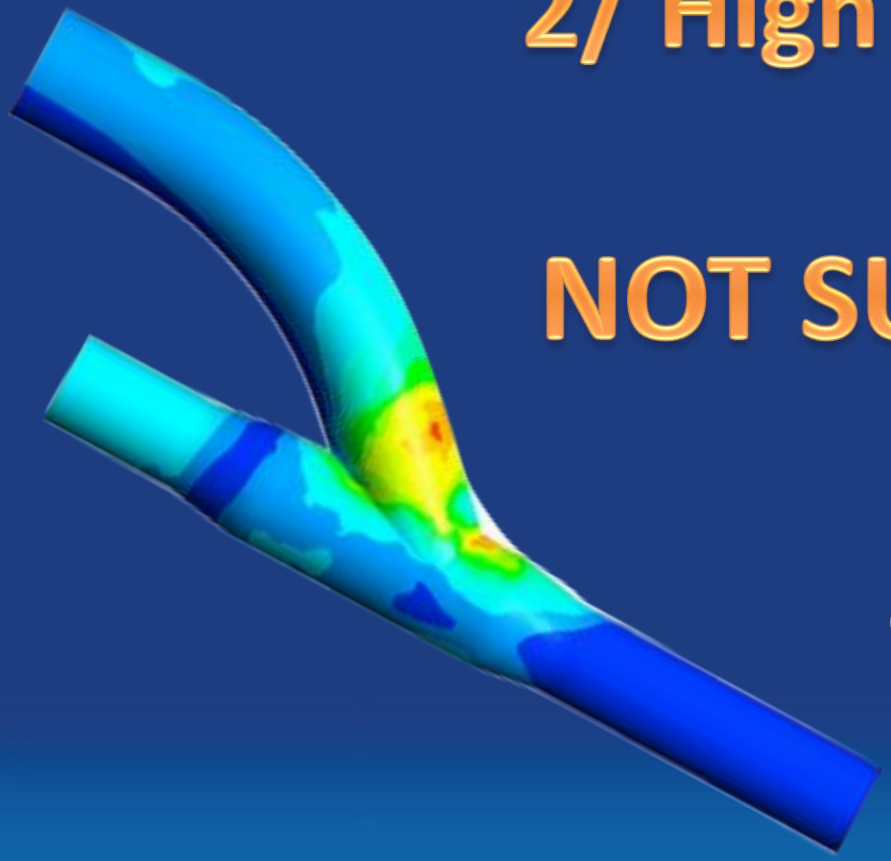
CONTROVERSIES & UPDATES IN VASCULAR SURGERY
JANUARY 22-24 2015
MARRIOTT RIVE GAUCHE & CONFERENCE CENTER PARIS, FRANCE

Anastomotic techniques reduce 1/ Juxta-anastomotic stenosis 2/ High flow



NOT SURE

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Clinique Arago
PARIS

Disclosure

Speaker name:G.FRANCO

.....

I do not have any potential conflict of interest

Chronic Hemodialysis Using Venipuncture and a Surgically Created Arteriovenous Fistula

Michael J. Brescia, M.D.[†], James E. Cimino, M.D.[‡], Kenneth Appel, M.D.[§], and Baruch J. Hurwich, M.D.

N Engl J Med 1966; 275:1089-1092 | November 17, 1966 | DOI: 10.1056/NEJM196611172752002

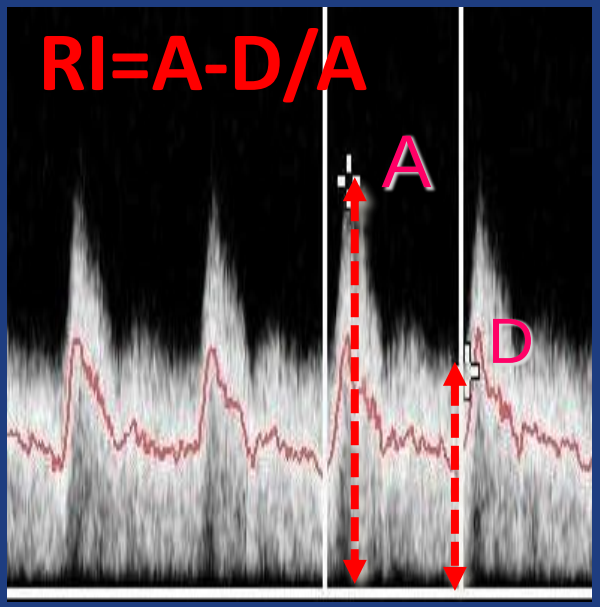
- **Side to side arterio venous anastomosis**
- **3 à 5 mm**
- **86% patency rate**

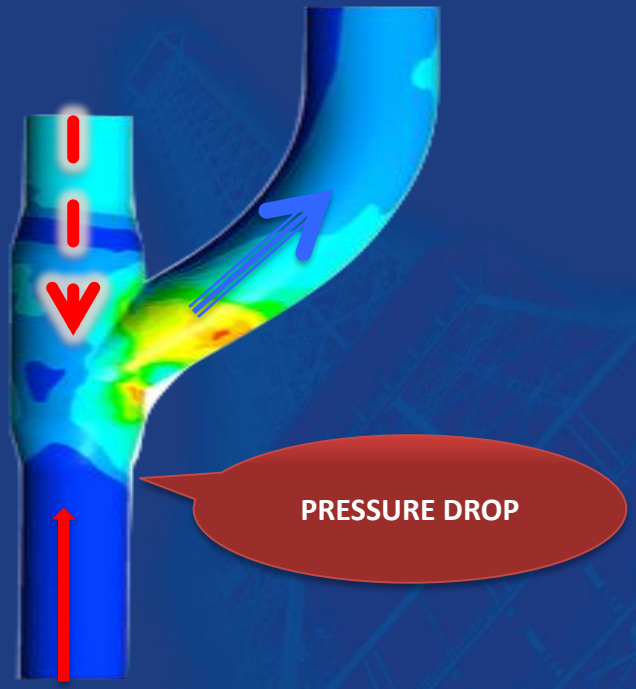
NOT FISTULA

THEY WOULD NEVER HAVE MET

AVF CREATION

Whatever anastomotic techniques ETS -STS

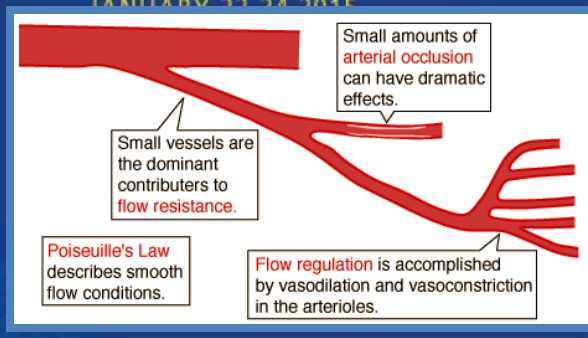




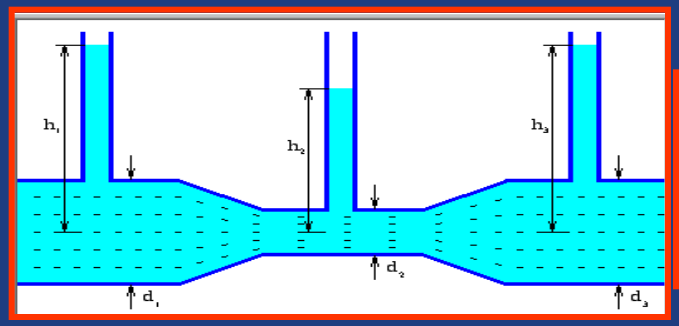
Connection of a low-pressure vein to the high-pressure arterial system: results in a chain of vascular events that starts with :

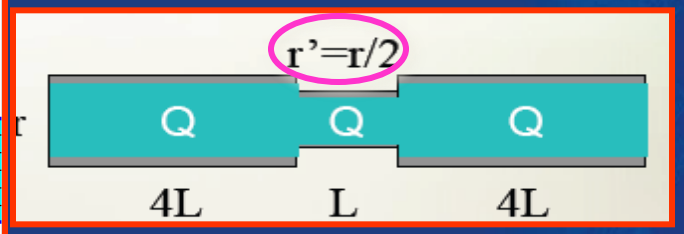
- **drop in resistance index from:1 to 0,5**
- increase of blood flow through both the artery and the draining vein

AAV resistance



- microcirculation comprises about 70% of the total resistance
- Poiseuille's equation : 50% reduction in radius should increase resistance 16-fold (1500% increase)





$$\frac{R'}{R} = \left(\frac{r}{r'}\right)^4 = 16$$

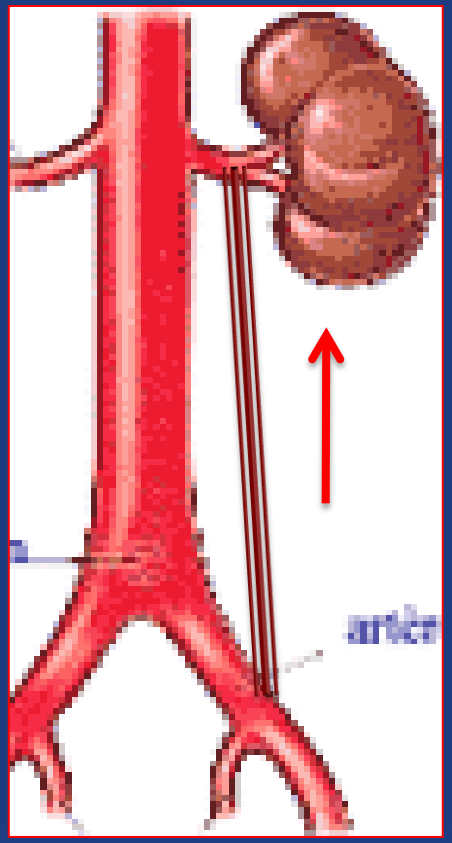
- However, total resistance will only increases by about 16% because the large artery resistance is normally only about 1% of the total resistances
- Clinically, a critical stenosis typically is thought of in terms of a 75% reduction in the diameter of the large distributing artery

FLOW /RESISTANCE

RI:1 100 ml/mm

FEMORO POPLITEAL GRAFT

RI:0,7 300 ml/mm



ILIO RENAL GRAFT

RI:0,5 800 ml/mm

BRACHIO AXILARY GRAFT

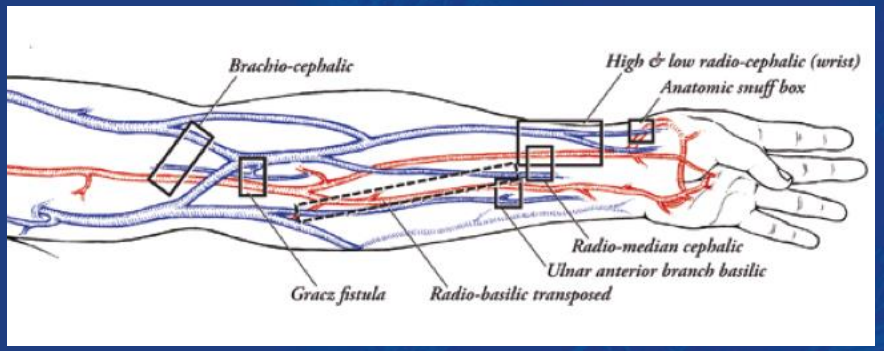
ANASTOMOTIC TECHNIQUE

- Can ensure maturation preventing IH
- Avoid swing point and compression
- Control flow level
- Take care of the relationship artery/vein
- Deal with prexistant vasculopathy
- Deal with endothelial dysfonction
- Control local adipose tissue and negative remodelling
- Prevent ischemia

Relationship artery and vein

Should be taken into account and help:

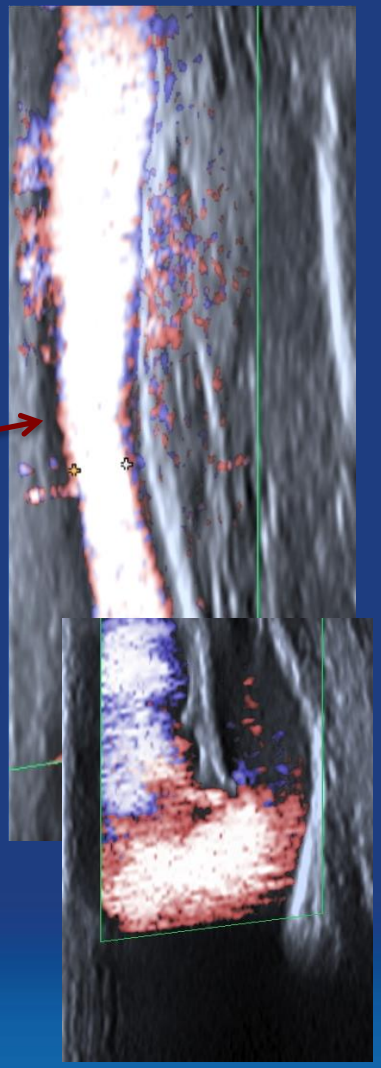
- To choose the anastomosis site
- Wrist
- Snuff box
- Elbow (brachial artery or radial artery)

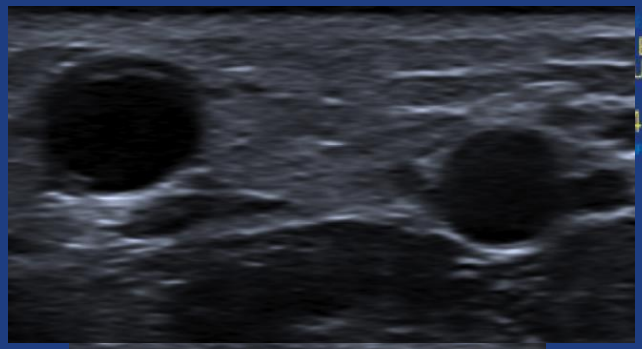


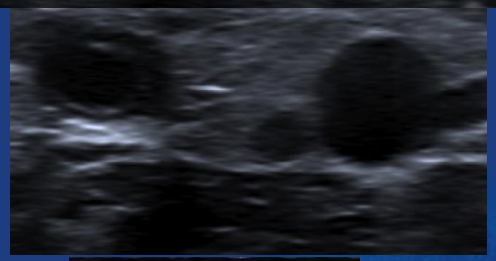
it is at snuff that the artery and vein are the closest

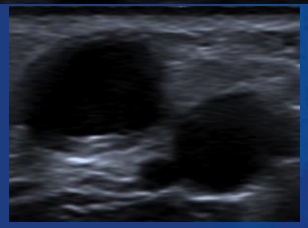
Shenoy *S.J Vascular Access 2009*

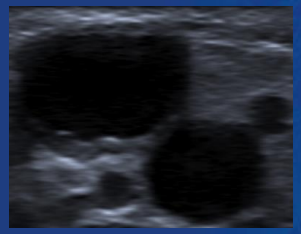
Stenosis at the crossing of the scar

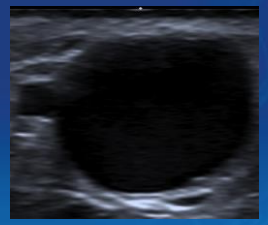












WALL SHEAR STRESS

Intense response is limited to the first 1 to 4 cm

WSS to pre-AVF levels (5–10 dyn/cm^2)

AVF CREATION :3-fold increase in WSS (24.5 dyn/cm$^{2)}$

NO

3-fold increase in luminal venous calibre

WSS gradually returned to a physiological range

Corpataux JM, *Nephrol Dial Transplant 2002*

MATURATION FAILURE

ADVERSE VASCULAR RESPONSE THAT HAMPERS AVF FUNCTION

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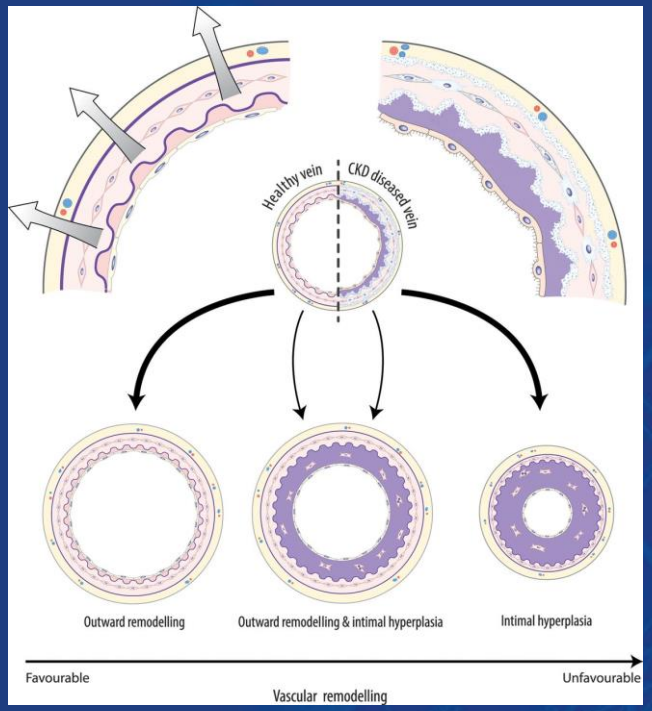
outward remodelling

IH outbalances outward remodelling

Stenosis

Fistula failure.



Rothuizen T C et al. *Nephrol. Dial. Transplant 2013*

Vascular remodelling response after AVF creation

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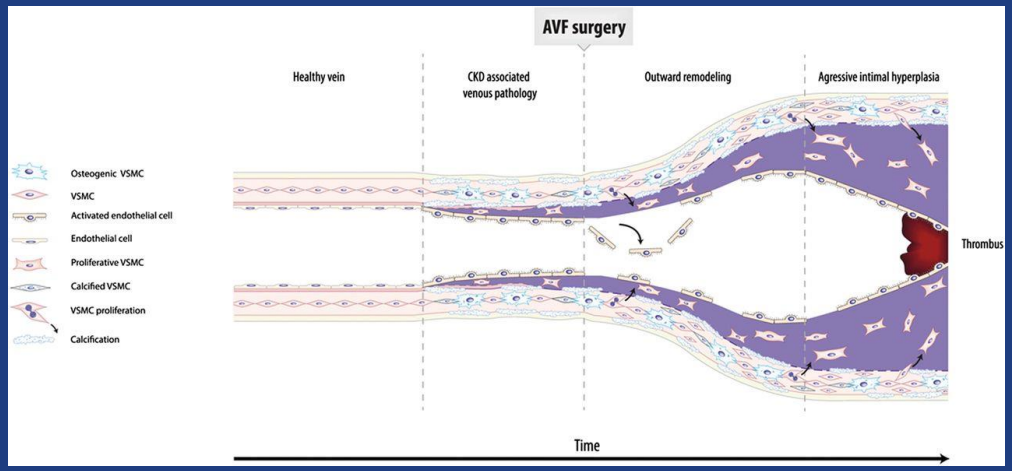
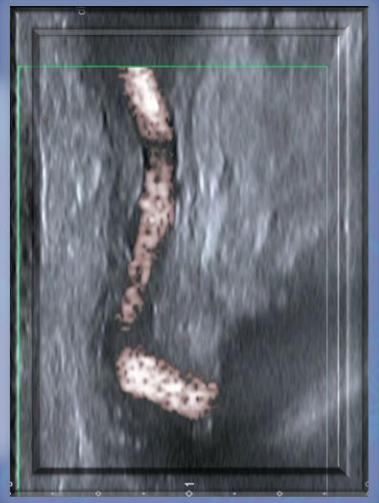
Mechanisms of the remodelling



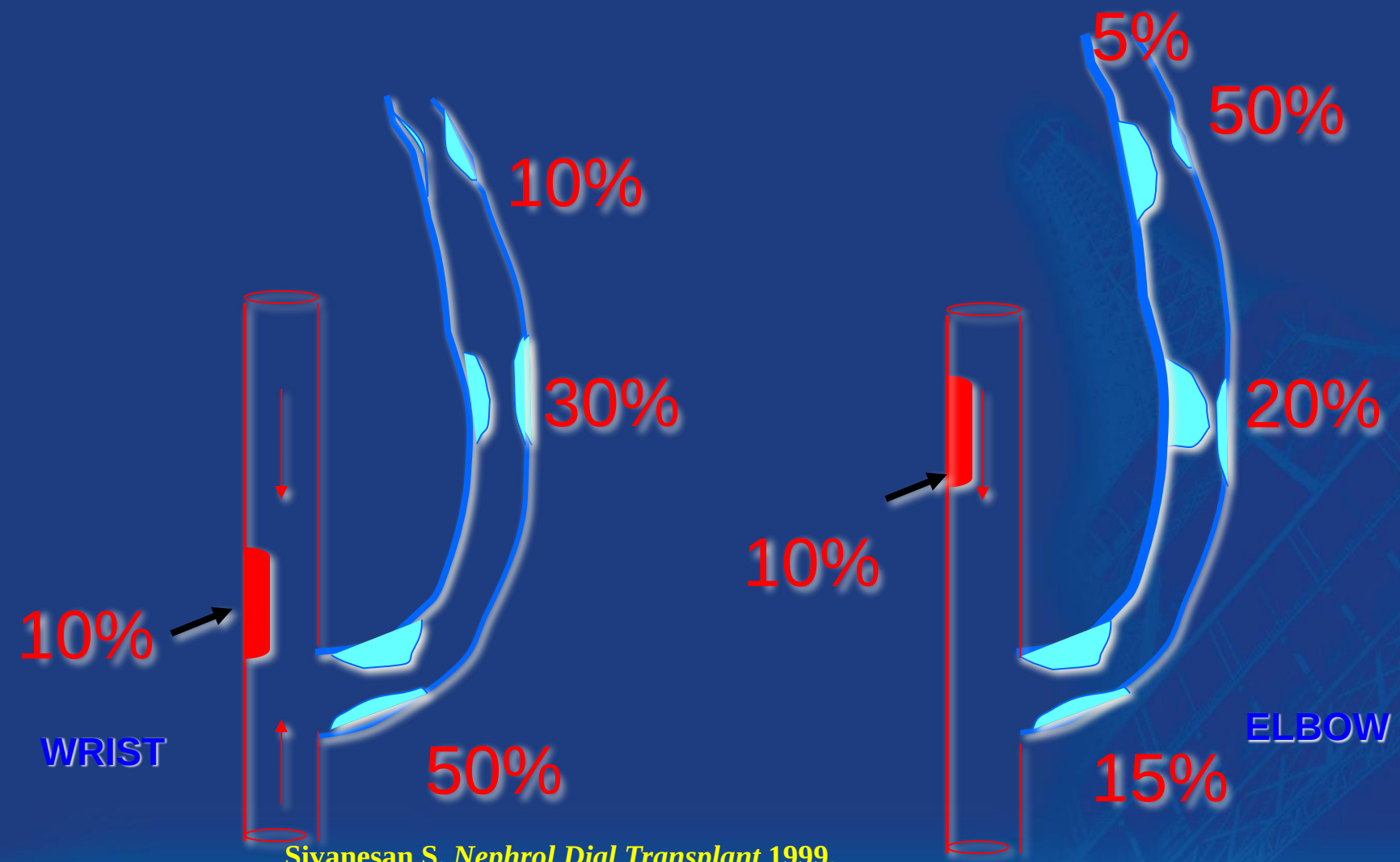


- surgery induced endothelial denudation
- VSMC proliferation and migration contributing to IH
- outward remodelling may compensate for detrimental intimal lesions

Rothuizen T C et al. *Nephrol. Dial. Transplant 2013*

NDT Nephrology Dialysis Transplantation

LOCALISATION OF STENOTIC LESIONS



Sivanesan S. *Nephrol Dial Transplant* 1999.
Turmel-Rodrigues LA. *Nephrol Dial Transplant 2001.*
Turmel-Rodrigues LA. *Nephrol Dial Transplant 2003.*

Computational fluid dynamic :CFD

- CFD evaluation of the AVF anastomosis brings theoretical arguments about:

Type
Size
Shape
Angle

Computational fluid dynamic CFD

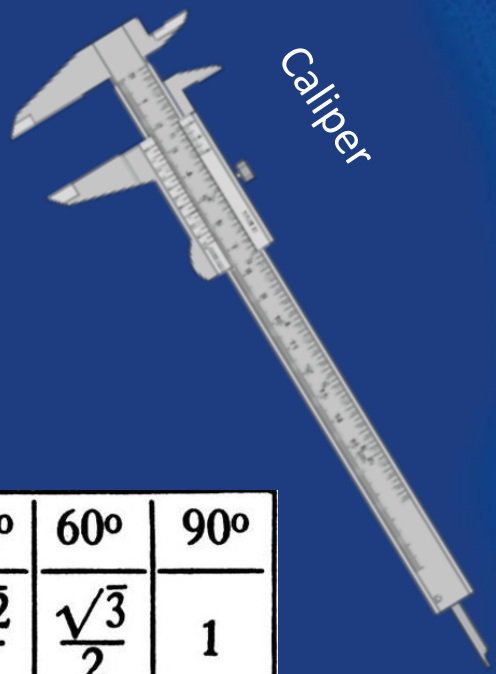
➢ **CFD evaluation have many important limits:**

- **evaluation of dissection**
- **vessel tension, twisting, compliance**
- **patient blood pressure, cardiac output**
- **size, shape, and compliance could not be modelled**
- **vessel compliance are considered the same for arteries and veins !!! Mismatch?**
- **situation of angle shape and size of AVF**
- **anastomosis are in continuous remodelling.**
- **use newtonian fluid**

➢ **CFD explore only 10/12 possibilities**

over 100 possible at each anastomosis level

NEW SURGICAL TOOLS



α	0	30^o	45^o	60^o	90^o
$\sin \alpha$	0	$\frac{1}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{\sqrt{3}}{2}$	1
$\cos \alpha$	1	$\frac{\sqrt{3}}{2}$	$\frac{\sqrt{2}}{2}$	$\frac{1}{2}$	0

Table of constants

Initial size of the AAV and the vessels might change during maturation

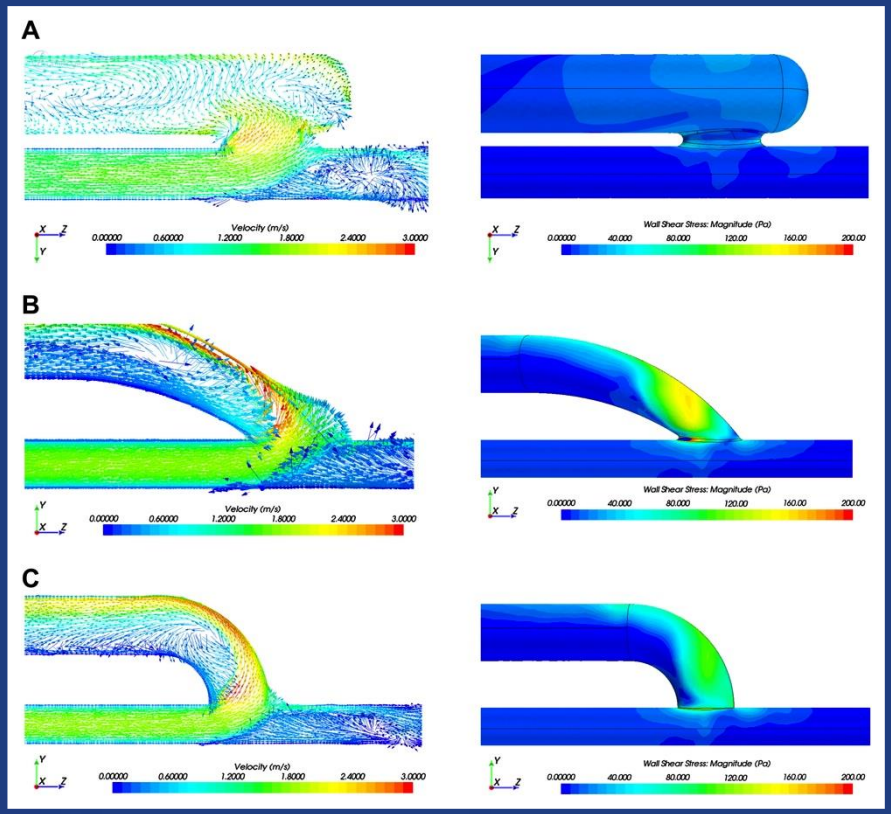
AAV length at the wrist 7 to 10 mm
Evolve towards an elliptic shape
CSA of 8,2 to 27 mm2

AAV length at the elbow 5 to à 7 mm
Evolve towards an elliptic shape
CSA of 15 to 38 mm2

LENGH AAV

ART ⊘	5	6	7	8	9	10
1,5	5,8	7	8,2	9,4	10,5	11,7
2	7,8	9,42	10,9	12,5	14,1	15,7
2,5	9,8	11,7	13,7	15,7	17,6	19,6
3	11,7	14,1	16,4	18,8	21,1	23,5
3,5	13,7	16,4	19,2	21,9	24,7	27,4
4	15,7	18,8	21,9	25,1	28,2	31,4
4,5	17,6	21,1	24,7	28,2	31,7	35,3
5	19,6	23,5	27,4	31,4	35,3	39,2
6	23,5	28,2	32,9	37,6	42,9	47,1
6,5	25,5	30,6	35,7	40,2	45,9	51
7	27,4	32,9	38,4	43,9	49,4	54,5
7,5	32,3	38,8	45,2	51,7	58,2	64,7
8	43,1	51,7	60,3	69	77,6	86,2

Velocity vector and WSS at a constant flow rate of 900 mL/min Anstomosis size :18 mm2



4 + 6 vein-pair models :
STS **(A)**
45° ETS **(B)**
90° ETS **(C)**
Uniform WSS in **(A)**
Variance +++in WSS **(B)** and **(C)**

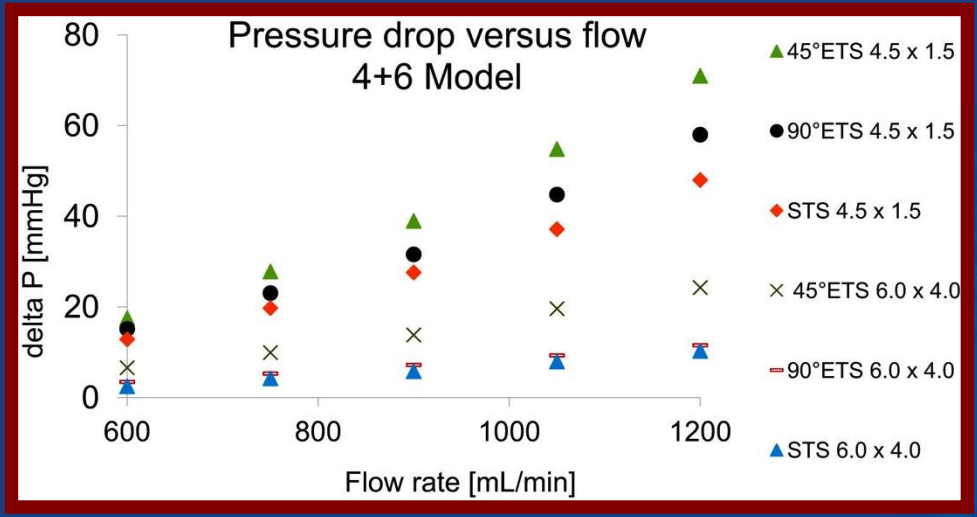
The areas of low WSS (*blue*) adjacent to high WSS (*green*/*yellow*/*red*) in the proximal venous outflow of the 45° and 90° ETS configurations

INTIMAL HYPERPLASIA

Jeffrey E. Hull *.jvs.2012*

Source: Journal of Vascular Surgery 2013; 58:187-193.e1 (DOI:10.1016/j.jvs.2012.10.070)

Pressure drop across the anastomosis



- inversely proportional to anastomosis CSA, and to venous outflow
- proportional to arterial inflow
- STS and 90° ETS had the highest venous flow and distal arterial flow reversed
- 45° ETS configuration had reduced flow and resist to reversed arterial flow
- increases with fistula flow (BERNOUILLI'S law)

Computational fluid dynamic evaluation of the anastomosis for arteriovenous fistula

Jeffrey E. Hull, MD, Boris V. Balakin, PhD, Brad M. Kellerman, BSc and David K. Wrolstad, BSc

Journal of Vascular Surgery 2013

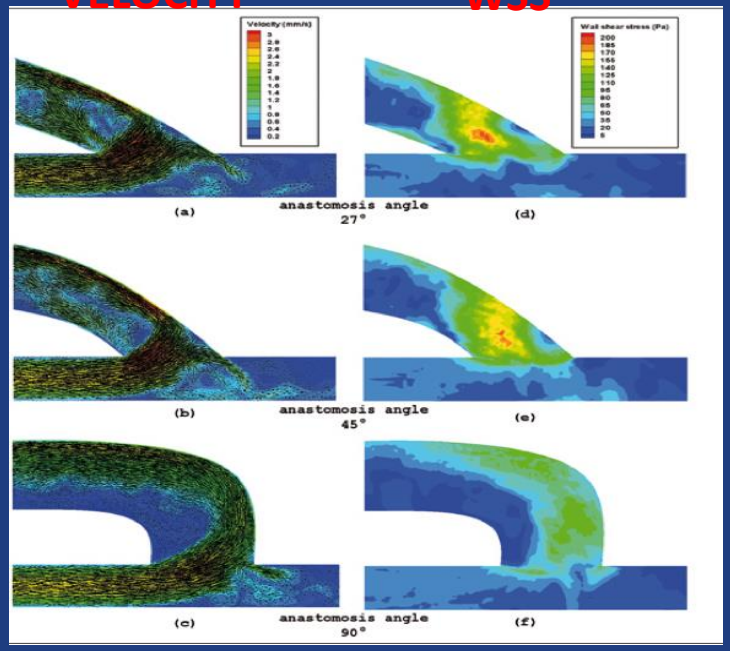
Angle size and flow disturbance

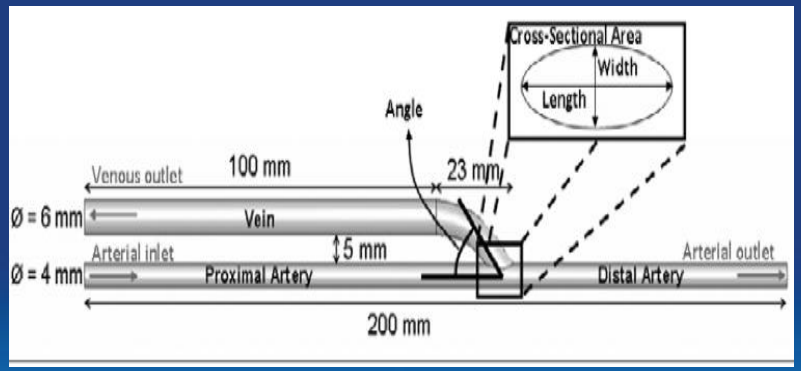
VELOCITY WSS

27°

45°

90°



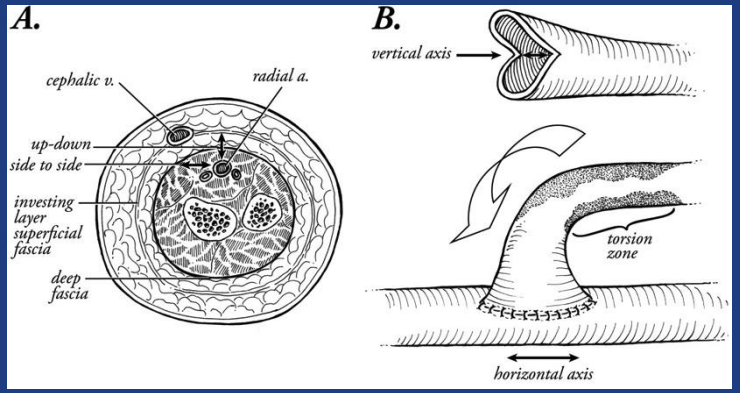


Q:600 à 1200mm/mm

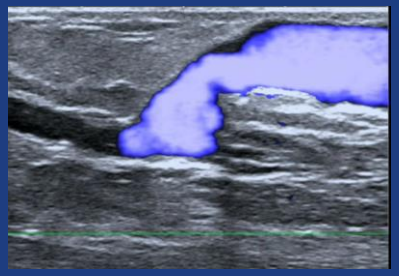
- **A change of 2 mm AAV length increase the pressure drop by more than 30%**
- **CSA STUDIED :12 to 24 mm ^{2}**
- **PRESSURE DROP ↑ CSA ↓ ANGLE >45°**
  Q ↑=CSA ↑
  Angle > 58 ° =REVERSE FLOW

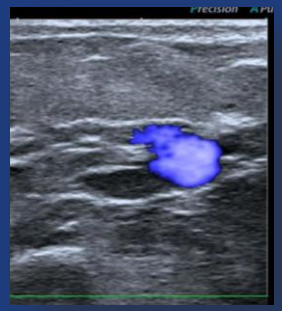
Van Canneyt K,*J Vasc Access 2010*

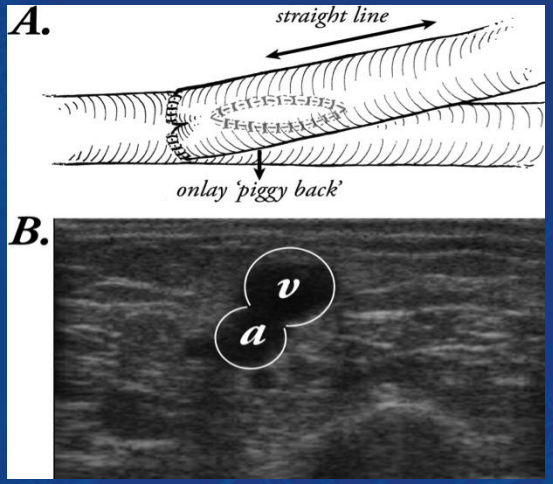
ETS anastomosis : three-dimensional movement of the vein



more important
If the vein artery distance is greater





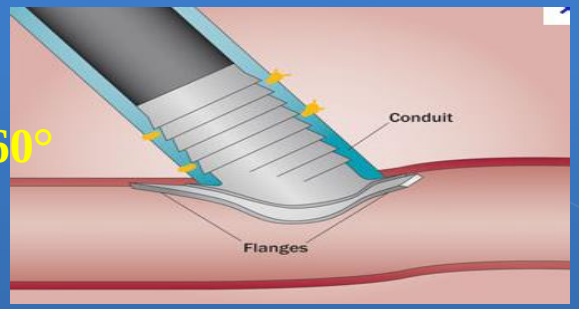


Piggyback SLOT(pSLOT)

A novel technique of vascular anastomosis to prevent juxta-anastomotic stenosis

Ankit Bharat, MD Journal of Vascular Surgery 2012 55, 274-280DOI: (10.1016/j.jvs.2011.07.090)

Solution ? Ready made



AVF

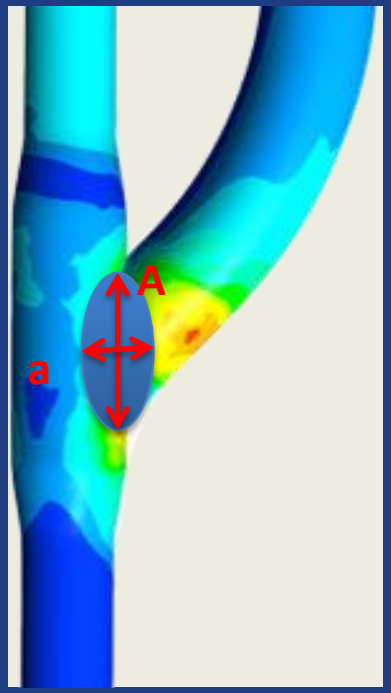
114 patients

64 males,50 femeles

age :60 years

- **32 Brachio basilic AVF**
- **30 Brachio céphalic AVF**
- **49 Radio céphalic AVF**
- **3 Ulno basilic AVF**

Determinant factors of the flow



Anastomosis shape :elllpsoid

CSA:π *½ A*½ a

Q: flow
CSA
Artery Ø
Venous Ø
Long axis : A
Short axis : a
RI
CSA / Artery cross section
Anastomosis level
Age
Gender
Comorbidities

Flow level parameters

univariate analysis

CSA	NS (p= 0.23)
Artery Ø	**S (p<0,0001)**
Vein Ø	**S (p<0.0001)**
Long axis	NS
Short axis	NS
RI	**S (p<0,003**
Anastomosis level	S
Age	NS
gender	NS
Comorbidities	NS
CSA/ artery csa	NS

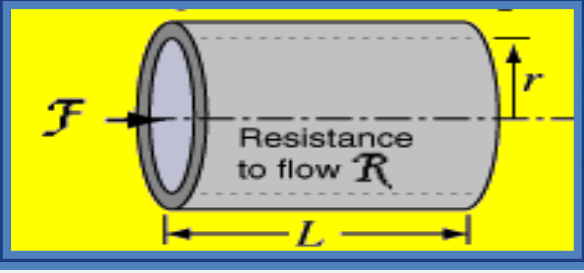
Flow level parameters

Multivariate analysis

	OR	CI	p
Vein ø	1,3	95% (1,05 -1,57)	p=0,012
RI	0,002	95% (8.10^{-8}- 0.8) (	p=0.047)

Flow Reduction

➢ Banding



$$\mathcal{R} = \frac{8\eta L}{\pi r^4}$$ where η = viscosity

* With other parameters held at original values

$$\text{Volume Flowrate} = \mathcal{F} = \frac{P_1 - P_2}{\mathcal{R}} = \frac{\pi(\text{Pressure difference})(\text{radius})^4}{8(\text{viscosity})(\text{length})}$$

A 19% decrease in radius
halve
the volume flow rate

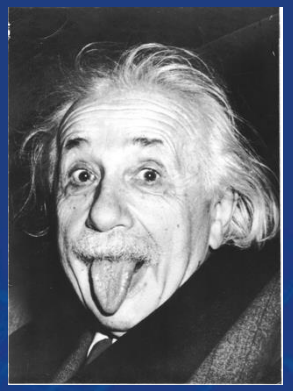
Recurrent high flow (>2 L/min) developed in 52% of the patients

VAES .RHD *J VASC SURG 2014*

AVF OFTEN ILLUSTRATES THIS THOUGHT

La théorie,c'est quand on sait tout et que rien ne fonctionne.
La pratique,c'est quand tout fonctionne et que personne ne sait pourquoi...
Ici, nous avons réuni théorie et pratique :
Rien ne fonctionne ....et personne ne sait pourquoi.

A.EINSTEIN



The theory, it is when we know everything and nothing works.
Practice is when everything works and no one knows why...
Here, we brought together theory and practice:
nothing works.. And no one knows why.

A.EINSTEIN