



Brigham and Women's Hospital

Founding Member, Mass General Brigham

Dialysis Vascular Access – Assessment and Complications

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Medicine Residency @ Montefiore Medical Center
Nephrology Fellowship @BWH-MGH
Interventional Nephrology @St. Louis
Assistant Professor of Medicine@ HMS
Director, Interventional Nephrology

- Clinical focus: Dialysis Access
- Research focus: Dialysis Access Outcomes

DISCLOSURES

- Consultant: Bard, Inari, LaminateMedical, Metronic, Merit Medical, Mozarc, VenoStent, Venofa
- Advisory Board: Nephrodite
- Co-Investigator: Humacyte, WAVE-Trial



OBJECTIVES

Use case vignettes to:

- Connect dialysis access physiology with anatomy and development of dysfunction over time
- Combine tunneled catheter design, positioning, and compartments to understand function, dysfunction, and approach to infection



What is the typical stenosis of this type of access?



Question 1

The typical location of stenosis for this type of access is

- a. the juxta-anastomotic segment
- b. Needle cannulation segment
- c. the cephalic arch
- d. the arterial anastomosis

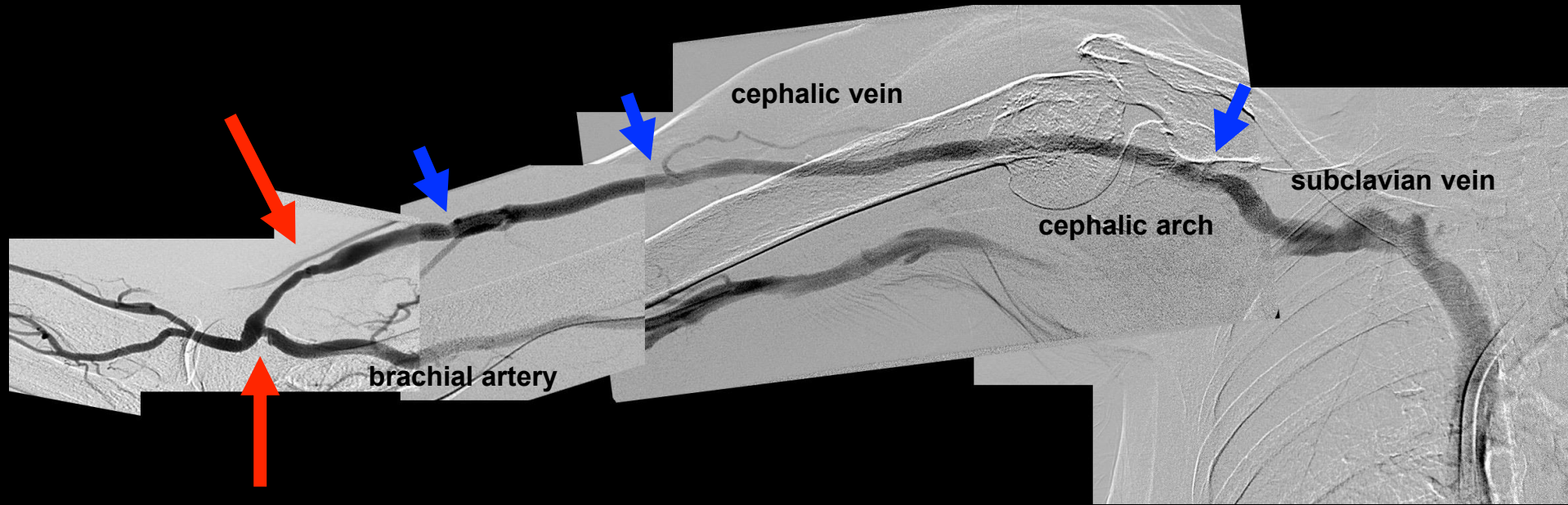


Question 1

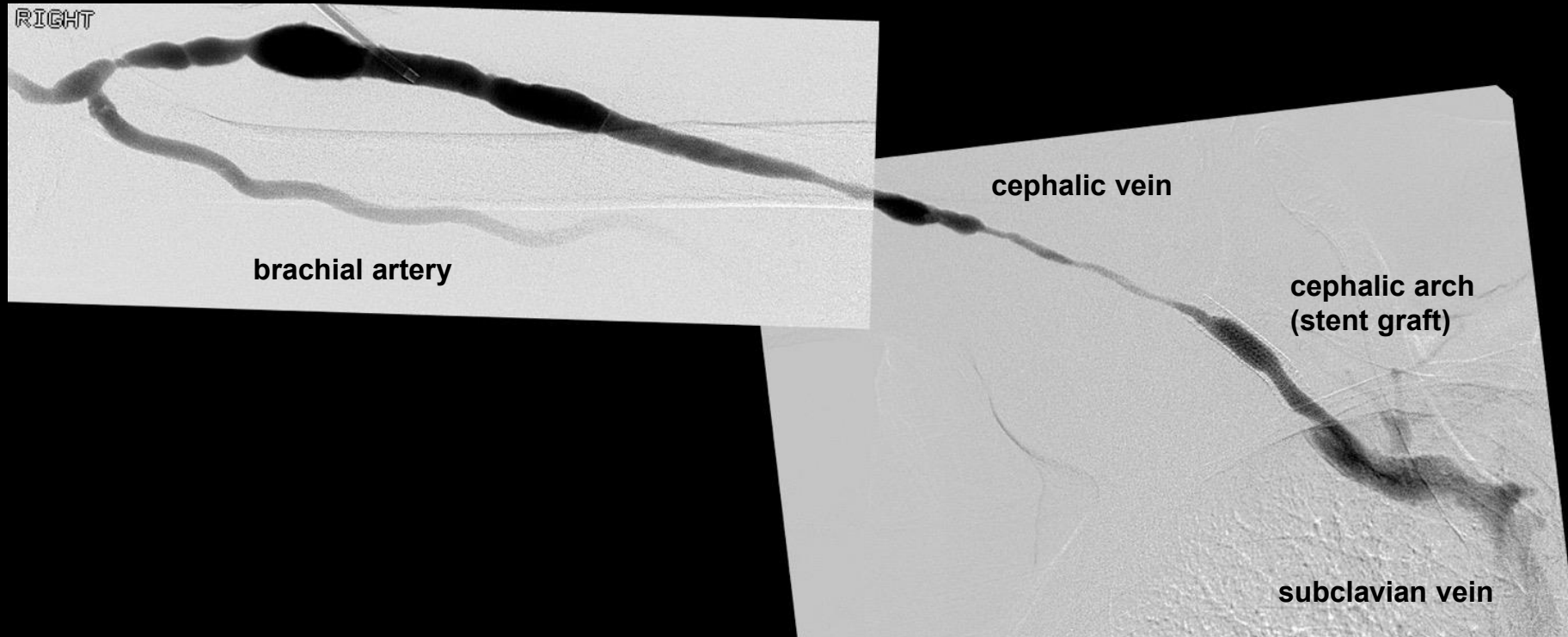
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“Chronic Access Disease”



Driven by symptoms and clinical finding during dialysis: angioplasty of cephalic vein and cephalic arch on 1-13-2009, 2-27-2009, 4-17-2009, 6-3-2009; stent graft in cephalic arch on 8-12-2009, and thrombectomy 12-1-2009

Angioplasty on 2-12-2010, 3-12-2010, 7-30-2010, 10-4-2010, 1-14-2011, and 3-11-2011. Cephalic vein stent graft on 6-22-2011.



Question 2

What is the most common site of stenosis in each of the typical types of upper extremity accesses?

- 1 - Radial-cephalic
- 2 - Brachial-cephalic
- 3 - transposed brachial-basilic
- 4 - prosthetic graft

- A - cephalic arch
- B - venous anastomosis
- C - swing point
- D - juxta-anastomotic segment

- a. 1C, 2B, 3A, 4D
- b. 1C, 2A, 3D, 4B
- c. 1D, 2A, 3C, 4B
- d. 1A, 2D, 3C, 4B
- e. 1D, 2A, 3B, 4C



Question 2

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a. 1C, 2B, 3A, 4D

b. 1C, 2A, 3D, 4B

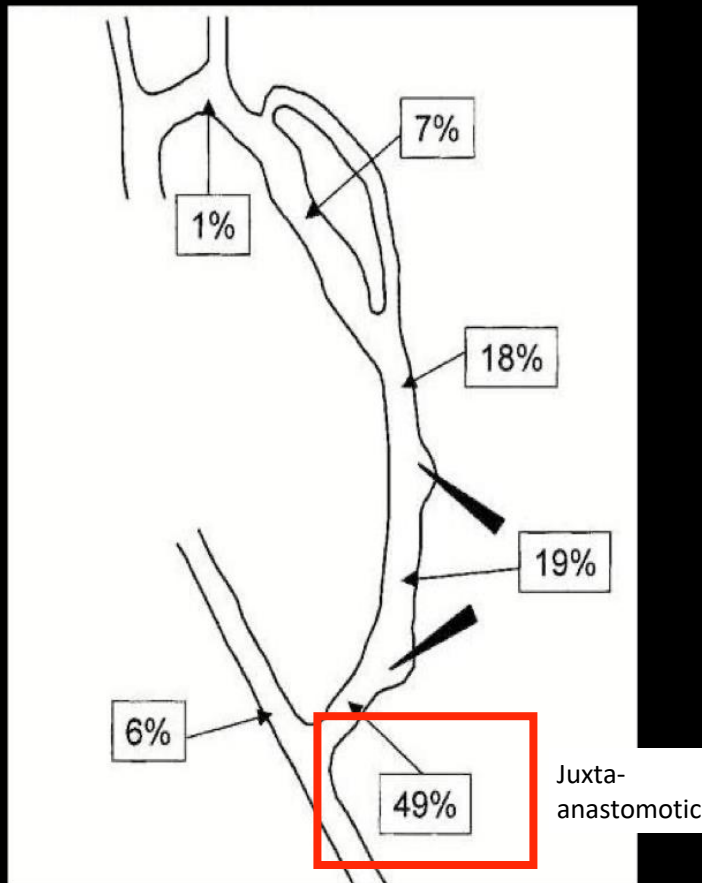
c. 1D, 2A, 3C, 4B

d. 1A, 2D, 3C, 4B

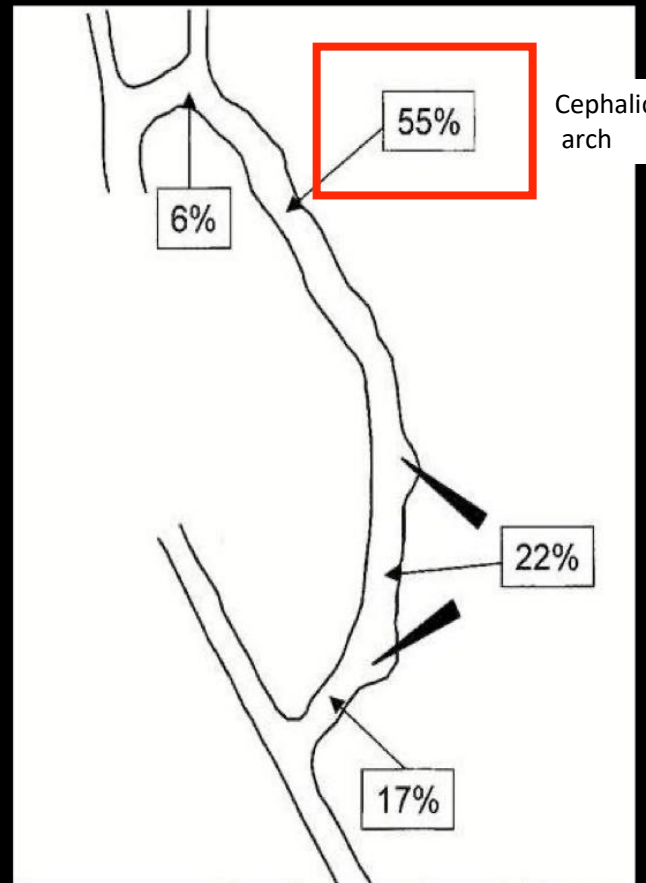
e. 1D, 2A, 3B, 4C



Location of Stenoses in Autogenous Accesses



radial-cephalic



brachial-cephalic

Rx – Cephalic Arch

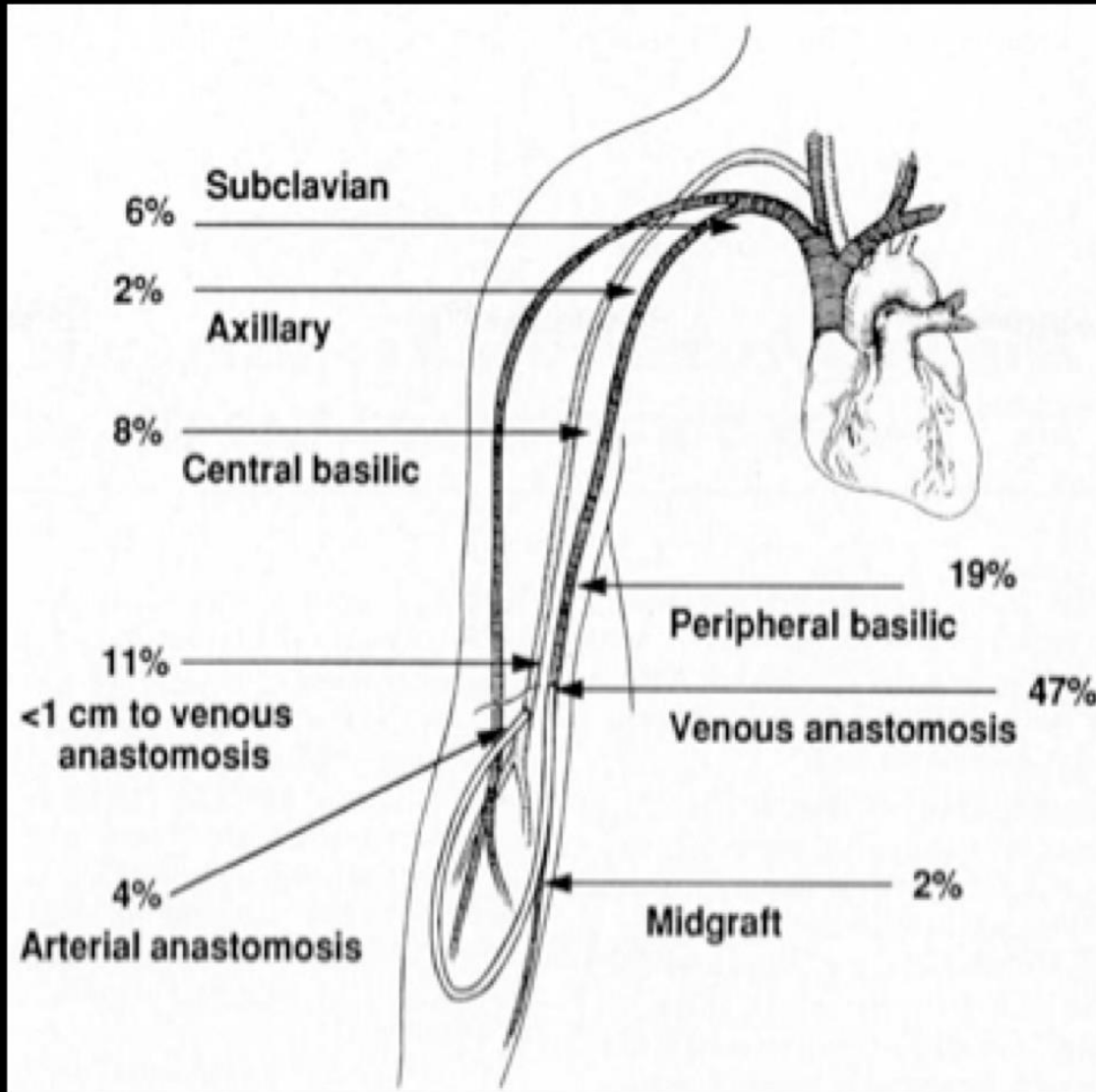
- Stent grafts superior to angioplasty

Rx – Juxta-anastomotic

- External Support Devices (Nitinol and absorbable)

Use of drug-coated balloons still unclear

Location of Stenoses in Grafts



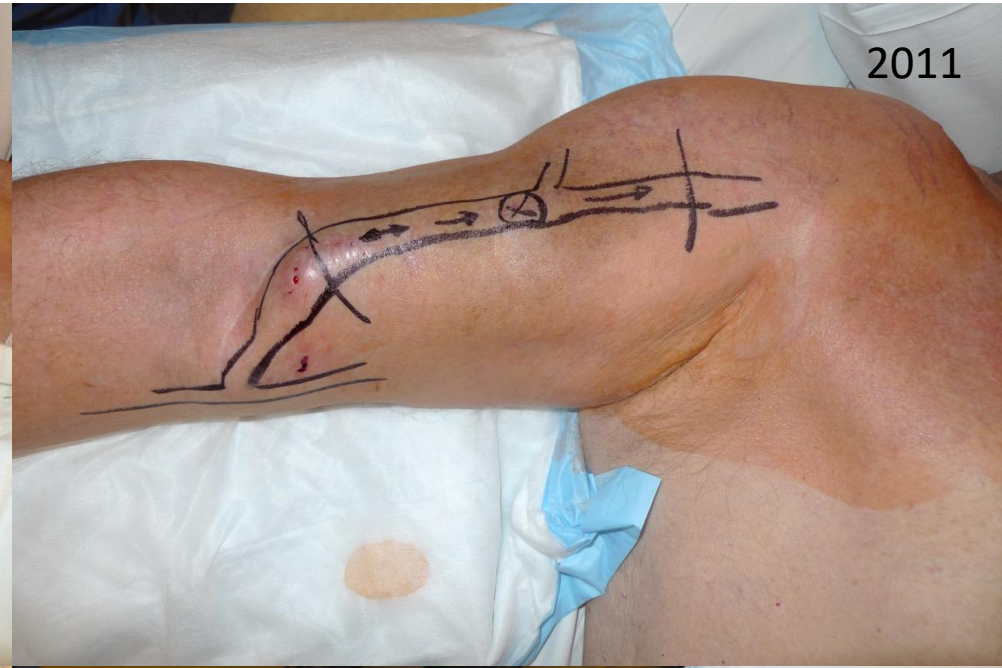
Rx – venous anastomosis
- Stent grafts are superior (2RTCs)

“Chronic Access Disease”

- pre-programmed sites of stenosis:
 - ★ venous anastomotic stenosis (grafts) - AVG
 - ★ cephalic arch - BC or pRC upper arm AVF
 - ★ basilic swing point - tBB AVF
 - ★ sites of side-branch ligations - cephalic vein accesses
 - ★ juxta-anastomotic segment - RC AVF
- increase in flow and shear-stress increases arterial diameter...
- exposure to thrombus induces chronic scarring...
- stenoses recur after angioplasty...
- stent grafts are associated with turbulent flow at edges leading to deposition of “debris”...
- repeated needle insertions lead to enlargement of overlying skin coverage...



Why do HD accesses transform like this?



Question 3

What are the dominant drivers in aneurysm formation in dialysis accesses?

- 1 - Outflow stenosis
- 2 - Focal Needle insertions
- 3 - High inflow
- 4 - Gender and Genetics
- 5 - Race and Age

- a. 1, 3, 5
- b. 2, 3, 4, 5
- c. 1, 2, 3
- d. 1, 2, 3, 4, 5
- e. 4, 5



Question 3

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- 4 - Gender and Genetics
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b. 2, 3, 4, 5

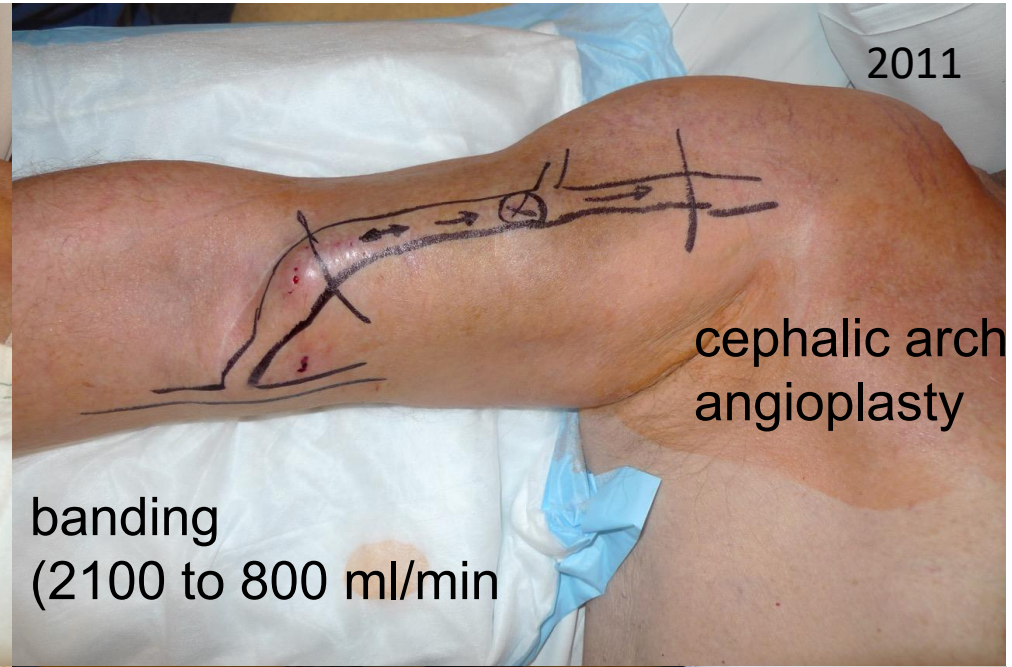
c. 1, 2, 3

d. 1, 2, 3, 4, 5

e. 4, 5

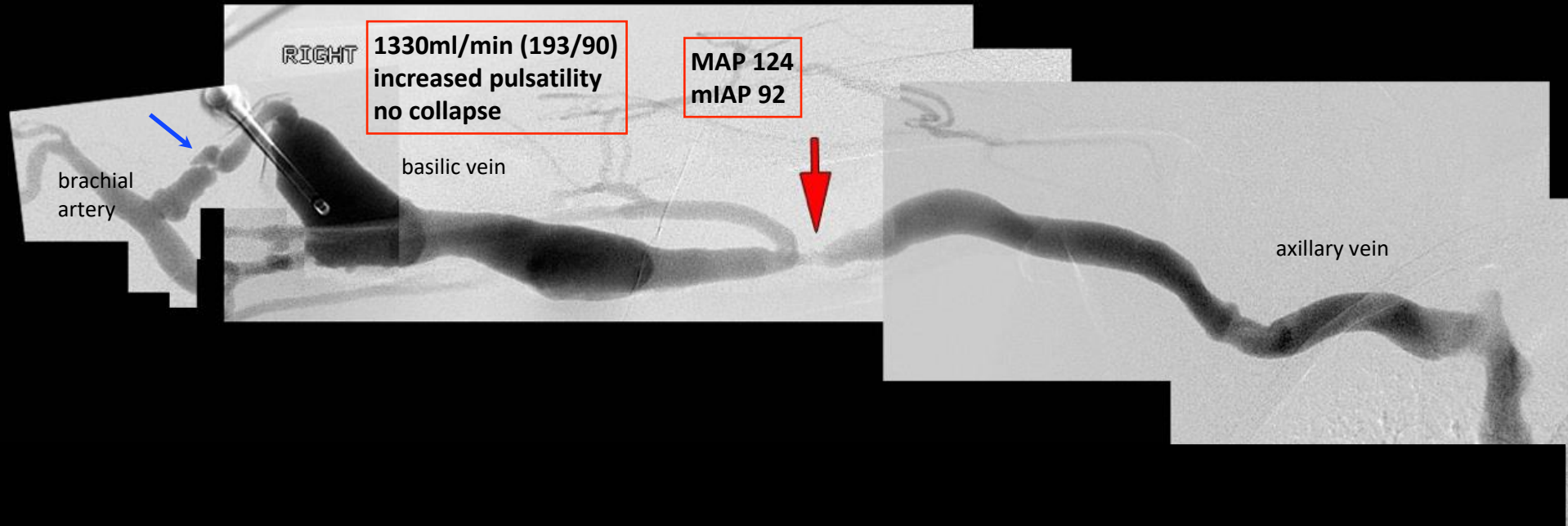


Intra-Access Pressures and Needle Insertion Site Aneurysm





Outflow stenosis: pressure change dominates flow



Inflow Stenosis - Flow change dominates pressure

Juxta-anastomotic stenosis



Right upper arm brachial-cephalic autogenous access

	pre	post
flow	310	775
MAP	65	62
IAP	20	25



77-year-old Caucasian Women

- BC-AVF created in 2007
- initiates dialysis in early 2014
- presents shortly thereafter with
 - ✓ shortness of breath
 - ✓ bleeding after needle removal
 - ✓ L hand numb, occ. painful

Question 4

What clinical condition best fits the presentation ?

- 1 - Shortness of breath
 - 2 - Hand numbness and pain
 - 3 - Bleeding after needle removal
 - 4 - Initiation of dialysis 7 years after creation of AVF
-
- a. CKD-related coronary heart disease
 - b. Advanced uremia (cardio-renal Syndrome)
 - c. Beta-2-microglobulin deposition disease
 - d. High flow dialysis access



Question 4

What clinical condition best fits the presentation ?

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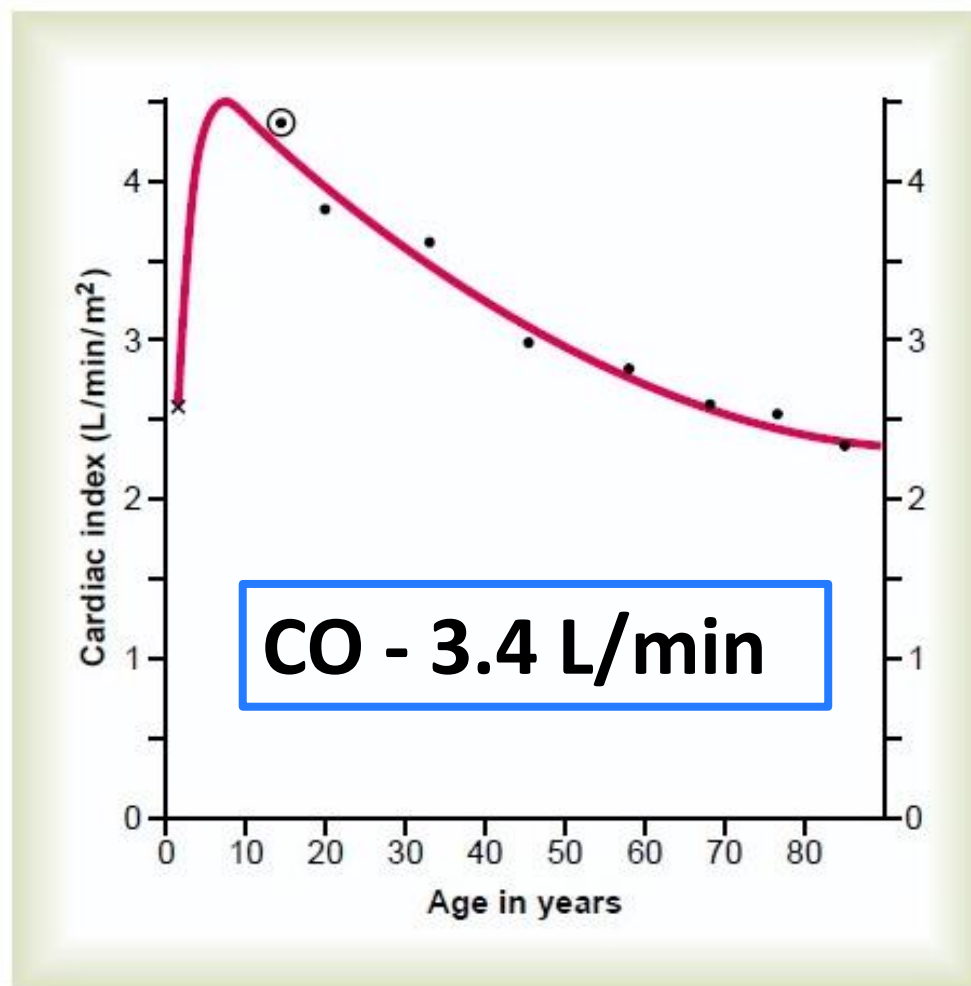


Figure 20-1

Cardiac index for the human being (cardiac output per square meter of surface area) at different ages. (Redrawn from Guyton AC, Jones CE, Coleman TB: Circulatory Physiology: Cardiac Output and Its Regulation. 2nd ed. Philadelphia: WB Saunders Co, 1973.)

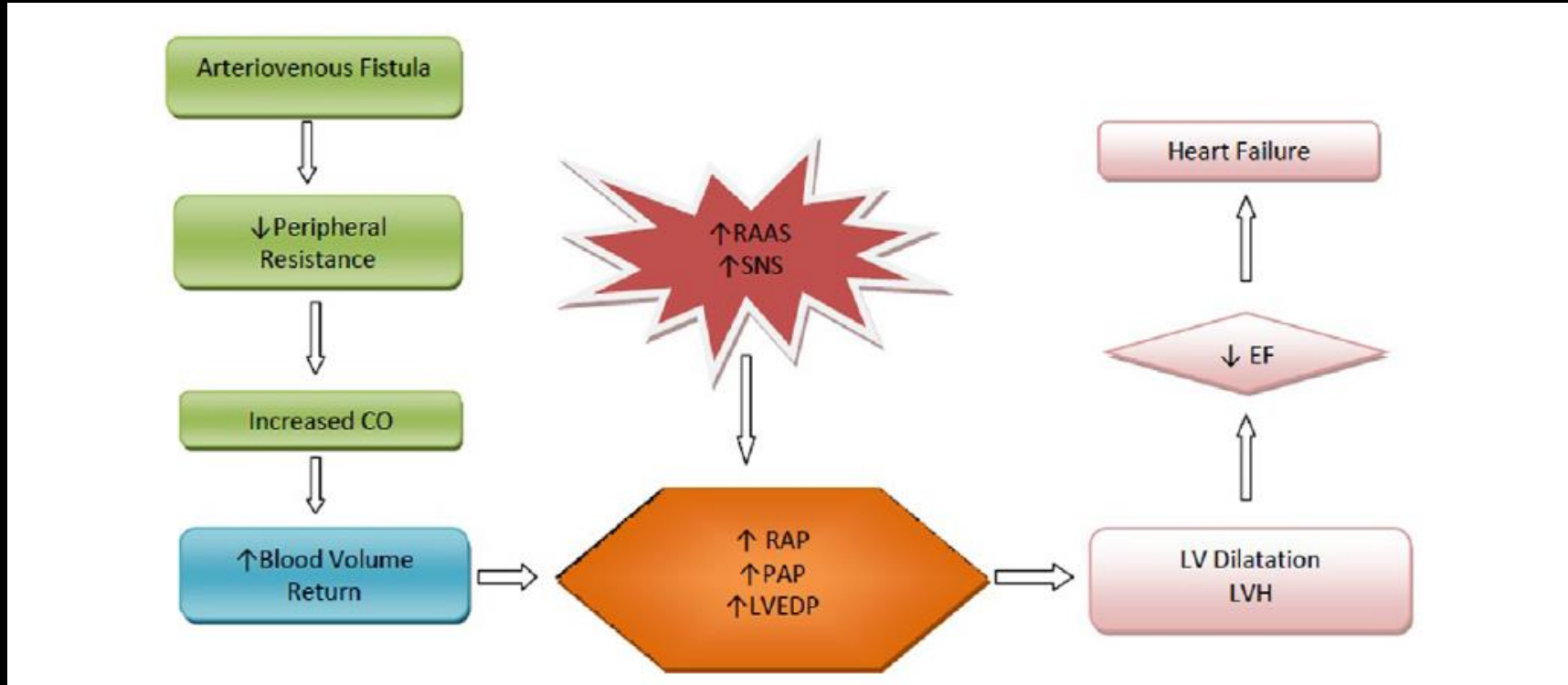
77-year-old Caucasian Women

- BC-AVF created in 2007
- initiates dialysis in early 2014
- presents shortly thereafter with
 - ✓ shortness of breath
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 - ✓ L hand numb, occ. painful

Access flow 2,400 ml/min

Dose of Dialysis Access

High output cardiac failure

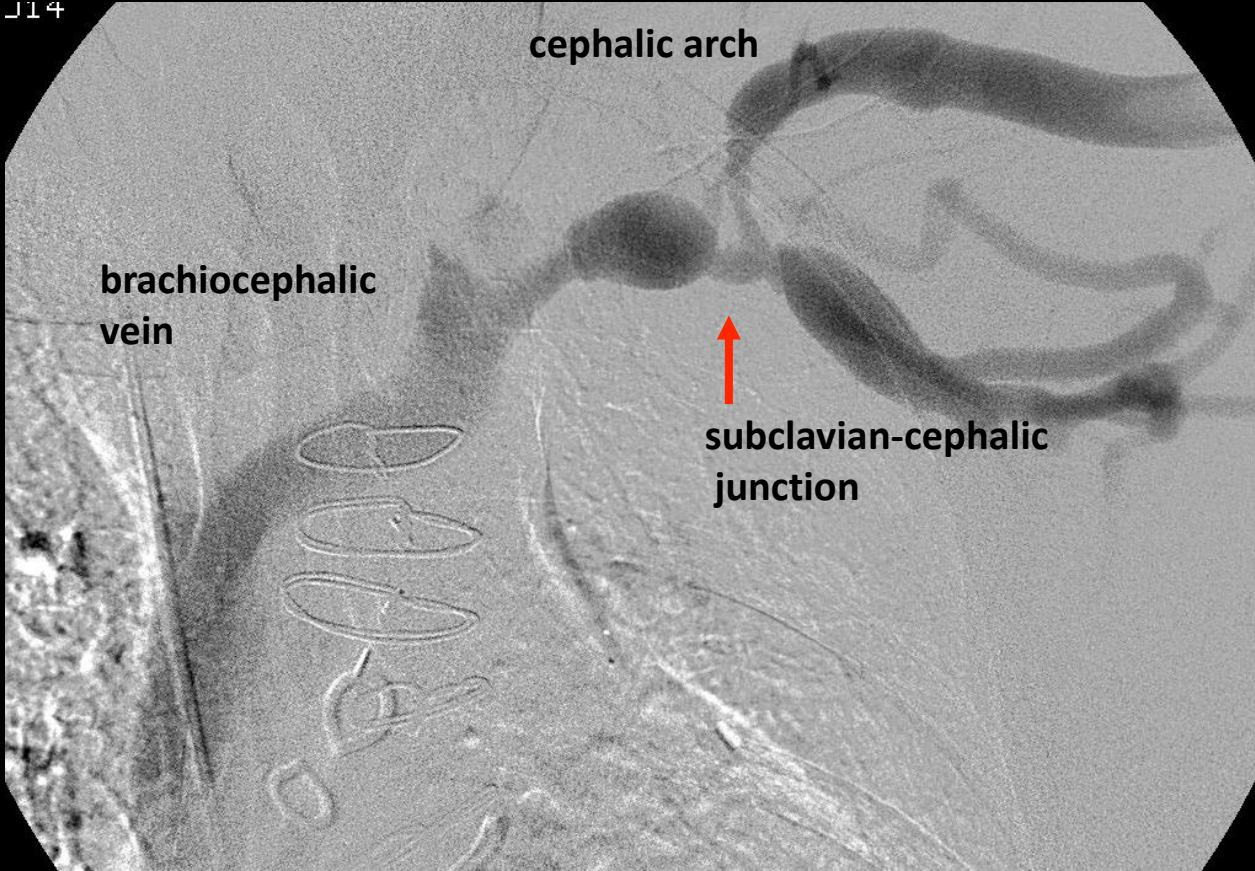


pulmonary artery pressures
right atrial pressures
left ventricular end-diastolic pressures

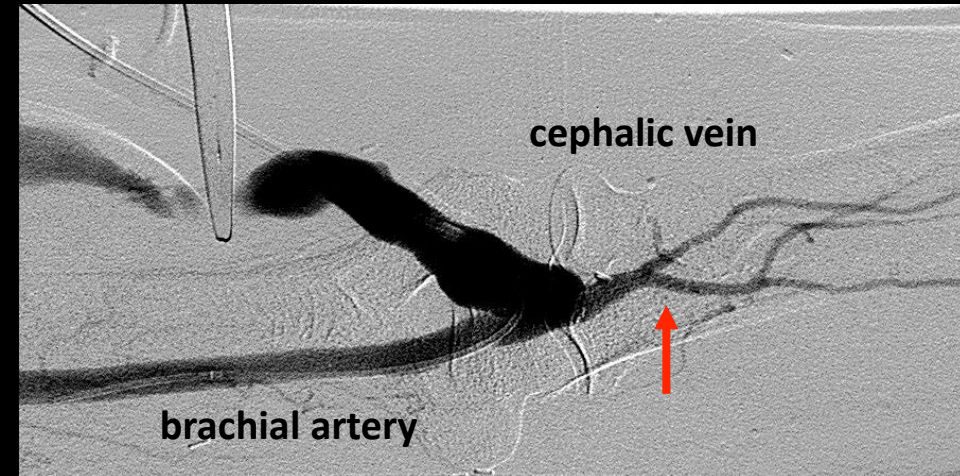
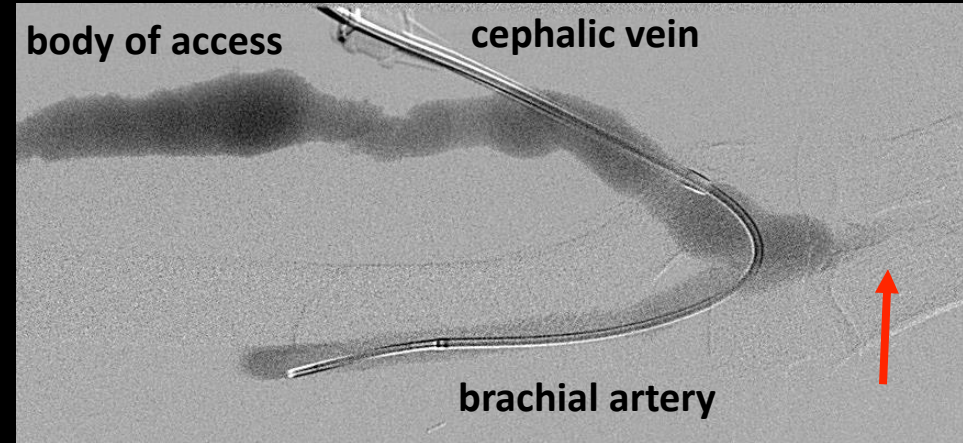


Inflow-Outflow Balance

J14



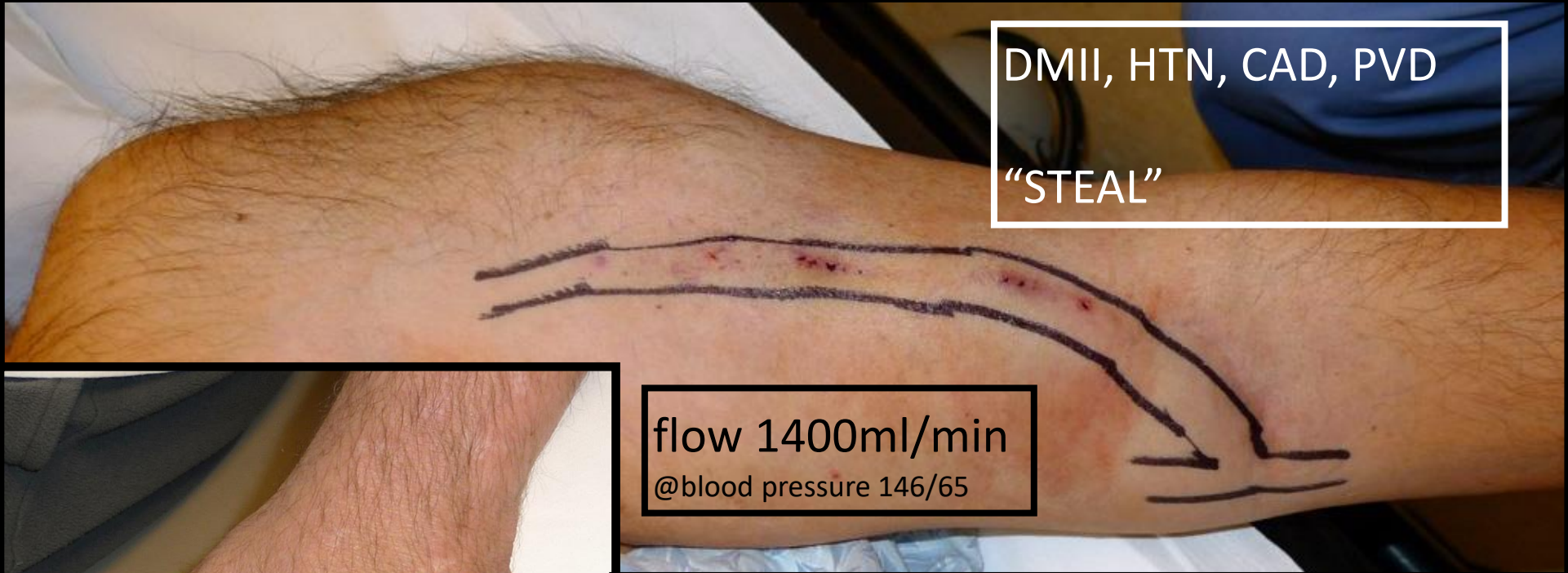
Treatment with angioplasty and
stent graft placement



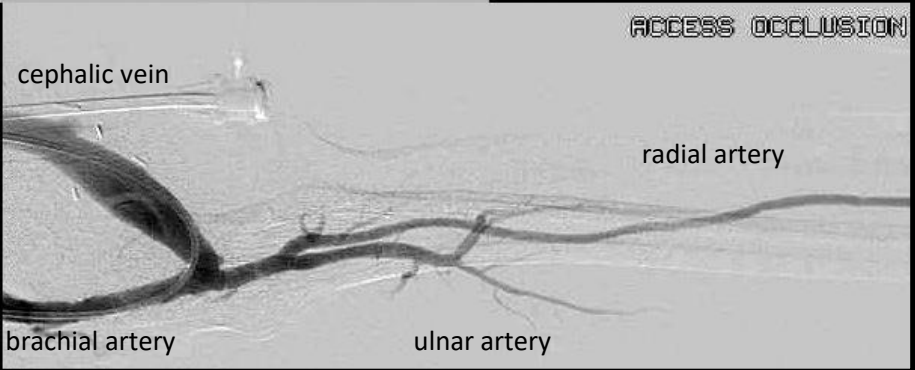
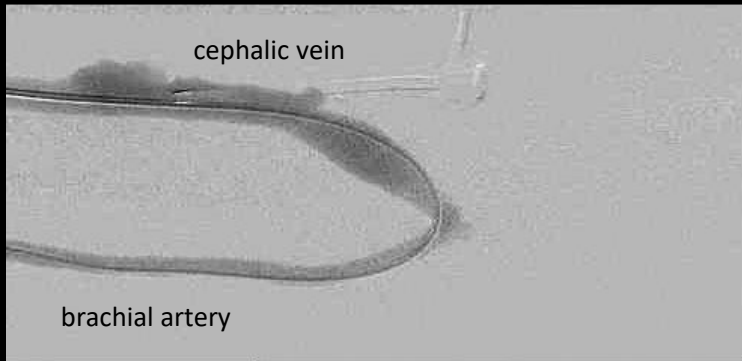
Treatment with inflow banding



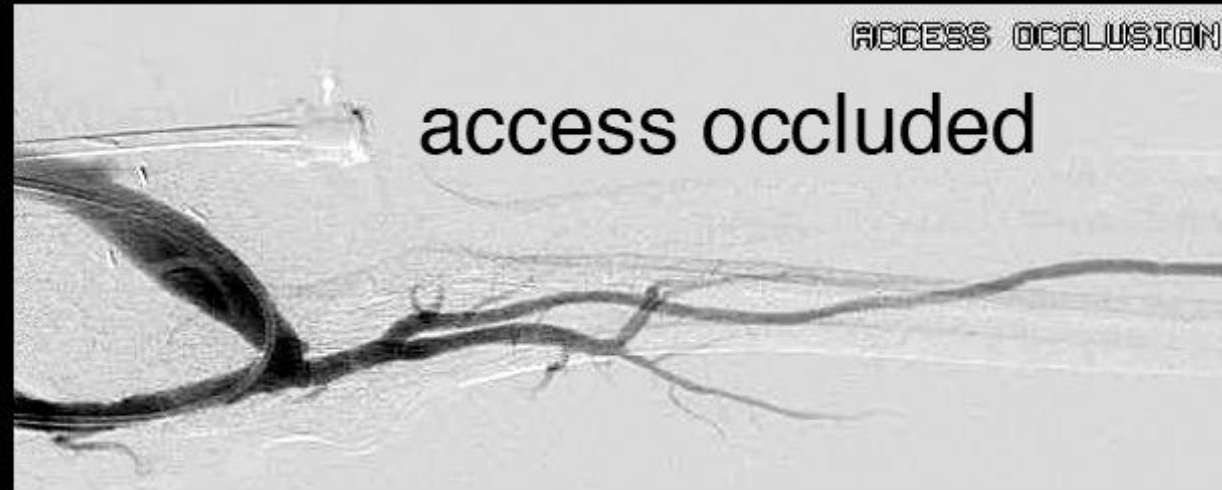
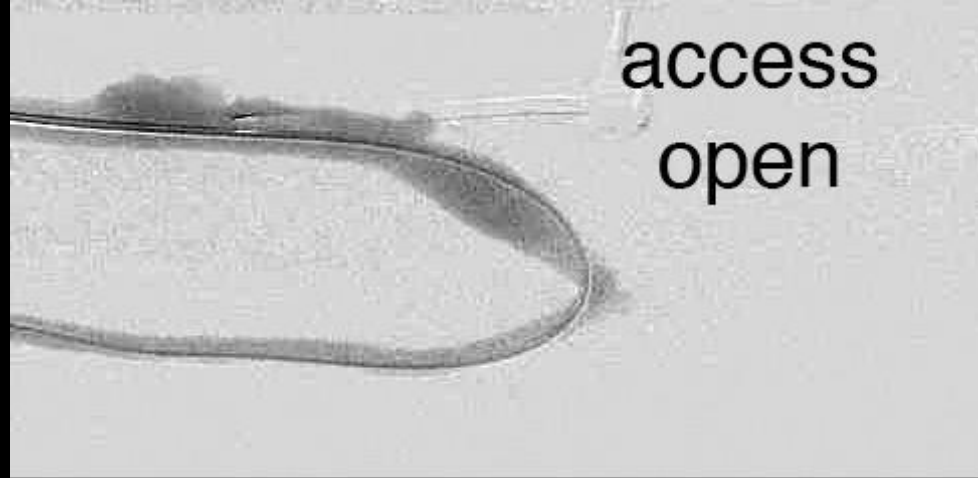
DMII, HTN, CAD, PVD
"STEAL"



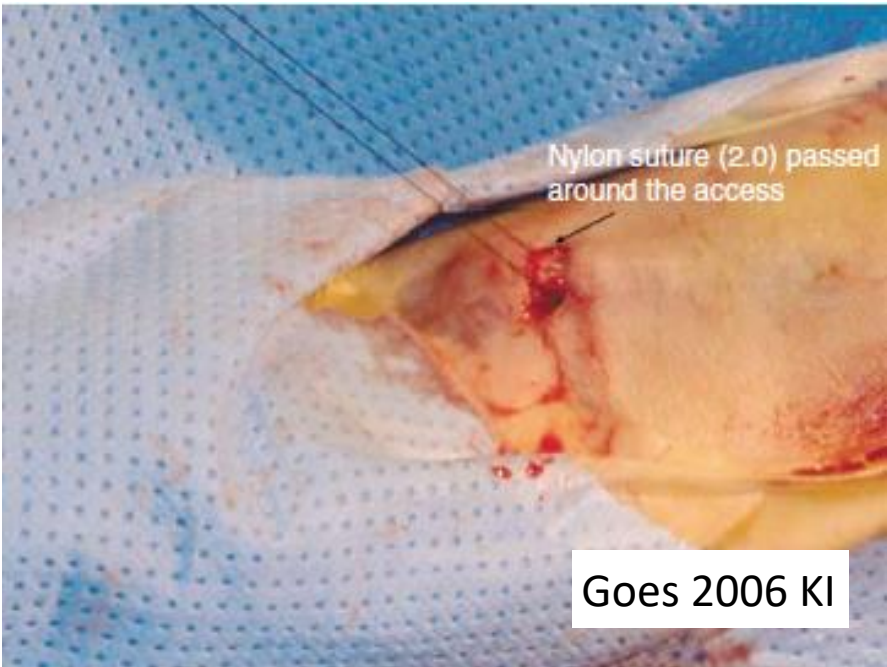
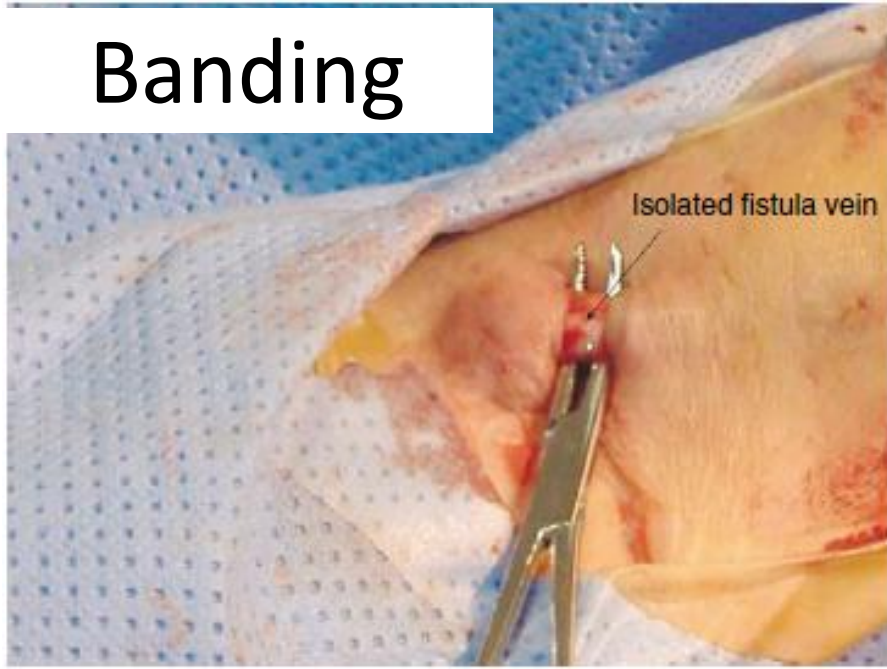
flow 1400ml/min
@blood pressure 146/65



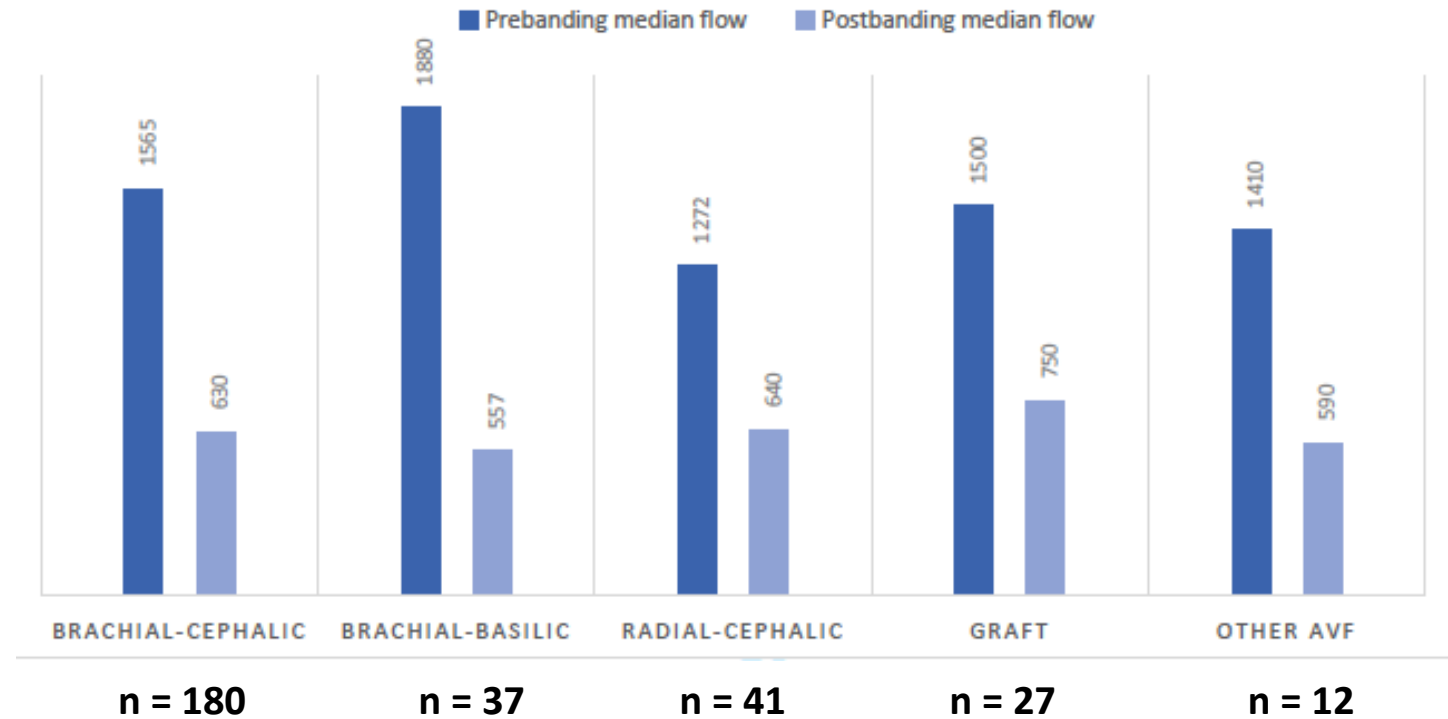
Case 2



Banding



Banding is effective for inflow control
(Soo Hoo, Scully J Vasc Access 2022)



- 297 patients, 398 banding procedures
- Indication: **Flow Imbalance 222 (51%)**, Ischemic Steal 134 (34%), Overt Heart Failure 42 (11%)
- 30-thrombosis rate 3.8%, re-banding @ 1 year 14% (median 134 days)

L BC-AVF 2008 with 2nd
interposition biograft in 2017



L BC-AVF in 1995 with
continuous self-cannulation



How does the physical exam likely differ?

Left

Right



Question 5

What do you expect for the physical exam?

1 - pulsatility	increased, normal, decreased
2 - thrill	location; continuous, discontinuous
3 - flow murmur	pitch; continuous, discontinuous
4 - augmentation	absent, weak, moderate, strong
5 - collapse against gravity	none, partial, complete

- a. Left – Pulsatility increased, outflow thrill
- b. Left – Pulsatility increased, complete collapse
- c. Right – Increased pulsatility, juxta-anastomotic thrill
- d. Right – Increase pulsatility, no collapse



Question 5

What do you expect for the physical exam?

1 - pulsatility	increased, normal, decreased
2 - thrill	location; continuous, discontinuous
3 - flow murmur	pitch; continuous, discontinuous
4 - augmentation	absent, weak, moderate, strong
5 - collapse against gravity	none, partial, complete

a. Left – Pulsatility increased, outflow thrill

b. Left – Pulsatility increased, complete collapse

c. Right – Increased pulsatility, juxta-anastomotic thrill

d. Right – Increase pulsatility, no collapse



Pulsatility (increased)



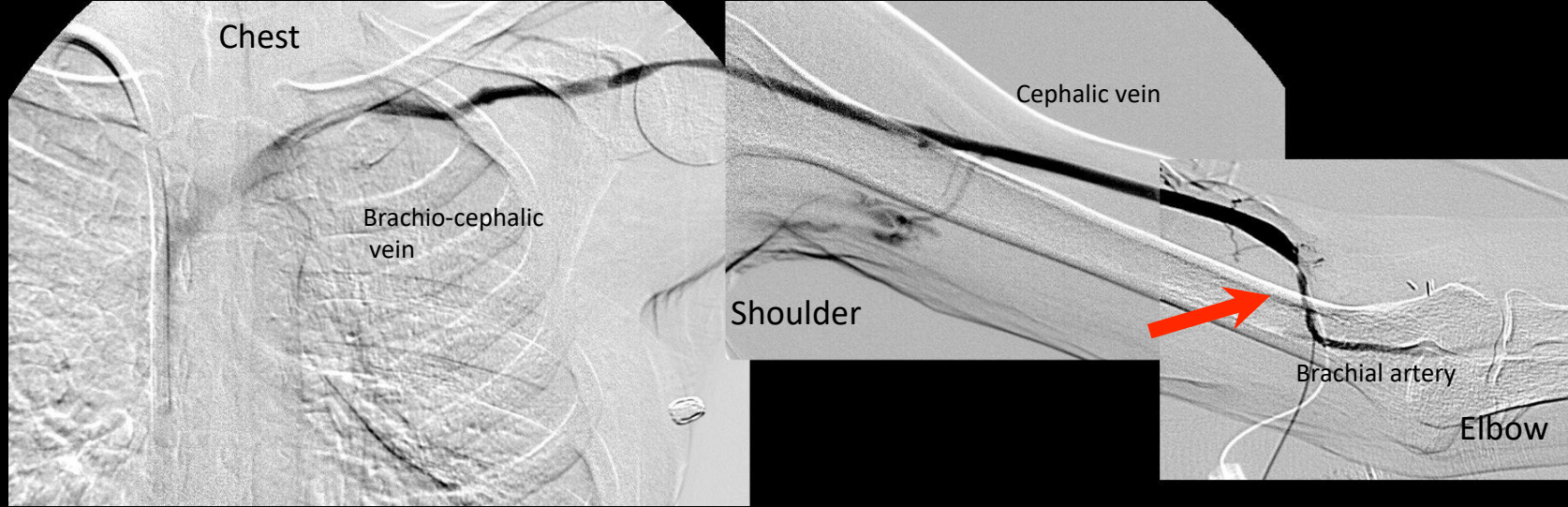
Non-maturing left upper arm autogenous brachial-cephalic access



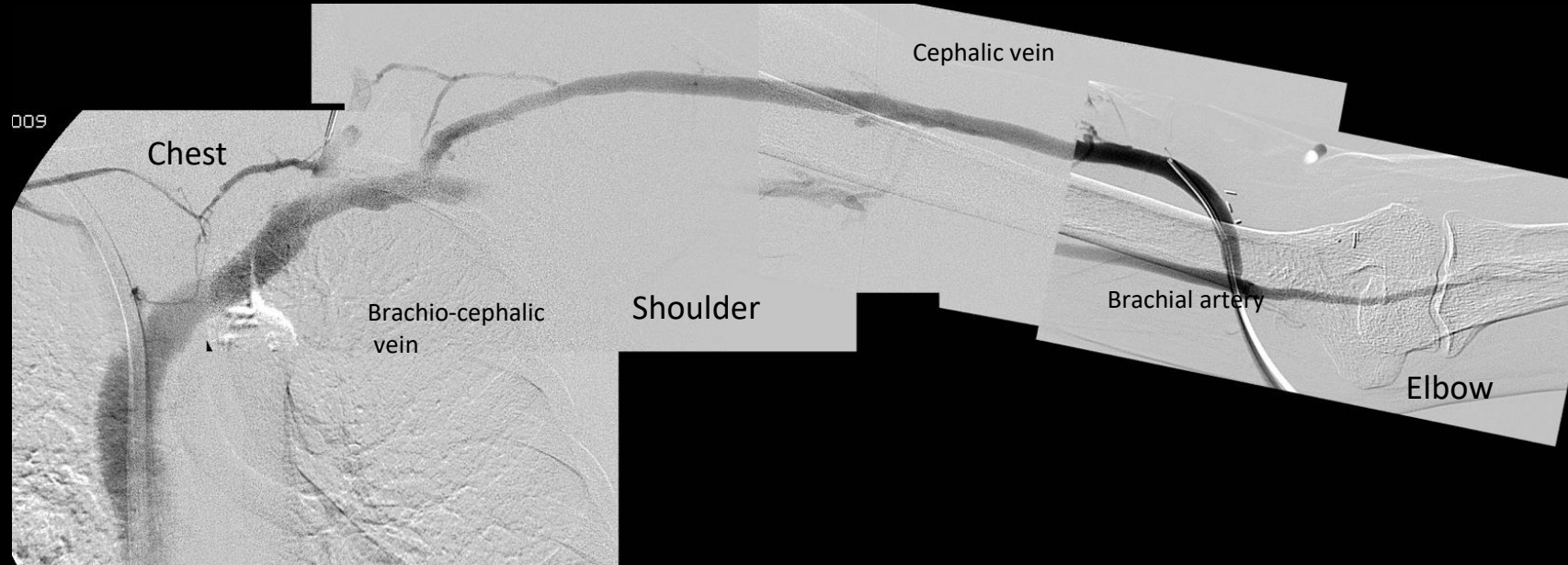
juxta-anastomotic stenosis

1. Increased pulsatility at anastomosis
2. Thrill just after anastomosis
3. Diminished augmentation
4. Discontinuous flow murmur in juxta-anastomotic segment

Left upper arm autogenous brachial-cephalic access 7/27/09
9/25/09 - flow <400ml/min



10/8/09 - flow 1100ml/min



Insufficient Augmentation



Successful Augmentation



Segmental Sidebranch Ligation - Functional Stick Zone

Right forearm radial-cephalic access 11-26-2012
flows 400 ml/min (61/40)
February 2013



February 2013



Segmental Sidebranch Ligation - Functional Stick Zone

March 2013



April 2013



63-year-old ESRD patient with
left forearm autogenous radial-
cephalic access created 15 years
ago



Arm Elevation



increase pulsatility
thrill @ outflow stenosis
discontinuous flow murmur
moderate-strong augmentation
no collapse (AVG segment)



Left

normal pulsatility
thrill @ juxta-anastomosis
continuous flow murmur
moderate augmentation
complete collapse

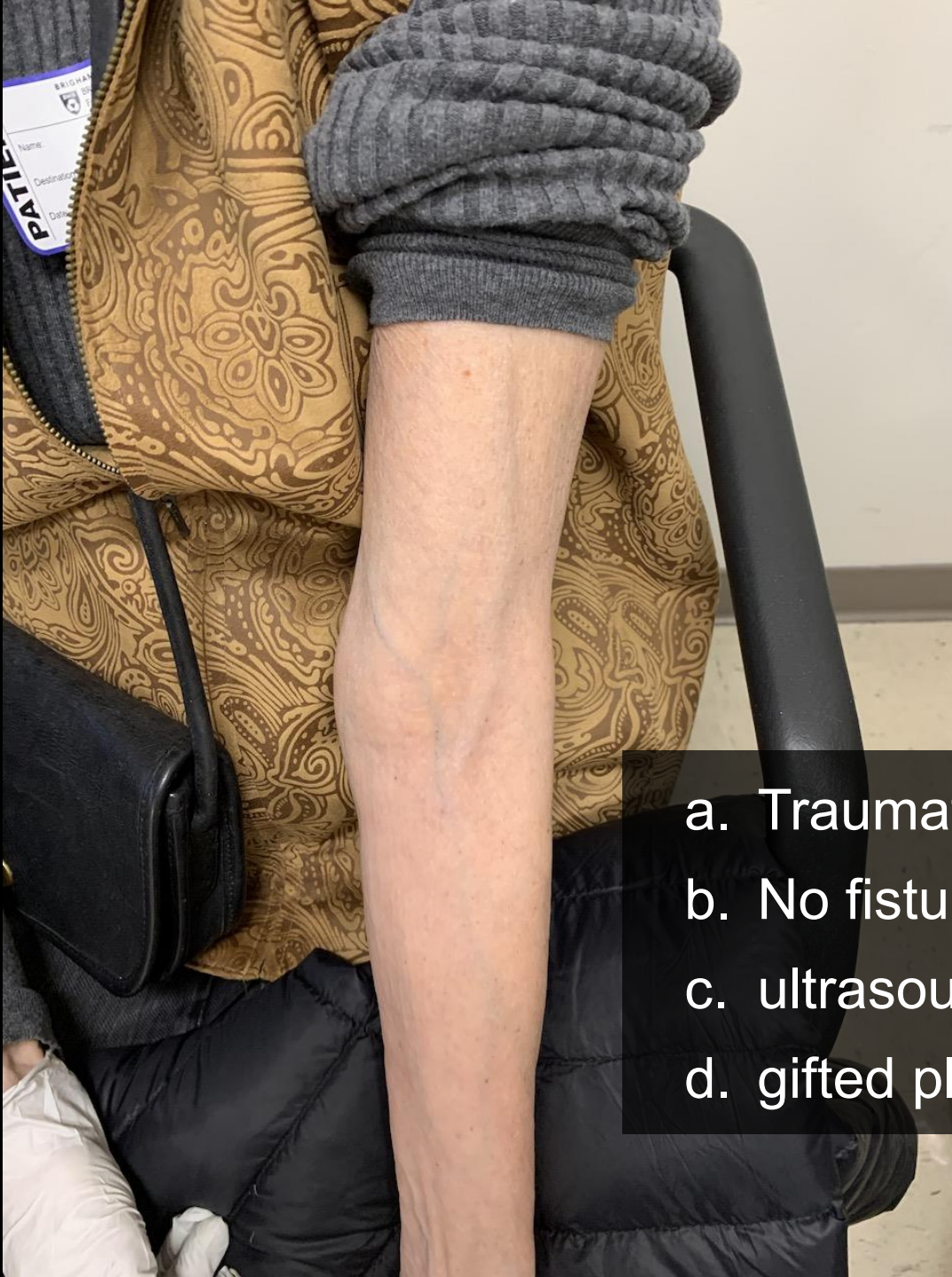


Right

Question 6

What kind of fistula is this?

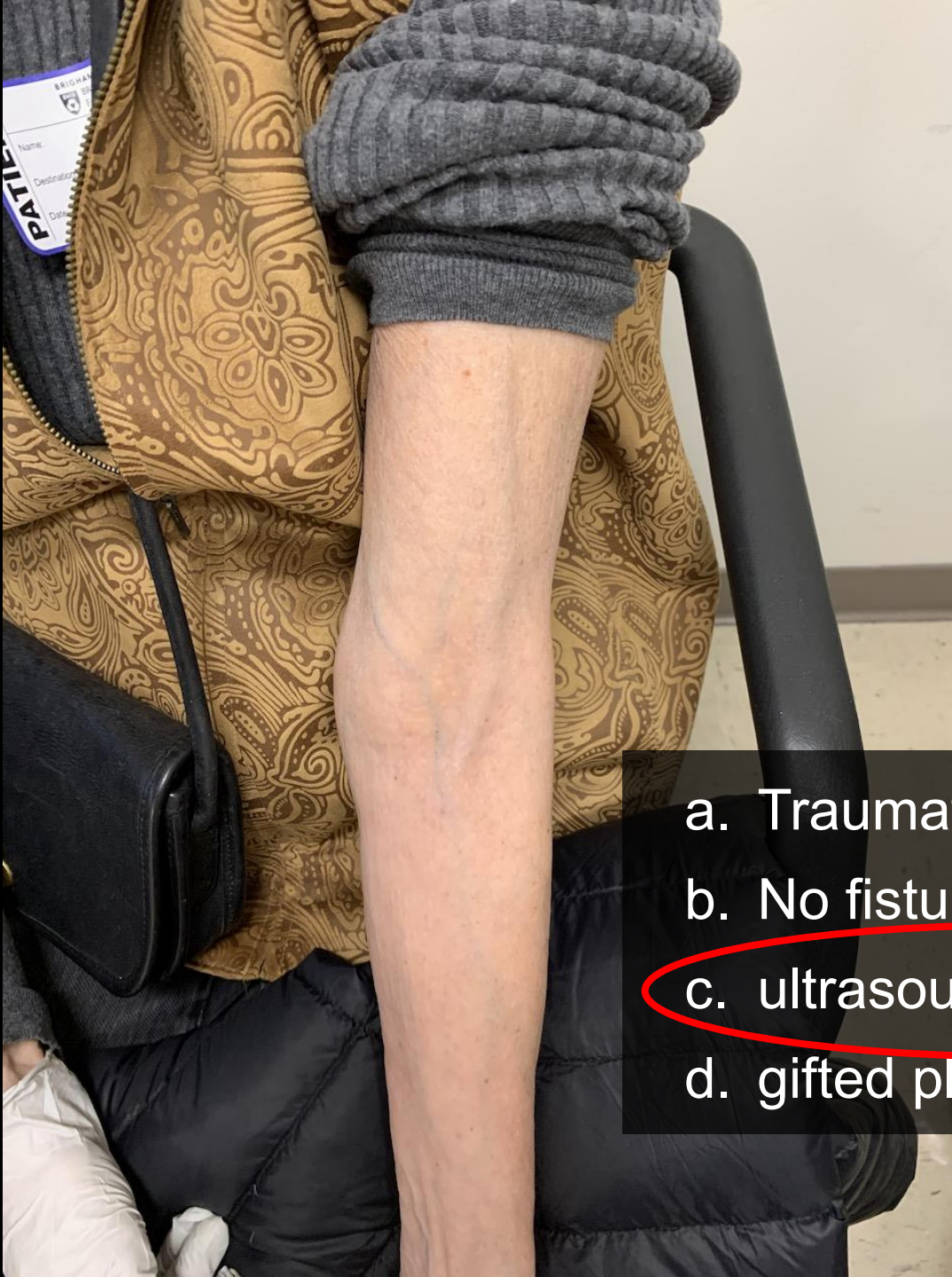
- a. Traumatic after childhood forearm fracture
- b. No fistula - former olympic rower
- c. ultrasound guided fistula
- d. gifted plastic and vascular surgeon



Question 6

What kind of fistula is this?

- a. Traumatic after childhood forearm fracture
- b. No fistula - former olympic rower
- c. ultrasound guided fistula
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endo-AVF Revolution

Usable Cannulation-Zone

- Redirect flow to cephalic vein
 - Band or ligate basilic vein
 - Limit / prevent brachial (deep) venous outflow by coil or ligation
 - New brachial-cephalic anastomosis
- Transpose basilic vein
- Interposition forearm loop graft

Anatomic Type

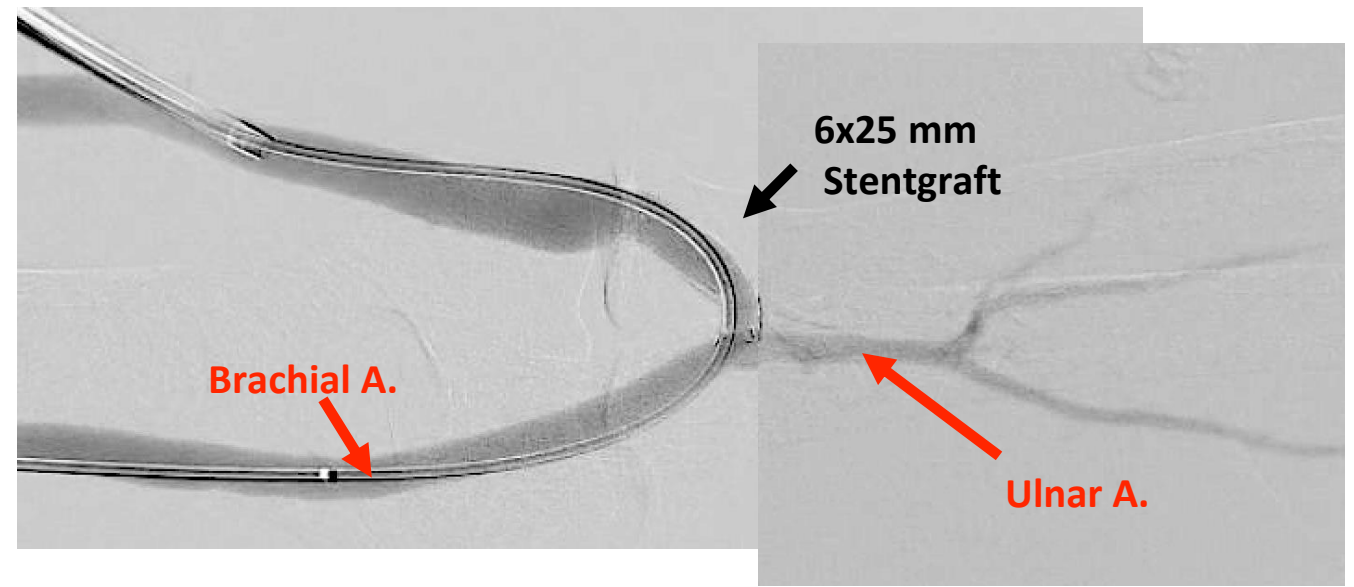
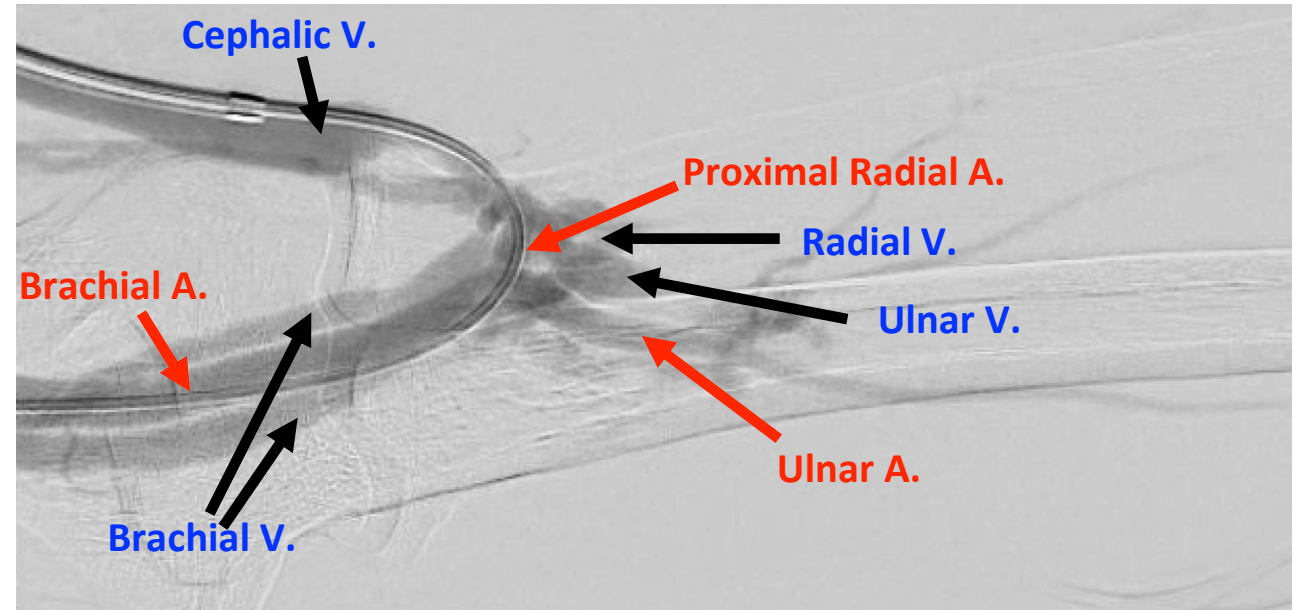
Type 1 - cephalic, basilic, and brachial

Type 2 - cephalic and brachial

Type 3 - basilic and brachial

Type 4 - brachial alone

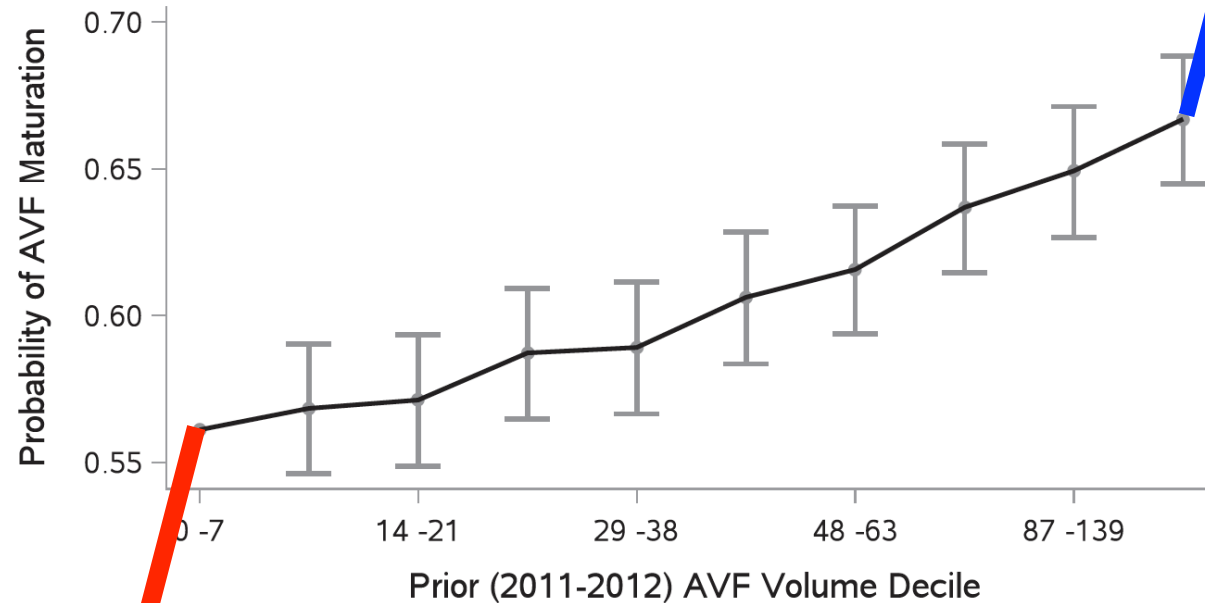
Juxta-anastomotic Stent-Graft



US National Access Landscape - Surgeons

Case Volume correlates with Successful Maturation (Shahinian AJKD 2020)

**85 %
top 9.7 %**



“Develop” Surgeons

- Endo-support
- Team integration
- Observe use of access in HD unit

**bottom
6.9 %**

23%

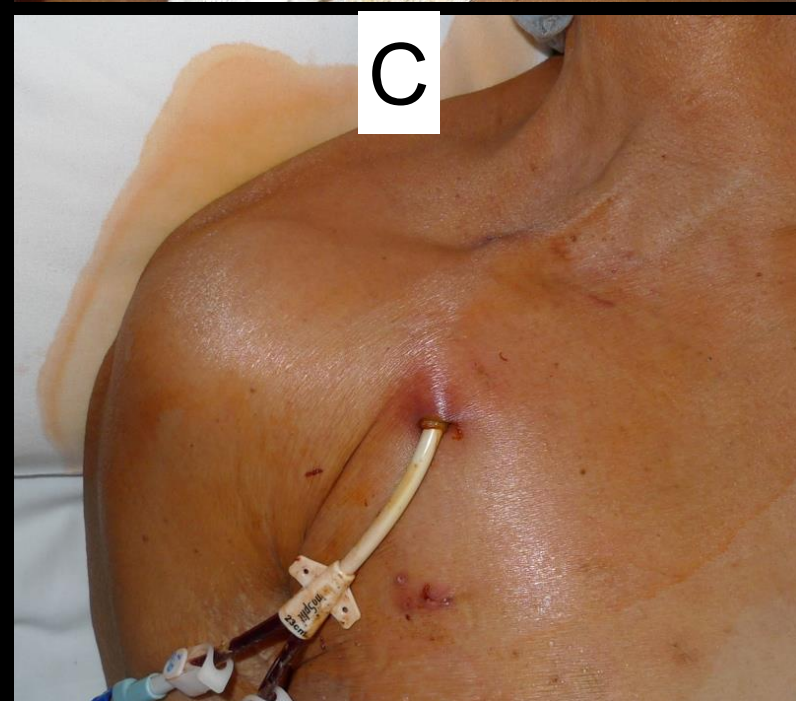
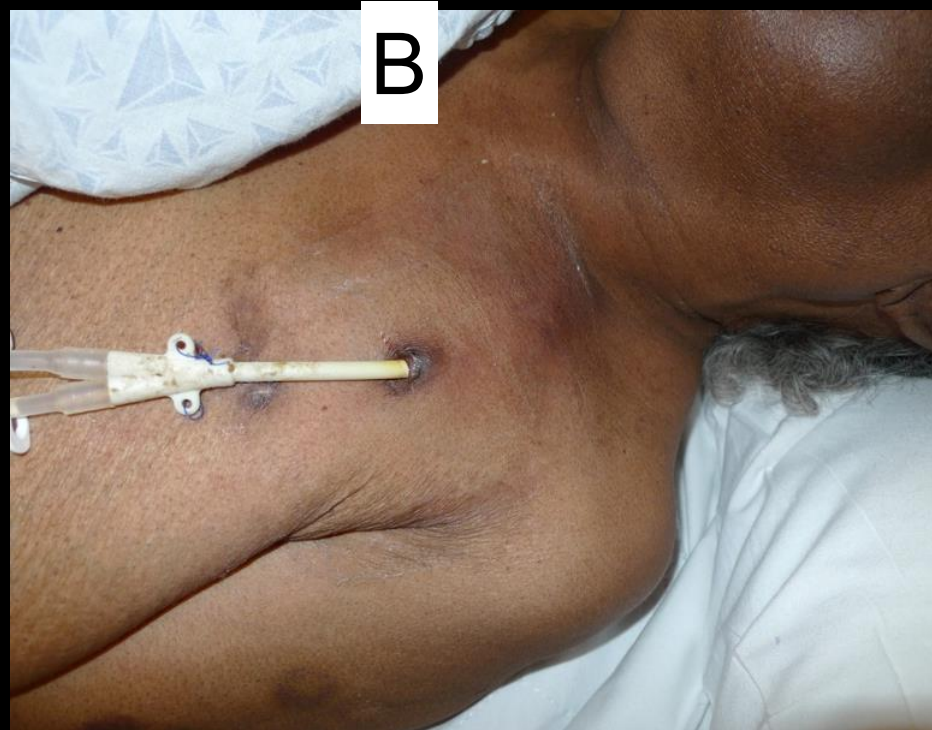
- 2,770 surgeons who placed > 5 AVFs in 2013 and 2014, total 49,826 AVFs in CMS patients
- Maturation Success does not plateau
- Extremes: top 243 (9.7%) surgeons 85%, bottom 174 (6.9 %) 23 % success rate, ~ 1,500 surgeons < 5 AVF/y
- Important to know:
 - 2016 - 1,251 surgeons placed more than 10 access (AVG or AVF), total 32,767 accesses
 - 2016 - 3,071 surgeons placed an additional 27,035 accesses



Question 7

1. Exposed Cuff
2. Operator without catheter experience
3. Tunnel Infection
4. Exit Site Infection

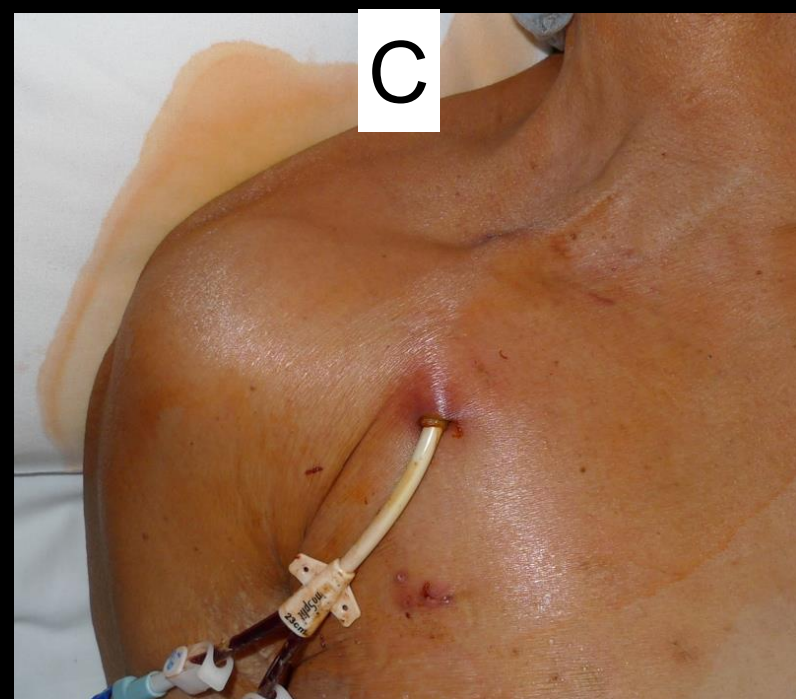
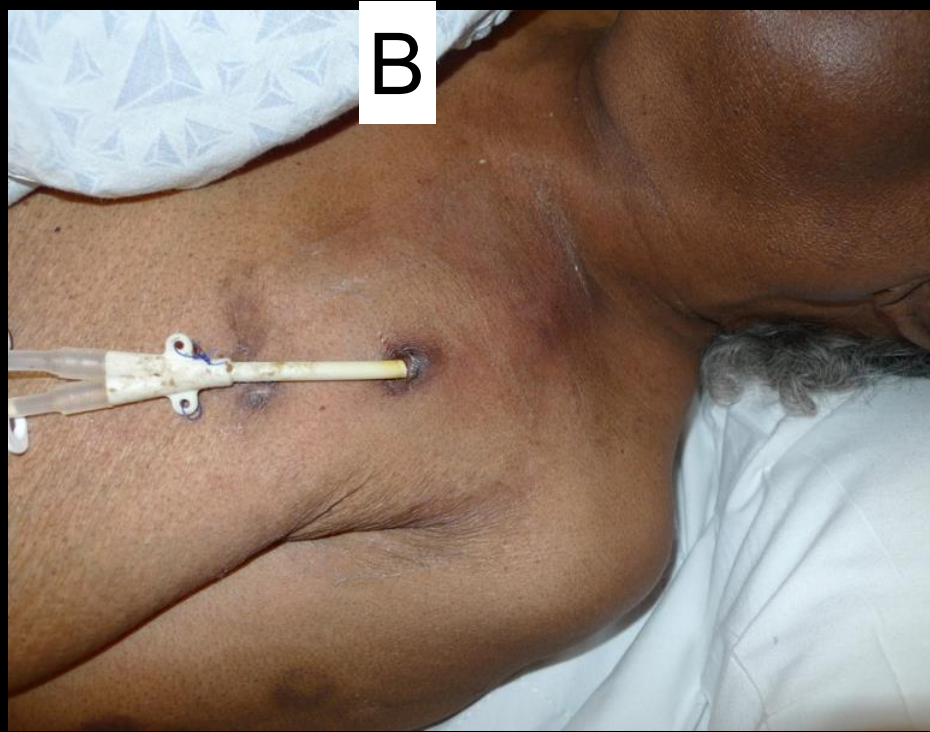
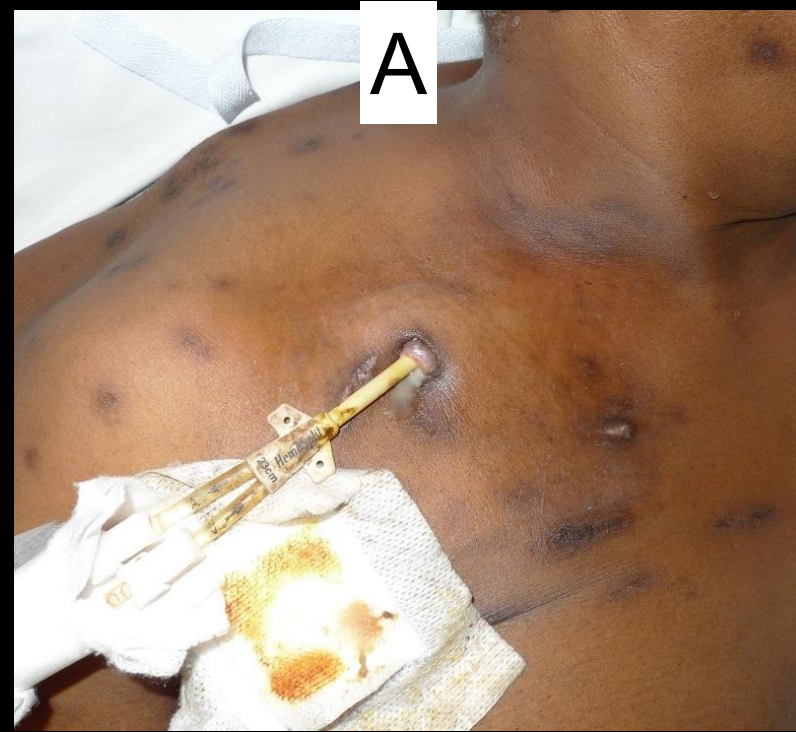
- A. 1B, 2C, 3A, 4D
B. 1C, 2B, 3D, 4A
C. 1C, 2D, 3B, 4A
D. 1A, 2D, 3B, 4C



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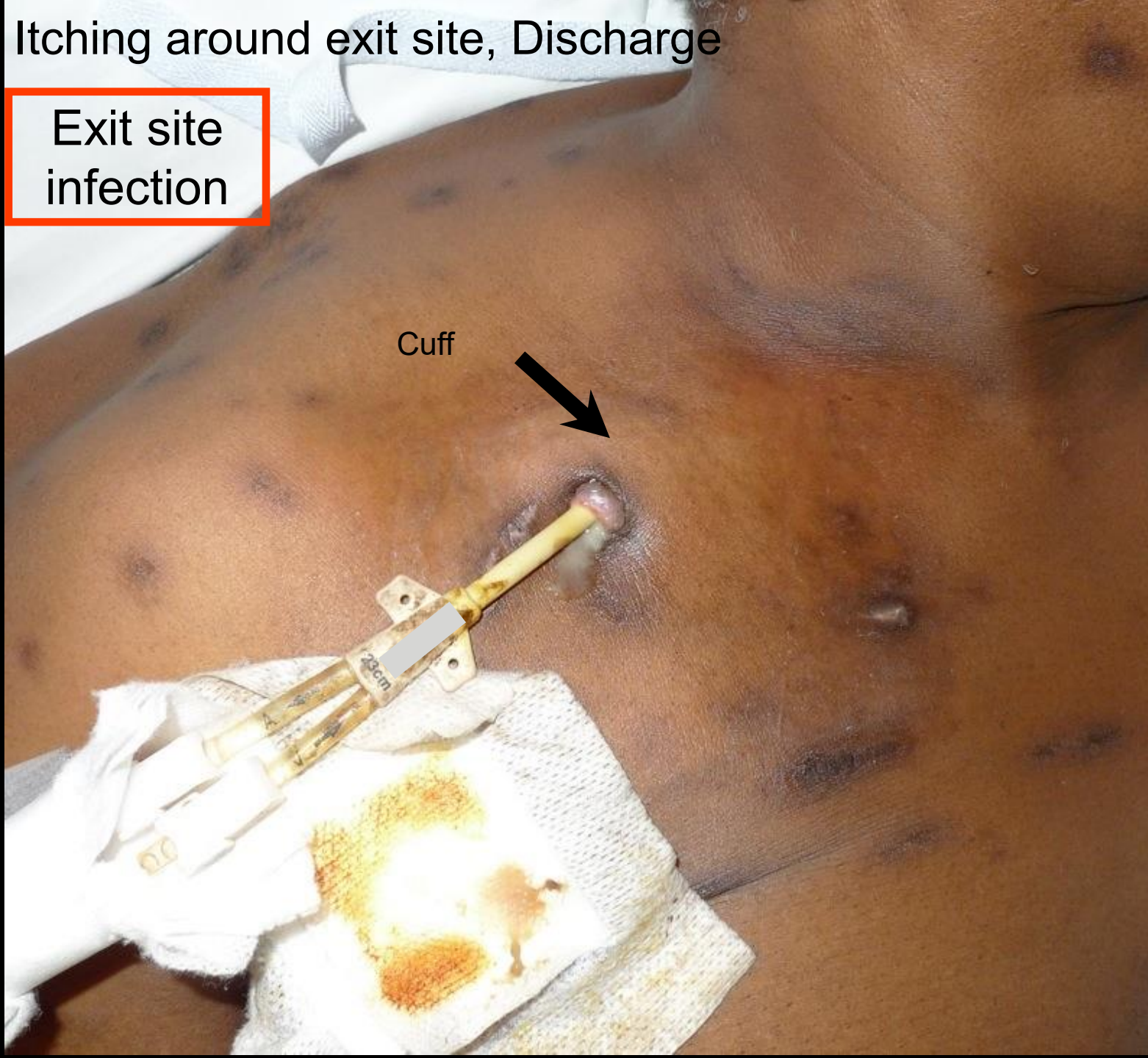
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- C. 1C, 2D, 3B, 4A
- D. 1A, 2D, 3B, 4C



Itching around exit site, Discharge

Exit site
infection

Cuff



Change in mental status
Tender area over clavicle
Erythema along tunnel

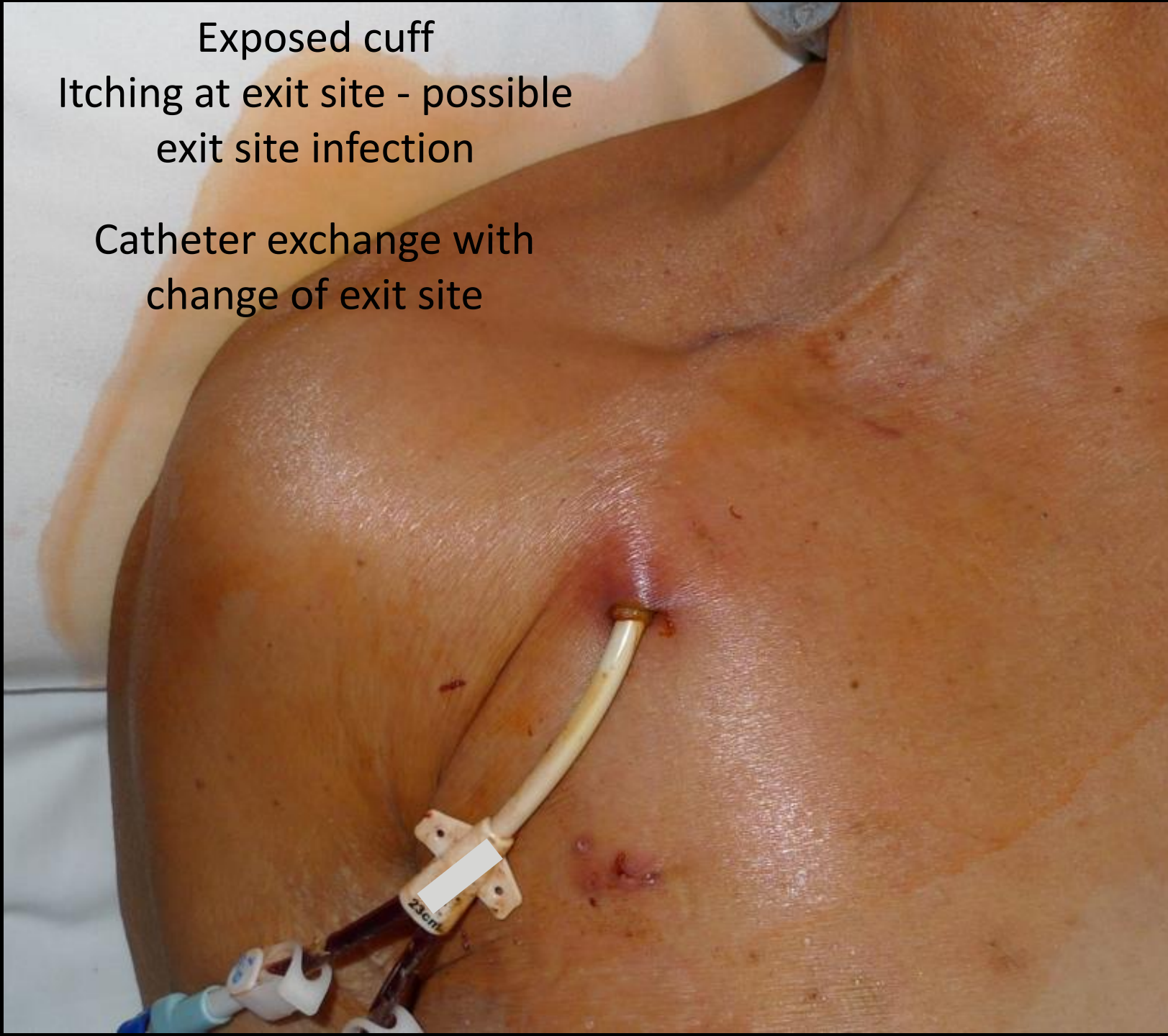


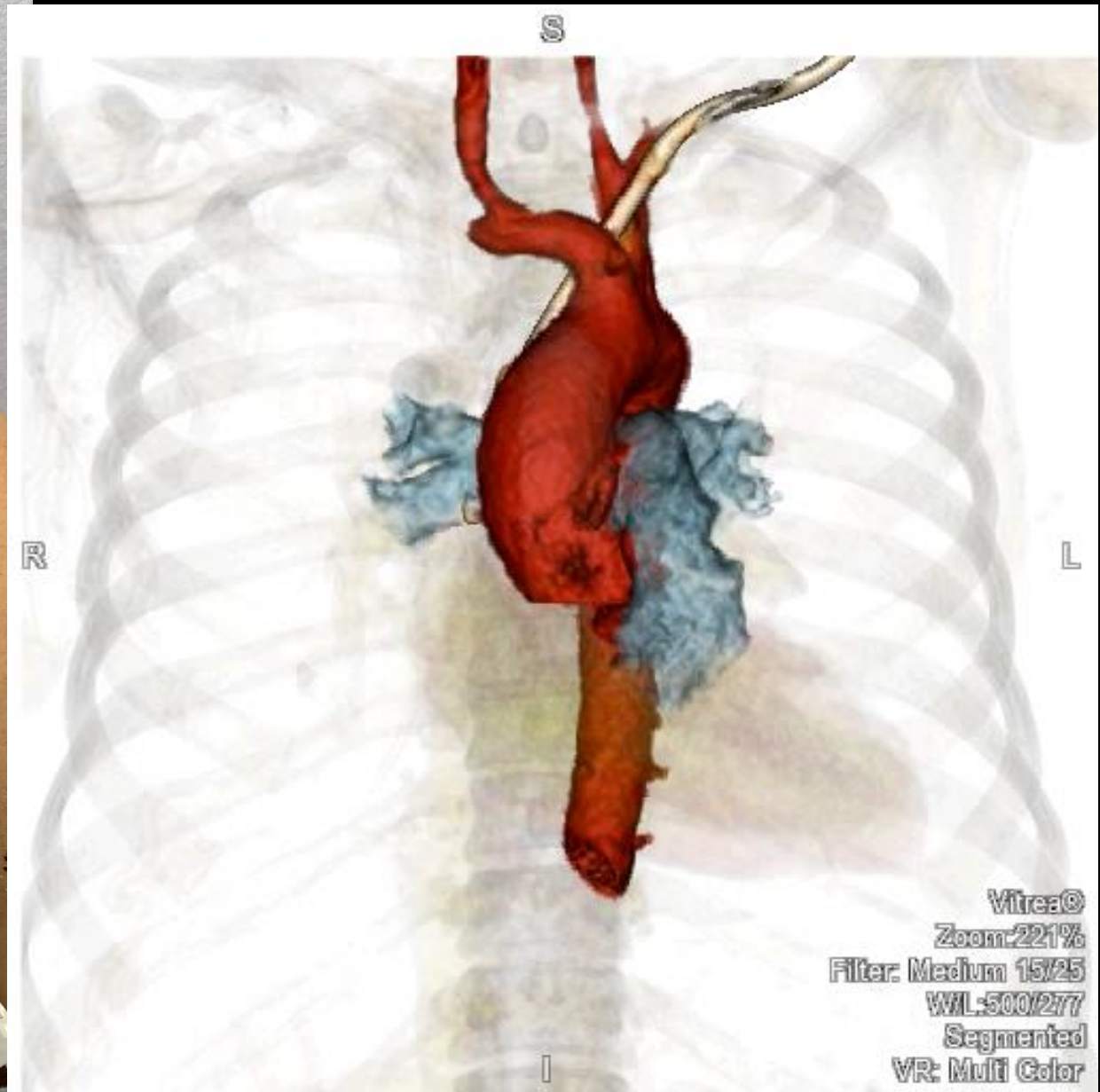
Tunnel infection



Exposed cuff
Itching at exit site - possible
exit site infection

Catheter exchange with
change of exit site





Question 8 - What sequelae are associate with this catheter tip location?



65-year-old African-American man with DMII and HTN initiates dialysis with a right internal jugular vein catheter on 6/15/2007

Question 8 - What sequelae are associated with this catheter tip location?

- 1 - catheter dysfunction
- 2 - central vein stenosis
- 3 - infection
- 4 - dialysis access arm edema
- 5 - fibrinous sheath formation

- a. 1, 3, 4
- b. 1, 2, 3
- c. 1, 2, 4
- d. 2, 3, 4
- e. 2, 3, 5



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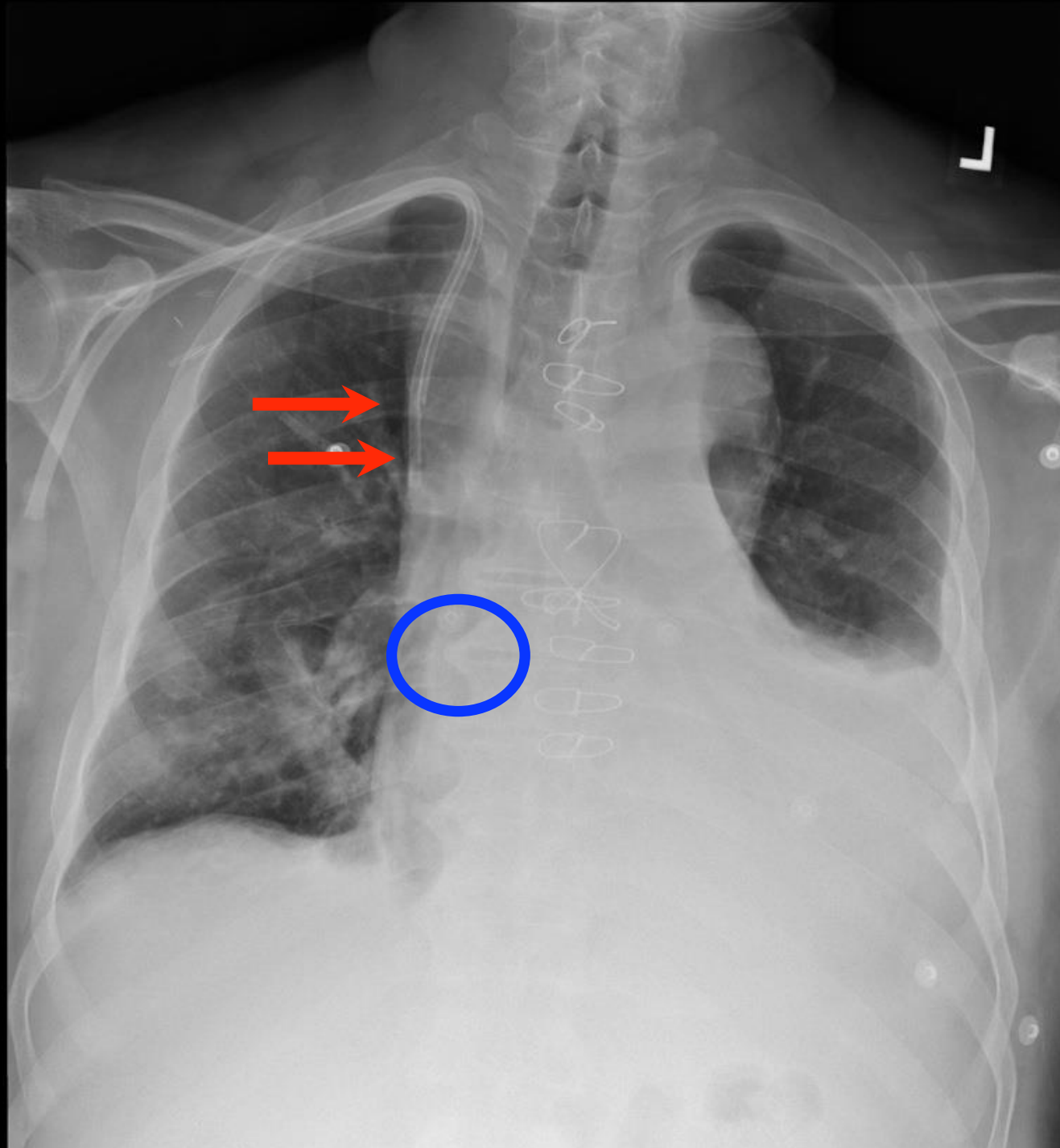
b. 1, 2, 3

c. 1, 2, 4

d. 2, 3, 4

e. 2, 3, 5





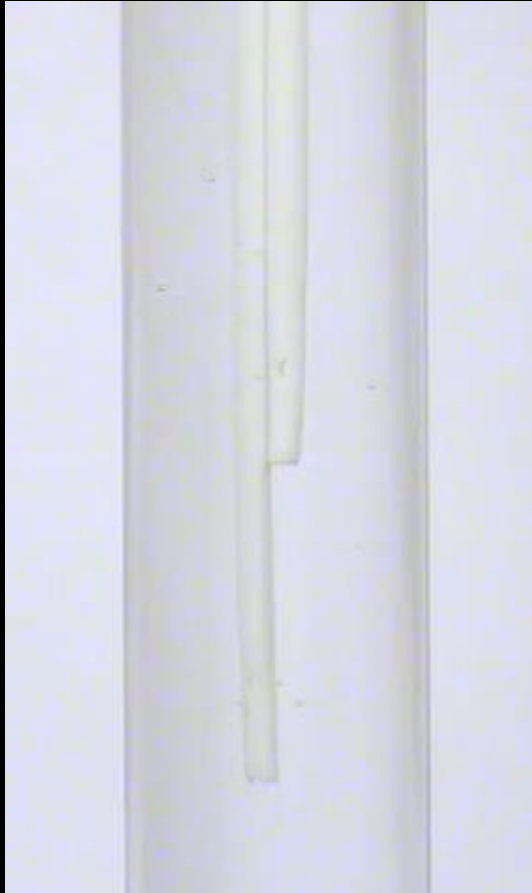
65-year-old African-American man with DMII and HTN initiates dialysis with a right internal jugular vein catheter on 6/15/2007

A right upper arm transposed brachial-basilic access is created on 1/23/08
and first used in May 2008.

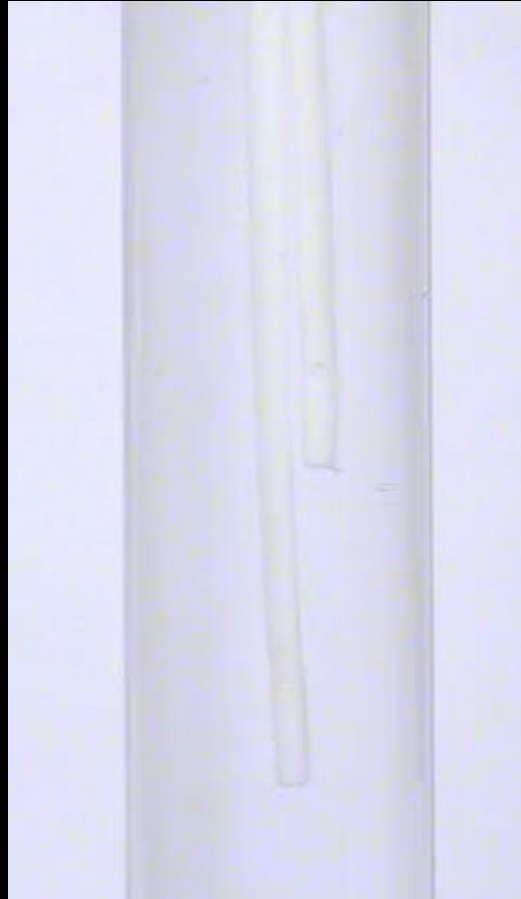
He presents with arm swelling in September 2008.



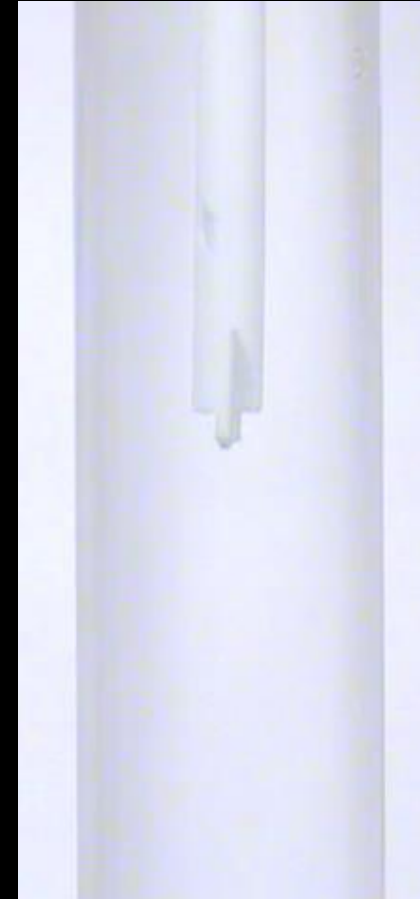
Tip and Sheath effect on central veins



Split tip
Standard



Split tip
Reversed

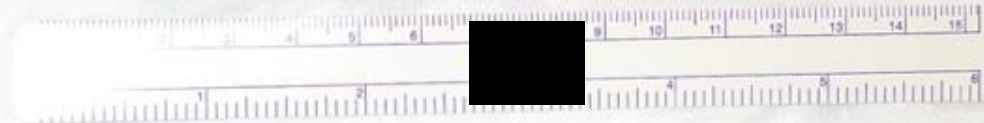


Symmetric tip
Reversed

Dynamic Catheter Dysfunction

Fibrinous Sheath

Sidehole



Dynamic Catheter Dysfunction

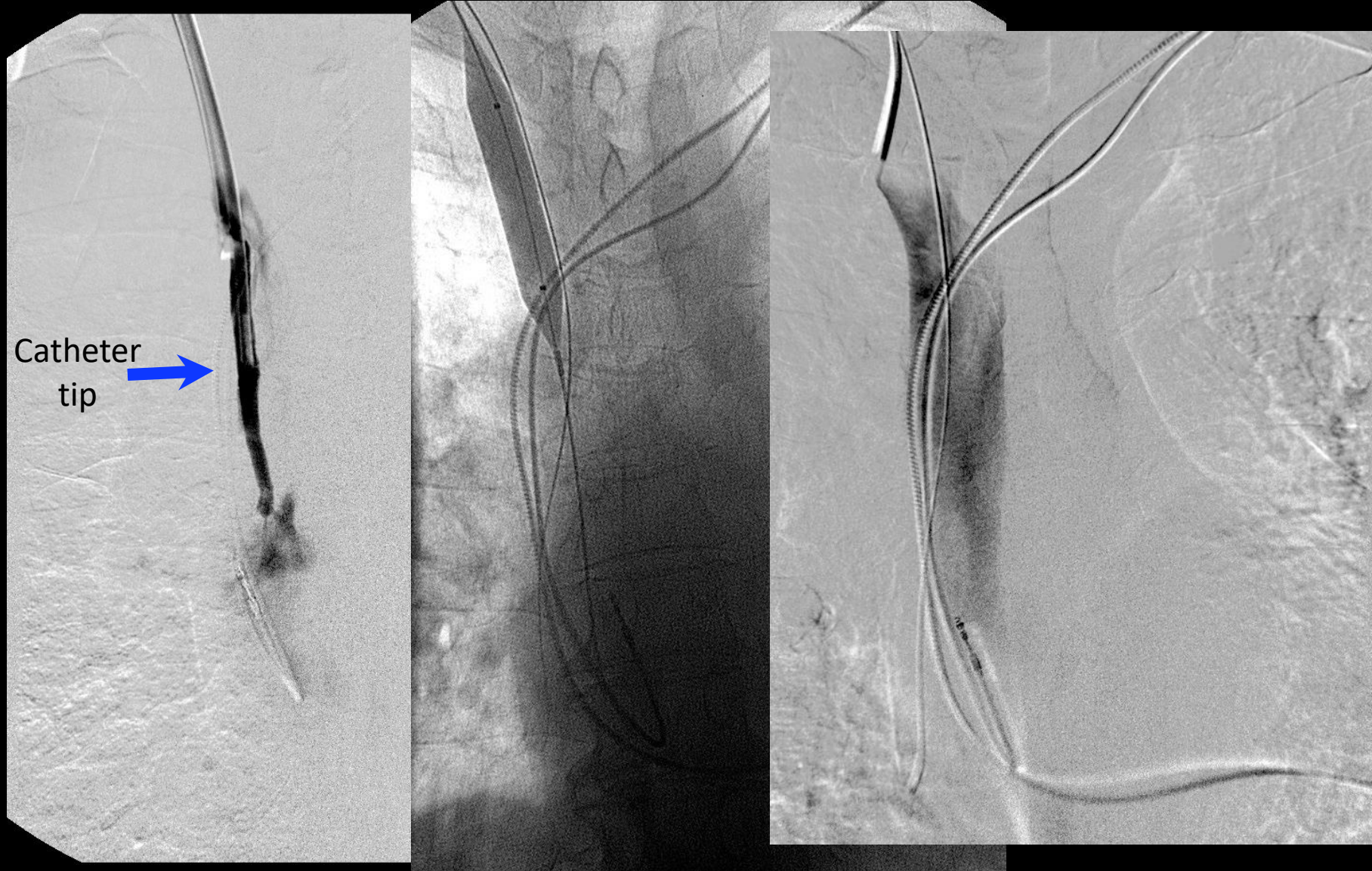
Fibrinous Sheath

Sidehole

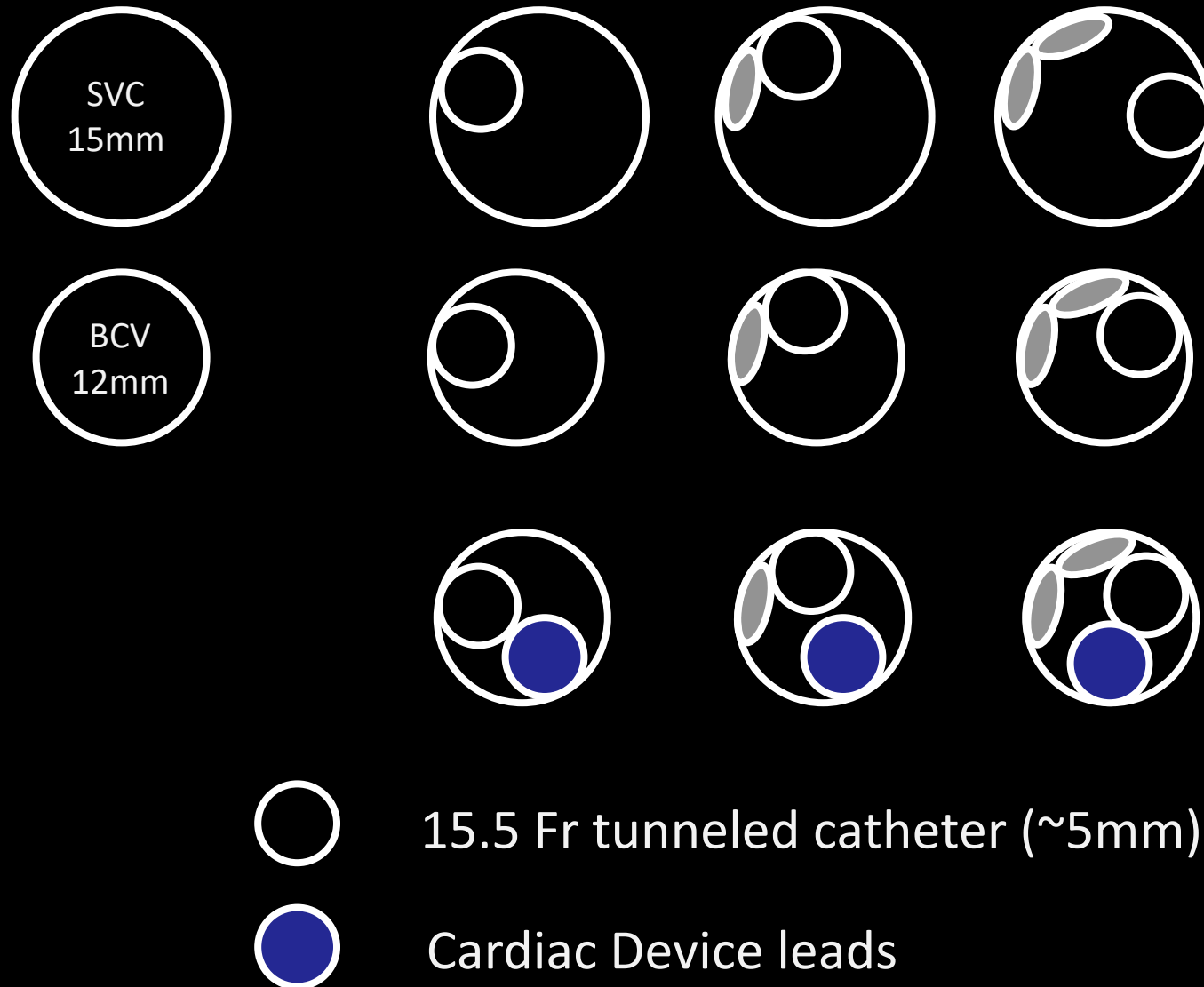


Dynamic Catheter Dysfunction

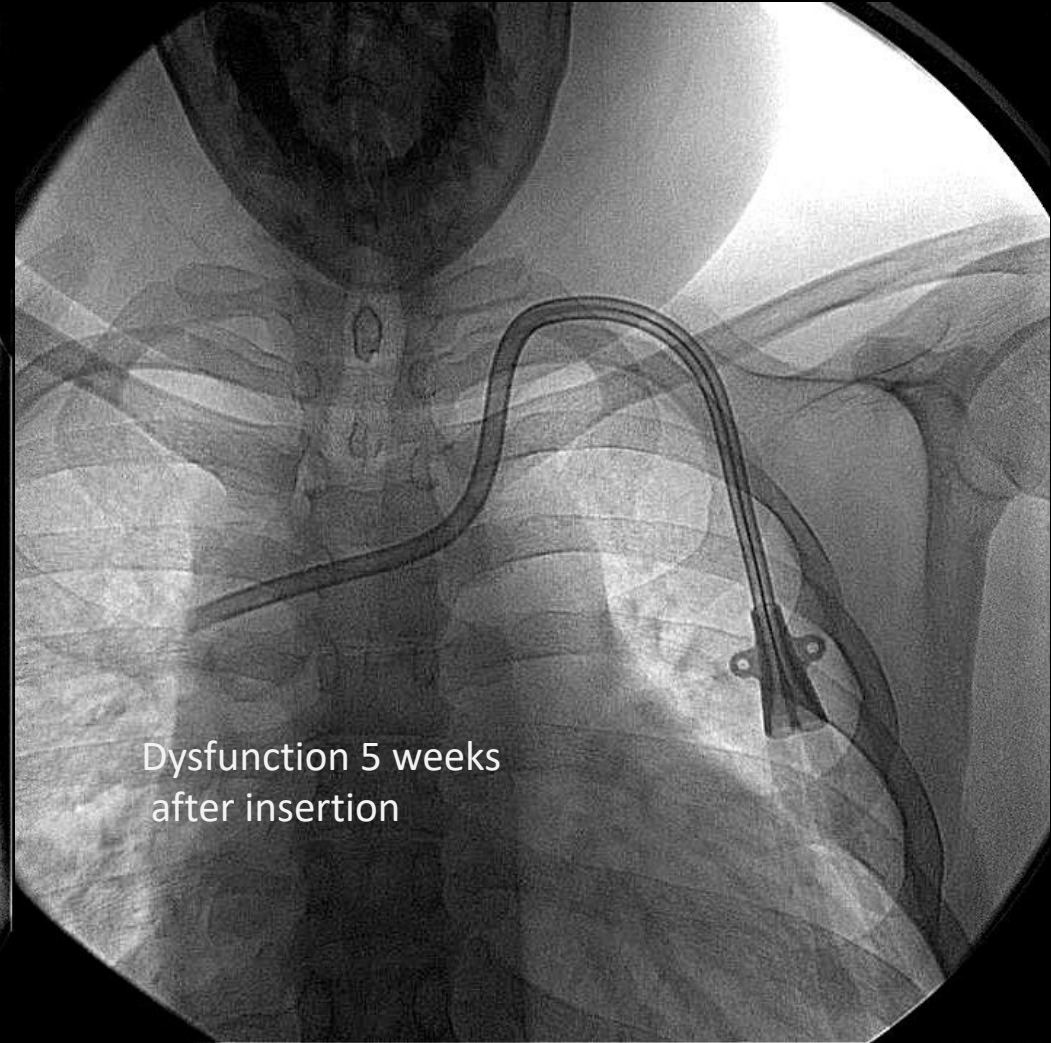
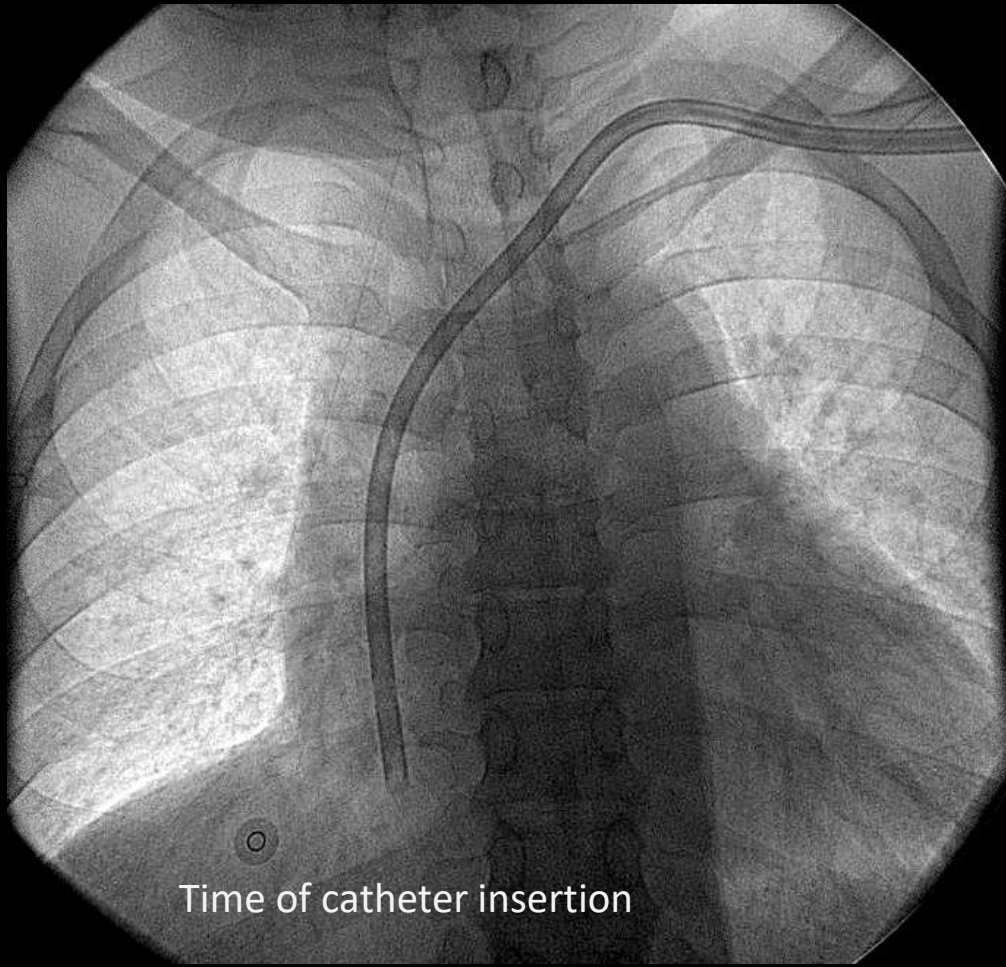
Fibrinous Sheath



Cumulative exposure to tunneled catheters



Dynamic Catheter Dysfunction



Catheter tip position



Success rates of different CRB strategies

(Review of available literature, total of 21 studies reporting on recurrent infections after catheter exchange/removal)

Strategy \ Organism	Overall success	Staph aureus	coag neg Staph	Enterococcus	GNR	Multiple Organisms	fungus
Abx alone	49% (203/418)	53% (25/47)	67% (84/126)		51% (41/80)	0% (0/10)	100% (1/1)
Abx plus Cath lock	57% (218/381)	40% (54/134)	77% (41/53)	59% (48/81)	66% (53/80)	37% (3/8)	0% (0/1)
Abx plus GW exchange	89% (196/219)	80% (16/20)	88% (29/33)	100% (1/1)	89% (40/45)	70% (7/10)	83% (24/29)
Abs plus Removal and Delayed Reinsertion	88% (174/198)	87% (74/85)	89% (41/46)		88% (64/73)		85% (11/13)

see also: Aslam JASN 2014, Voiculescu JVA 2021



Tunnel infection



Continuous sheath from tunnel into vessel



TAKE HOME MESSAGES

- Access flow has to be sufficient for dialysis
- Limit Access flow to preserve cardiac function and prevent steal
- Intra-access pressure are elevated BEFORE access flow falls significantly
- Aneurysm formation and skin thinning is related to increased intra-access pressures
- Higher flow in setting of outflow stenoses leads to higher intra-access pressures
- Forearm accesses on average have lower flow, lower intra-access pressure, and develop fewer systemic complications
- Tunneled catheter tip position is key to continuous function
- Tunneled catheters are associated with central venous stenosis and infection
- Catheter-related bacteremia may be approached with guidewire exchange if the patient is clinically stable and site preservation important



REFERENCES

J Vasc Access 2023 May;24(3):358-369.

ASDIN white paper: Management of cephalic arch stenosis endorsed by the American Society of Diagnostic and Interventional Nephrology

[Gerald A Beathard](#) ¹, [William C Jennings](#) ², [Haimanot Wasse](#) ³, [Surendra Shenoy](#) ⁴, [Abigail Falk](#) ⁵, [Aris Urbanes](#) ⁶, [John Ross](#) ⁷, [George Nassar](#) ⁸, [Dirk M Hentschel](#) ⁹, [Bharat Sachdeva](#) ¹⁰, [Micah R Chan](#) ¹¹, [Loay Salman](#) ¹², [Arif Asif](#) ¹³

Consider limiting flow (e.g. banding) **before** or in addition to treating outflow stenosis

J Am Soc Nephrol 2014 Dec;25(12):2927-41.

Systematic review and meta-analysis on management of hemodialysis catheter-related bacteremia

[Saima Aslam](#) ¹, [Florin Vaida](#) ², [Michele Ritter](#) ³, [Ravindra L Mehta](#) ⁴

For treatment of Catheter related bacteremia **Guidewire exchange** performs better than catheter lock (in addition to systemic antibiotics)



CLINICAL TRIALS

Clinical Trials	Change in Management	
Haskal et al. NEJM 2010 – Stent graft vs AP for AVG venous anastomosis	Stent graft cost-effective	Open question: across joints? Compared to surgery?
Lockstein JVIR 2023 - IN.PACT AV – drug-coated balloon in AVF	International trial, DCB with improved target lesion patency	DCB use not yet supported by overall evidence.
Trerotola JVIR 2020 - Lutonix AV Randomized Trial of Paclitaxel-coated Balloons	US trial, DCB with variable improvement	target lesion still needs to be identified

