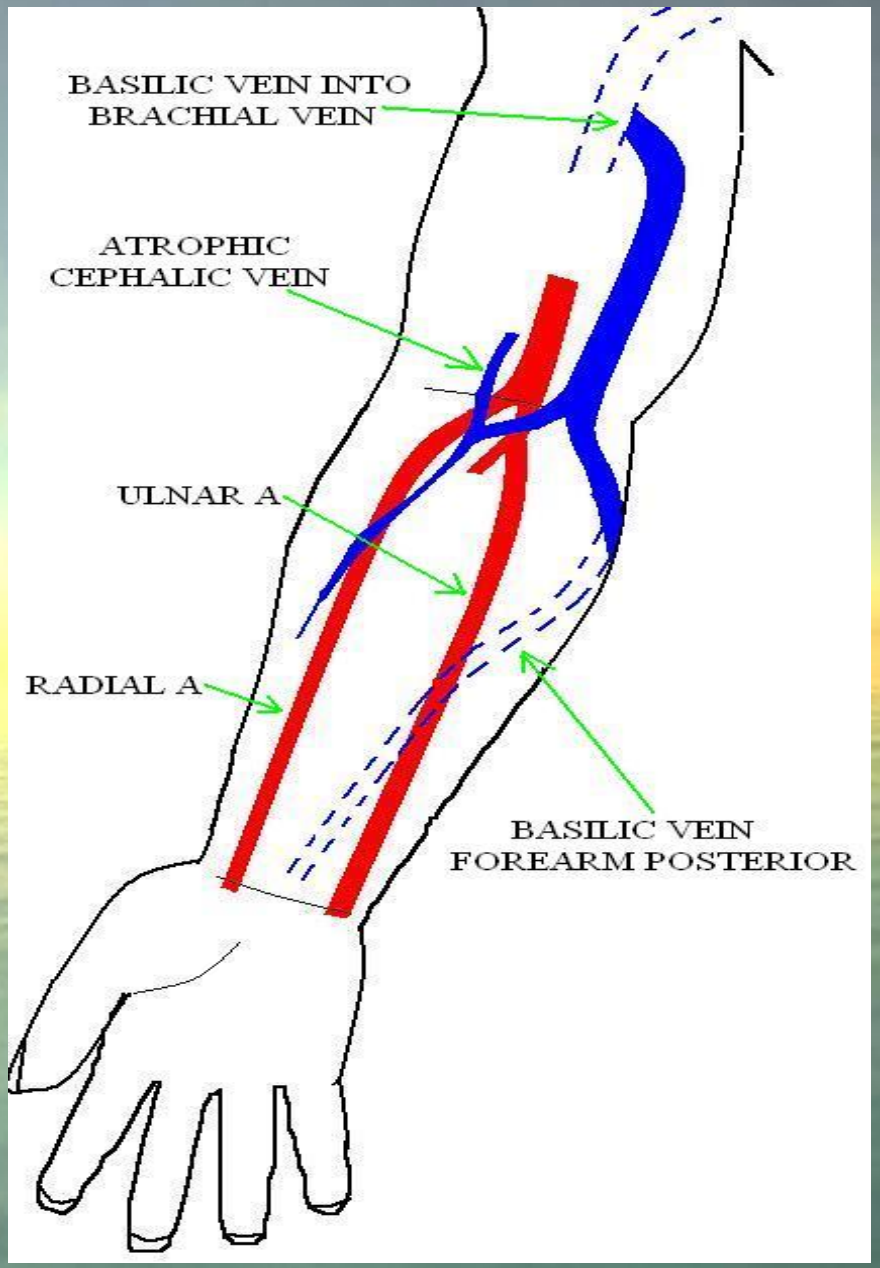


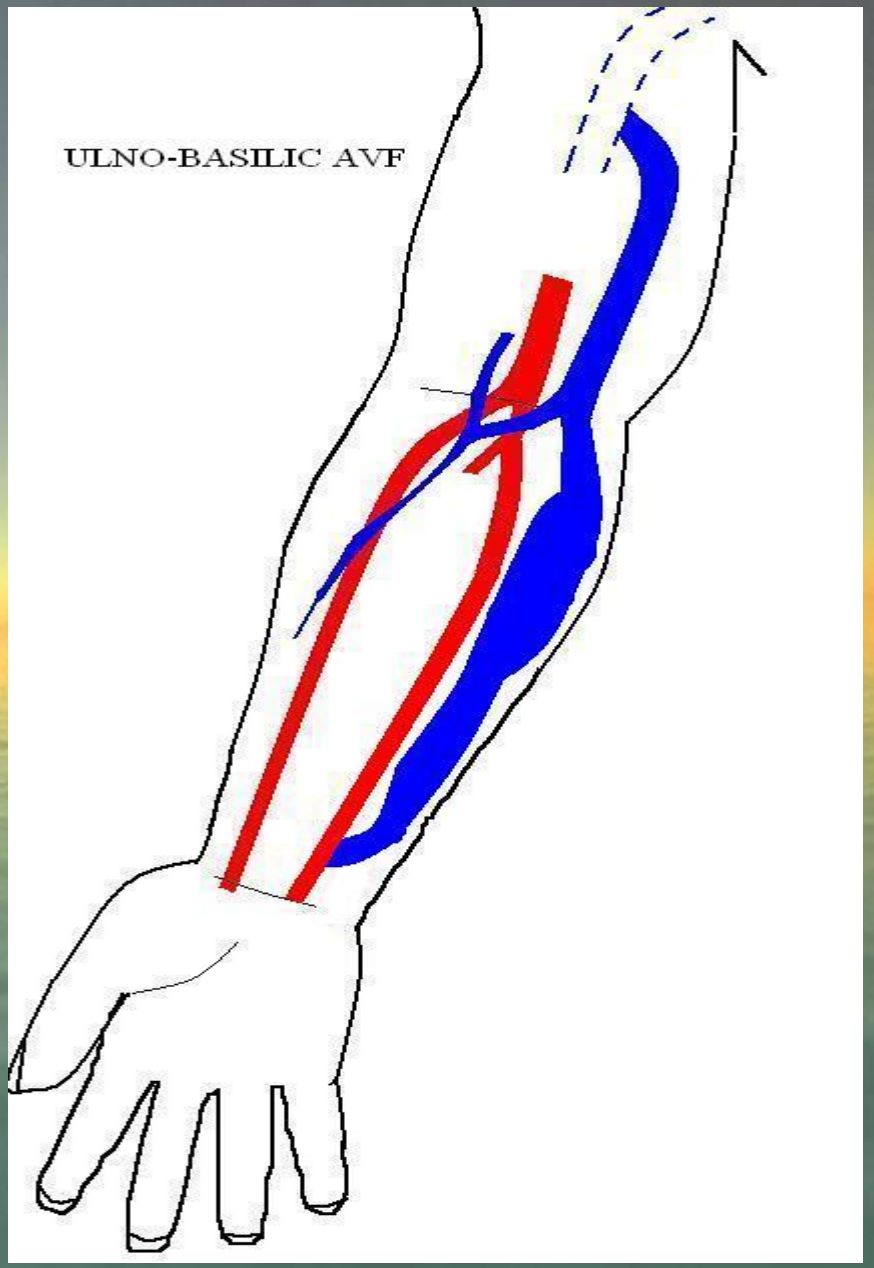


Loop Forearm BC AV Fistula



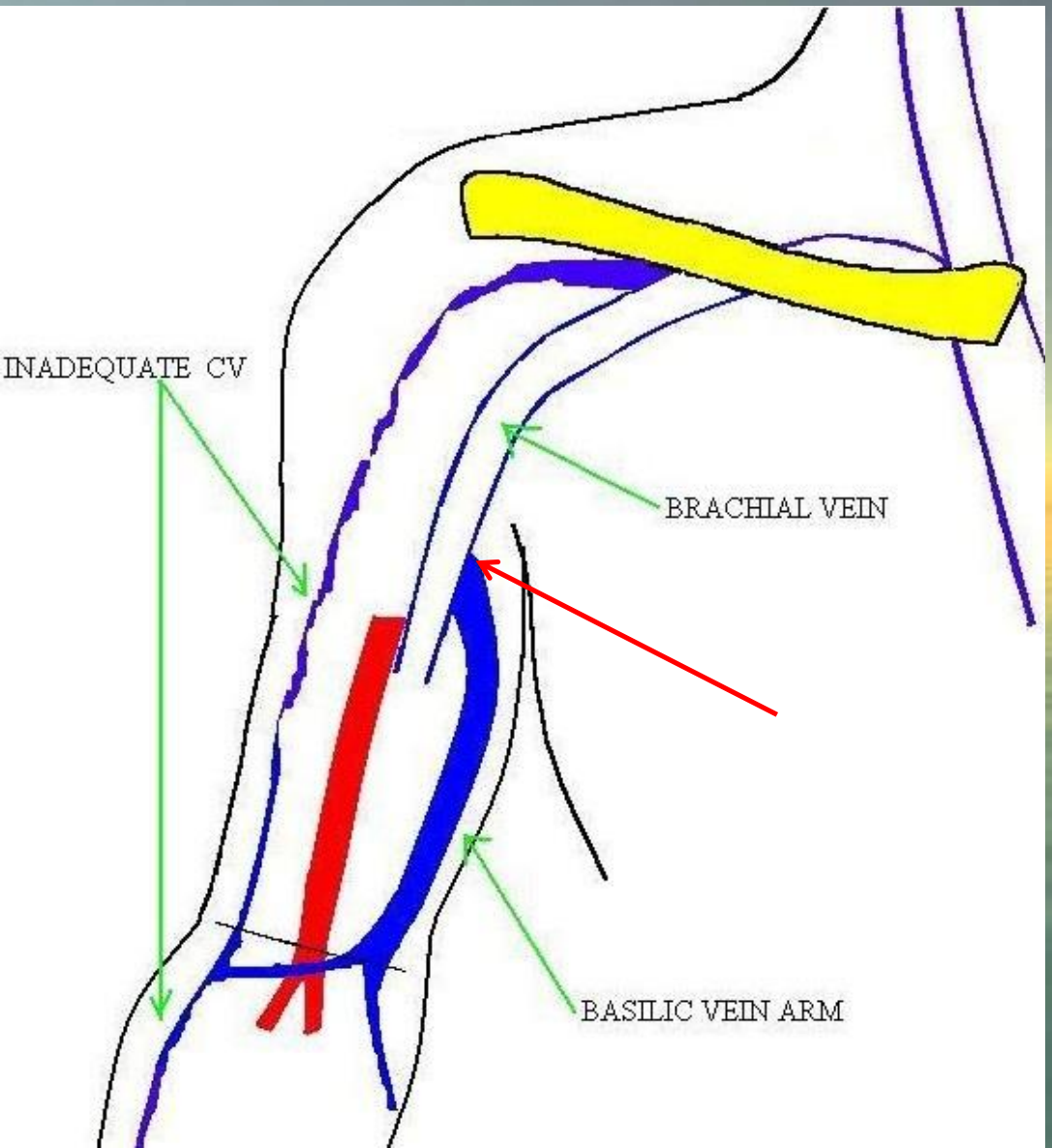
“Ulno Basilic AVF”





Non-transposed Ulno-basilic AVF

“Brachio- Basilic AVF”



ANATOMY OF THE BASILIC V

- Variable junction to brachial v
- Basilic vein preserved/protected from damage by depth & position
- Usually good caliber vein
- Excellent outflow !
- One or Two Stage Surgery
- A good fistula !

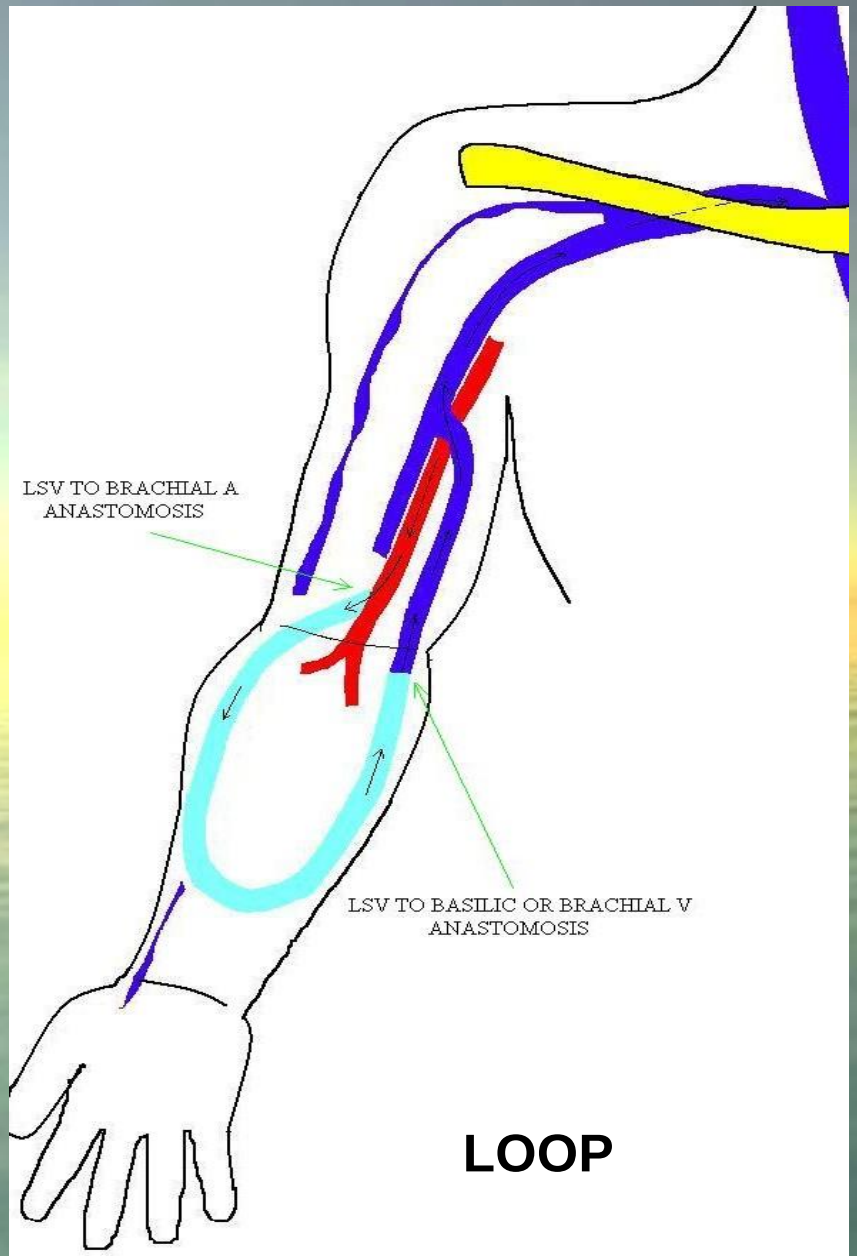
“Brachio- Basilic AVF”

Dr R Allen

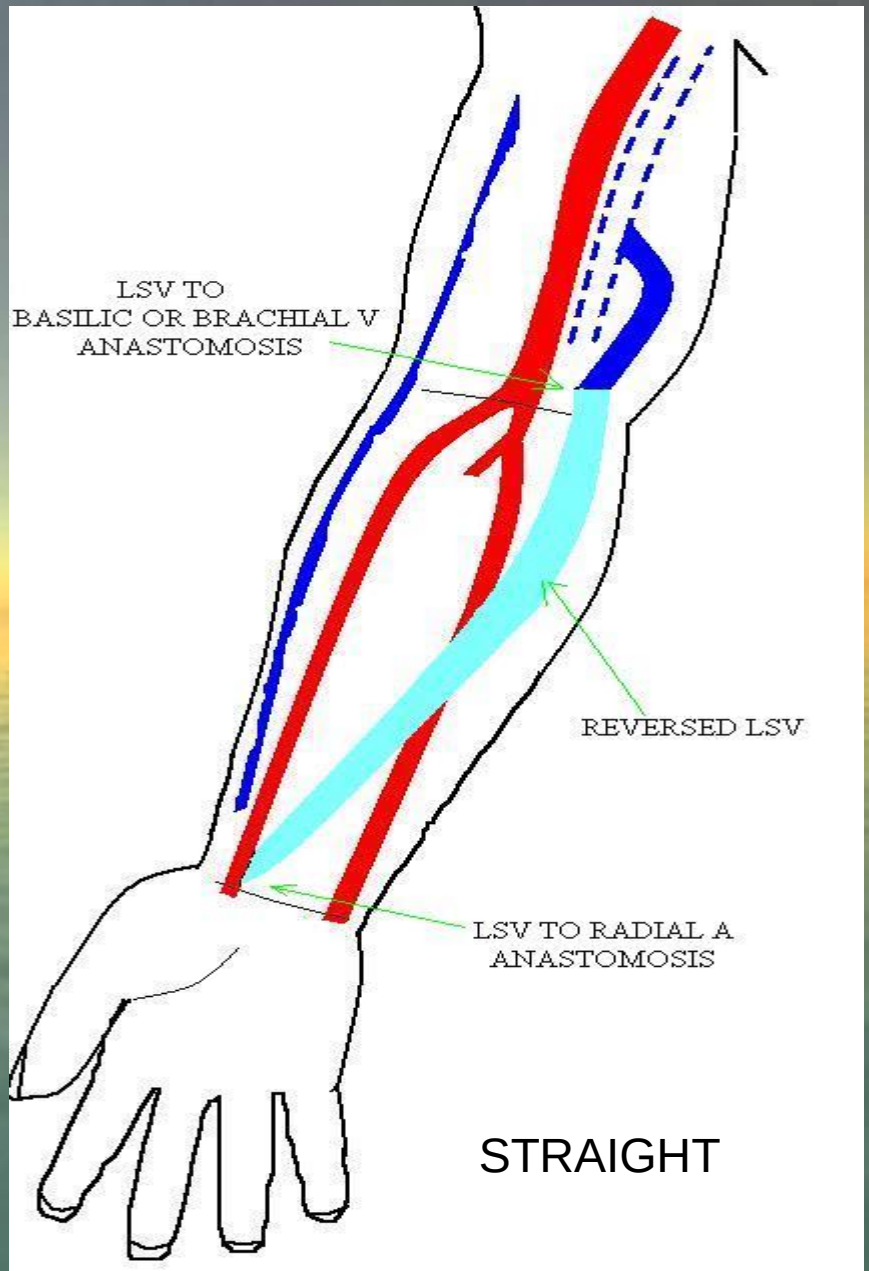
Loop & Straight LSV Forearm AVF

- LSV may be only undamaged superficial v
- LSV prone to stenosis
- Primary patency rates ~ Synthetic grafts
- Can be matured & maintained with aggressive endovascular techniques

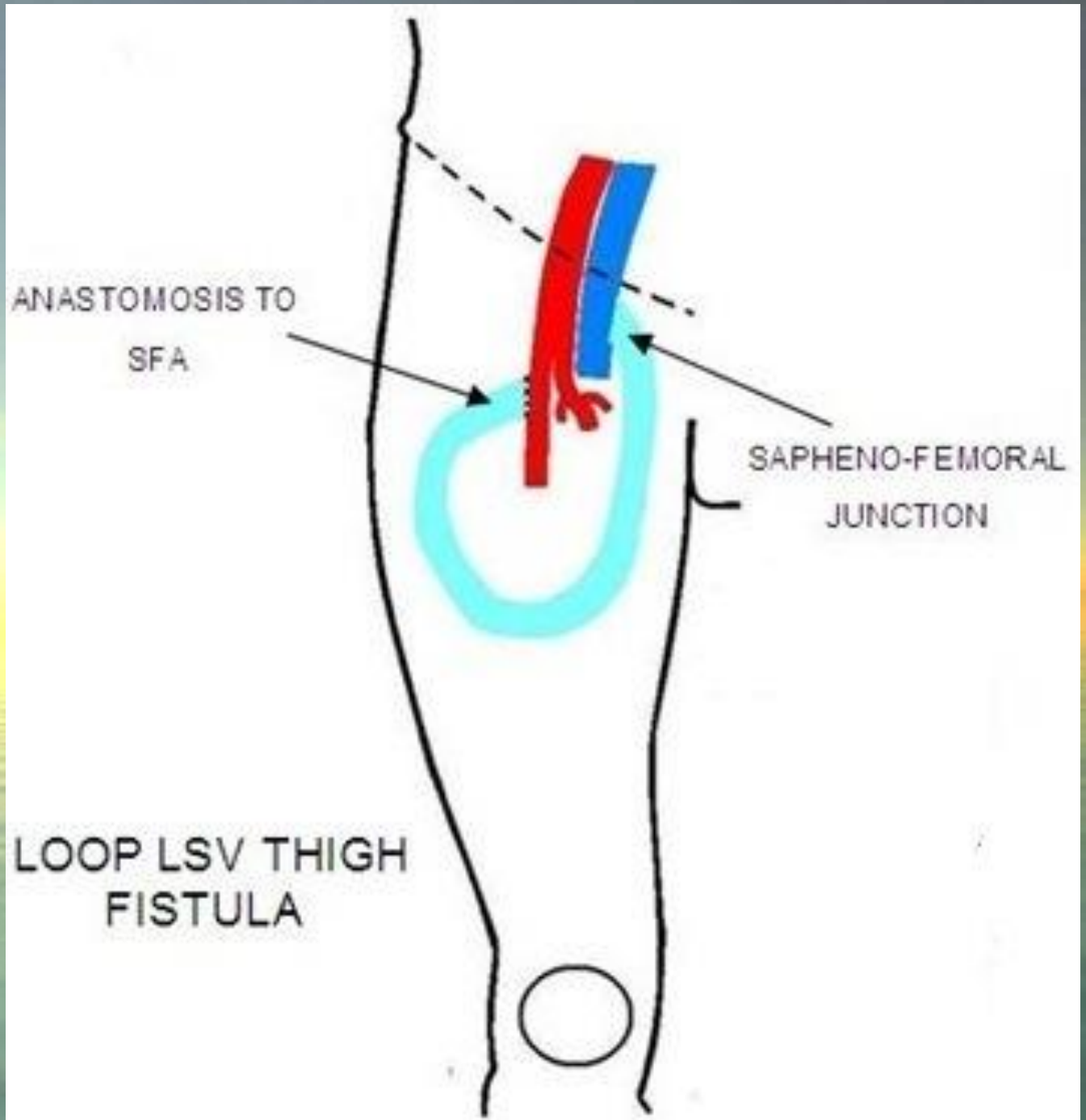
Loop & Straight LSV Forearm AVF



LOOP



STRAIGHT



"Loop LSV Thigh AVF"

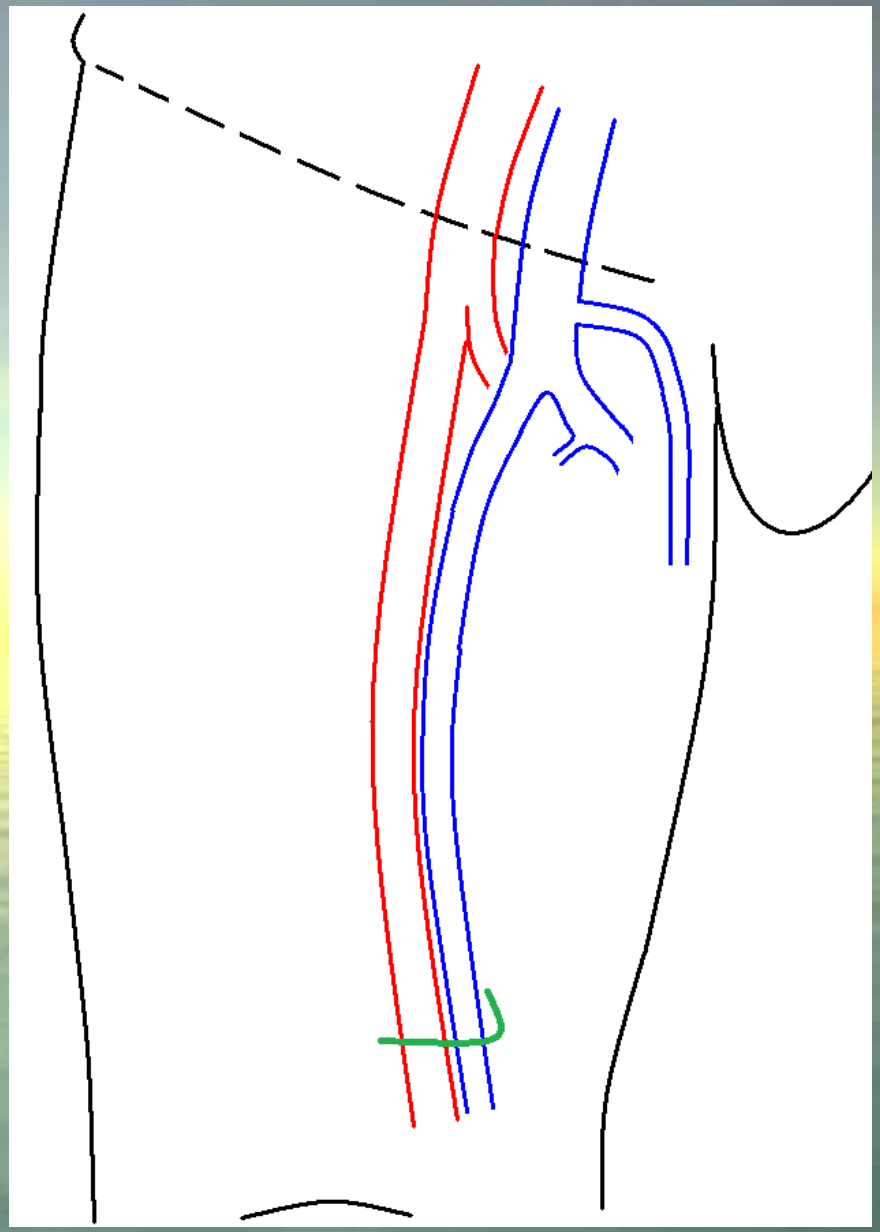
Superficial Femoral Vein AVF

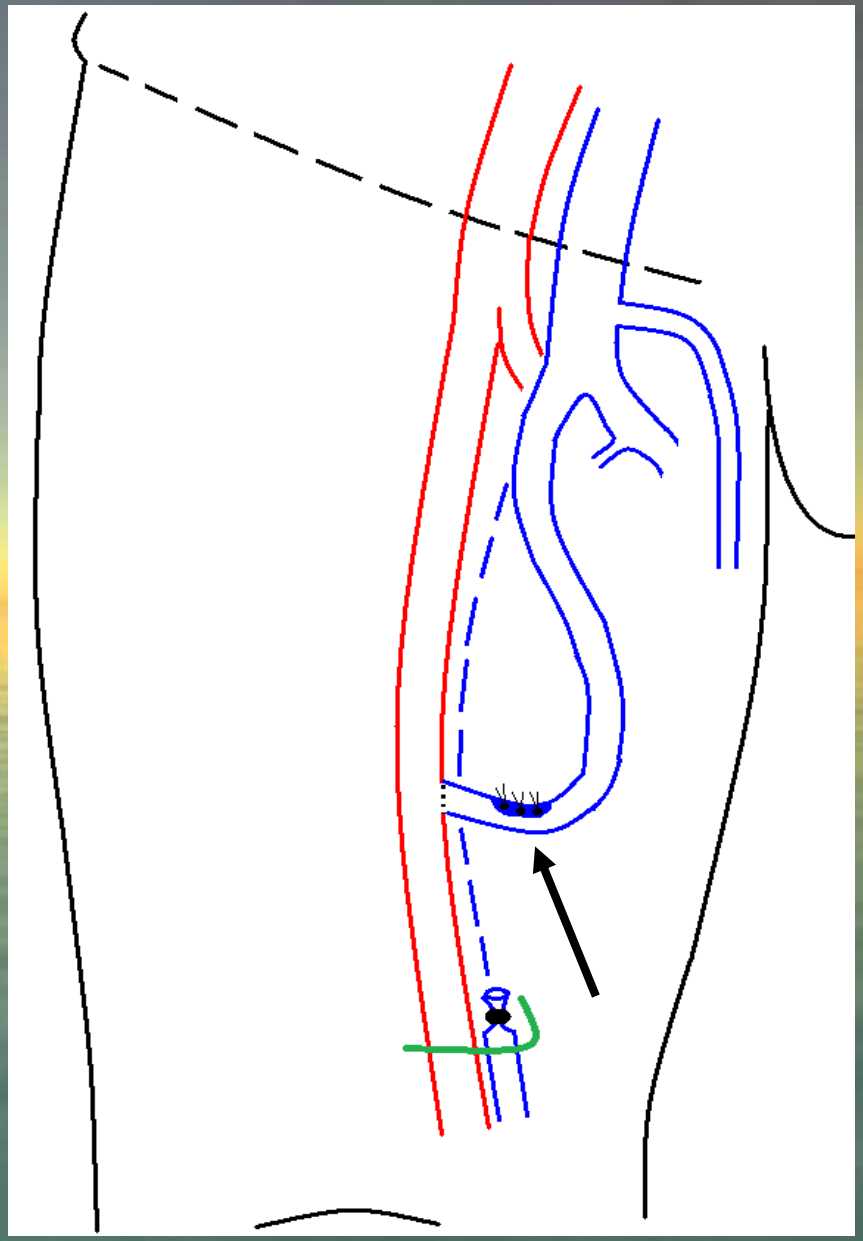
- Pioneered by Dr D Gawler in Darwin, Aus.
- Makes an excellent, early maturing fistula

BUT

- Patient must have NORMAL arterial circulation
- May require choke to prevent “Giant AVF”

Superficial Femoral Vein AVF

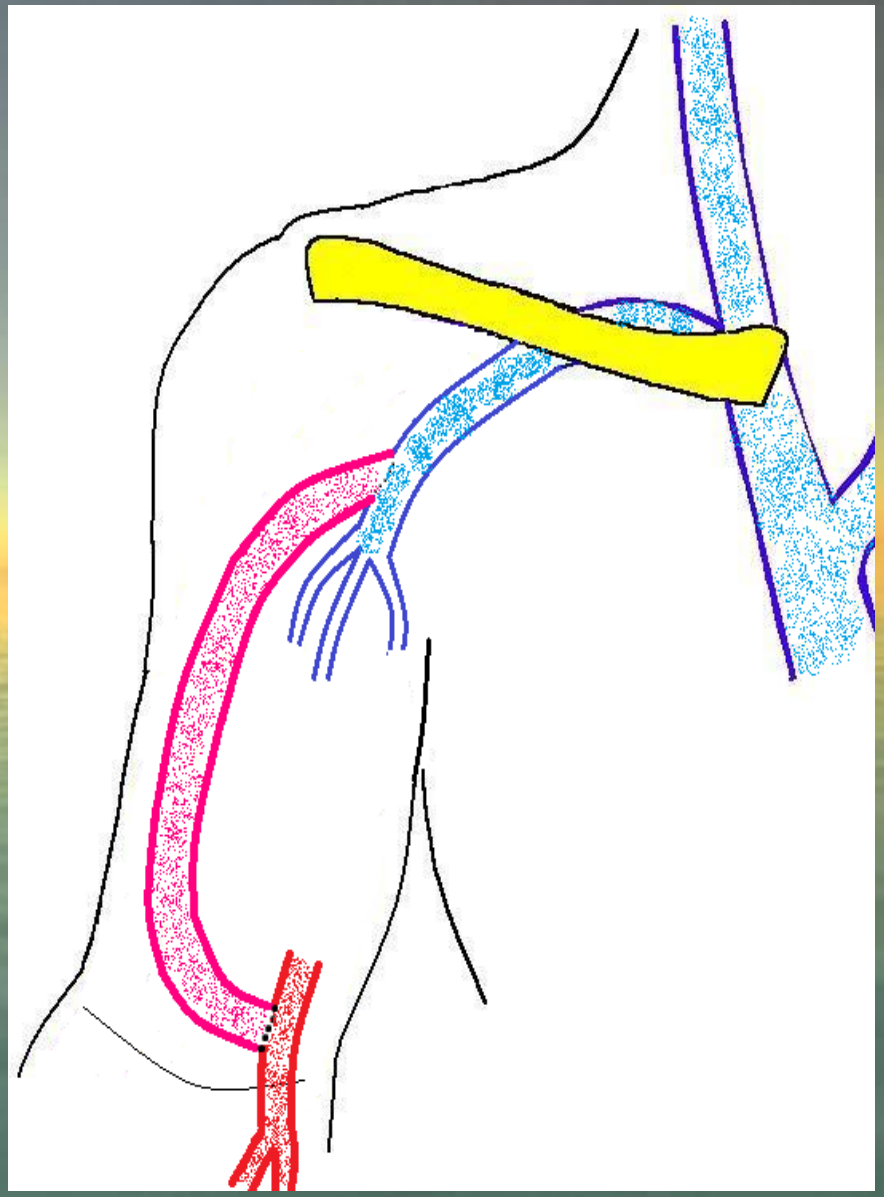




SIUT: Superficial Femoral Vein AVF

In Situ SFV AVF in L Thigh

Transposed SFV to R Arm



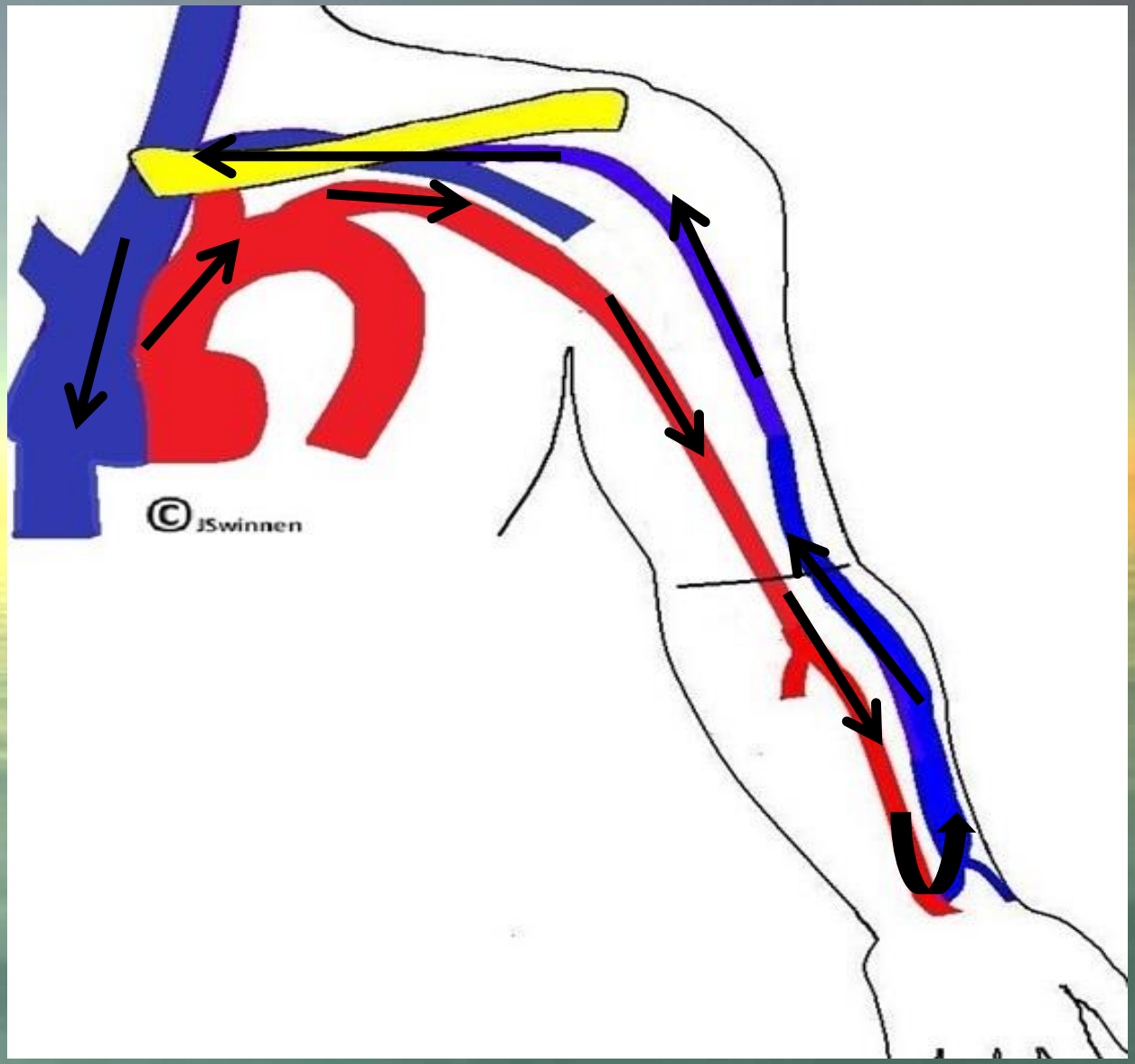
PHYSIOLOGY

Flow (Q) in Hemodialysis

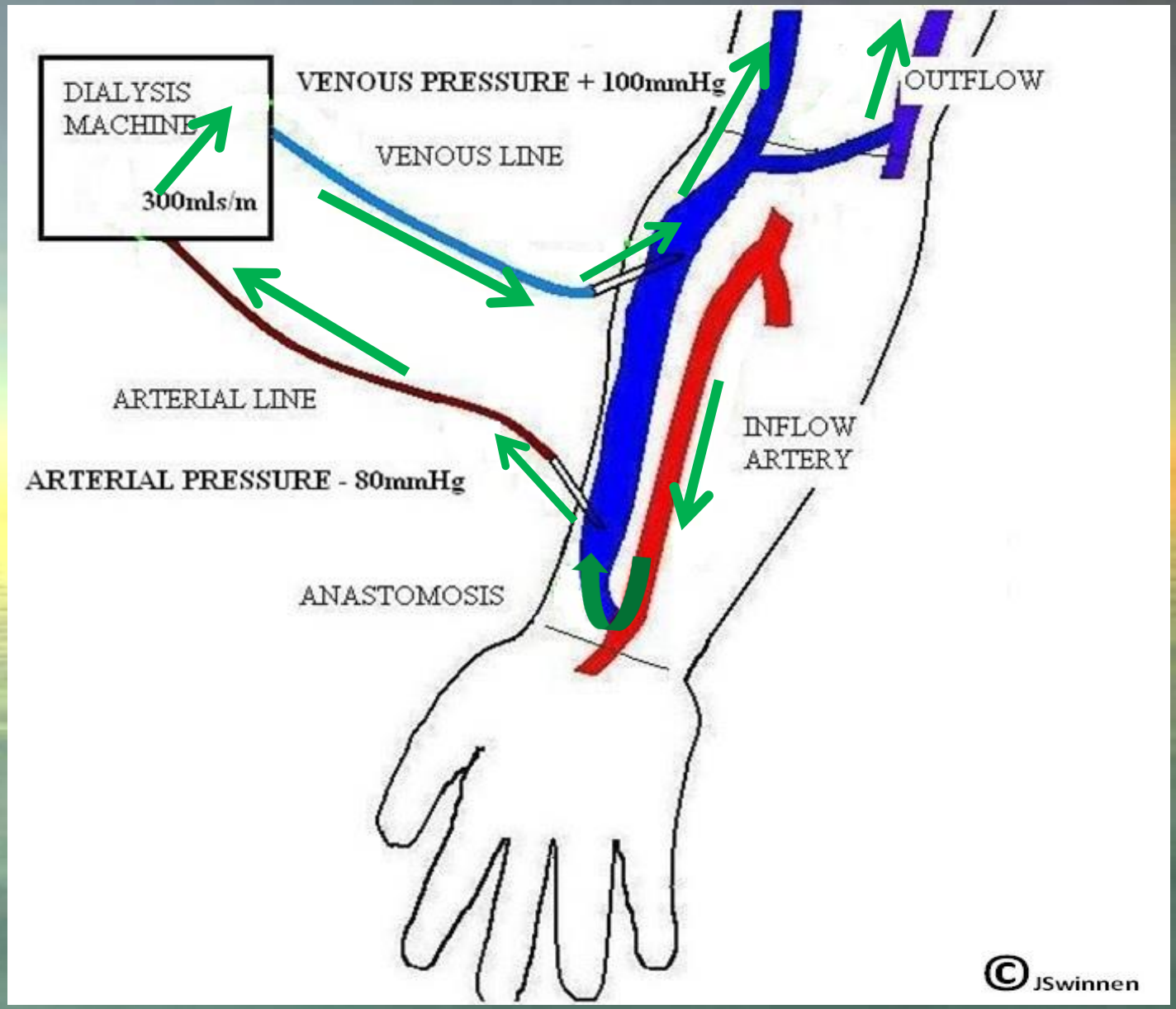
Qa Fistula Flow

Qb Dialysis Circuit Flow

Qa: Flow Thru the **Fistula Circuit**



Qb: Flow Thru the **Dialysis Circuit**



Qa:

Flow thru the Fistula Circuit

Qa: Fistula Volume Flow

1. For assessing fistula function

2. For assessing change in flow over time

3. For assessing significance of a stenosis

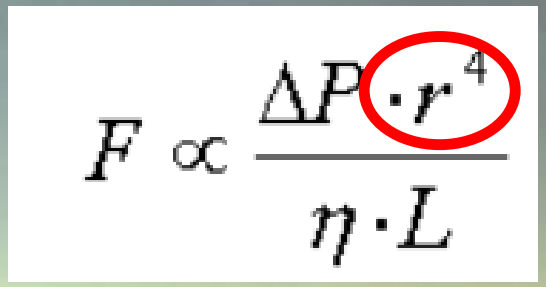
4. For assessing giant fistula formation

5. For fistula Surveillance

Measuring **Qa**

- On dialysis: eg Transonic
- With Ultrasound

Qa Measurement by Ultrasound Poiseuille's Law



- Sample AVF where ALL the flow goes
- Good "arterial" signal – "Clean" Wave Form
- Heart rate / rhythm: Assumes Sinus Rhythm
- Correct angle
- Correct sample volume
- The effect of Radius: Errors magnified

Qa Measurement by Ultrasound

Therefore:

- Qa is variably accurate – “Ballpark”
- Must be carefully done
- In a Standardised way at Standardised site

Site of **Qa** Measurement

- Qa should **ALWAYS** be measured in

  → the INFOW BRACHIAL ARTERY

- Qa should **ONLY** be measured in

  → the INFOW BRACHIAL ARTERY

Site of **Qa** Measurement

- Brachial artery carries ALL the flow to AVF
- Good arterial signal
- Reproducible site of sampling

Effect of Radius on Flow

True Radius Brachial a

2mm

Measured Radius Brachial a

4mm

True Flow (Qa) Brachial a at 2mm

=

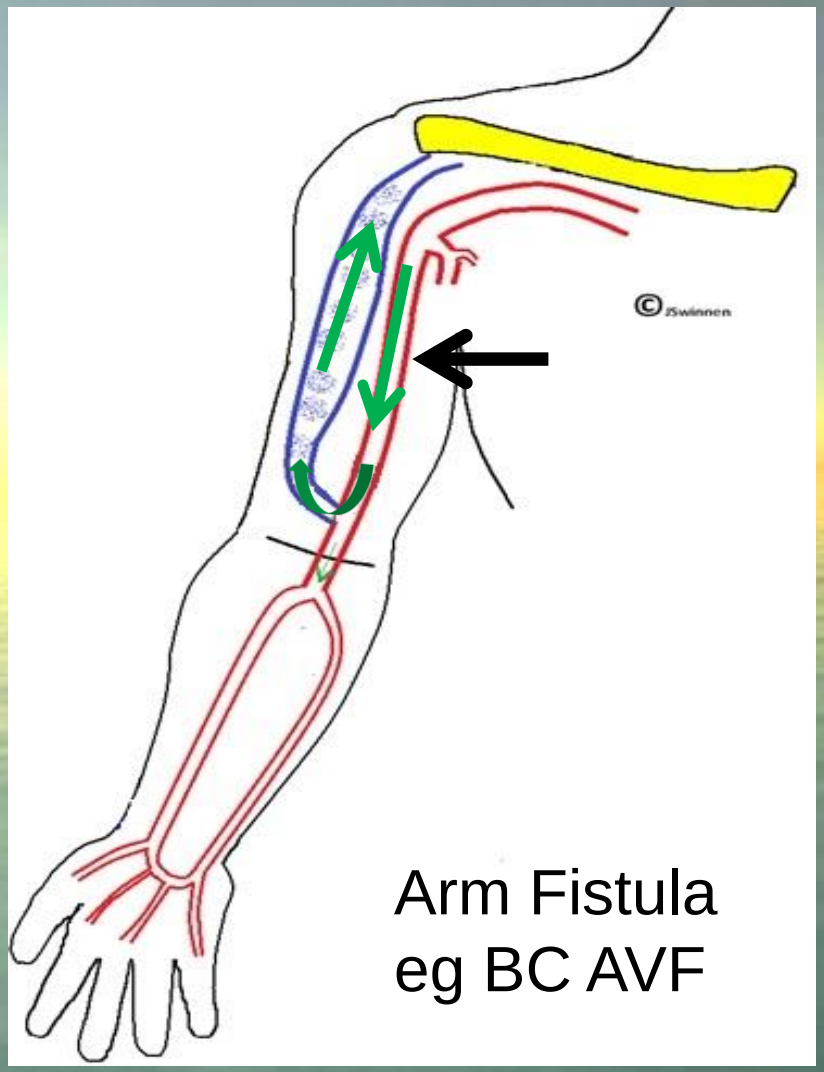
500 mls/min

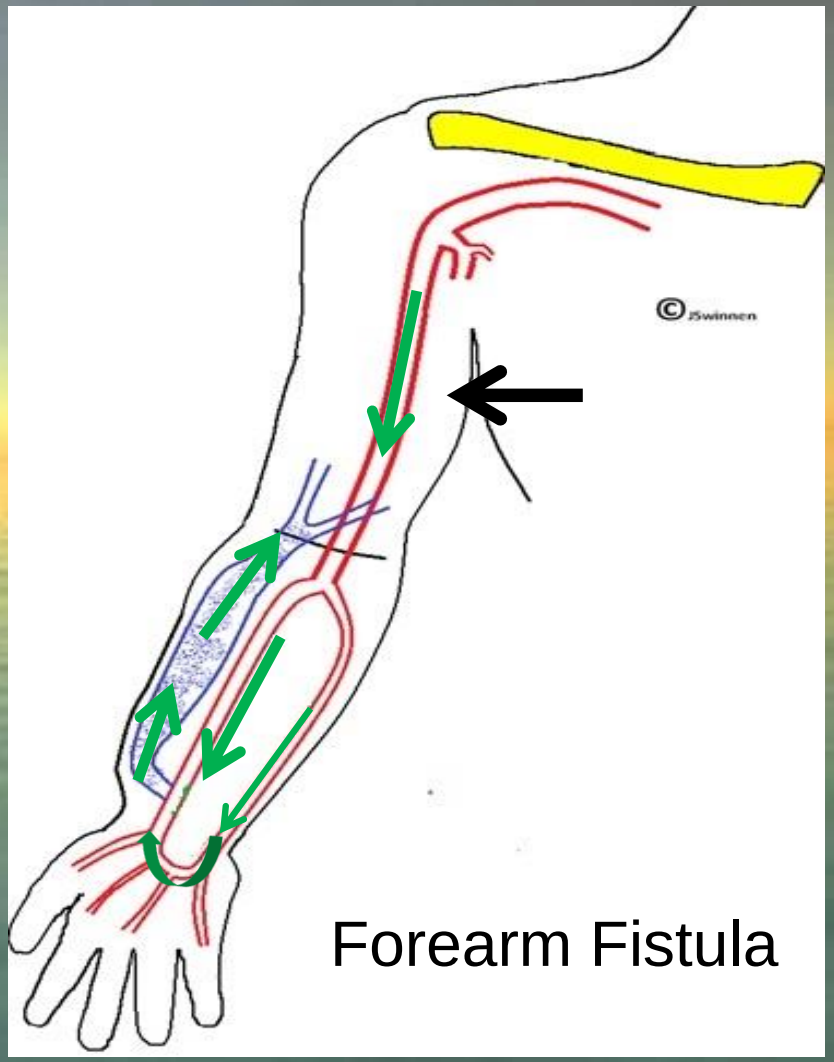
Measured Flow (Qa) Brachial a at 4mm

–

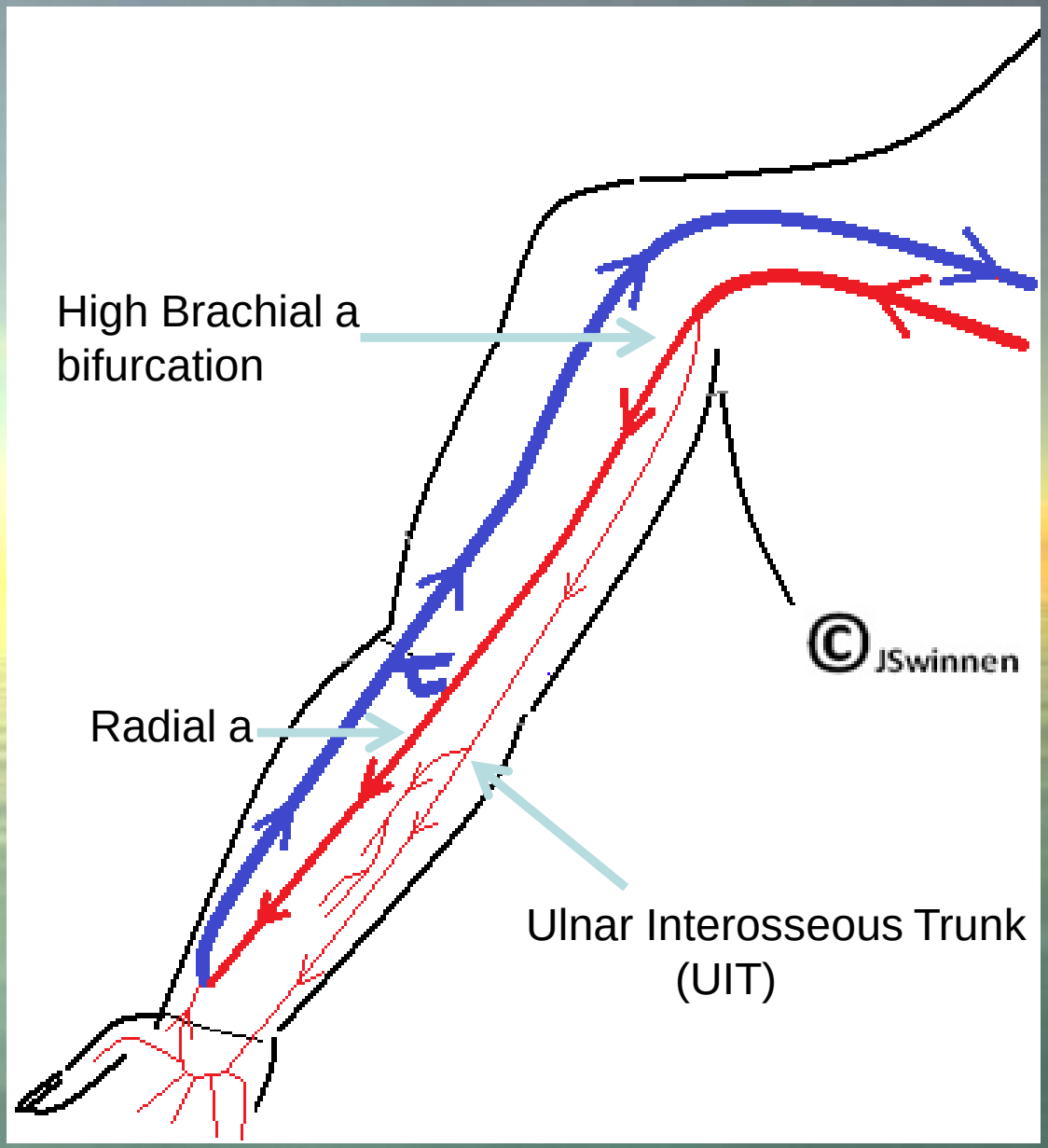
8000 mls/min

Qa is always measured in the **Inflow Brachial Artery**





2 Exceptions !!



High Bifurcation Brachial artery (~10% Patients)

&

Fistulas in the LEG

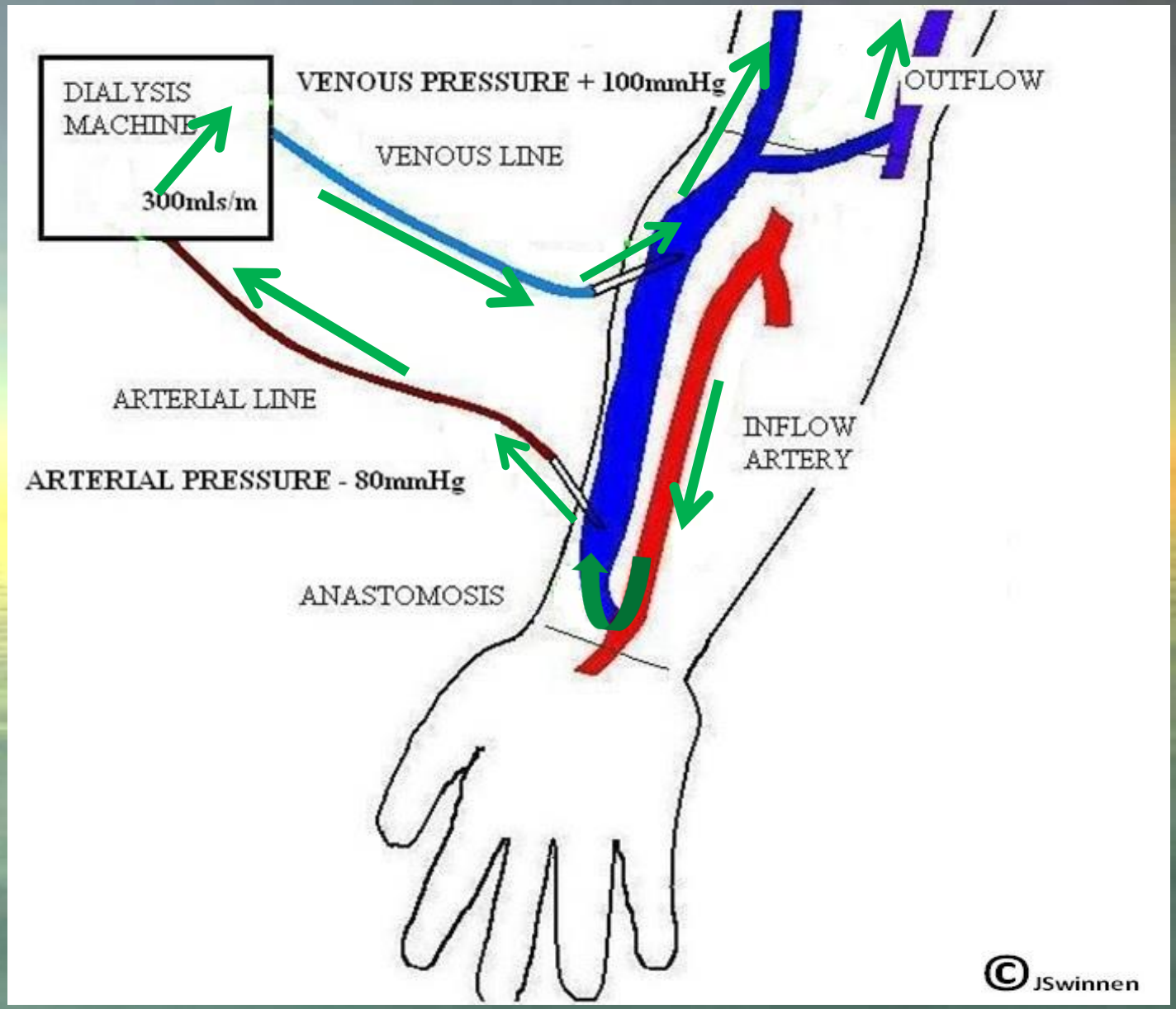
Fistula Flows

Qa	<	500ml/min	- Too Small
Qa	>	2000ml/min	- Too Big
Qa		500 – 2000ml/min	- Just Right!

Qb:

Flow thru the Dialysis Circuit

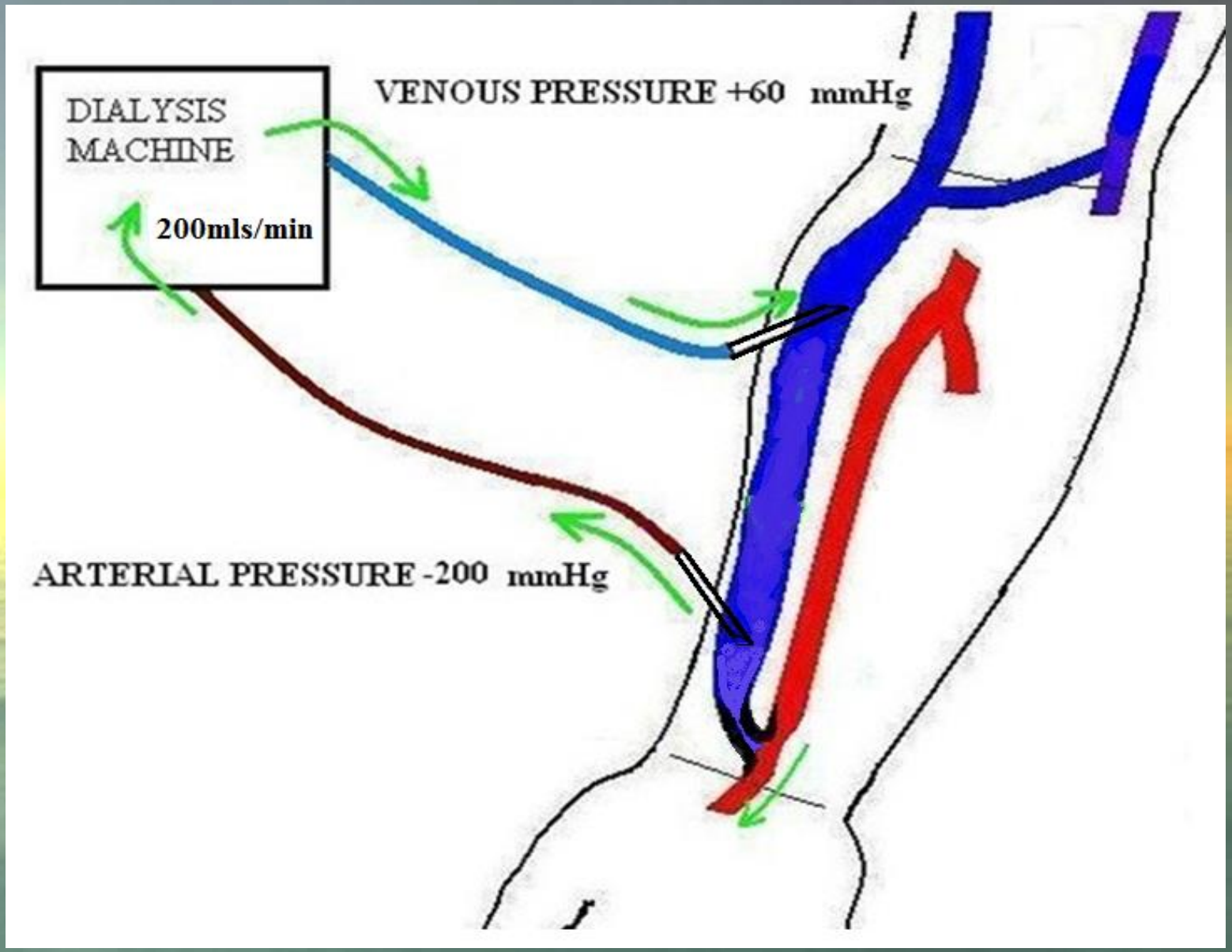
Qb: Flow Thru the **Dialysis Circuit**



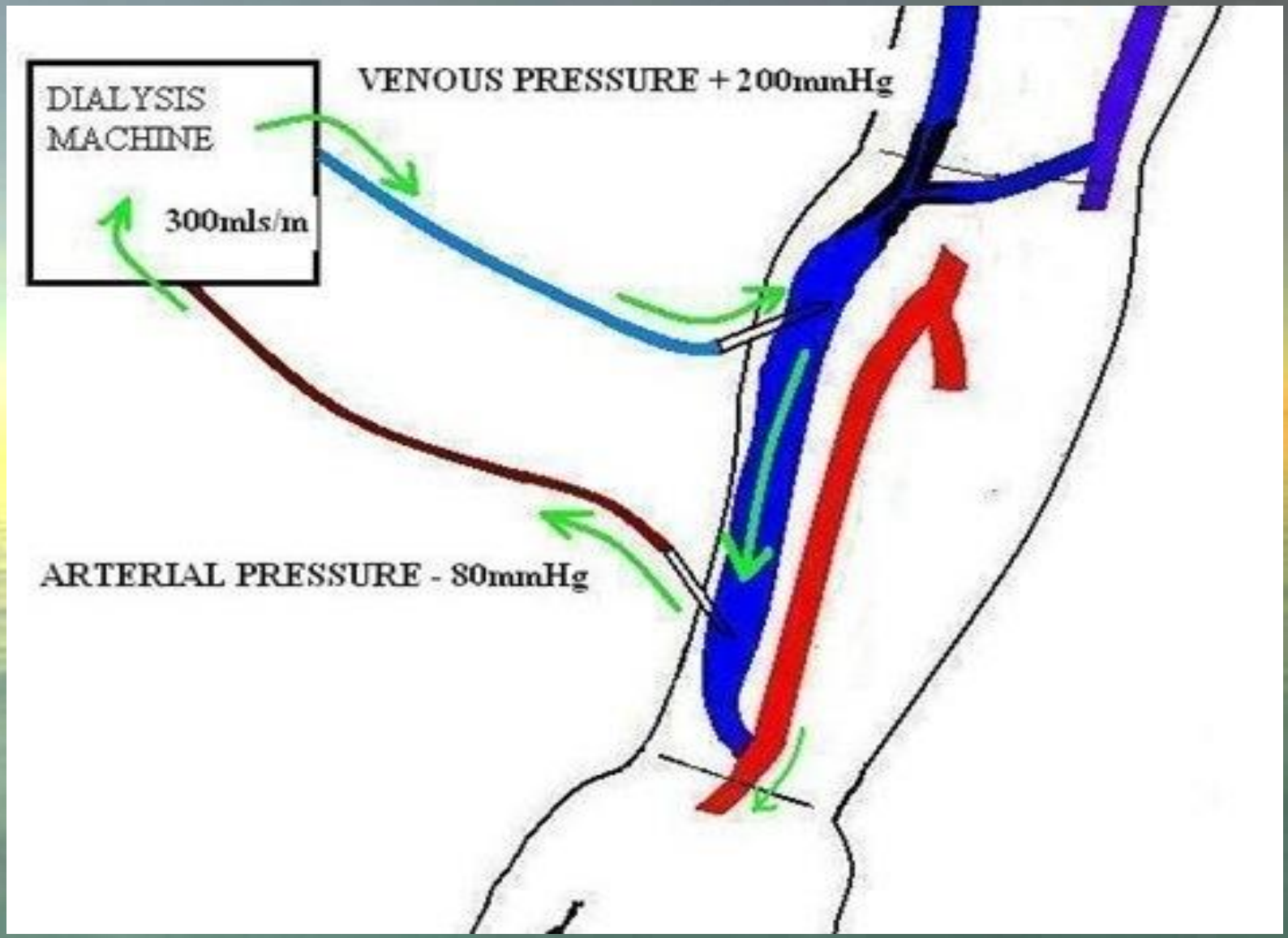
Qb: Flow Thru the **Dialysis Circuit**

- FLOW > 300 ml/min
- ARTERIAL PRESSURES - 100 mm Hg
- VENOUS PRESSURES + 100 mm Hg
- TREND OVER TIME !  OR 

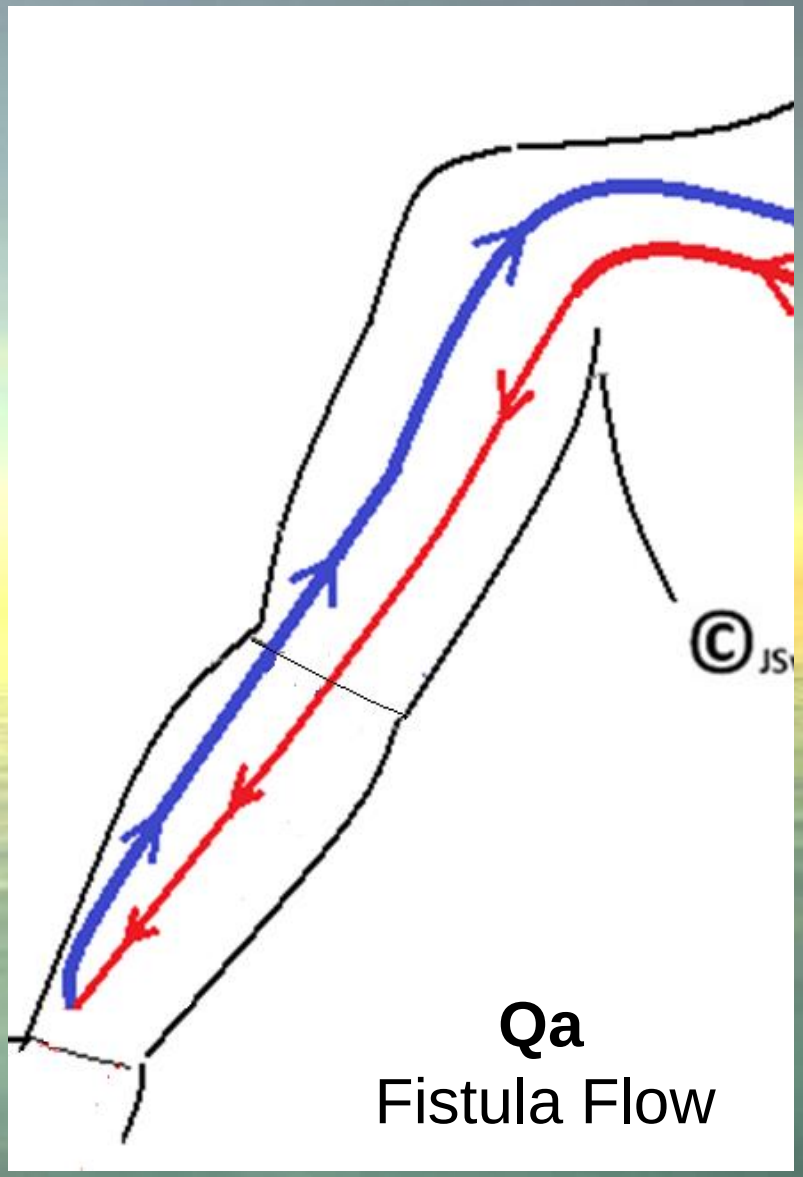
Inflow Stenosis

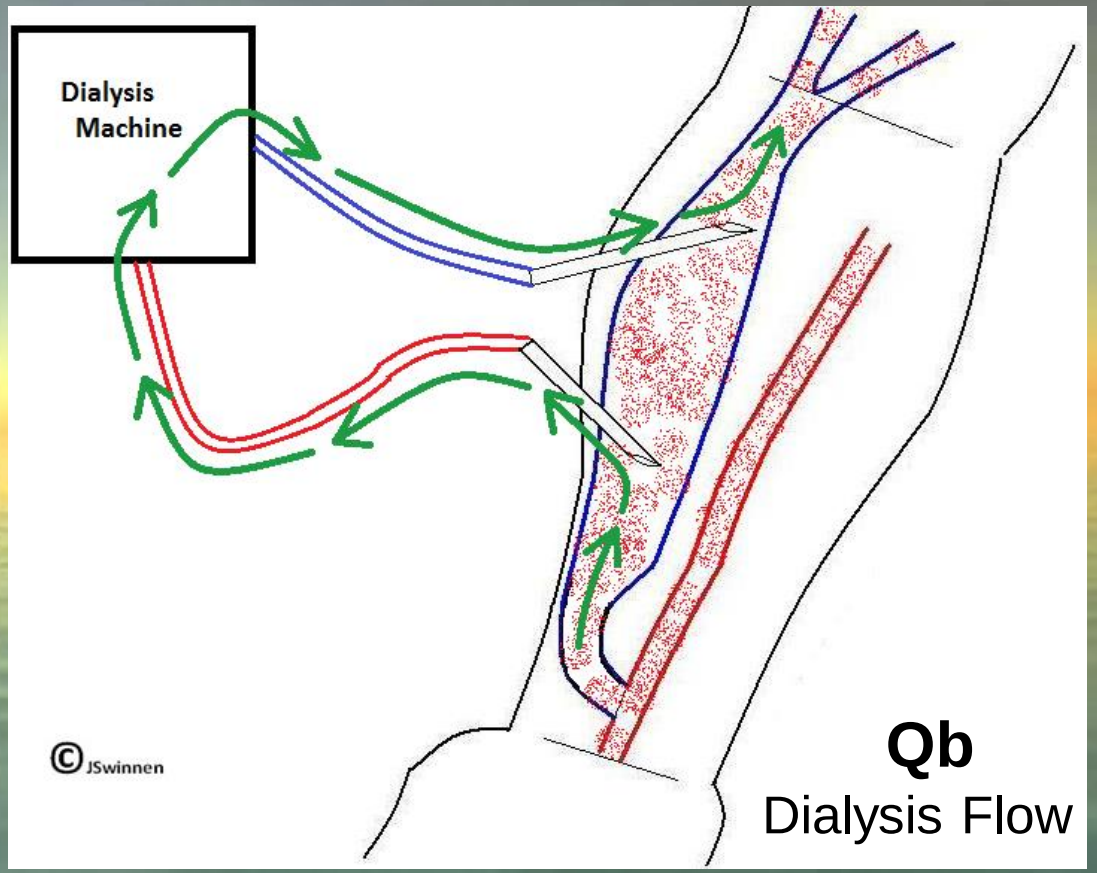


Outflow Stenosis



Fistula Flows: **Qa** and **Qb**





AVF of Interest to 3 Parties

- The DIALYSIS PUMP:
  → Adequate Dialysis / RRT
- The FISTULA LIMB:
  → Adequate Perfusion
- The HEART:
  → Adequate Cardiac Function

AVF Acted on by 2 Forces

- Fistula Stenosis:
  - → Driven by the body's healing response
- Fistula Growth:
  - → Driven by the inflow artery

The Native AVF

- It may be too big !
- It may betoo small !
- It may deprive the hand of adequate perfusion
- It may overburden the heart

Role of the Access Specialist

Ensure that all fistulas are:

- Big enough for adequate hemodialysis
- Not too big and a burden to the heart
- The donor limb is adequately perfused

Thank You
For Your Attention