

Prevention and treatment of catheter occlusion, News from the bedside



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CONFLICTS OF INTEREST : NONE

AT THE BEGINNING
THERE IS
A CATHETER
MALFUNCTION:

WHAT IS A CATHETER MALFUNCTION?

- Impossible or difficult injection/ Gravity flow rate doesn't meet our need
- Impossible or difficult aspiration that doesn't allow blood sampling

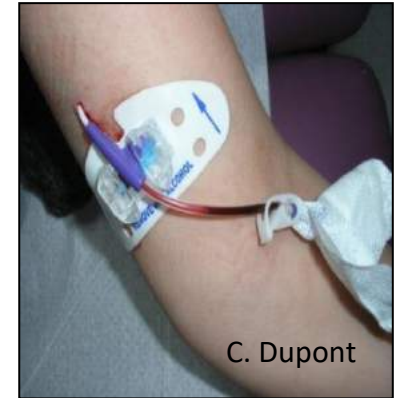
Difficult injection **WITH RESISTANCE** and no blood return
AND the colleague still used the port catheter **UNTIL IT**
WAS TOTALLY BLOCKED



WHERE IS THE PROBLEM LOCATED?

IS IT INTRALUMINAL?

Is it a blood clot?
Blood clot definition= A coagulum



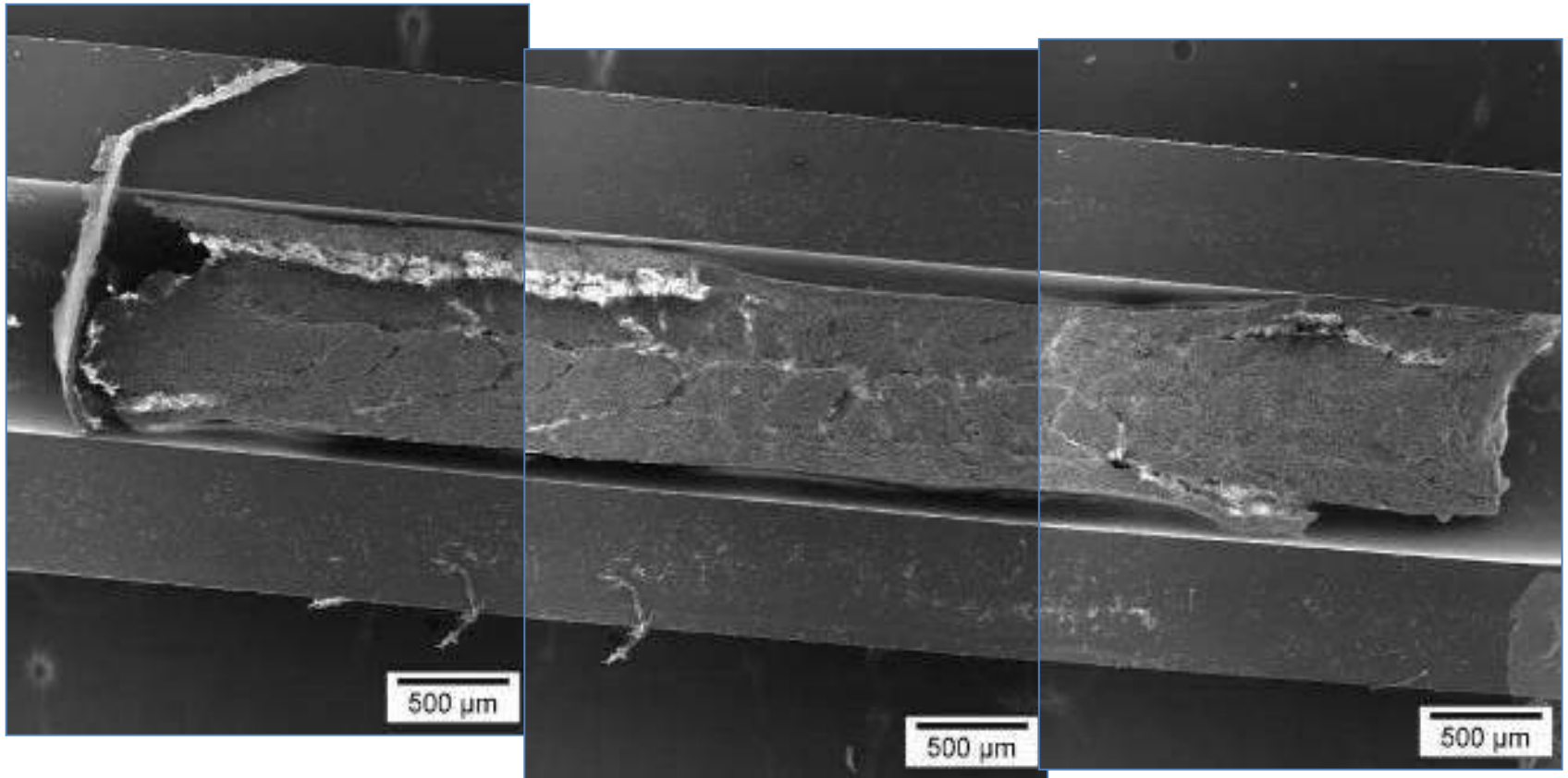
≠ thrombus (occurs exclusively inside a blood vessel).

≠ Precipitate

≠ Drug deposit

≠ Inert material

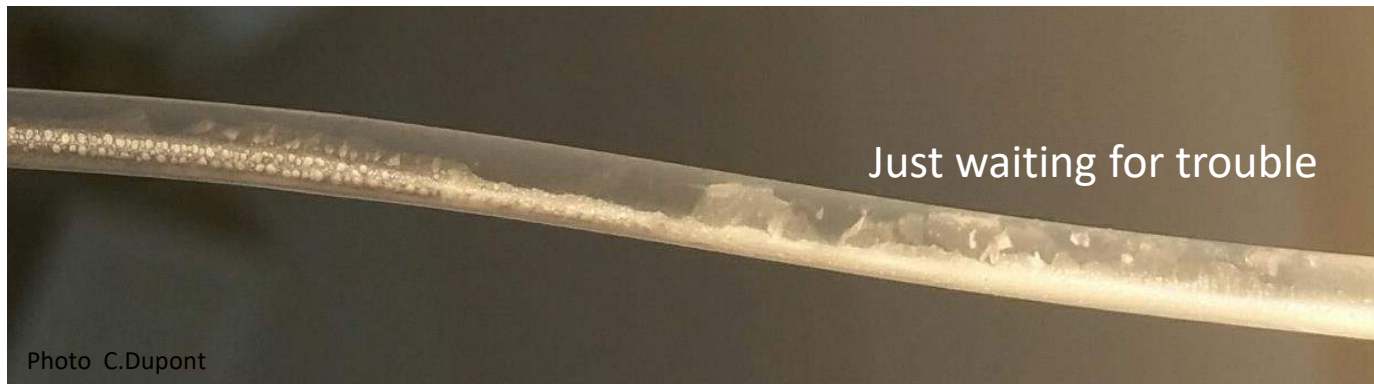
WHAT DO WE KNOW ABOUT THE BLOOD CLOT?



PREVENTION IS PARAMOUNT!

FLUSHING:

Injection of a liquid in order to remove drugs and other substances sticking on the inner catheter wall



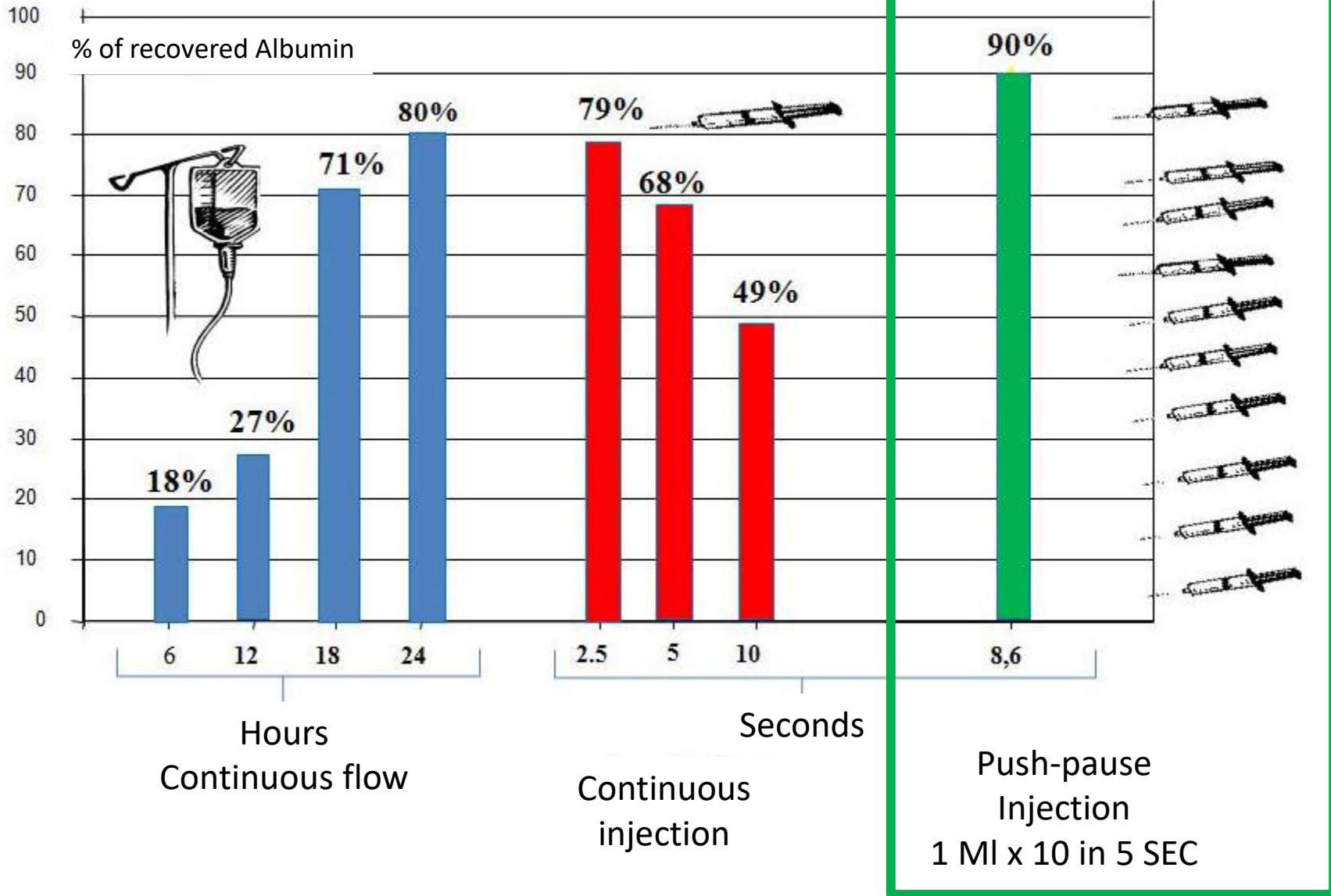
RINSING:

Injecting a fluid to eliminate a drug product or biological content in catheter

LOCKING:

Filling the catheter with a fluid in order to prevent or limit blood reflux in the catheter between 2 uses

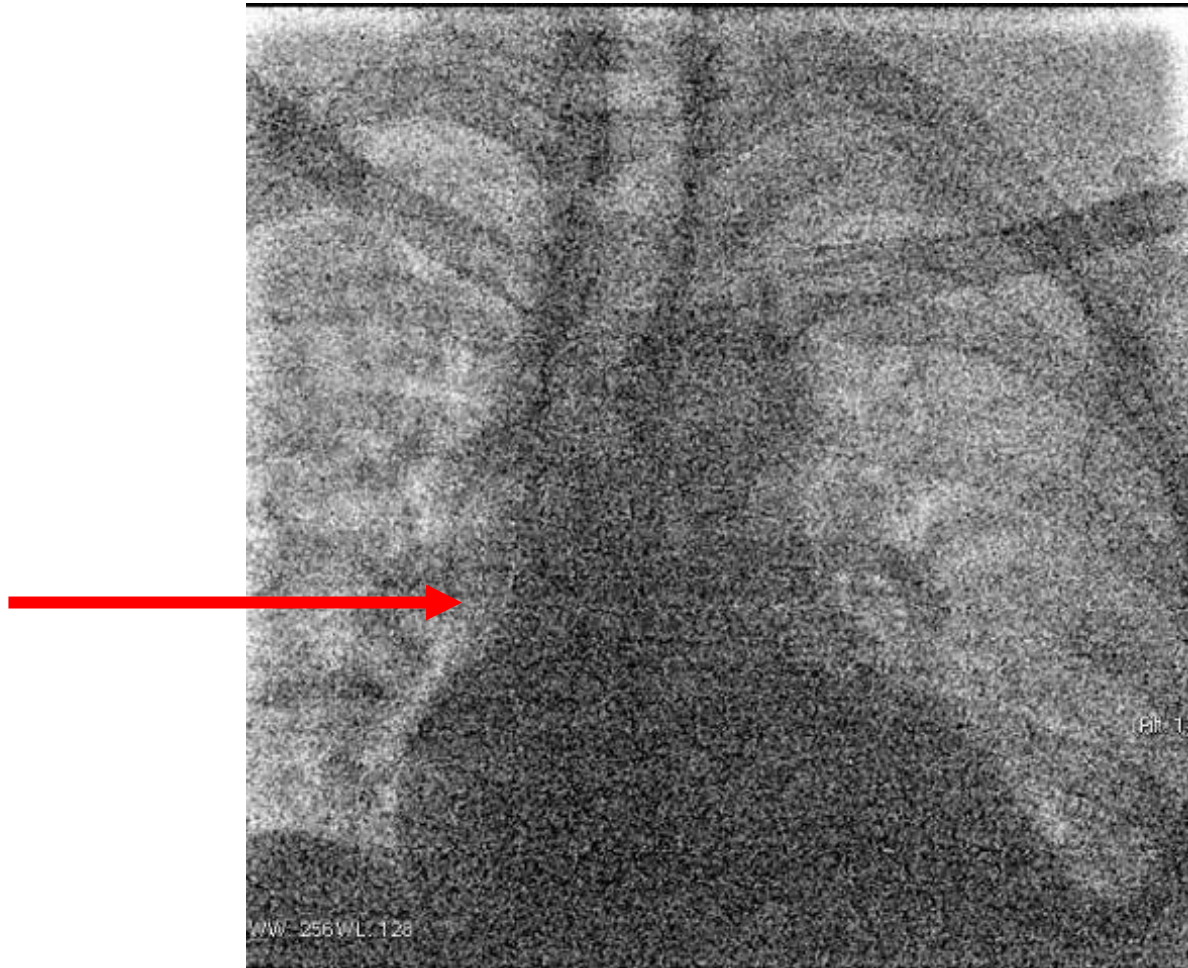
PREVENTION: FLUSHING



Flushing of intravascular access devices (IVADs) - efficacy of pulsed and continuous infusions. Merckx J. and Guiffant G.

J Vasc Access. 2012 Jan-Mar;13(1):75-8..

Consequences of non efficient communication



EVIDENCE BASED PRACTICE

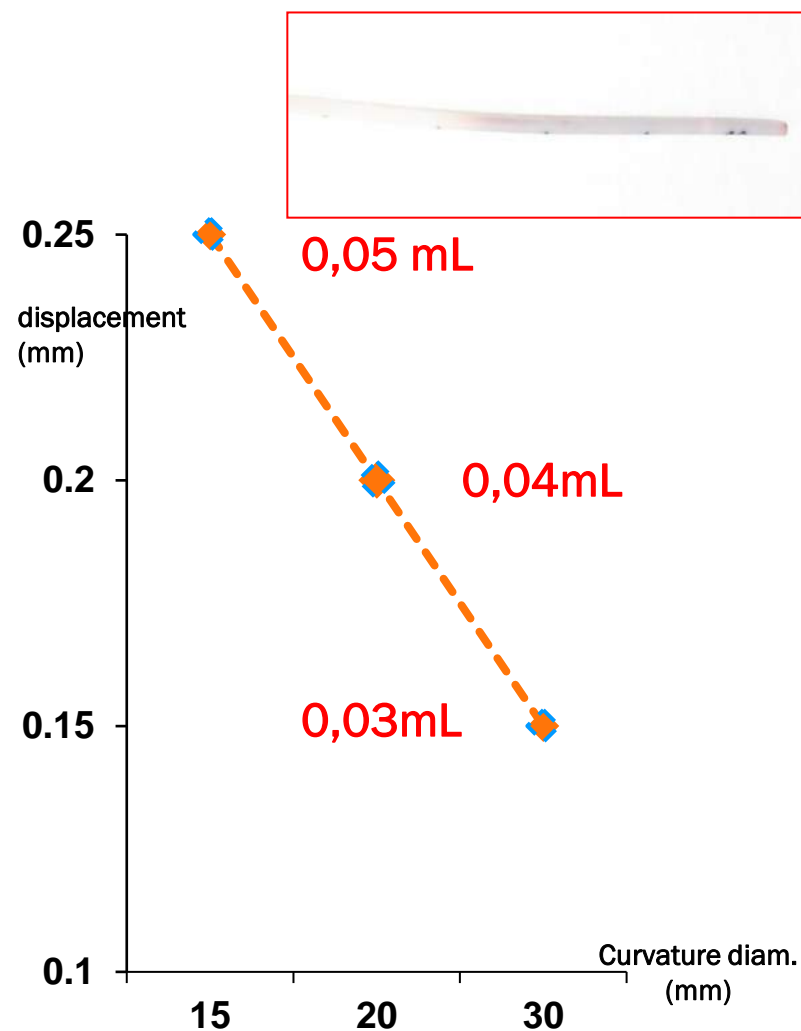
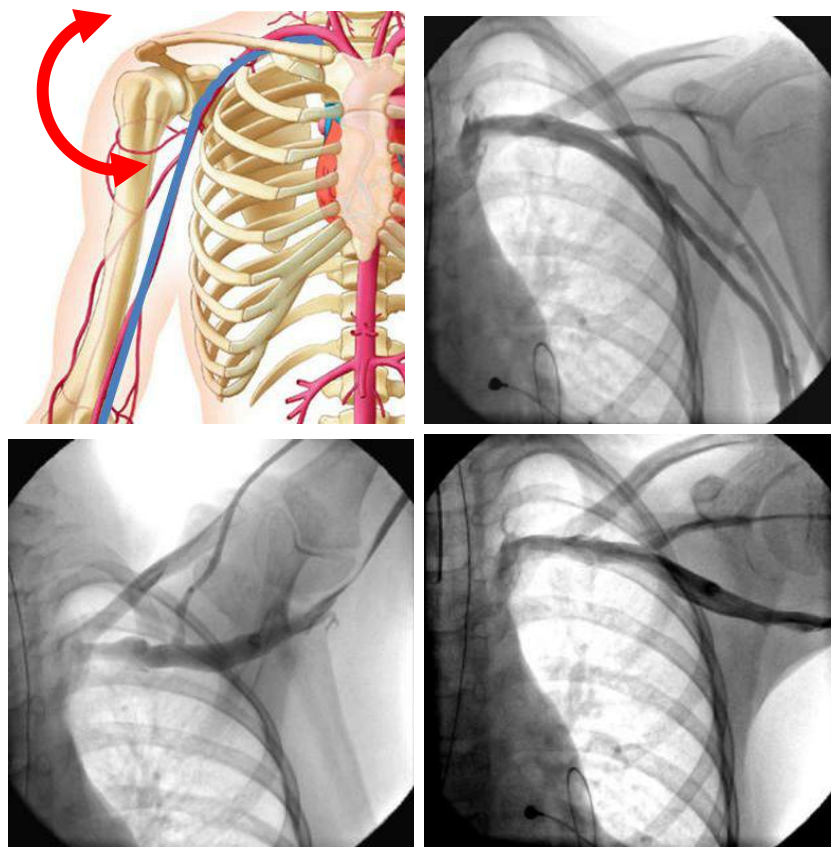


PREVENTION: LOCKING



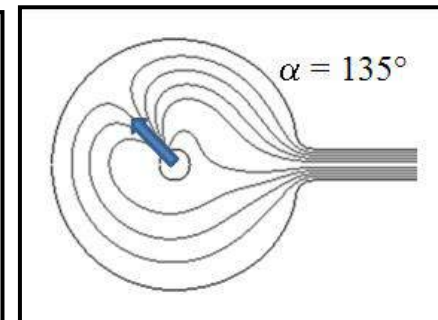
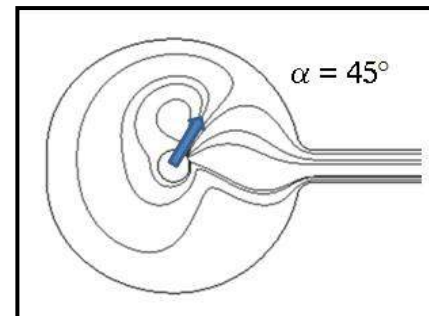
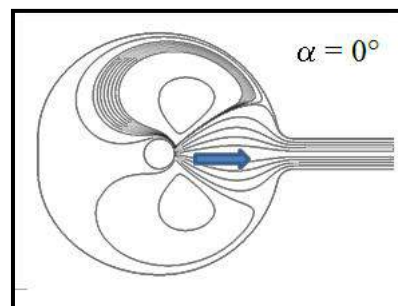
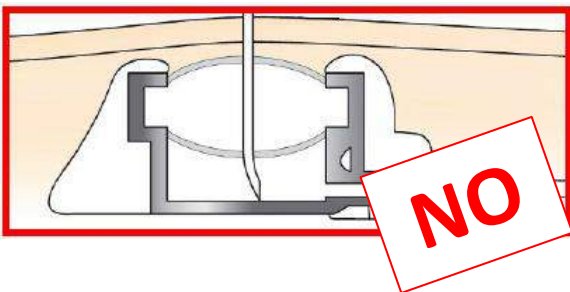
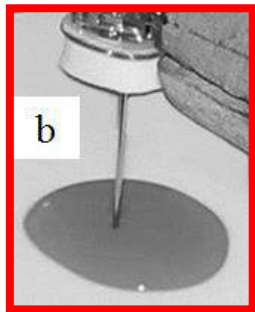
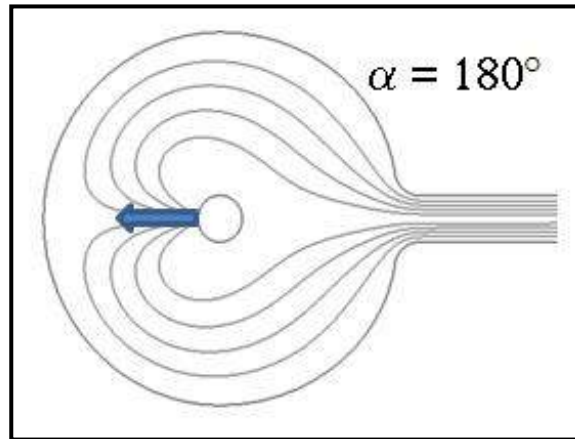
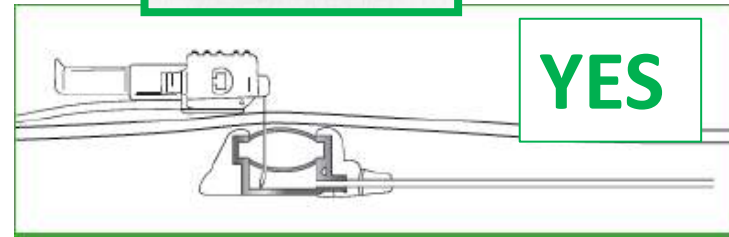
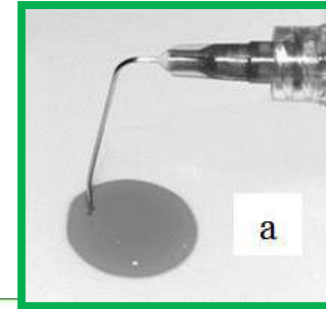
C. Dupont

The effect of positive pressure when locking a PICC/Mid line doesn't last



Incidence of the Curvature of a Catheter on the Variations of the Inner Volume: Application to the Peripherally Inserted Central Catheters. G. Guiffant et al.
ISRN Vascular Medicine Volume 2012 (2012)

THE ORIENTATION OF THE BEVEL IN THE PORT CHAMBER AFFECTS FLUSHING EFFICACY



Flow lines Recirculation ==> trap

Flushing ports of totally implantable venous access devices, and impact of the Huber point needle bevel orientation: experimental tests and numerical computation. G. Guiffant et al.

Medical Devices. 2012; 5: 31–37

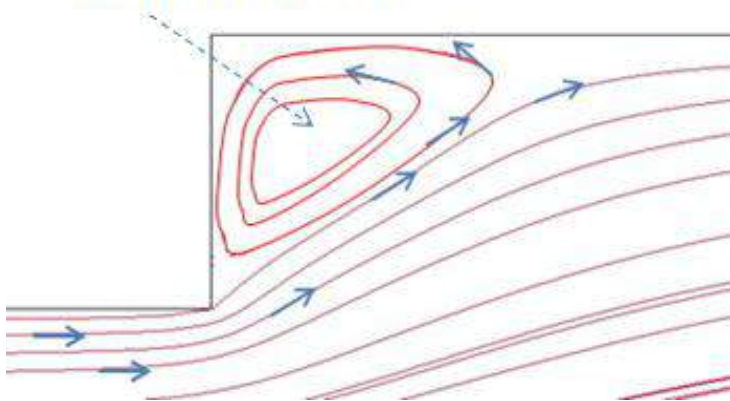
Impact of the shape of the needle tip of implantable ports on the efficiency of the flow (injection and flushing). Guiffant G., Dupont C., Merckx J.

Medical Devices 2014;7 : 319-324

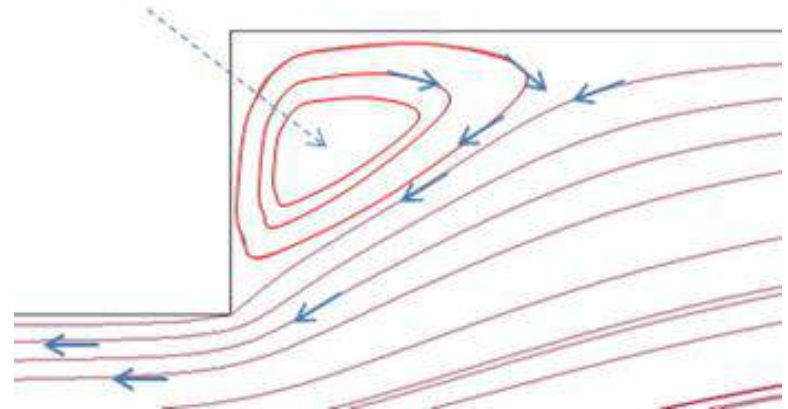
THE SHAPE OF THE PORT CHAMBER IMPACTS FLUSHING EFFICACY

Spherical Port chambers are easier to flush

Recirculation zone



Recirculation zone



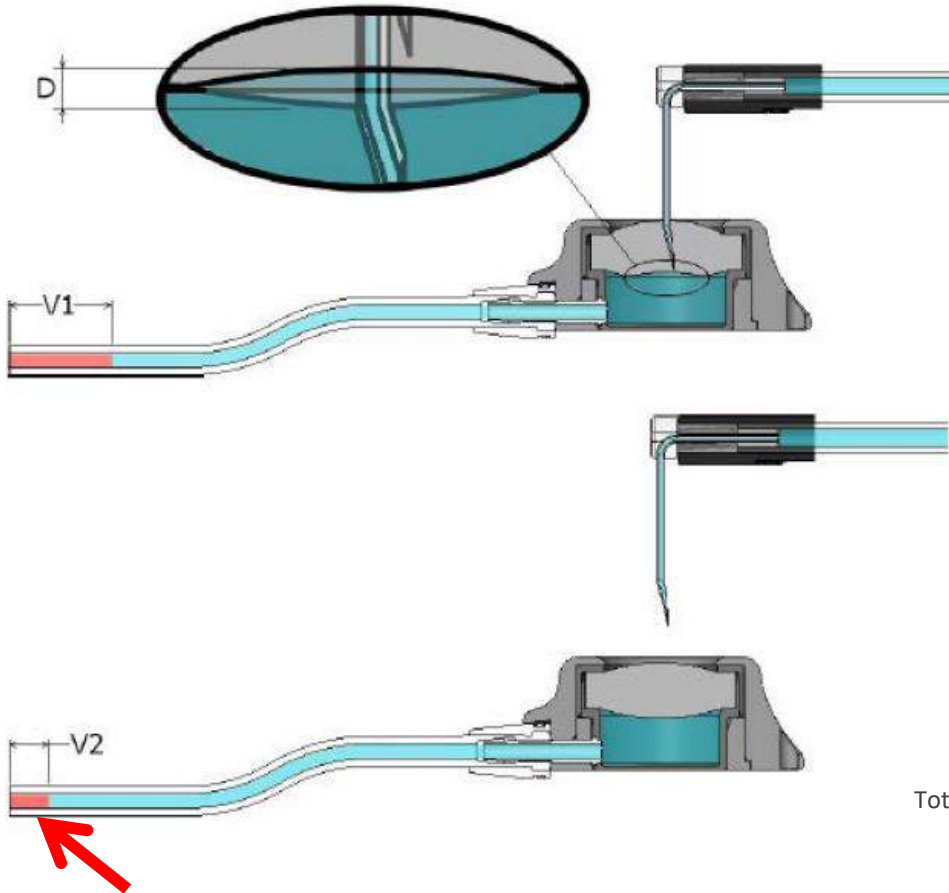
Flushing ports of totally implantable venous access devices, and impact of the Huber point needle bevel orientation: experimental tests and numerical computation. G. Guiffant et al.

Med Devices (Auckl). 2012; 5: 31-37.

POSITIVE PRESSURE PREVENTS BLOOD ASPIRATION AT THE TIP OF THE CATHETER

Classical technique of withdrawing Huber needles (without positive pressure)

« Suction » effect : blood return phenomenon

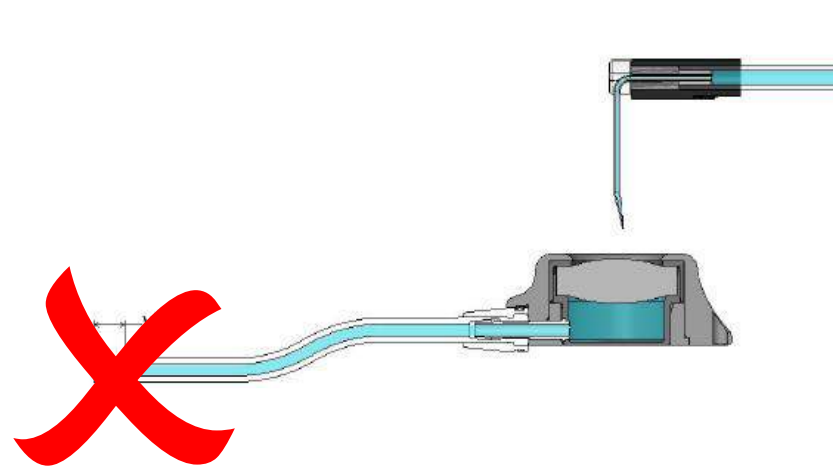


The beginning of the withdrawal raises the septum -> blood reflux at the tip of the catheter: V_1

At the end of the withdrawal, the septum returns to its initial position

Totally implantable port management: impact of positive pressure during needle withdrawal on catheter tip occlusion (an experimental study). Lapalu L. et al
JVA 2010; 11:46-51

A residue of blood persists in the catheter tip (V2)



Totally implantable port management: impact of positive pressure during needle withdrawal on catheter tip occlusion (an experimental study).
 Lapalu L . et al
 JVA 2010; 11:46-51

COLLABORATION WITH CHEMISTS IS PREVENTION!

FUROSEMIDE



G5%



AND IN DAILY PRACTICE?

With intermittent or continuous use of I.V. line:

- Systematic flushing after each injection

-> Increase flushing solution volumes if necessary (after blood withdrawal, transfusions, parenteral nutrition, vesicant drugs)

With continuously infused I.V. line and If systematic flushing after each injection is problematic:

- Use the fluid volume separator effect
- Flush the catheter once a day at the most proximal access point

In any case:

- Make a list of incompatible medications available on the unit
- never use Heparin to prevent or to treat intraluminal occlusion
- Because of its high viscosity, Contrast media injection in a Port is not recommended
 - Use power injectable polyurethane catheters
- Use neutral or positive displacement needle free connectors before disconnecting catheters with no clamp
 - Change the non coring needle every 7 days and use only 20 and 22 G needles
 - Change the I.V. line every 4 days

PREVENTION: INFUSION TEAM



WHAT ELSE?



AT THE BEGINNING
IS
A CATHETER MALFUNCTION:

100% blocked

What can I do?



- Is it a « clot »?
- Is it a blood clot?
- Where is it located?
- How long **has it been** here?



How much do we know about the problem when we face it?

IN DAILY PRACTICE

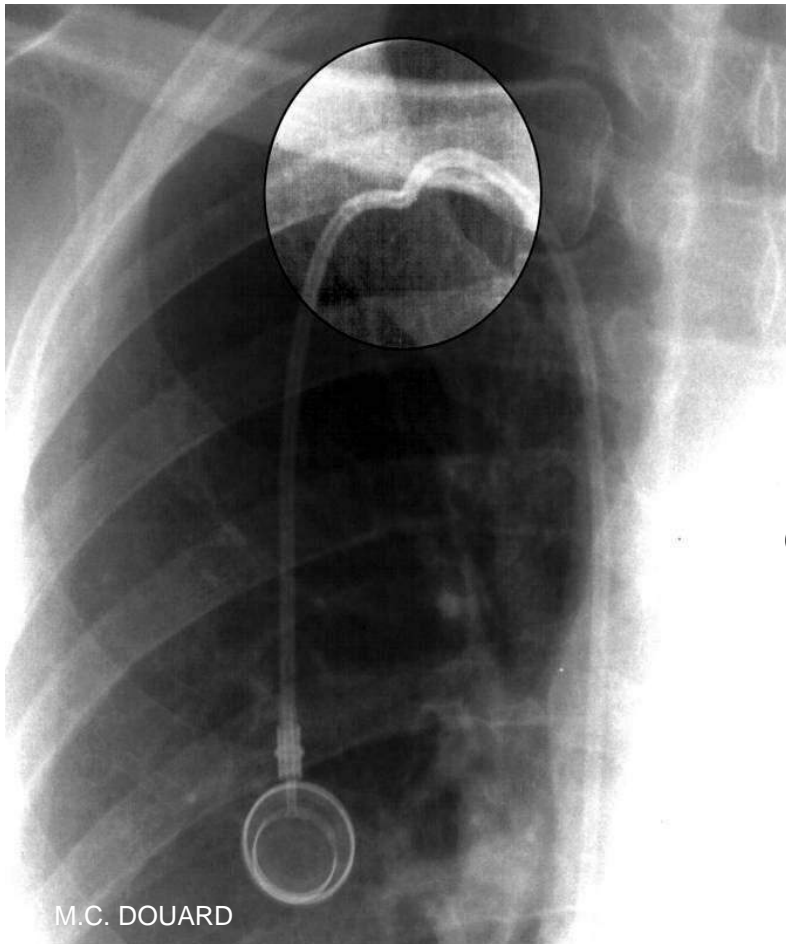
FIRST CONSIDER AN EXTRALUMINAL FACTOR

- **“Silly” causes** (kinking, stopcock and clamp)
-> Check the line
- **Non coring needle tip malposition**
-> insert a new non coring needle
- **Malfunction of the needle free connector (or integrated valve of the catheter) or connexion incompatibility**
-> Change it

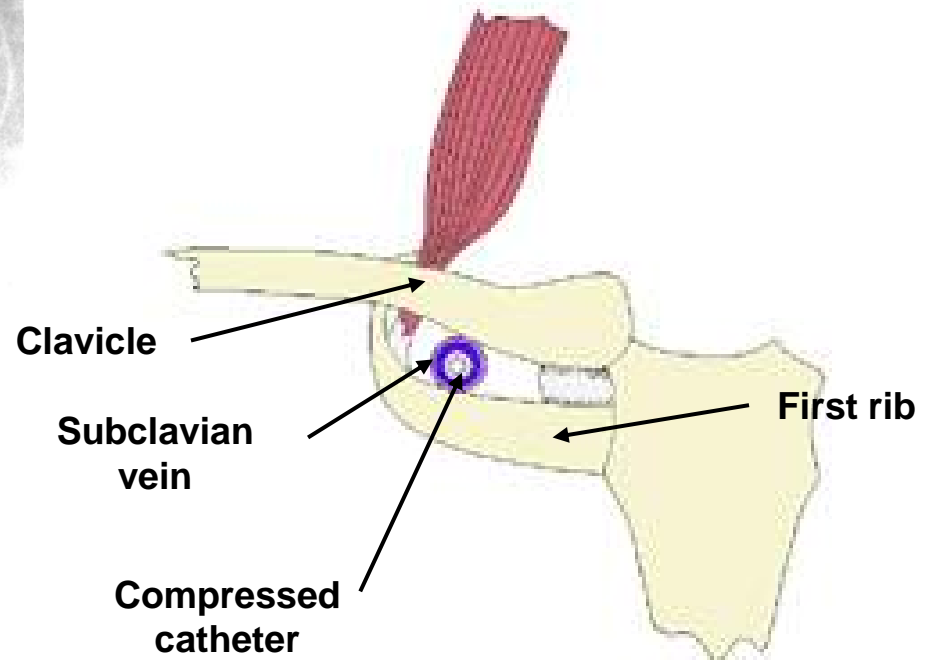
100% BLOCKED

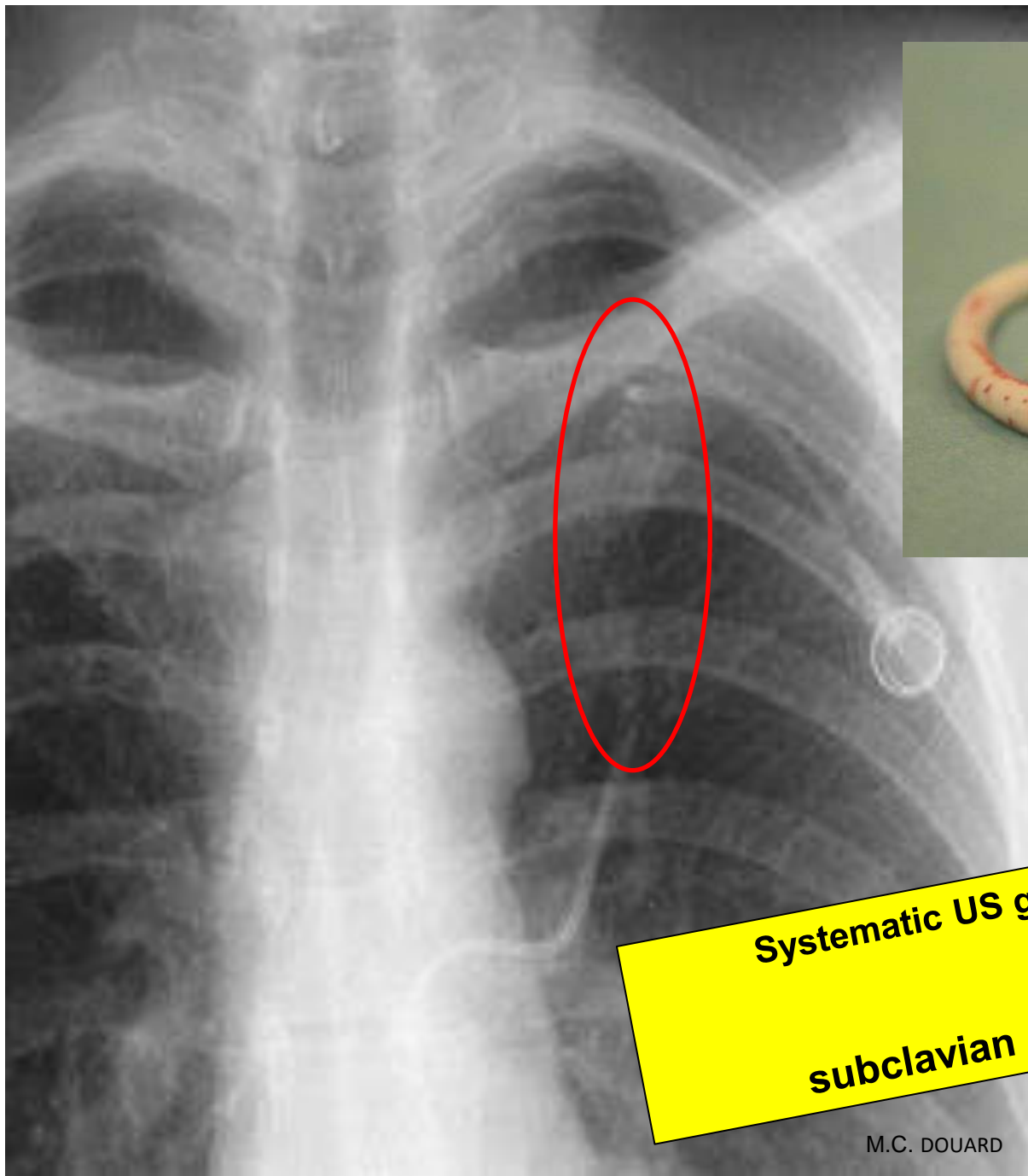
WHEN THE ARM IS ALONGSIDE PATIENT'S BODY

Catheter **pinch-off** -> Clinical signs



Pinch after pinch...





P.-Y. MARCY

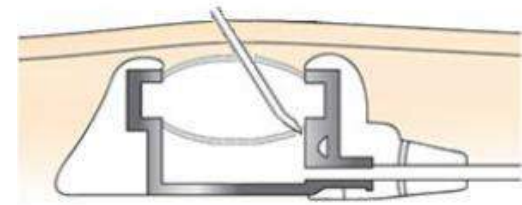
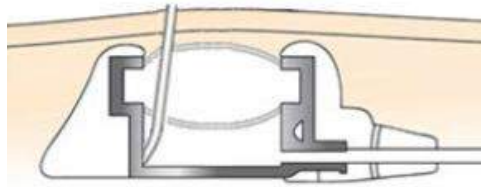
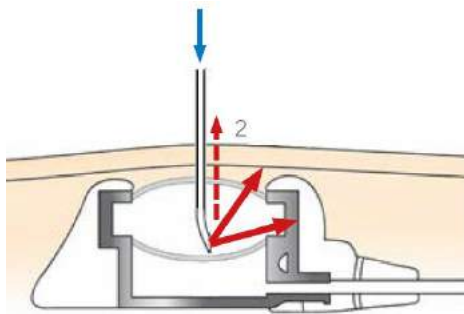
... the catheter breaks

**Systematic US guidance REQUIRED
for
subclavian catheter insertion**

M.C. DOUARD

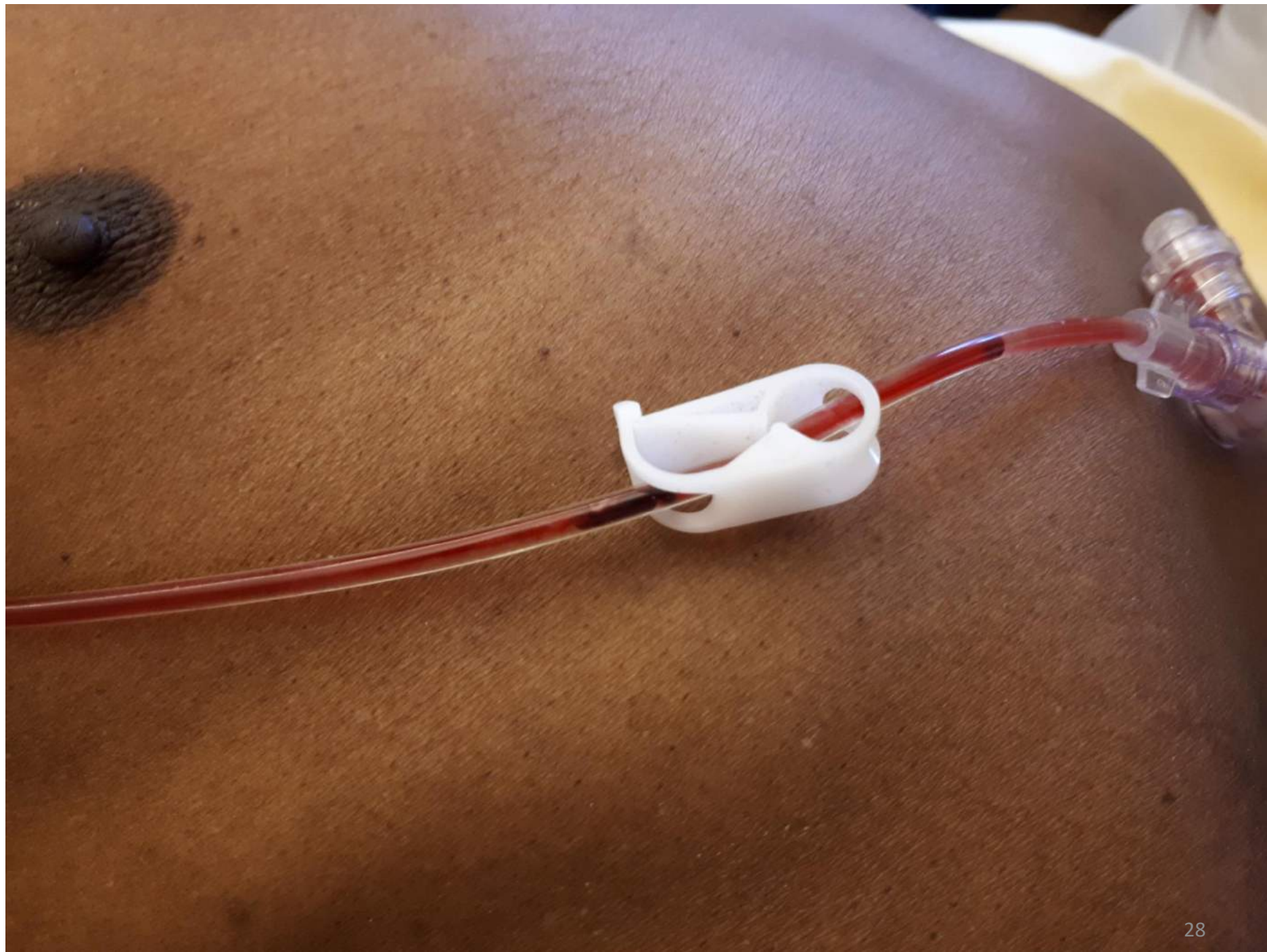
NON CORING NEEDLE

- **Be careful with** the length and the insertion angle of the non coring needle



- **Watch out for** non coring needle displacement (dressing and securement)





HOW TO CLEAR THE LUMEN?

Main objective : to reduce the surface tension between the obstructing material and the surface on which it is attached

- By reducing clot adherence (*dissolution-degradation of the obstructing substance **using a fibrinolytic, hydrochloric acid, 8.4% Sodium bicarbonate /sodium hydroxide, ethanol***)
- By **applying higher pressure** on the *obstructing substance* (*syringe, guidewire introduction*)
- By **changing the shape of the support** (*maximal aspiration with syringe, forced pressure on the plunger with at least a 10 mL syringe*)



MECHANICAL SOLUTIONS

- **Guidewire:**

Not recommended (The GAVECeLT manual of PICC and Midline). **In any case, it should be completed with a fibrinolytic treatment**

- « **Forced** » injection:

GAVECELT 2016: “if the catheter is of silicone or PUR material, but is not power injectable, 10 ml syringes must be used to unblock it hydraulically to avoid excess pressure in the system. **If the PICC is power injectable, 5 ml or 2 ml syringes can be used**, as they apply greater pressure: such pressure will, in any event, not exceed 325 psi (which is the pressure resistance limit for power injectable catheter)

Usually, the procedure involves repeated infusion of few milliliters of saline solution under pressure, preceded by pumping or small, rapid movements of aspiration/infusion, in order to mobilize the aggregates that obstruct the lumen.”

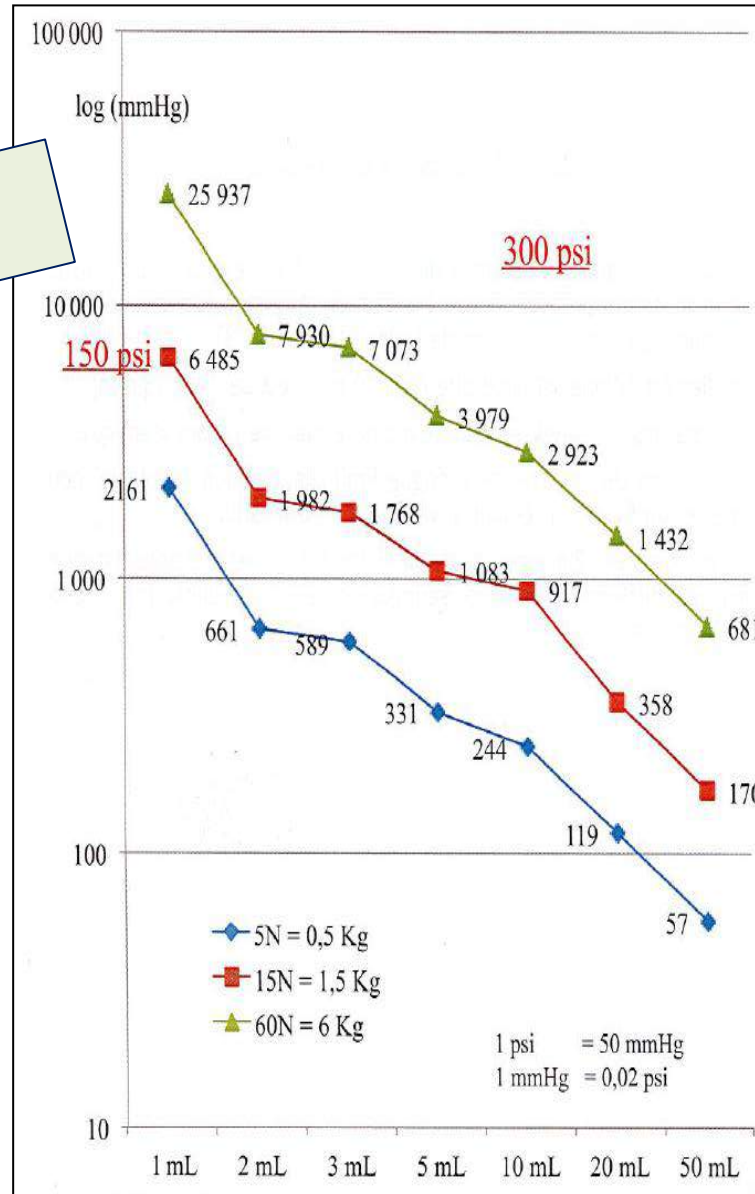
Infusion Nurse Society 2016, Sf2h 2012, 2013: « **Use a syringe no smaller than 10 mL for administration of a thrombolytic or catheter clearance agent.** »

**What about the fate of the clot
in the blood circulation?**

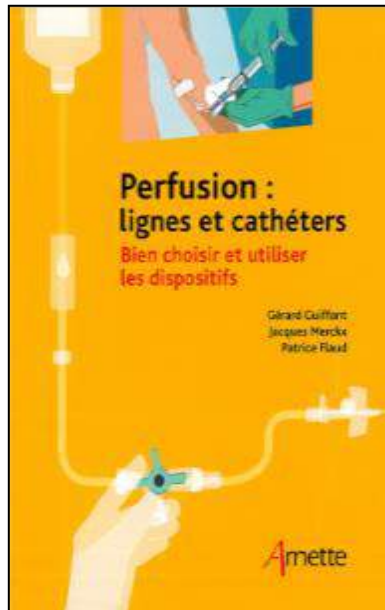


Foundations: Forces and Pressure

Never exceed 325 psi (PICC)
and
300 psi (Port)



837g => **11,2 psi**
 1000 g/cm² => 14,2 psi
 => 735 mmHg



Pressure (Psi) applied by actively pushing on the plunger

Interpretation risks

Risk factors

Misuse+
Silicone+
Extrusion

(= heterogeneity and
weakened integrity)



AND risk of not being gentle **enough** -> Misuse

Catheter breakage from applying too much pressure to a 10 ml syringe

TOO GREAT WAS
THE FORCE



POP procedure

1 - Connect a 10cc syringe containing 1-2 mL normal saline to the catheter hub

2 – Hold the syringe vertically throughout the process

3 – Aspirate about 4-5 mL
Pause and hold (~ 2 seconds)

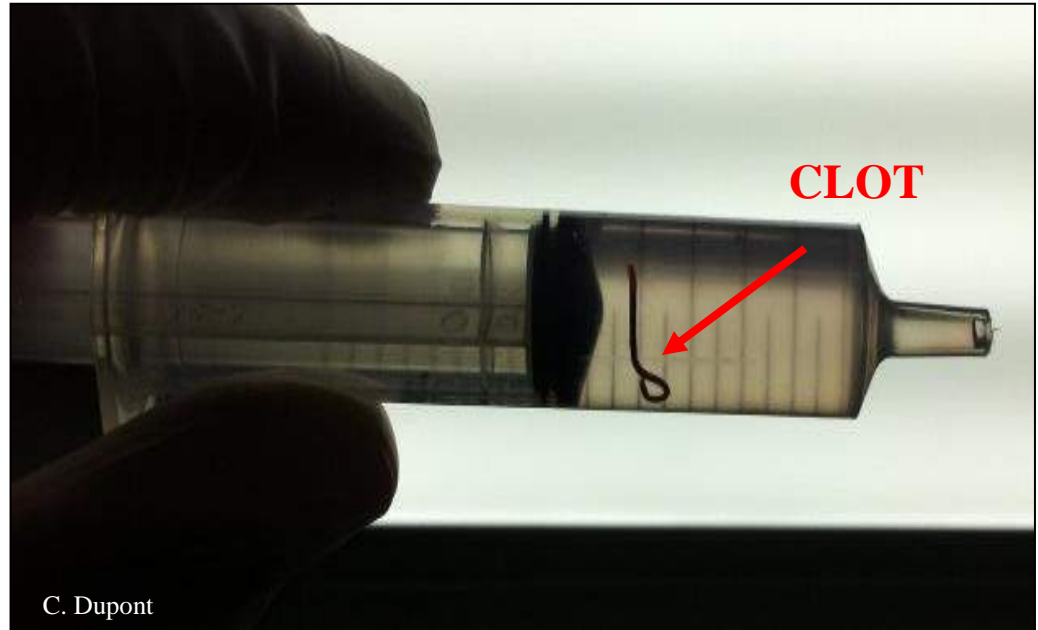
4 – Release the plunger ==> to initial position
Pause (~ 2 seconds)

5 – Repeat the process from step 3
Do not ever actively apply pressure on the piston

The POP Procedure



100% EFFICIENT.



POPping will release the clot only if adhesion is **WEAK**

=

in practice, effectiveness and use are limited

THE LUMEN IS FREE!!!! IS THE PROBLEM SOLVED?



At the end: thrombolytic solution

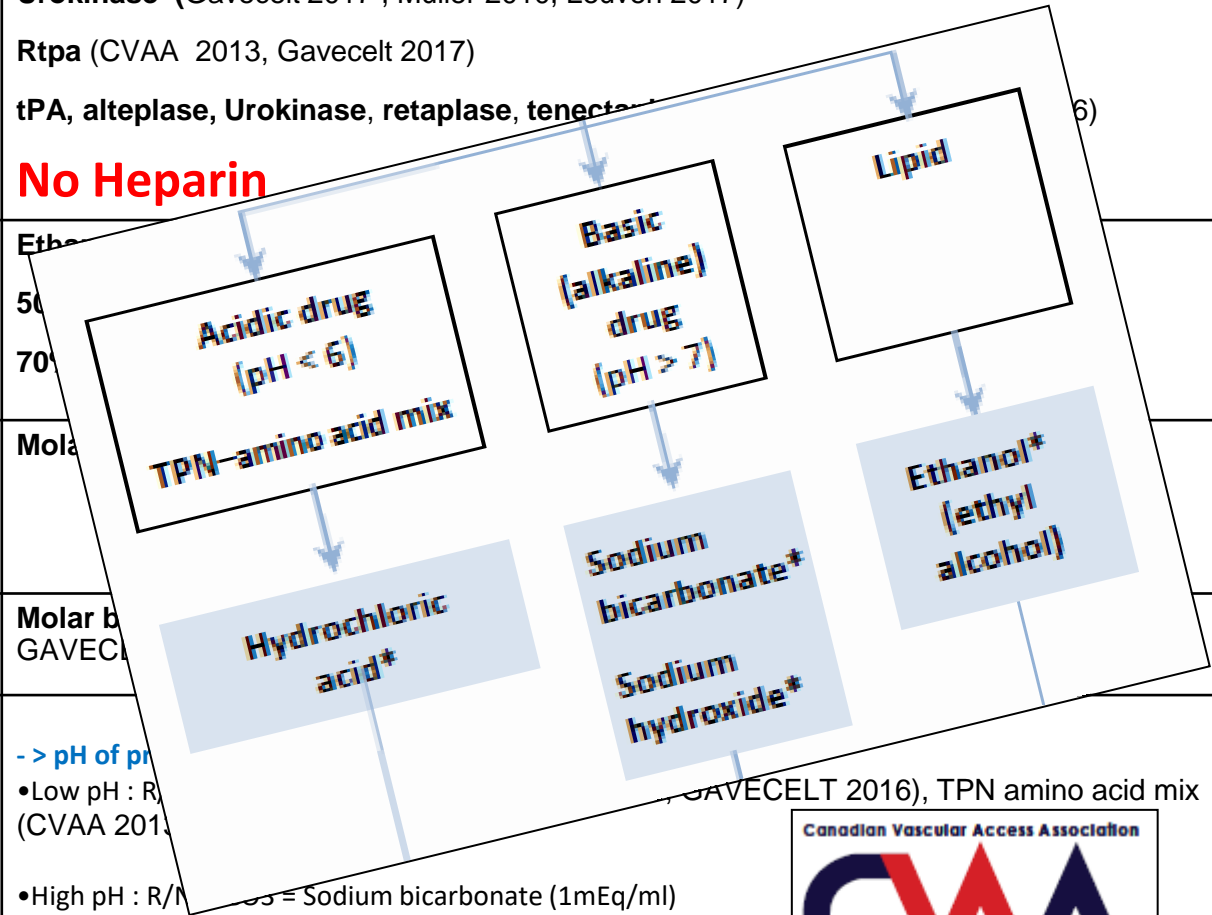
**What if mechanical maneuvers
don't work?**

CHEMICAL SOLUTIONS



CHEMICAL TREATMENTS: WHICH PRODUCTS HAVE BEEN TESTED AND RECOMMENDED?

Obstruction with blood clot	<p>Urokinase (Gavecelt 2017 , Muller 2010, Leuven 2017)</p> <p>Rtpa (CVAA 2013, Gavecelt 2017)</p> <p>tPA, alteplase, Urokinase, reteplase, tenecteplase (Leuven 2017)</p> <p>No Heparin</p>
Obstruction with lipid	<p>Ethanol*</p> <p>50% (Leuven 2017)</p> <p>70% (Leuven 2017)</p>
Obstruction with contrast media	<p>Molar b</p>
Obstruction with alkaline drug precipitate (pH greater than 7)	<p>Molar b</p> <p>GAVECEL</p>
Obstruction with acid drug precipitate (low pH, less than 6) and TPN amino-acid mix	<p>-> pH of pr</p> <ul style="list-style-type: none"> •Low pH : R/NaOH = Sodium hydroxide (1mEq/ml) •High pH : R/NaHCO3 = Sodium bicarbonate (1mEq/ml) <p>-> Precipitate of Calcium and Phosphate</p> <ul style="list-style-type: none"> •R/ HCl = Hydrochloric acid 0.1 M <p>GAVECELT 2016), TPN amino acid mix</p>
Obstruction with obstruction material containing different substances	<p>Suspicion of fibrin and lipid mixture: Urokinase,</p> <p>If the occlusion remains: NaCl 0.9% followed by Sodium hydroxyde (NaOH). (Leuven 2017)</p> <p>In any case of occlusion , infuse first Urokinase , 2nd: other products (it depends on the composition of the clot)). (Leuven 2017)</p>



CHEMICAL SOLUTIONS: PRACTICAL CONSIDERATIONS

- Do we know the catheter **priming volume**? Is it important for all patients or only for children?
- Aspirate and discard the degradation products prior to flushing the lumen is recommended but...
... Sometimes repeated injections are required without success **without being able to recover the injected solution**. Isn't it dangerous?
- What are the **effects of hydrochloric acid and sodium hydroxide when it comes into the bloodstream?** (CVAA 2013)
- Refer to the manufacturers' directions regarding catheter exposure to any form of alcohol. (Alcohol causes the proteins to precipitate and stick to the inner wall of the catheter). **Is using alcohol an option?**





CHEMICAL SOLUTIONS: AND IN DAILY PRACTICE?

- The chemical treatment should always begin with a thrombolytic injection
- Alteplase® properties are altered by glucose
- If resistance: use 3 way-tap method to inject the thrombolytic solution
- What is the most efficient concentration for Urokinase? Is there a threshold?
- Does the time spent unblocking the catheter depend on the concentration of the thrombolytic used?
- How long do we have to wait before giving up? A thrombolytic lock can take 1 to 3 days or more to be effective.

CHEMICAL SOLUTIONS: AND IN DAILY PRACTICE?

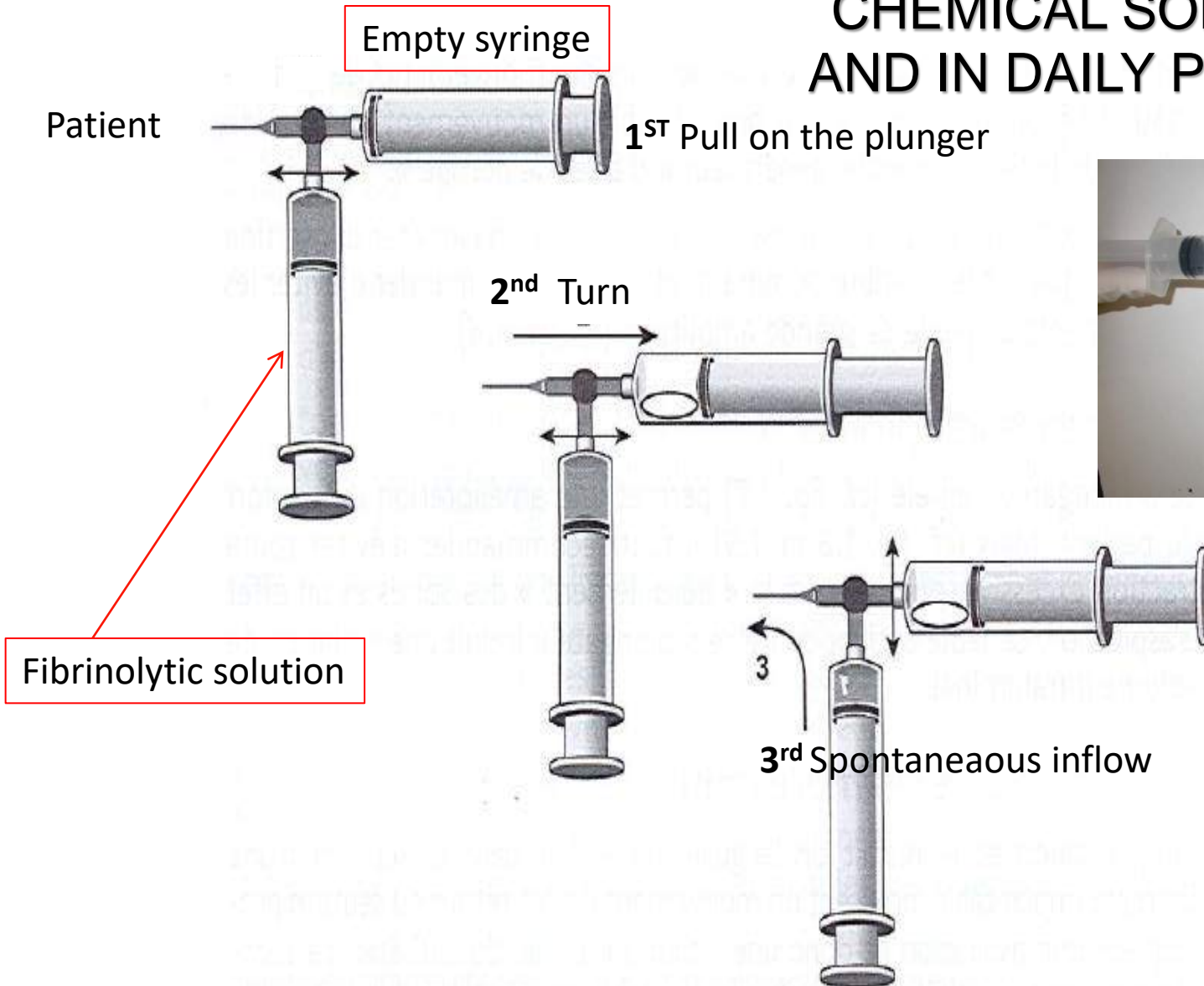


Photo M. Jerome

3 WAY-TAP METHOD TO INJECT THE THROMBOLYTIC SOLUTION

NOT 100% BLOCKED

When Injection is possible but with a poor flow rate + Poor or impossible blood reflux

What can I do if a thrombolytic solution doesn't solve the problem?

-> X-ray or US

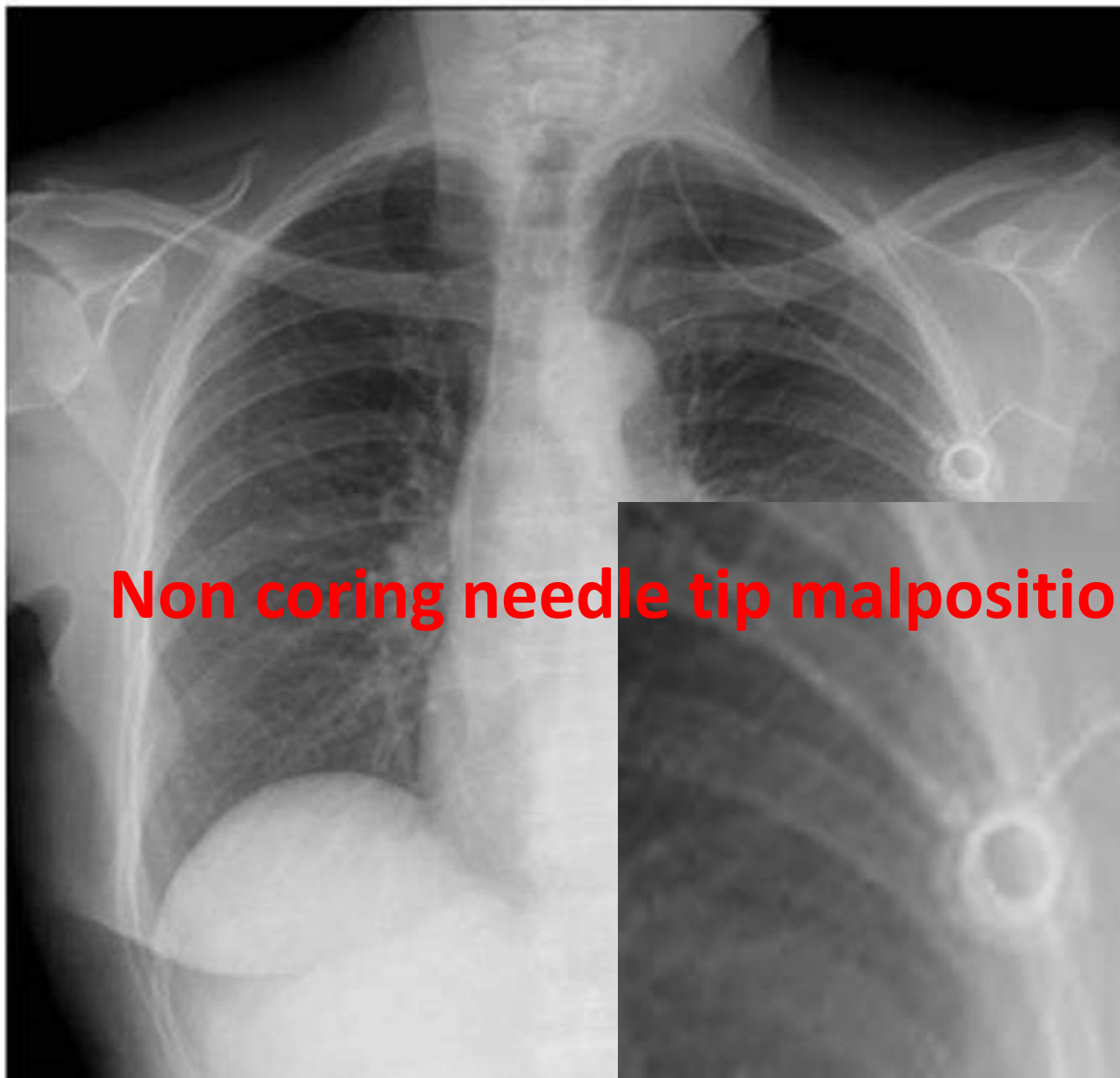
IN DAILY PRACTICE: WHY AND WHEN DO YOU PRESCRIBE AN X-RAY?

- **X- ray first when the patient reports strange sensations/pain:**



« I feel like a flux in my ear » the patient said

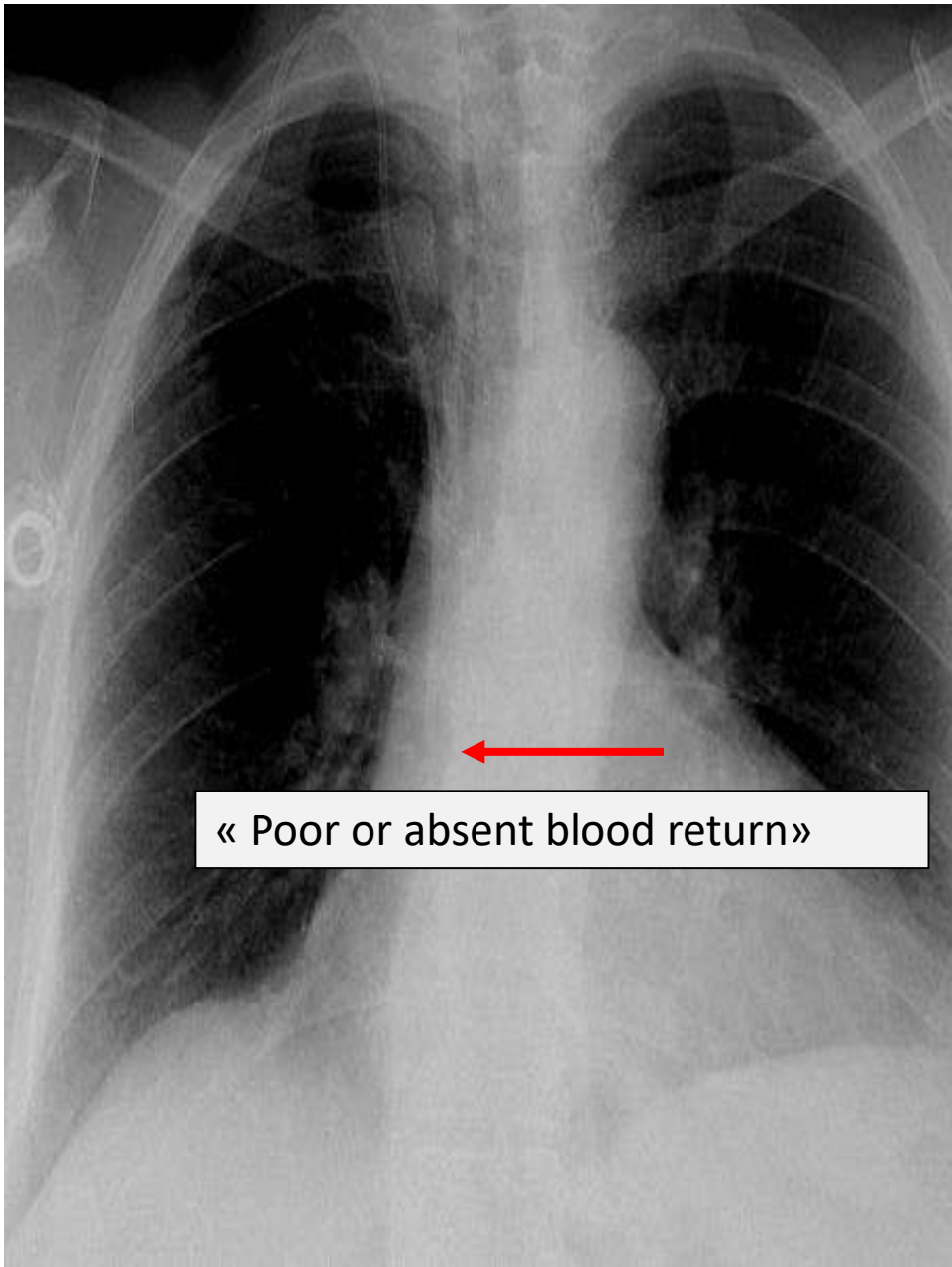
- **X-ray is often prescribed only after the bedside thrombolytic treatment fails**
 - To limit X-ray exposure,
 - To avoid wasting time and transport efforts
- ***But an X-ray is useful to be sure that:***
 - The catheter tip is correctly located
 - There is no catheter breakage
 - Hydrochloric acid, Sodium bicarbonate 8.4% or Sodium hydroxide infusion will be safe



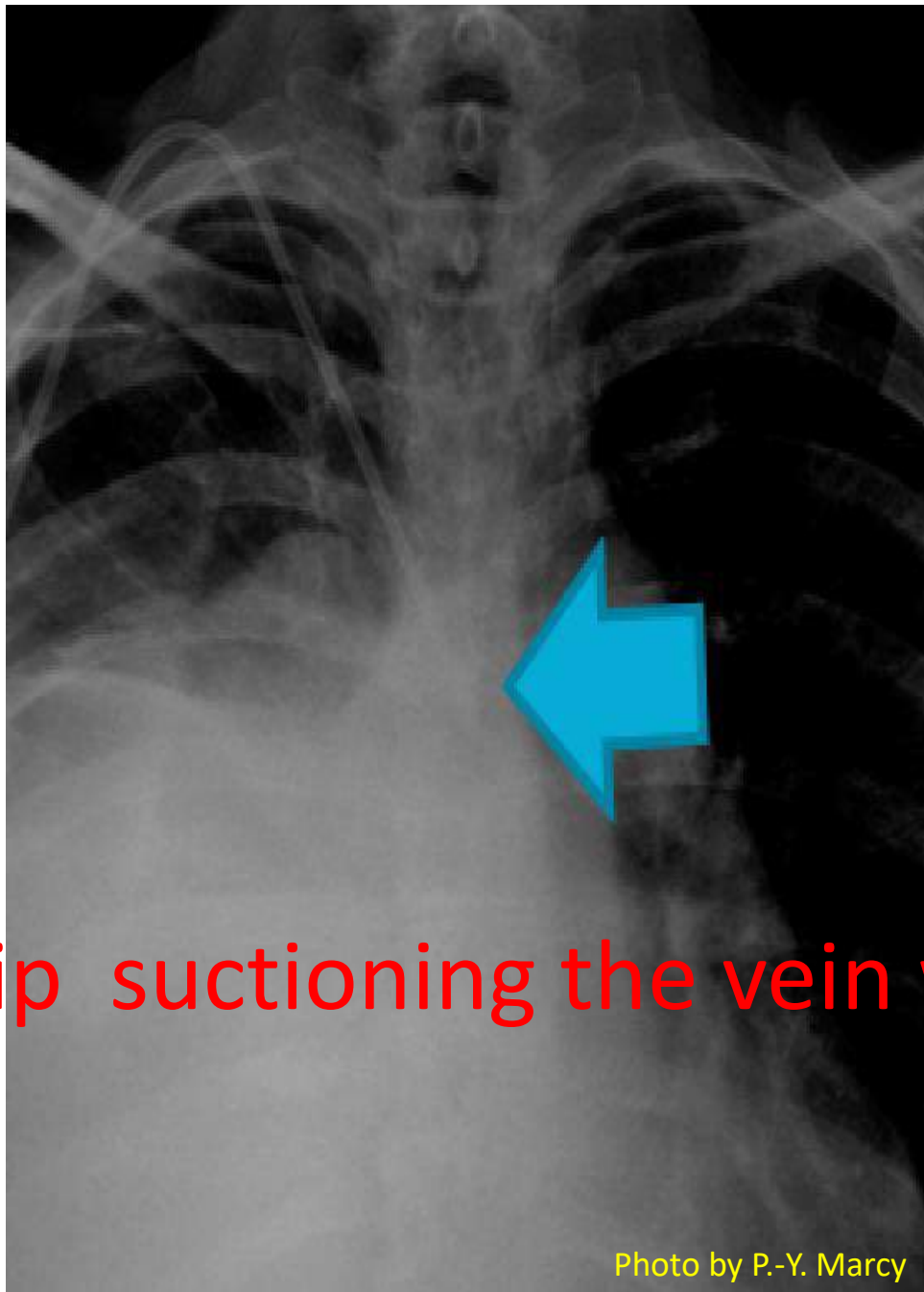
Non coring needle tip malposition



I. Kriegel



Catheter tip malposition
(tip in minor vessel or tip stuck
against the vein wall or suctioning
the vein wall
Or
catheter is too short/too long)




Tip suctioning the vein wall



Tip in a minor vessel

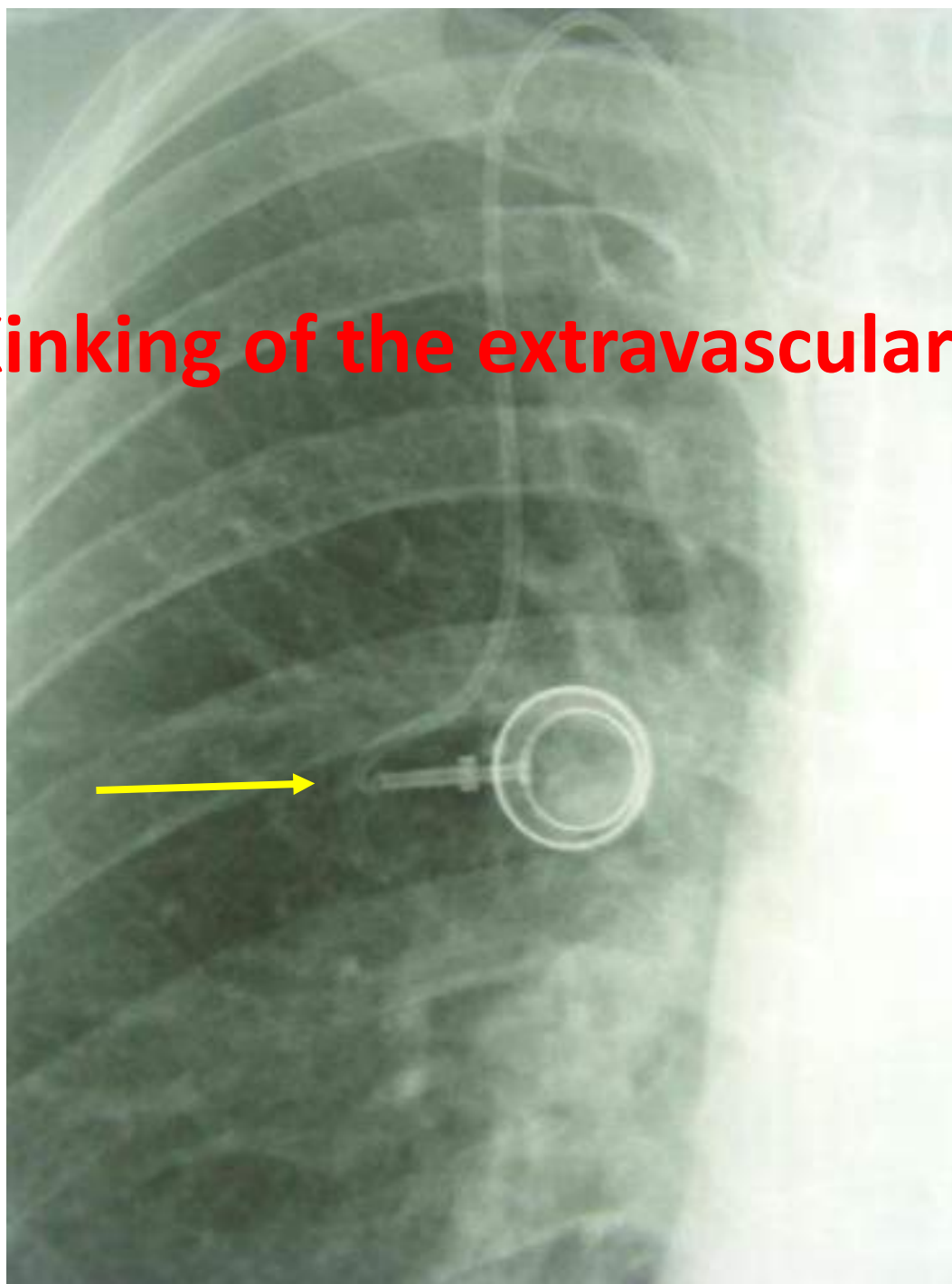
A chest X-ray showing the thoracic cavity. A white circular marker is placed in the upper left lung field. The text "Tip in a minor vessel" is overlaid in red.

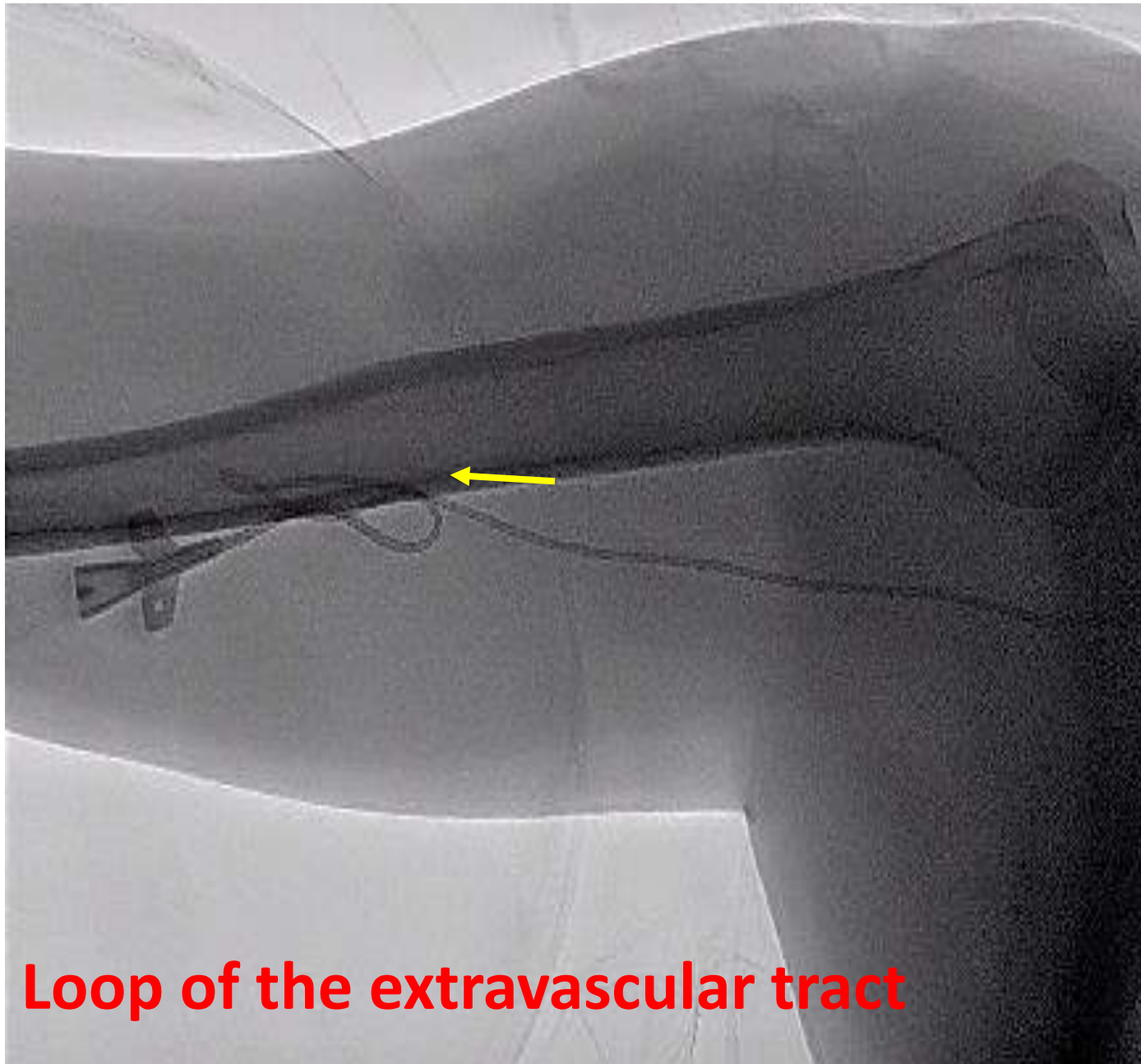
DEBOUT D

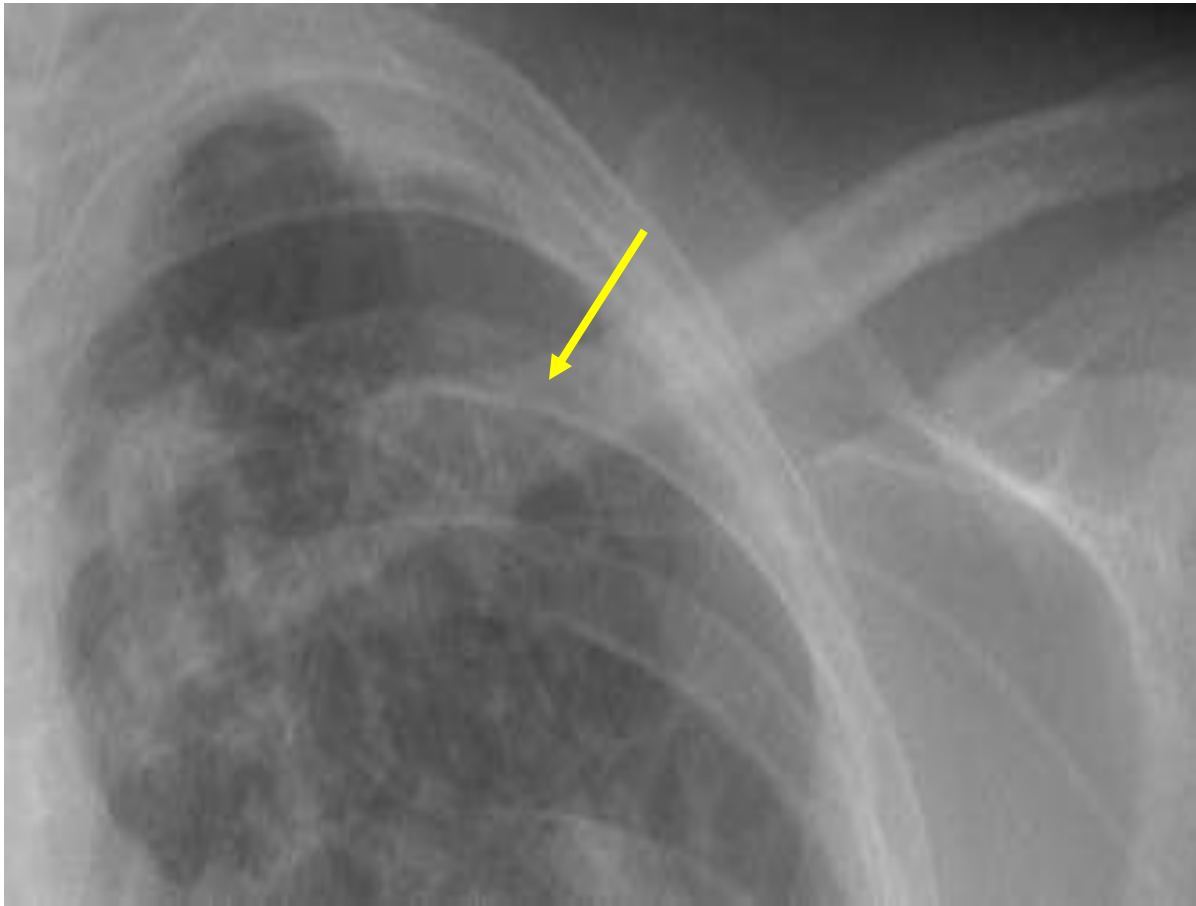


An inset chest X-ray showing a catheter tip positioned within a vessel. The text "DEBOUT D" is overlaid in white.

Kinking of the extravascular tract







Loop of the intravascular tract

Despite initial correct insertion and catheter tip location

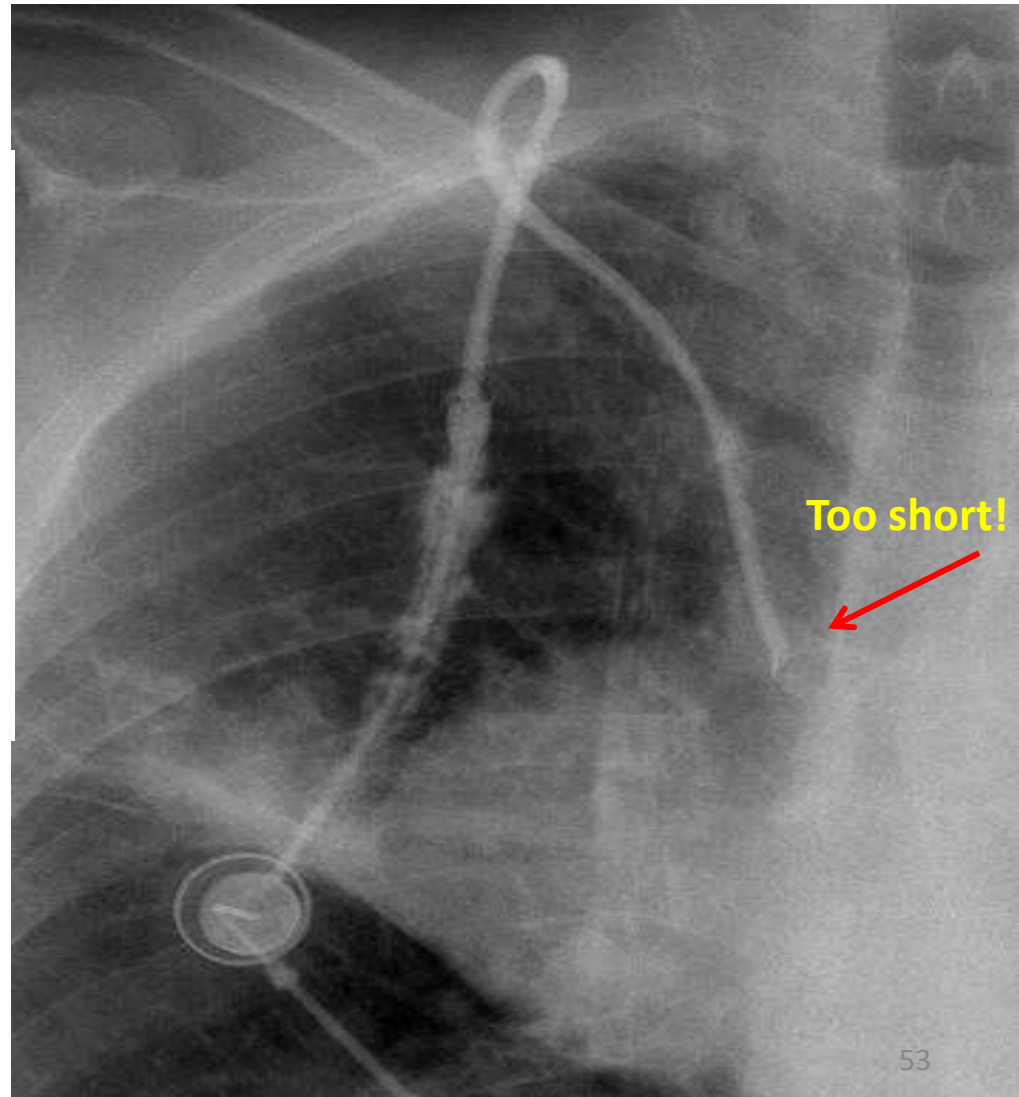
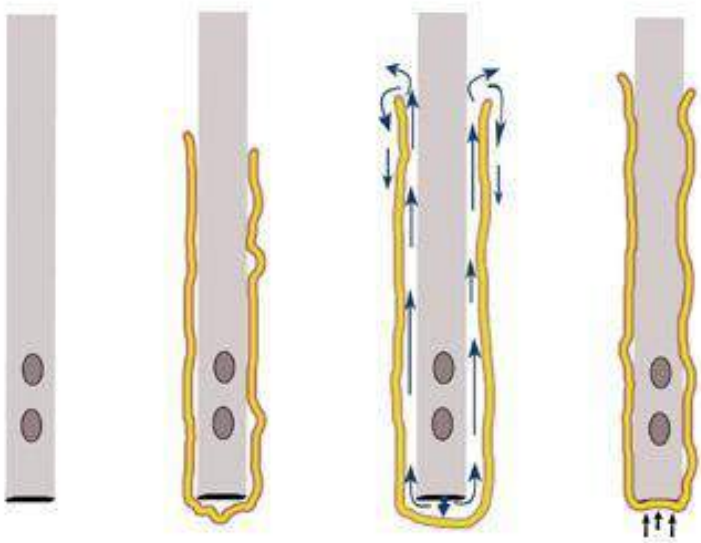


Catheter tip displacements at power PICC CT injection. P.-Y. Marcy, G. Guiffant, P. Flaud. *AJR Am J Roentgenol.* 2014 Dec;203(6):W742-3.

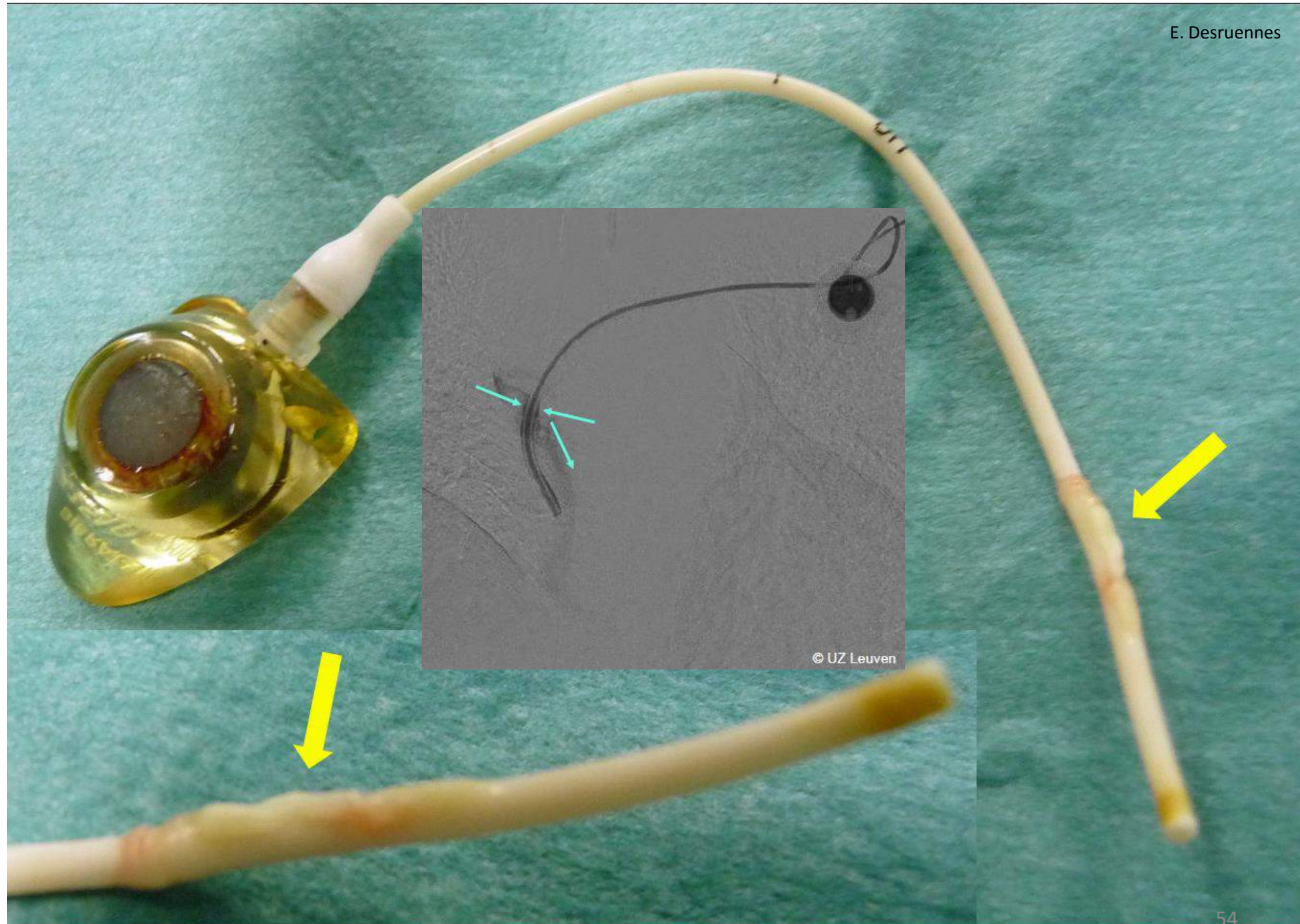
All photos by C. Dupont

Fibroblastic sleeve

-> X-ray and CM



The fibroblastic sleeve, the neglected complication of medical access devices: a narrative review. G.Passaro. JVA 2020



Fibroblastic sleeve



The fibroblastic sleeve, the neglected complication of medical access devices: a narrative review.
G.Passaro. JVA 2020



Fibroblastic sleeve

Malfunctioning of the catheter valve

JVasc Access 2014; 15 (6): 519-523
DOI: 10.5301/jva.5000280

ORIGINAL ARTICLE

A prospective, randomized comparison of three different types of valved and non-valved peripherally inserted central catheters

Mauro Pittiruti¹, Alessandro Emoli², Patrizia Porta², Bruno Marche², Rosa DeAngelis², Giancarlo Scoppettuolo¹

Conclusion: We found no clinical advantages of valved vs. non-valved PICCs.

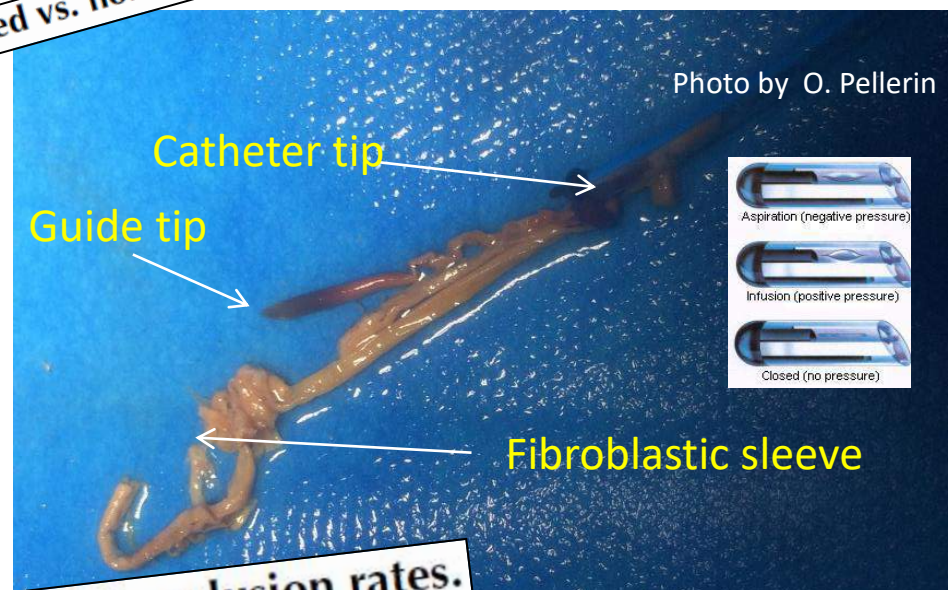
JVasc Access 2012; 13 (4): 421-425
DOI: 10.5301/jva.5000071

ORIGINAL ARTICLE

The effect of peripherally inserted central catheter (PICC) valve technology on catheter occlusion rates - The 'ELeCTRIC' study

Andrew J. Johnston^{1,2}, Carmel T. Streater¹, Remy Noorani¹, Joanne L. Crofts¹, Aldwin B. Del Mundo¹, Richard A. Parker²

Valved PICCs do not appear to influence PICC occlusion rates.



Malfunctionings > Advantages

Venous thrombosis around the tip of the catheter

-> Injection is possible but sometimes with a poor flow rate + Poor or impossible blood withdrawal



Medical advice

Coming very soon



BEST PREVENTION: AN INFUSION TEAM

- Local and prospective follow up
- Feedback and information
- Team management
- Research

are key