Selection, placement and complications in the use of the Central Venous Catheter in hemodialysis.

“The CVC :A wolf in a sheepskin ?”

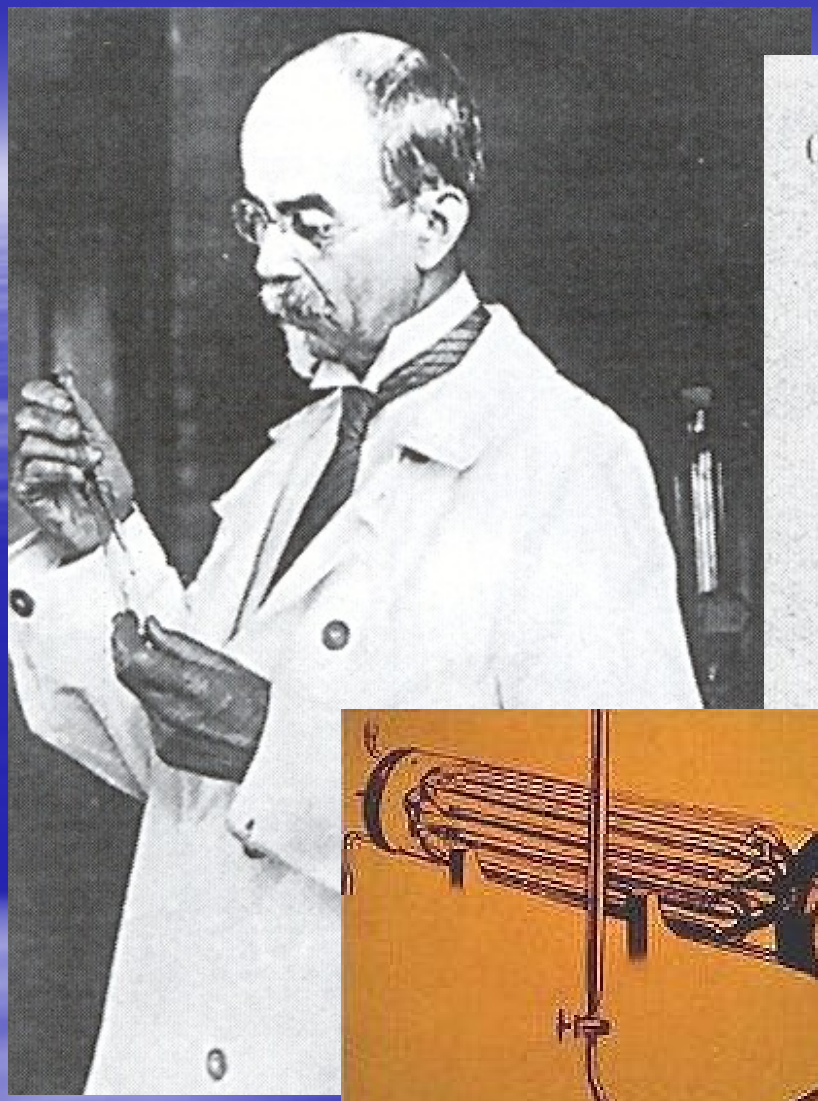
Jean-Marie Billiouw M.D.

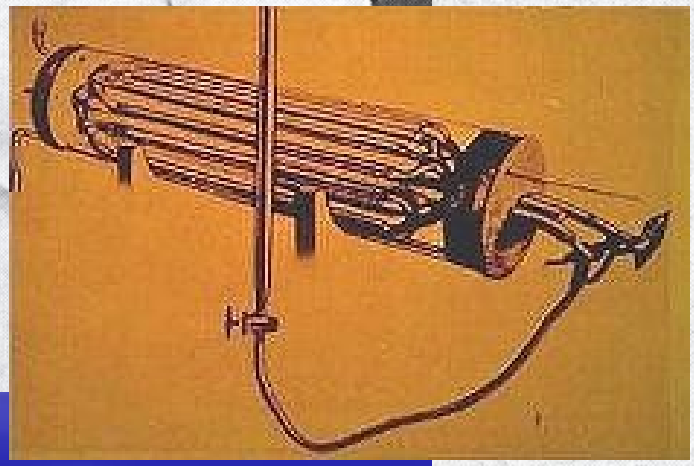
Department of nephrology – hypertension - dialysis

OLV Ziekenhuis Aalst

A young boy once asked Winston Churchill
“What should I study to become successful ?”

Winston Churchill replied : “You should study three things, my boy, first of all history then history and last but not least history . “





ON THE REMOVAL OF DIFFUSIBLE SUBSTANCES FROM THE CIRCULATING BLOOD BY MEANS OF DIALYSIS

Kidney

BY

JOHN J. ABEL, M.D., L. G. ROWNTREE, M.D.

AND

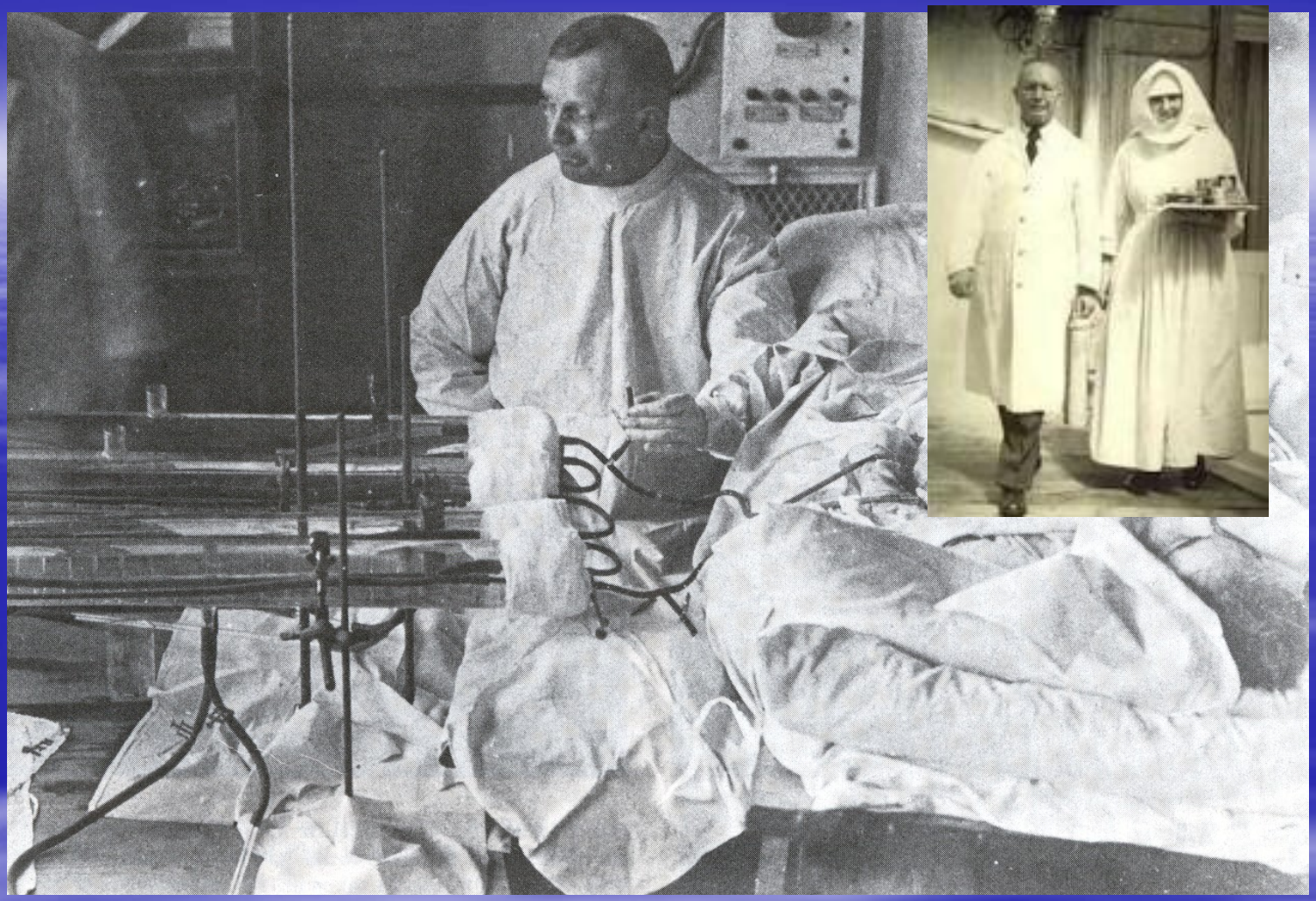
B. B. TURNER, M.D.

BALTIMORE

From the Transactions of the Association of American Physicians

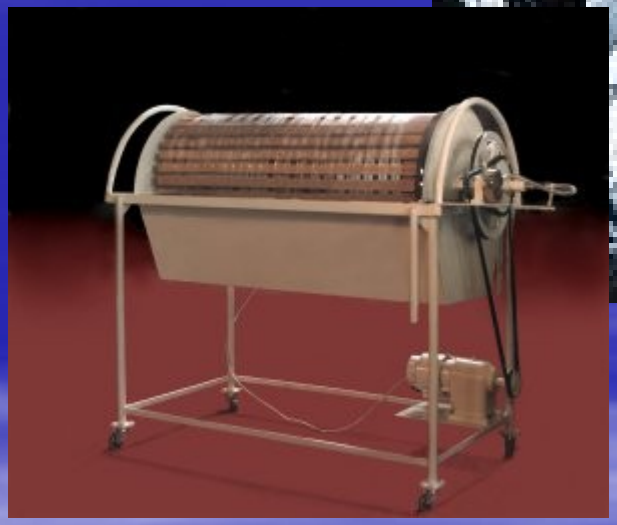
1913

John Jacob Abel
1857-1938



Georg Haas dialysing a uraemic girl. The apparatus consisted ol four glass containers each provided with two celloidin dialysing tubes (1926). These experimental dialyses were performed in the lecture theatre of the Department of Medicine in Giessen, Germany.

Sophia Schafstadt first patient to survive acute renal failure thanks to hemodialysis performed on september 11th 1945 by Pim Kolff in Kampen in the Netherlands



"…in cases of chronic irreversible uremia there is in general no indication for treatment with the artificial kidney. However temporary aggravation of chronic uremia caused by intercurrent infection, diarrhoea or surgery could benefit from dialysis to tide the patient over the critical period."

History of hemodialysis in a nutshell

1947 the Alwall kidney

"the patient has been alwalled"

1956 : Kolff's coil kidneys

1950-1960 : hemodialysis was regarded as being "experimental, expensive and dangerous"

1960: Frederik Kiil parallel plate artificial kidney

1968: First hemodialyser by Travenol

Major milestones in hemodialysis treatment

Bloodleak-detector, venous chamber , "single needle" dialysis

"central dialysate delivery", bicarbonatedialysis, hemofiltration, hemodiafiltration,

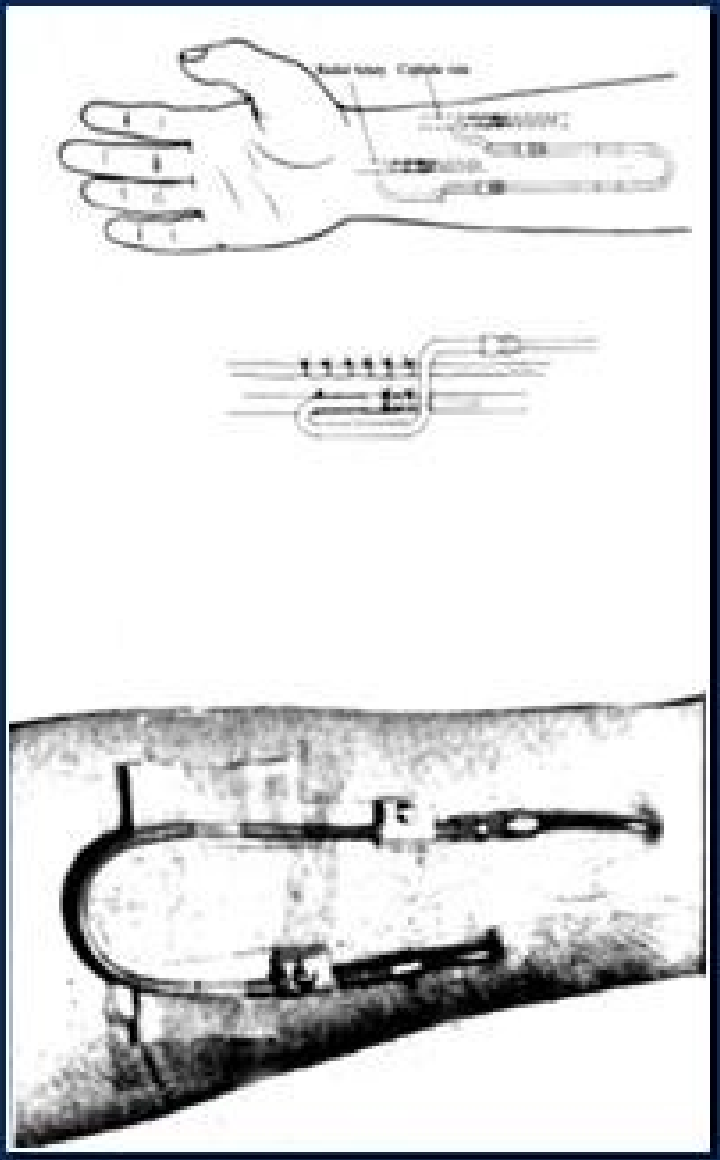
It was a major step to go from treating acute renal failure to chronic hemodialysis.

The keystone in the whole process was the search for a permanent vascular access

Original-Quinton-Scribner AV Shunt 1960

Original All Teflon Quinton-Scribner AV Shunt 1960:
Average life span *2 months*

Quinton-Scribner Silastic-Teflon AV Shunt 1962

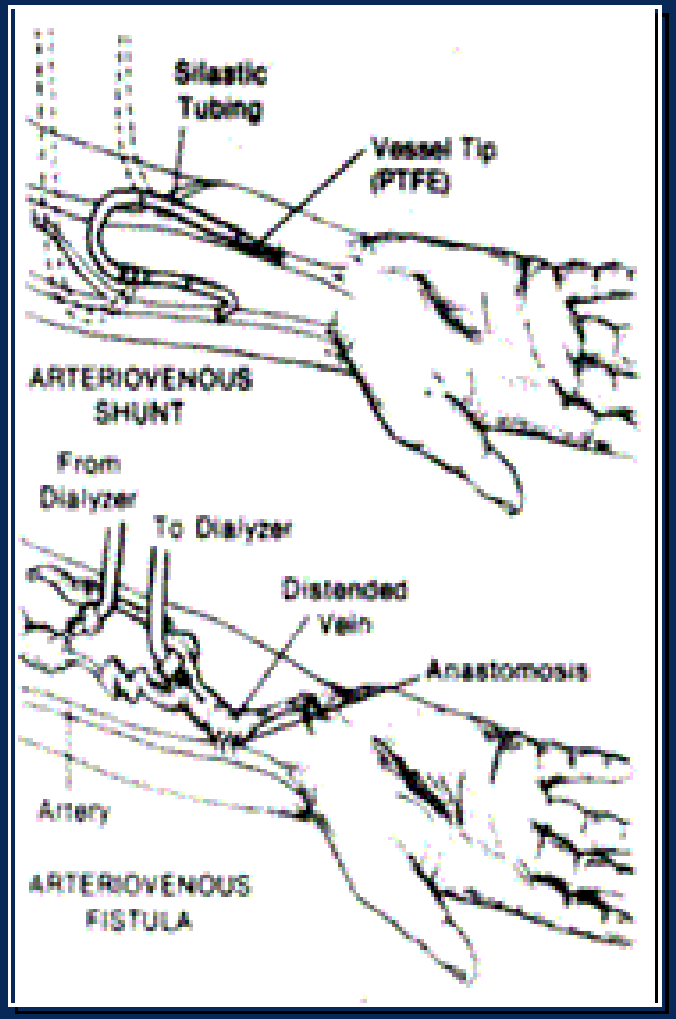


Definitive Silastic-Teflon Quinton AV Shunt 1962. Life Span *months* to *years:*

Without this innovation, I doubt that we would be treating ESRD patients today by long-term haemodialysis!

Quinton et al Trans.ASAIO 1962:8:236-243

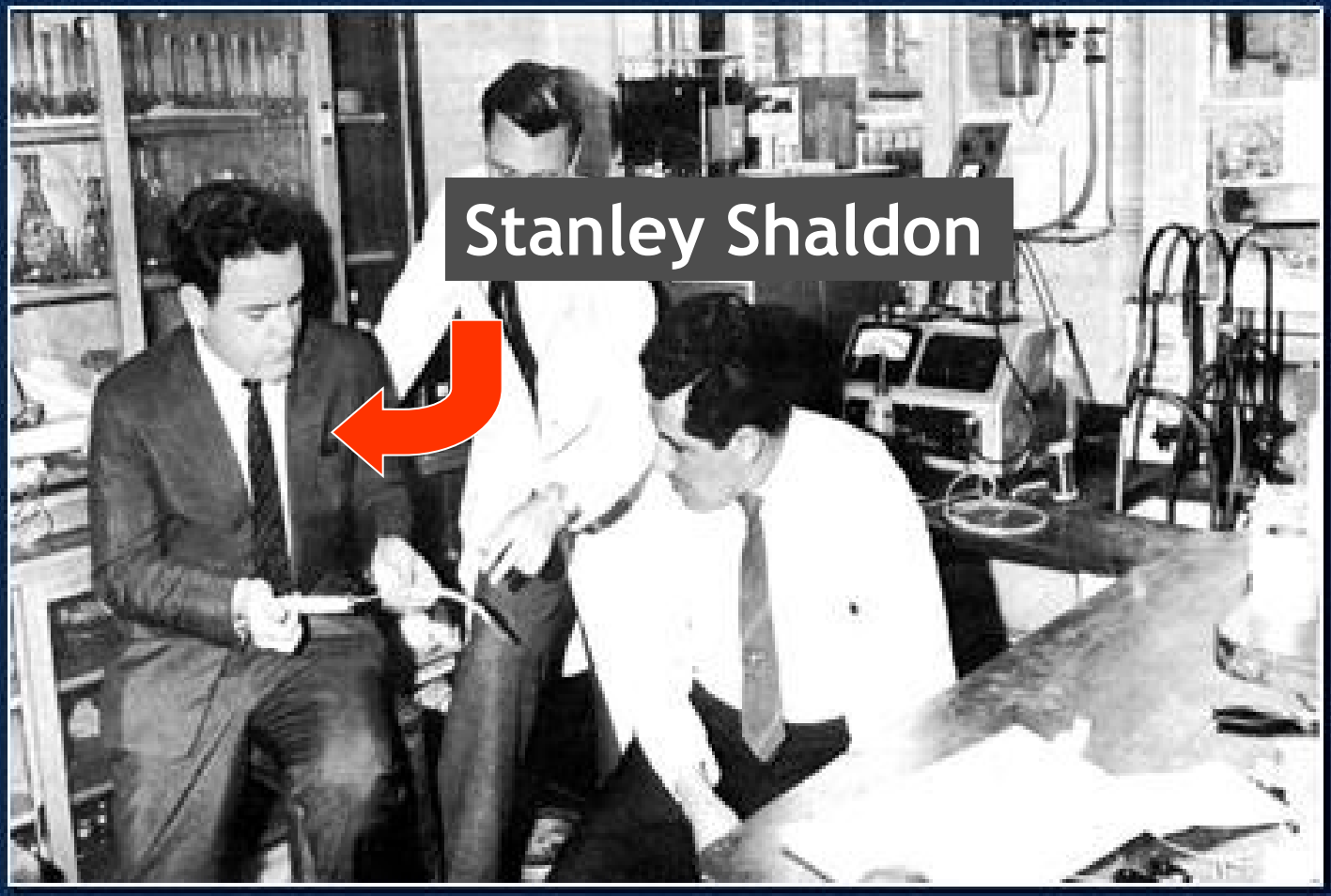
Brescia-Cimino AV Fistula



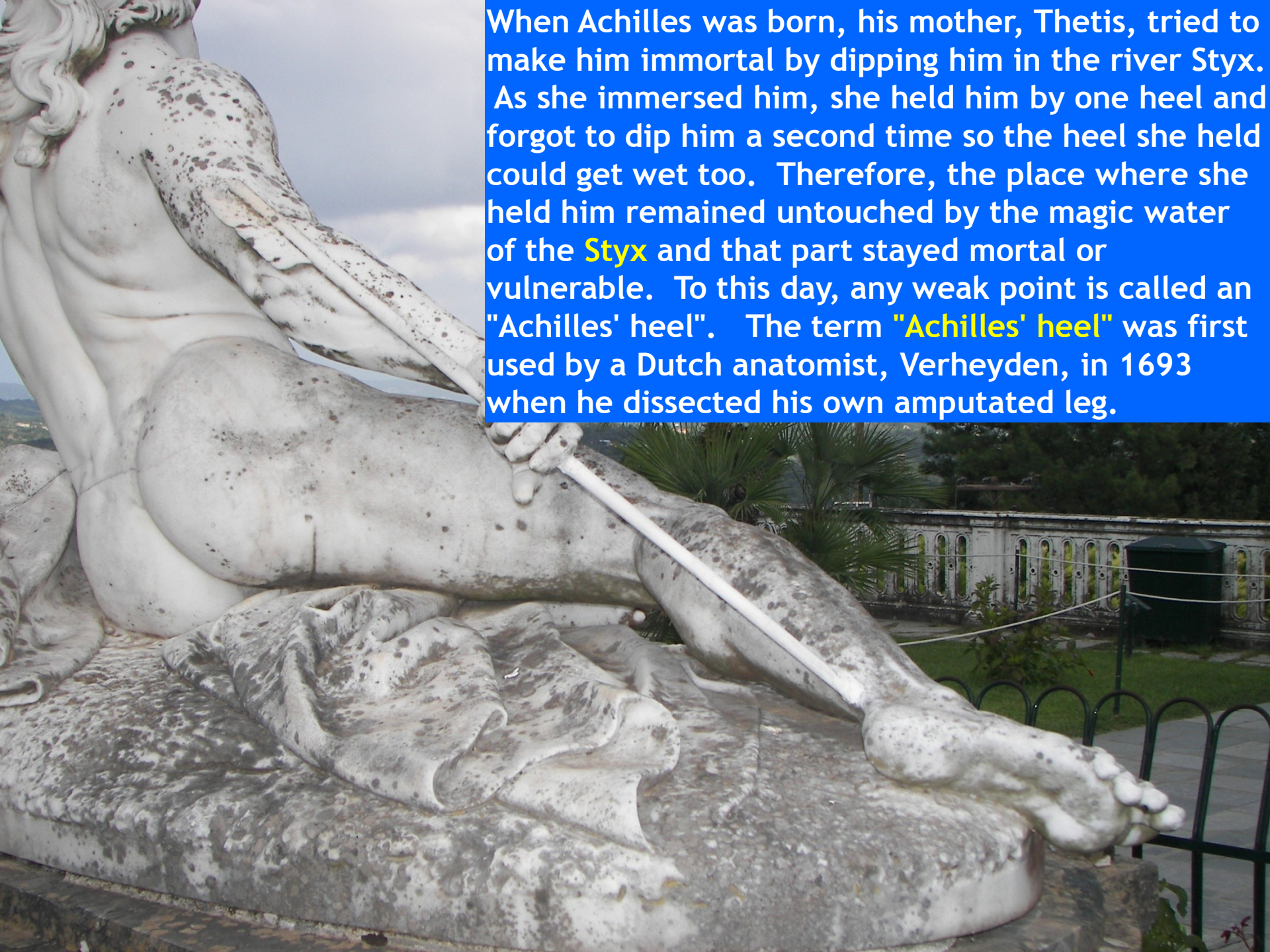
In my opinion, probably the ***most important contribution*** to long term survival of haemodialysis patients

Brescia MJ, Cimino JE, Appel K, Hurwich BJ Chronic hemodialysis using venepuncture and a surgically created arterio-venous fistula. NEJM 1966;275;1089

Catheter Making



Discussing catheter making with Angus Rae and Homero Silva, co-workers, circa 1962 in our laboratory at Royal Free Hospital



When Achilles was born, his mother, Thetis, tried to make him immortal by dipping him in the river Styx. As she immersed him, she held him by one heel and forgot to dip him a second time so the heel she held could get wet too. Therefore, the place where she held him remained untouched by the magic water of the Styx and that part stayed mortal or vulnerable. To this day, any weak point is called an "Achilles' heel". The term "Achilles' heel" was first used by a Dutch anatomist, Verheyden, in 1693 when he dissected his own amputated leg.

The vascular access has been , is and will be the Achilles' heel of the hemodialysis patient !

DOQI GUIDELINES FOR VASCULAR ACCESS
Dialysis Outcomes Quality Initiative
Selection of Permanent Vascular Access and Order of Preference for Placement of AV Fistulae

A. The order of preference for placement of AV fistulae in patients with kidney failure who will become hemodialysis dependent is:

1. A wrist (radial-cephalic) primary AV fistula (Evidence)
2. An elbow (brachial-cephalic) primary AV fistula (Evidence/Opinion)

B. If it is not possible to establish either of these types of fistula, access may be established using:

1. An arteriovenous graft of synthetic material (eg, PTFE) (Evidence) or
2. A transposed brachial basilic vein fistula (Evidence)

C. Cuffed tunneled central venous catheters should be discouraged as permanent vascular access.

“Tussen wensen en werkelijkheid staan wetten en praktische bezwaren…”

“Between wishes and reality stand laws and practical objections… “

W. Elsschot

Famous Flemish author

7 may 1882 – 31 may 1960

DOPPS the dialysis outcomes and practice patterns study

Prospective cohort study of hemodialysis practices

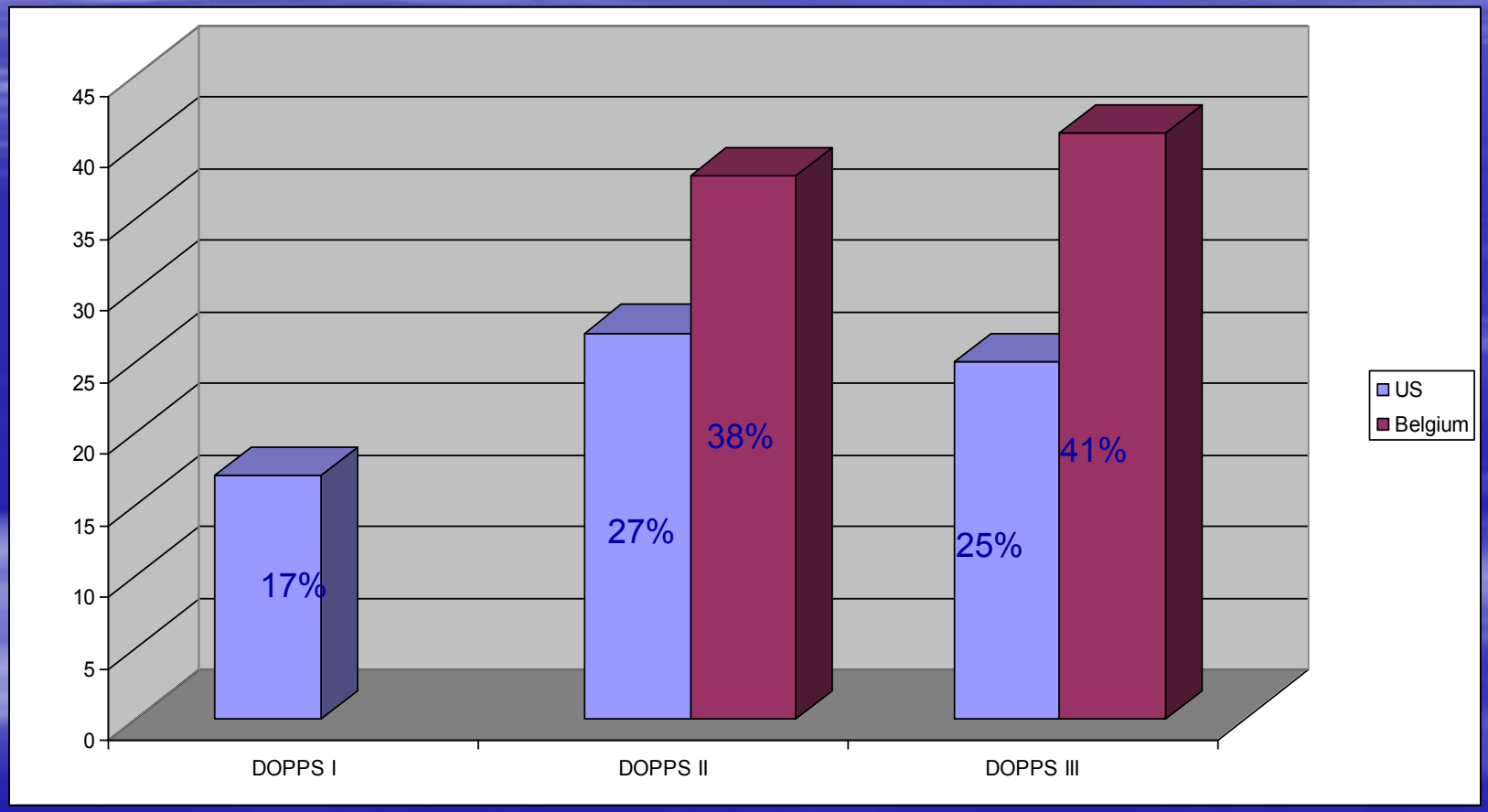
Based on the collection of observational longitudinal data

Random sample of patients

From a representative and random sample of units

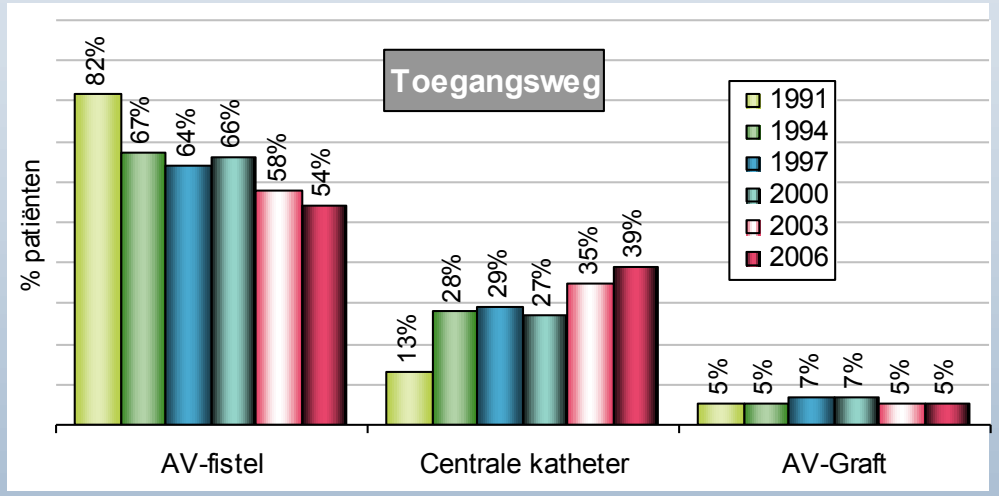
In 12 countries

Tunneled Cuffed Catheters



Hemodialysis : vascular access

Enquête 2006



- ✓ Het gebruik van centrale katheters variëerde van 0 tot 73% per centrum. Eenentwintig HD centra gebruikten centrale katheters in meer dan 40% van hun patiënten (4 in 2000, 16 in 2003). Twee satellietcentra hadden geen patiënten met katheters.
- ✓ 57 patiënten werden gedialyseerd met een combinatie van AV-fistel en katheter (65 in 2003).

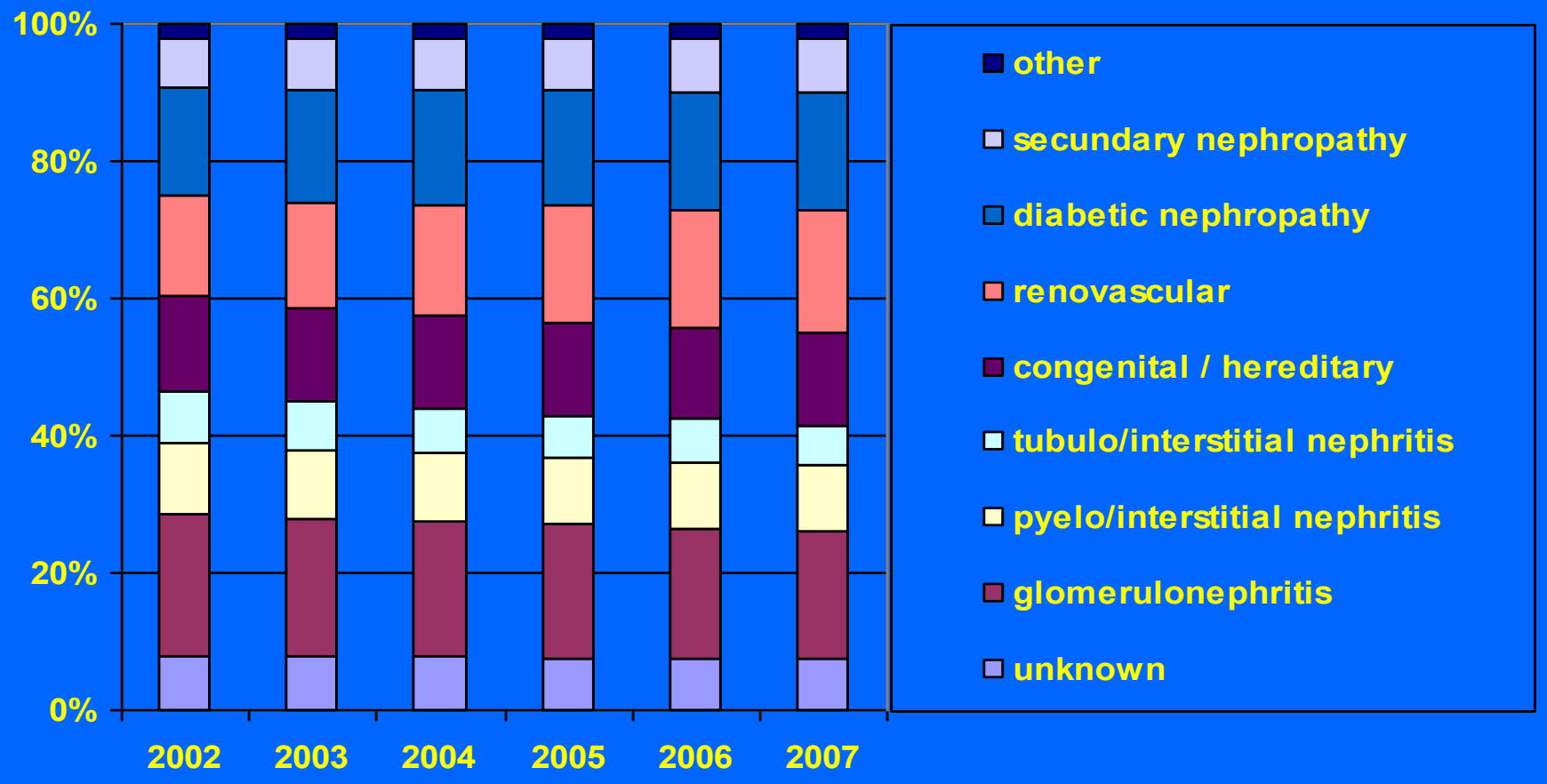
Hemodialysis unit OLV Aalst

November 30th 2010

193 pts

CVC	86	44.5 %
AV fistula	94	48.7 %
Graft	13	6.8 %

Causes of ESRD prevalence Belgium (TX included)



mean age of the belgian hemodialysis patients is 71 yrs

The cardiorenal syndrome : too wet or too dry ?

We are dealing with very sick patients

“endothelial catastrophies”

comorbidity study 2002 - 2006 NBVN

description

- 789 incident ESRD patients in 2002
- mean age 67,7 years
- 56% were men
- 28% diabetic nefropathy
- 31% renovascular disease

Co-morbidity

- 72% hypertension
- 32% diabetes
- 23% angina pectoris
- 22% vascular problems
- 36% heart failure (NYHA II)

NBVN

THE PERFECT VASCULAR ACCESS

Instant or rapid maturation

Long Survival

High blood flow rates

Small risk for thrombosis

Small risk for infection

Easy to cannulate

Quick hemostasis at the conclusion of dialysis

Concealed from view with clothing

Permits comfortable arm position during dialysis

No needles required

Use of Central Venous Hemodialysis Catheters

As a temporary vascular access

- acute renal failure
- awaiting peritoneal dialysis catheter maturation
- awaiting transplantation

As a backup vascular access

- failure of vascular access
- dialysis access graft revision or replacement
- removal of peritoneal catheter

Bridge access to allow time for maturation of permanent access

- native fistula
- PTFE graft

Permanent vascular access

- Severe peripheral vascular disease
- Severe Heart Failure – cardiorenal syndrome
- Morbid obesity

Tunneled cuffed venous catheters have been shown to have the following advantages, relative to other access types:

1. They are universally applicable.

2. They can be inserted into multiple sites relatively easily.

3. No maturation time is needed, ie, they can be used immediately.

4. Skin puncture not required for repeated vascular access for HD.

Tunneled cuffed venous catheters have been shown to have the following advantages, relative to other access types

5.They do not have short-term hemodynamic consequences, eg, there are no changes in cardiac output or myocardial load.

6.They have lower initial costs and replacement costs.

7.They possess the ability to provide access during a period of months, permitting fistula maturation in patients who require immediate HD.

Tunneled cuffed venous catheters possess the following **disadvantages** relative to other access types:

1. High morbidity caused by:
   - Thrombosis
   - Infection.
2. Risk for permanent central venous stenosis or occlusion.
3. Discomfort and cosmetic disadvantage of an external appliance.
4. Shorter expected use-life than other access types.
5. Overall lower Blood Flow Rates, requiring longer dialysis times.

Tunneled Cuffed Catheter Placement

Patient selection

Tunneled cuffed venous catheters are the method of choice for temporary access of longer than 3 weeks duration

Patients who have exhausted all other access options

Patients with severe peripheral vascular insufficiency

Patients with severe heart failure

Patients with morbid obesity

Tunneled Cuffed Catheter Placement : what is important ?

The preferred insertion site for tunneled cuffed venous dialysis catheters is the right internal jugular vein

Tunneled cuffed catheters should not be placed on the same side as a maturing AV access

Fluoroscopy is mandatory for insertion of all cuffed dialysis catheters

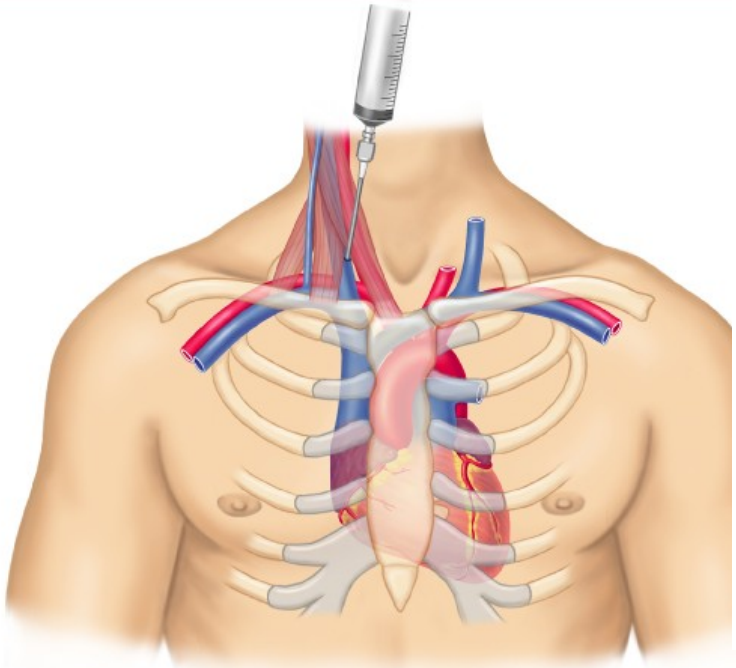
Tunneled Cuffed Catheter Placement : what is important ?

The catheter tip should be adjusted to the caval atrial junction or into the right atrium to ensure optimal blood flow.

Atrial positioning is only recommended for catheters composed of soft compliant material, such as silicone.

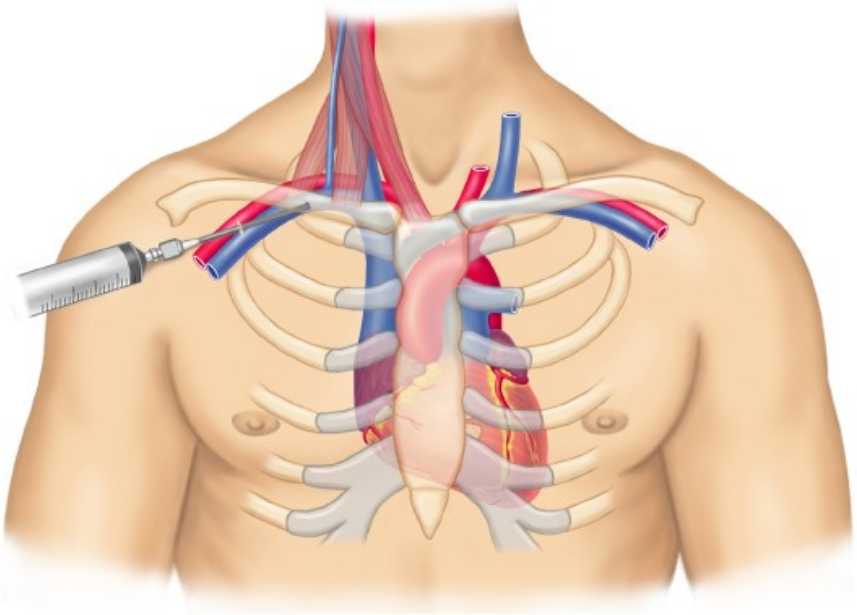
Real-time ultrasound -guided insertion is recommended to reduce insertion-related complications

Central approach to the internal jugular vein



The central approach to cannulation of the internal jugular vein is most common. Insert the needle at the apex of the angle formed by the two heads of the sternocleidomastoid, lateral to the carotid artery pulsation, at an angle approximately 30 degrees from the skin. Direct the needle towards the ipsilateral nipple. Blood is usually aspirated within 2.5 cm of insertion. If blood is not aspirated while advancing, slowly withdraw the needle. Aspiration often occurs as the needle is pulled back.

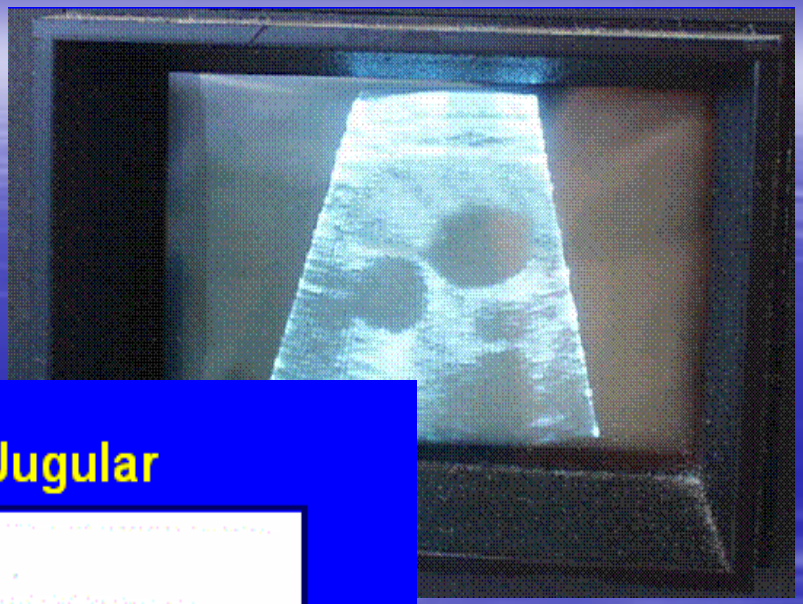
Infraclavicular approach to the subclavian vein



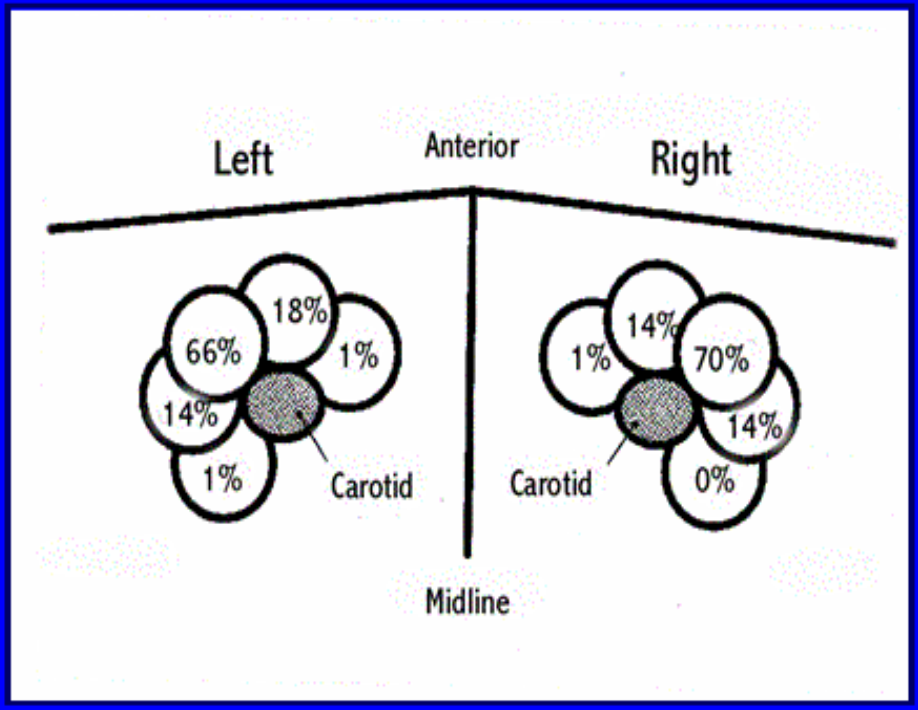
The midpoint approach to cannulation of the subclavian vein is most common. Insert the needle 2 to 3 cm inferior to the midpoint of the clavicle. Advance the needle aiming just deep to the suprasternal notch, keeping the needle parallel to the ground.

Important

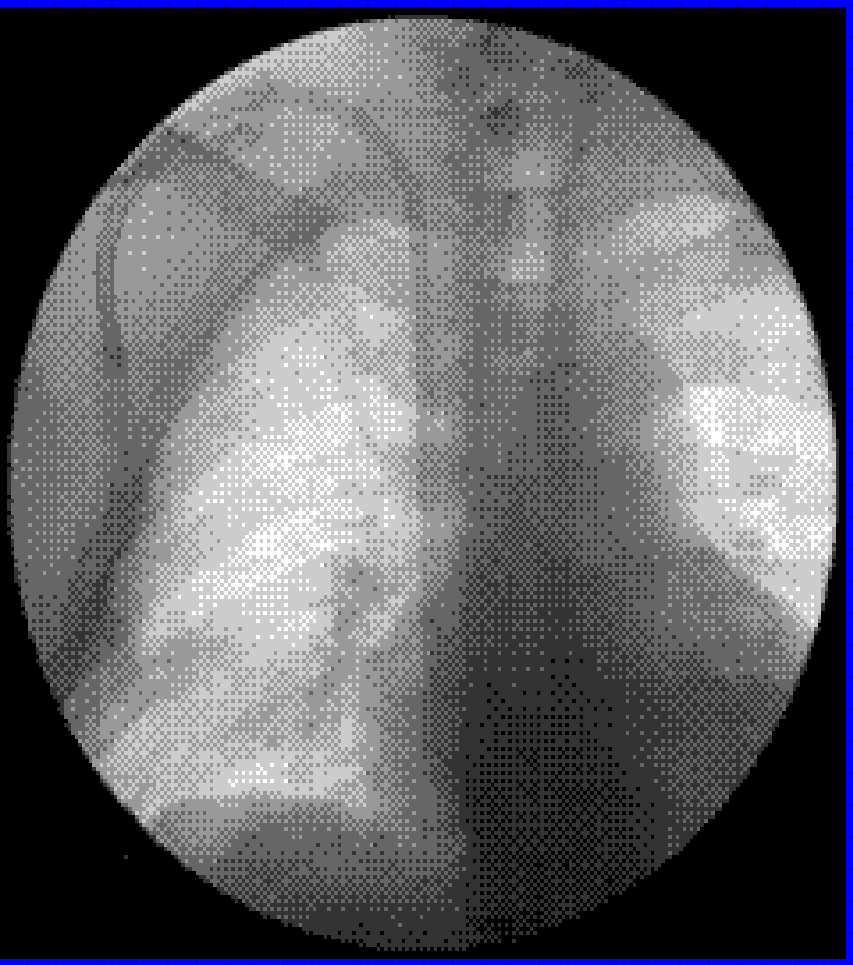
- Blind cannulations should not be routinely done
- Ultrasound guided cannulation should be mandatory



Location of Internal Jugular



Catheter Placement



- Right internal jugular
  - Lowest risk of central venous stenosis
    0 – 10% vs 40 – 50% for subclavian
  - Lower puncture–related complications
    Especially with ultrasound guidance

By far the preferred site

Alternative placement sites

Left internal jugular

- higher incidence of flow problems
- higher risk for stenosis

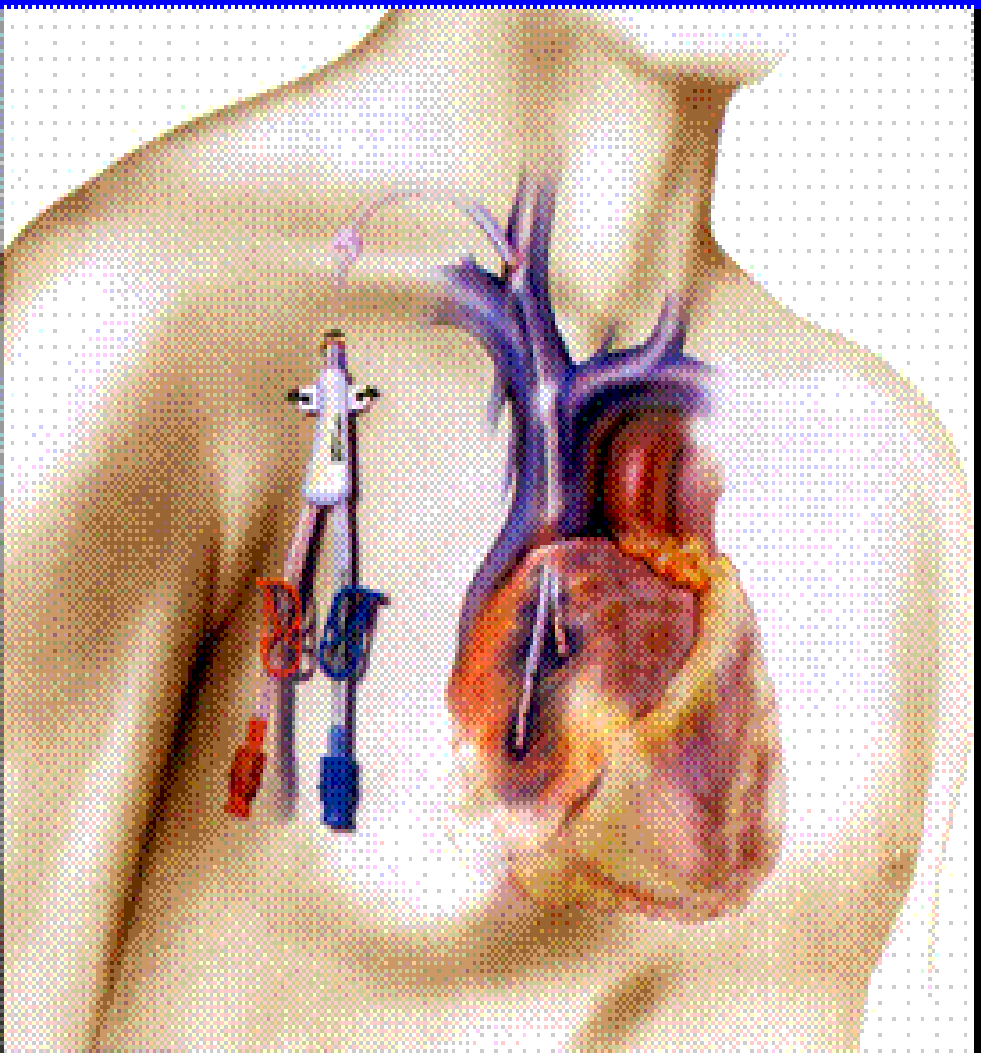
Inferior vena cava

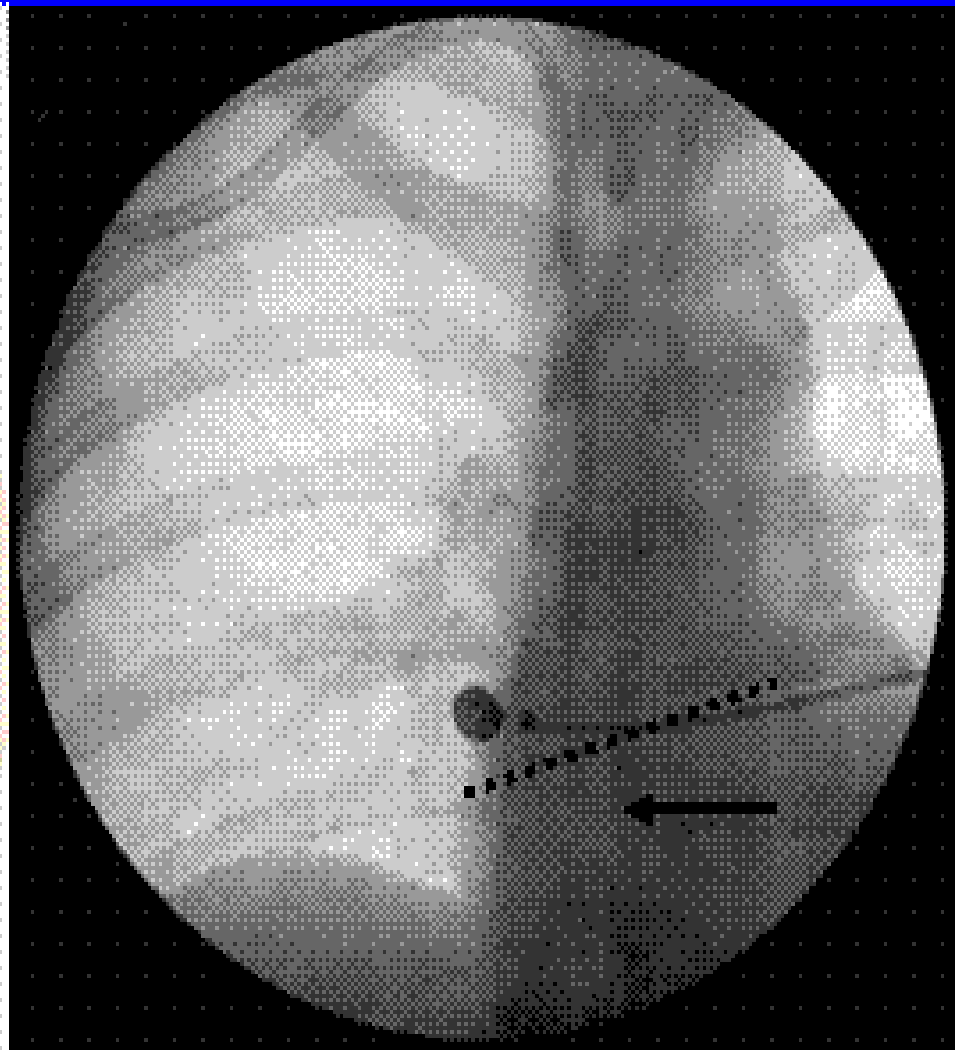
- femoral approach is the best alternative
- translumbar route

Subclavian

- high risk for stenosis
- acceptable only if no further arm access planned

Optimum Catheter Tip Position





Complications of tunneled-cuffed Catheters

1. Complications related to placement

2. Catheter flow problems

    early : malposition

    late : thrombosis

3. Catheter related infections

    local infection

    systemic infection

Complications of tunneled-cuffed Catheters

1.Complications related to placement

air embolism

bacteremia

sepsis

cardiac arrhythmias, cardiac tamponade

central vein stenosis

pneumothorax

hemothorax

arterial puncture, hematoma formation

hemomediastinum

thrombosis

Complications of tunneled-cuffed Catheters

2.catheter flow problems

early : malposition

differential diagnosis of immediate flow problems

kink : usually at apex of loop

tip malposition - too high/low

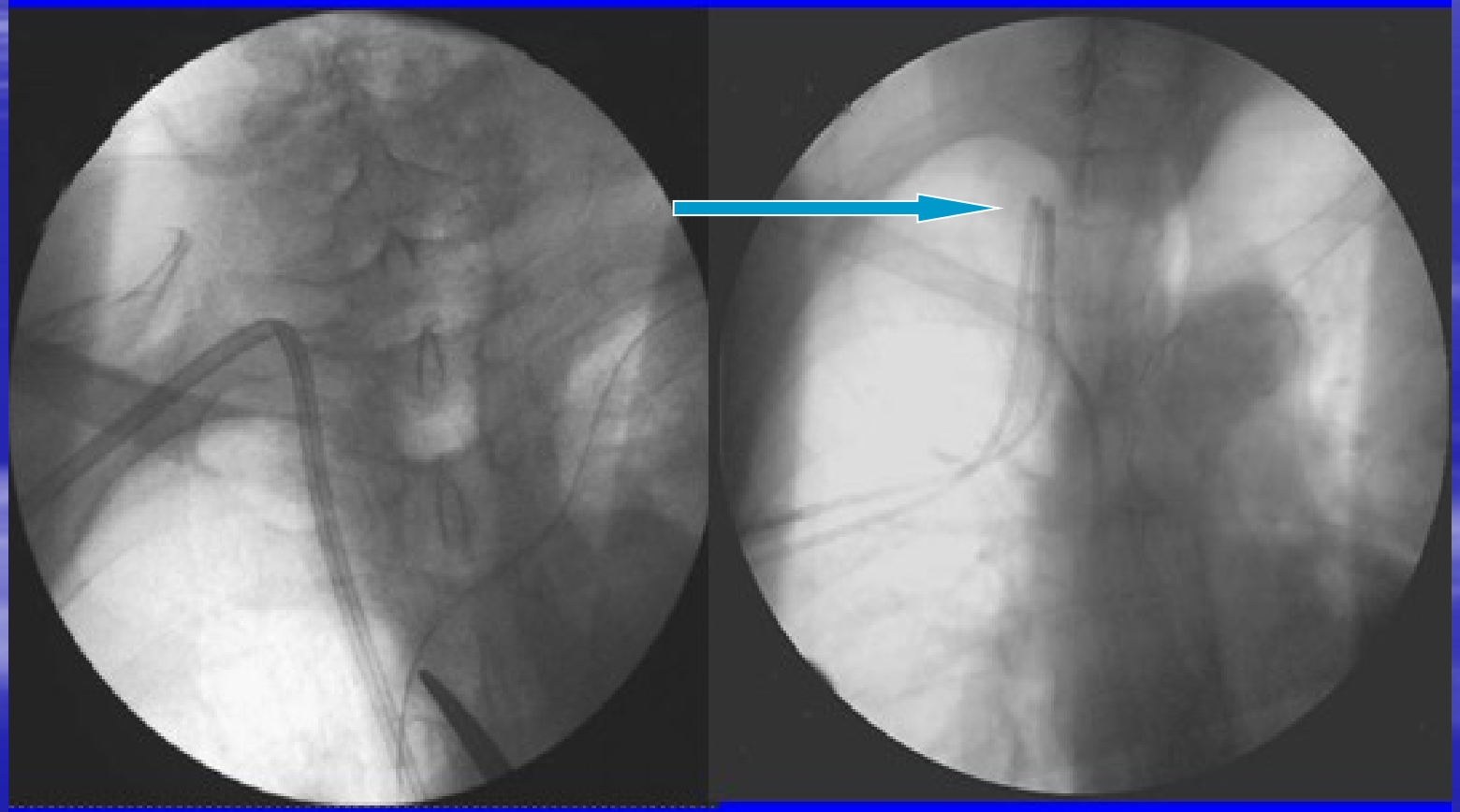
tip malorientation – arterial against the wall

tight suture

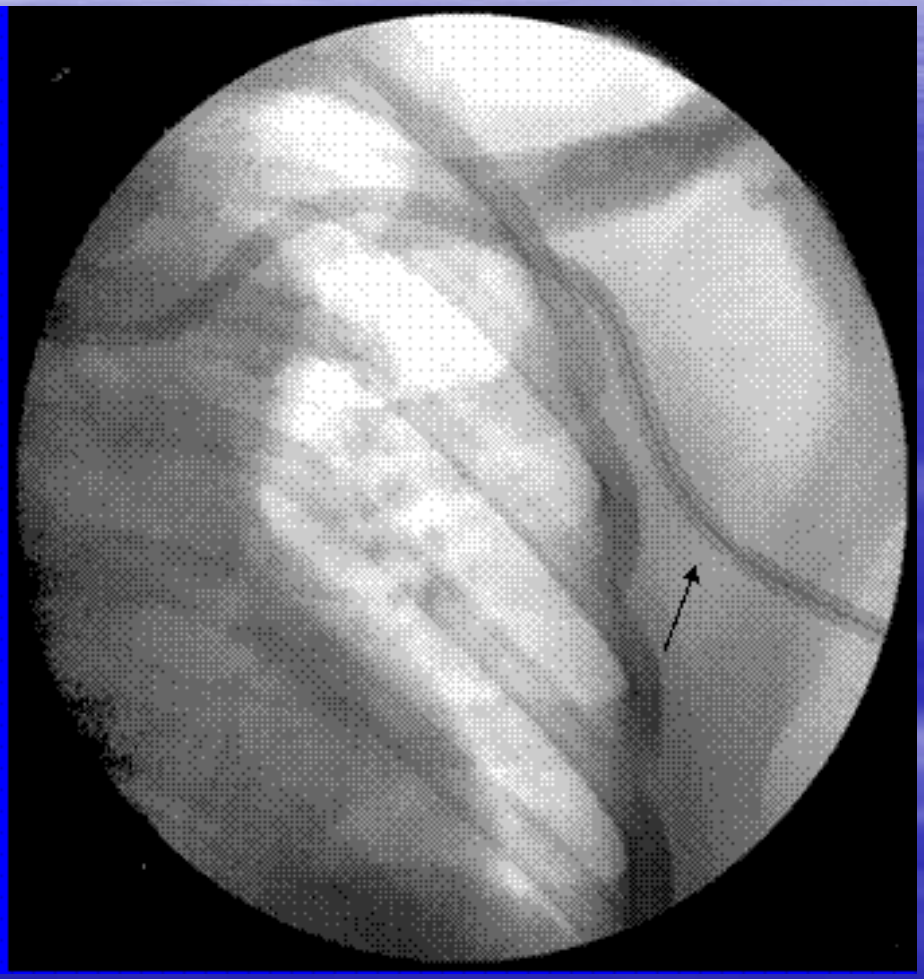
tip in wrong vessel : azygos

late : thrombosis

Kinked Catheter



Suture too tight subclavian vein



Complications of tunneled-cuffed Catheters

2.catheter flow problems

late :

thrombosis

fibrin sheath formation

Catheter fibrous sheating is still a major problem

How to prevent this

New types of catheters : The CENTROS CATHETER

chemical impregnation of the catheters

cfr drug eluting stents

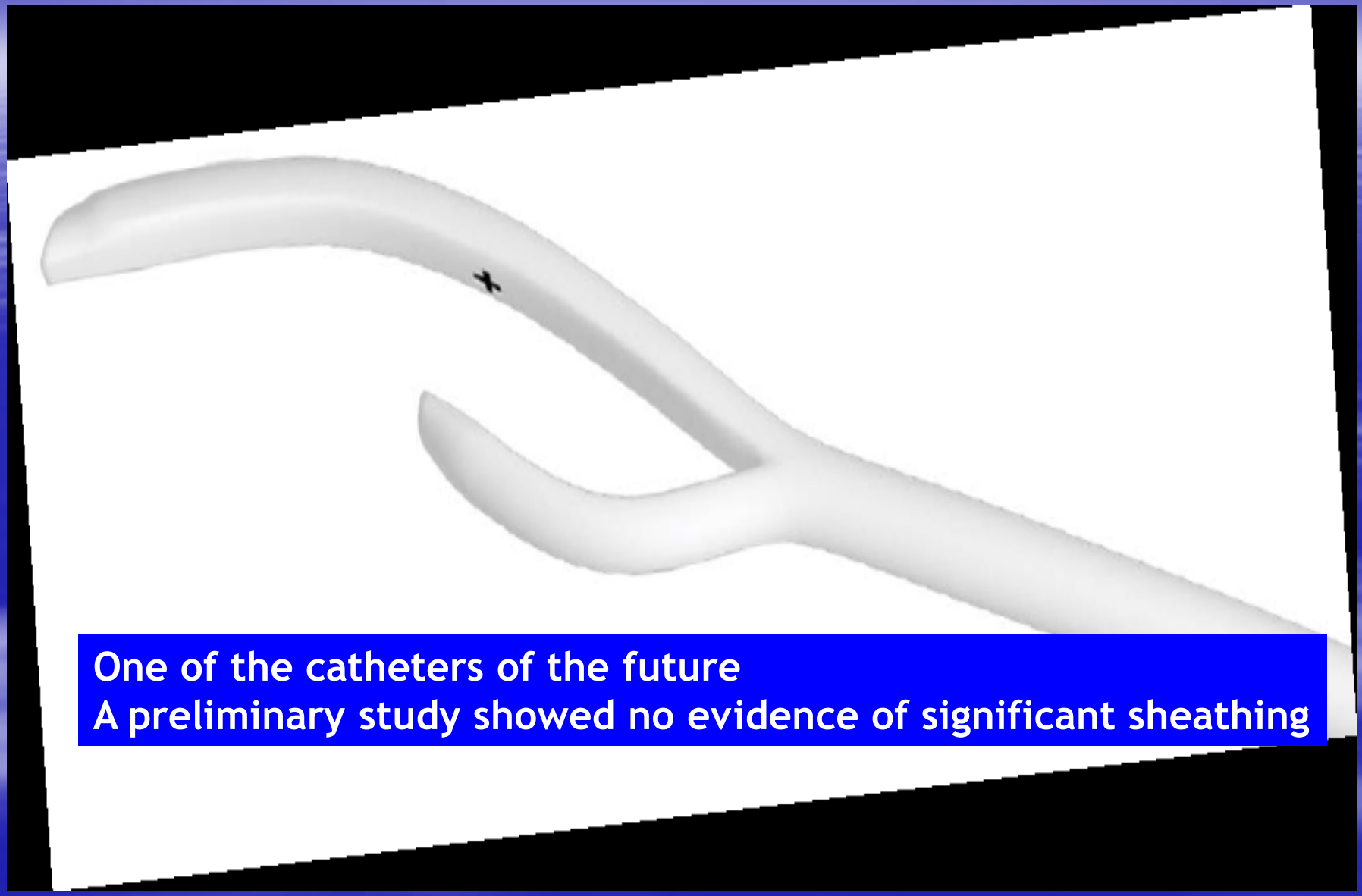
Very difficult to prevent : the irritation of the vein is a very strong stimulus for sheath formation

New catheters that can close the tip allowing the catheter to retain the anticoagulant between tow dialysis sessions

Late Flow Problems

- Fibrin sheath is major problem – stripping
- Thrombosis- tPA of limited value

Fibrin Sheath



One of the catheters of the future
A preliminary study showed no evidence of significant sheathing

Complications of tunneled-cuffed Catheters

3. Catheter related infections

local infection : exit site infection

tunnel infection

systemic infection : **CRBSI**

catheter related blood stream infections

DEFINITIONS

*Exit site infection (ESI)

* Exudate at catheter exit site yields a microorganism

* erythema, induration, and / or tenderness within 1-2 cm of the catheter exit site.

* Signs and symptoms of infection (fever, pus)

* Concomitant bloodstream infection

* Less frequently confirmed by catheter tip, blood or exit site cultures

* ESIs have been associated with early catheter removal and an increased risk of bacteremia

DEFINITIONS

- *Tunnel infection*
-

  + Erythema, and/or tenderness > 2 cm from the exit site, along the tract of the tunneled catheter.

  + Concomitant bloodstream infection

  + Less frequently confirmed by catheter tip, blood or exit site cultures

Treatment Exit Site Infection / Tunnel Infection

* Loss of a central venous site should be avoided

* Appropriate IV antibiotics

* Removal of a nontunneled catheter

* Change of the tunneled catheter over wire with creation of a new tunnel

* Avoid occlusive dressings at exit sites

CRBSI

Catheter related blood stream infections

Epidemiology

*Incidence of dialysis catheter related bacteremia is reported to be 2.5 – 5.5 cases per 1.000 catheter days

*Increased relative risk of bacteremia in patients with Central Venous Catheters (CVC) compared with patients with A-V fistulas (AVF)

*50 % higher adjusted risk of mortality compared with use of AV-Fistulae

Am J Kidney Dis 2004, 44: 779-791

Am j Infect Control 2004, 32: 155-160

J Am Soc Nephrol 16: 1449-1455

PROBLEM / PATHOGENESIS

15 million CVC are inserted each year in the USA

More than 200.000 nosocomial bloodstream infections occur each year in the United States.

Nontunneled CVC infection is often related to

*extraluminal colonization of the catheter originates from the skin and, less commonly, from hematogenous seeding of the catheter tip

*intraluminal colonization of the hub and lumen of the CVC

Tunneled CVCs or implantable devices

*contamination of the catheter hub and intraluminal infection is the most common route of infection

Pathogenesis

Important pathogenic determinants of catheter-related infection are

1.The material of wich the device is made

polyvinylchloride

polyethylene

less resistant to the adherence of microorganisms than catheters made of

Teflon

silicone elastomer

polyurethane

2.The intrinsic virulence factors of the infecting organisms

Risk factors for CRBSI

catheter related blood stream infections

*site of catheter

*duration of catheter

*previous bacteremia

*S.aureus nasal carriage

*Tunneled versus Non-tunneled

*older age

*lower hemoglobin

*lower serum albumin

*diabetes mellitus

*intravenous iron

*peripheral atherosclerosis

*recent hospitalizations or surgery

How to prevent haemodialysis catheter related blood stream infections

1. Catheter insertion and position

2. Strict hygienic measures

3. Antimicrobial / antiseptic impregnated catheters and cuffs

4. Antimicrobial lock solutions

5. exit site dressing

6. Antibiotic ointments

Antimicrobial / antiseptic impregnated catheters and cuffs

Chlorhexidine/sliver sulfadiazine

Minocycline / rifampin

- multicenter randomized trial
- lower rates of CRBSI

Platinum / silver

- ionic metals have broad antimicrobial activity
- are being used in catheters and cuffs to prevent CRBSI

Silver cuffs

There is increasing evidence that

Certain antimicrobial locks applied within the catheter

Are effective in preventing catheter-related BSI

What is the rationale for the antibiotic lock

- some locks have extra antimicronial or biofilm removing properties

- e.g. citrate

In contrast with heparin that even tends to antagonize the bactericidal properties of certain antibiotics

Annals of internal medicine

15 april 2008 / volume 148 Issue 8 / pages 596-605

Meta-analysis : antibiotics for prophylaxis against hemodialysis catheter-related infections

Conclusion: Both topical and intraluminal antibiotics reduce the rate of bacteremia as well as the need for catheter removal secondary to complications.

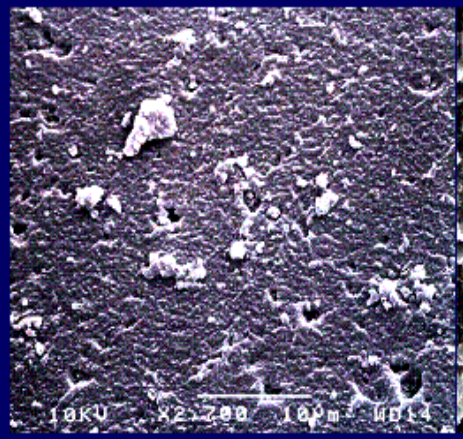
16 randomized trials

Most trials were short in duration and were not blinded

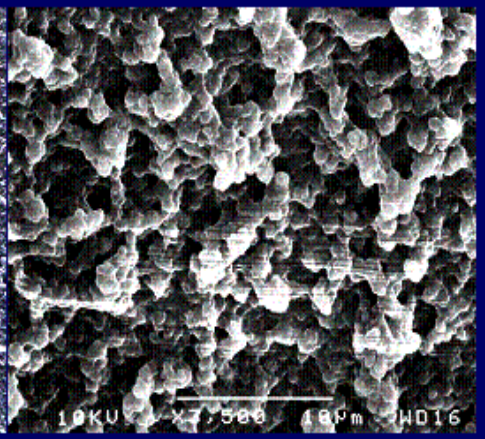
Rationale for antibiotic lock

- Bacterial biofilm develops within 24 hours in all indwelling catheters, and is the source of catheter-related bacteremia.
- IV antibiotics do not eradicate the biofilm.
- Instillation of a highly concentrated antibiotic (~100X plasma conc) eradicates catheter biofilms *in vitro*.

New catheter



Catheter with biofilm



The clinical advantages offered by CITRATE have been confirmed in several meta-analyses

Over time progressively lower concentrations of citrate have been used

from 46,7 % to 4 %

One potential draw back : spilling during injection and between dialyses.

arrhythmia
toxicity
allergic reactions

Catheter-lock solutions

Dogra et al.

Heparin vs; Gentamycine/citrate (40 mg/ml, 3.13 % citrate),
112 TCD catheters

	mean infection free catheter survival	incidence of CRB /1000 cath days
Treatment	282 days	0.3
Control	181 days	4.2

J Am Soc Nephrol 2002; 13: 2133-2139

Catheter-lock solutions

Saxena et al.

cefotaxime 10 mg/ml with 5000 units heparin,

1 year study period

	prevalence catheter infection (/1000 cath days)	catheter related mortality (/year)
Treatment	0.55	4.47 %
Control	1.99	7.5 %

How to prevent haemodialysis catheter related blood stream infections

1. Catheter insertion and position

2. Strict hygienic measures

3. Antimicrobial / antiseptic impregnated catheters and cuffs

4. Antimicrobial lock solutions

5. exit site dressing

6. Antibiotic ointments : STOP after healing of the insertion site

Treatment CRBSI

* Empirical systemic antibiotics

  consider local pathogen prevalence to cover both grampositive and gramnegative

* Length of antibiotic tratment

  + uncomplicated 10-14 days

  + 4-6 weeks for persistent bacteremia, endocarditis or septic thrombosis

  + 6-8 weeks for the treatment of osteomyelitis

Removal of the catheter

European Best Practice Guidelines

Nephrology Dialysis and Transplantation

2010 june 25th

Vanholder et al

Removal of the catheter should be considered as an additional intervention to systemic antibiotic treatment

1. in severe complications
   - severe sepsis
   - suppurative thrombophlebitis
   - metastatic infection

2. Persistent blood stream infection or persistent clinical signs of infection in spite of 48-72 h of appropriate antibiotic therapy

3. Infection with Staphylococcus aureus, Pseudomonas aeruginosa,multi-resistant organisms or fungi.

Removal of the catheter

European Best Practice Guidelines
Nephrology Dialysis and Transplantation
2010 june 25th
Vanholder et al

Removal of the catheter should be considered as an additional intervention to systemic antibiotic treatment continued..

4.Tunnel infection with fever

5. Exit site infection if systemic antibiotic therapy fails

Catheter removal or not ?

Authors of several series have suggested that a significant number of catheters can be salvaged assuming

- the catheter is functioning properly
- exit site is not infected
- tunnel tract is not infected

One study in NDT 13 episodes of catheter-related sepsis

- all patients were succesfully treated with vanco or ciproxine systemically and “locked”
- fever subsided within 48 hours
- no catheter removal

Data from larger studies

- lower succes rate
- 25 to 33 percent of catheters salvaged
- *Marr et al Ann Intern Med 1997; 127:275*

Treatment of CRBSI

Catheter exchange

the low succes rate of the antibiotic salvage trial and the observation of no increased risk of metastatic infection with attempted salvage prompted the initiation of several studies evaluating the effectiveness of guidewire catheter exchange.

Rationale for this technique

based upon the hypothesis that bacteria adherent to the catheter are responsible for the failure of the antibiotic therapy

patients were selected for this exchange only if they met

with the following criteria

*afebrile after 48 hours of antibiotherapy

* clinically stable

* no evidence of tunnel tract involvement

* normalization of C-reactive protein (CRP)

Catheter exchange continued…

In these studies roughly 50 % of the initially enrolled pts required catheter removal

Infection-free catheter survival was observed in more than 90 and 80 % of patients at 45 and 90 days

This approach has been less successful in clearing infection caused by highly adherent species (S.aureus, enterococcus Spp)

High success rate was observed even among those with evidence of tunnel or exit site infection

among 28 pts exchange over a guidewire with creation of a new tunnel

was associated with a cure rate of 75 %

Beathard et al J Am Soc Nephrol 1999; 10: 1045

Treatment recommendations

The efficacy and safety of catheter "salvage" and the optimal duration of antibiotic therapy have yet to be defined.

- Whenever possible, catheters should be removed when catheter-associated bacteremia is recognized
- All non-cuffed catheters should be removed in the presence of bacteremia
- Catheter removal is recommended if follow-up blood cultures remain positive for more than five days despite appropriate antimicrobial therapy
- Infected catheters that have signs of accompanying exit-site or tunnel infection (erythema or pus at the exit-site) should be removed and cultured.
- The catheter should also be removed if it is infected with Candida or if an infected clot appears to be present
- An infected clot should be suspected if infusing or drawing blood through the line is difficult or associated with rigors

I HAVE A DREAM ….. (M.L.King)

That one day CVC will be a effective and safe longterm access for our dialysis patients

That thanks to new catheter materials and designs , new impregnation methods and bacterial lock solutions the incidence of catheter related BSI will go down significantly

That we will be able to avoid catheter clotting and fibrous sheating formation

And do the other things … (J.F.Kennedy inauguration speech)

But finally let us not forget : **FISTULA FIRST !**

THANK YOU SO MUCH FOR LISTENING !