

VASCULAR ACCESS MONITORING

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Diapositive 1

F2

ITS HAS BECOME A VERY IMPORTANT ISSUE
BUT I HAD THE TEMPTATION TO TRANSFORM THE QUESTION TO WICH ROOM FOR AN ANGIOLOGIST
BECAUSE DESPITE WE TRY TO SPEAK ENGLISH WE ARE STILL IN FRANCE WHERE ANGIOLOGY WORKED A LOT TO DEVEOP THE
TECHNIQUE

FRANCO; 08/06/2007

Aim of CDUS

Need for structured routine method

LESS

Invasive and expensive
than

phlebography and arteriography

WHEN

Physical examination alone is inadequate

**To identify access dysfunction
to**

AVOID LOSS OF THE AVF

Diapositive 2

F3

DEVELOPMENT OF CDUUS RESULT FROM THE NEED for structured routine method

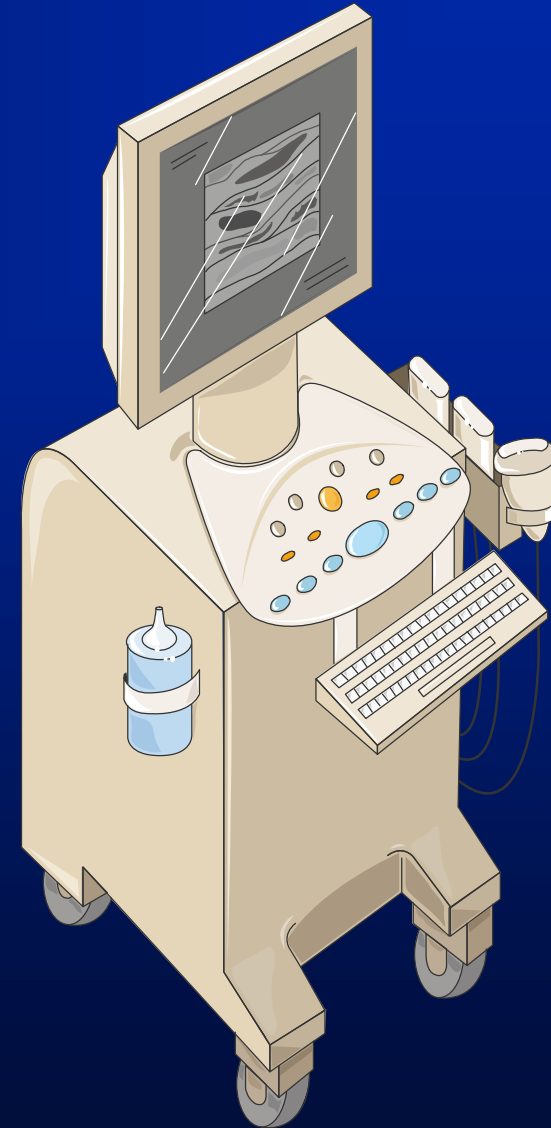
LESS Invasive and expensive than phlebography and arteriography WHEN Physical examination alone is inadequate To assess veins and arteries patency Prior to creation of the AVF Or

To identify access dysfunction to AVOID LOSS OF THE AVF

FRANCO; 08/06/2007

CDUS PLATFORM

- **CW and PW 4 à 10 Mhz**
- **B-MODE REAL TIME: 3 à 17 Mhz**
AXIAL RESOLUTION/ 0.3/0.1mm
- **COLOR FLOW**
- **POWER DOPPLER**
- **TM /COLOR DOPPLER**



Diapositive 3

F7

FRANCO 08/06/2007

PLATFORM MUST BE COMPLETELY EQUIPED WITH ALL THE TOOLS ESPECIALLY HIGH FREQUENCY PROBES
ONLY ABLE TO PROVIDE TINY DETAILS OF WALL VESSELS AND TM DOPPLER USEFULL TO BIOMETRY

FRANCO; 08/06/2007

VASCULAR ACCESS PROBLEMS

PSEUDO INADEQUATE MATURATION

PRIMARY FAILURE | EARLY THROMBOSIS
INADEQUATE MATURATION
FAILURE FOR FIRST CANNULATION
OTHERS COMPLICATIONS

(ischemia infection oedema hematoma liquid mass)

SECONDARY FAILURE

PAIN -OEDEMA -DIFFICULTY OF PUNCTURE-ACCESS DISFUNCTION PV ↗

COMMON CDUS PROTOCOL

FLOW CALCULATION

NORMAL FLOW
ABSENCE OF STENOSIS
SOFT TISSUE THICKNESS

HIGH FLOW

LOW FLOW
INFLOW OR OUT LOW STENOSIS

SURGERY
RADIOLOGY

PSEUDO DELAY: SUPERFICIALISATION

CDUS Flow Calculation

Crucial phase in AVF study

Performed on the arterial and not on the venous slope:

Flow (ml/min) = time average velocity (m/s) x cross-sectional area (mm²) x 60.

The normal fistula flow rate is usually between 600 and 1200 ml/min

Detect AVF at risk for dysfunction and thrombosis

Decreasing flow as a trend :
increasing probability of demonstrating anatomic lesions

Put in touch anomalies of flow with inflow or outflow lesions

OR
EXCLUDE STENTOTIC LESION



BLOOD PRESSURE VOLEMIC PROBLEM HEART RATE

Diapositive 5

F20

Flow calculation is a crucial phase in AVF study.

It must be performed on the arterial and not on the venous slope of the access. Direct and indirect flow measurements are common surveillance tools and can be obtained using also CDUS .

FRANCO; 10/06/2007

LOW FLOW

Inadequate maturation
Detect AVF at risk for dysfunction and thrombosis

Decreasing flow as a trend :
increasing probability of demonstrating anatomic lesions

Put in touch anomalies of flow with inflow or outflow lesions

OR

EXCLUDE STENTOTIC LESION



BLOOD PRESSURE VOLEMIC PROBLEM HEART RATE

LOW FLOW < 400ml/ mm :RISK OF THROMBOSIS

Patency in native AVF can be maintained with lower flows than in prosthetic access

Grafts with flows greater than 800 ml/minute have a risk of thrombosis that is significantly less than those under 800 ml/minute.

Diapositive 6

F26

LOW FLOW < 400ml/ mm carry RISK OF THROMBOSIS but Patency in native AVF can be maintained with lower flows than in prosthetic access Grafts with flows greater than 800 ml/minute have a risk of thrombosis that is LOW FLOW < 400ml/ mm carry RISK OF THROMBOSIS but Patency in native AVF can be maintained with lower flows than in prosthetic access Grafts with flows greater than 800 ml/minute have a risk of thrombosis that is significantly less than those under 800 ml/minute.

However, such studies provide a unique opportunity not only to measure flow, but also to delineate stenosis accurately and to put in touch anomalies of flow, low or high with inflow or outflow lesions OR EXCLUDE and move toward blod pressure volemic or heart rate problems.Low flow after AVF creation make search cause of inadeqtae maturation as previously discribed.

FRANCO; 10/06/2007

HIGH FLOW RATE

HIGH FLOW > 1500 ml/mm

Cardiac repercussions

Pathologic development of the AVF

Factor that aggravates stenosis dysfunction

The increase in PV and oedema
are common reasons to search for
venous stenosis

Its quantification should be re-estimated as a function of flow
its reduction is sometimes sufficient to diminish impact of a venous
stenosis

steal must be concomitantly evaluated

Examinations should include an evaluation of the possibilities of flow
reduction

Diapositive 7

F21

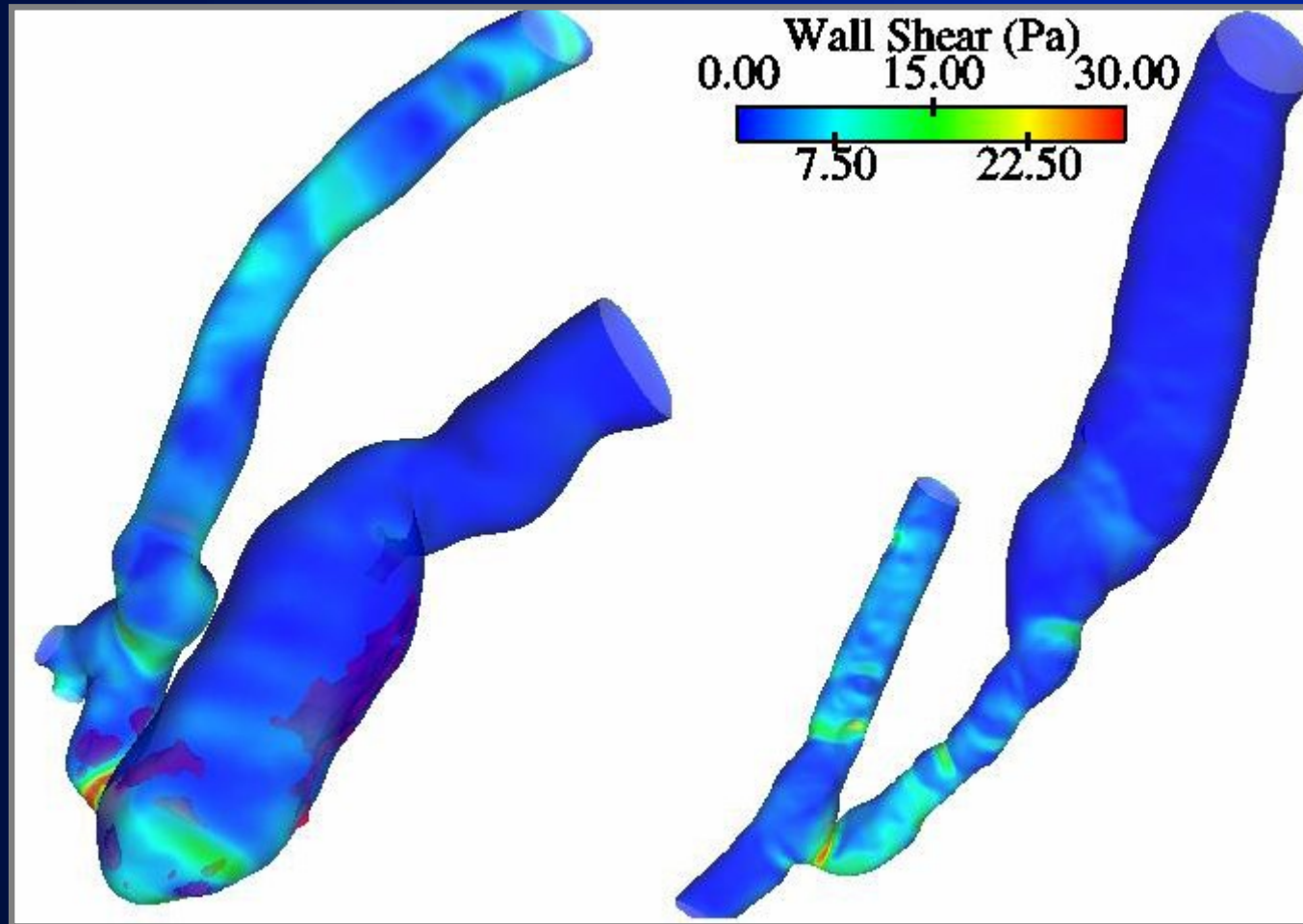
High flow is frequent and should be borne in mind during AVF exploration, as it may be associated with many other pathologic situations .in addition to the effects on the functioning and pathologic development of the AVF itself examinations should include an evaluation of the possibilities of flow reduction Steal must be concomitantly evaluated, as previously stated.

The high flow associated with venous stenosis is a frequent problem that must be carefully assessed. The increase in venous pressure and the presence of oedema are common reasons for requesting exploration, and immediately prompt a search for venous stenosis. Its quantification should be re-estimated as a function of flow, because the presence of high flow is a factor that aggravates stenosis dysfunction. If the flow rate is too high, its reduction must be envisaged, as curing the stenosis will only favour a further increase in flow. Moreover, its reduction is sometimes sufficient to diminish the significance of a venous stenosis.

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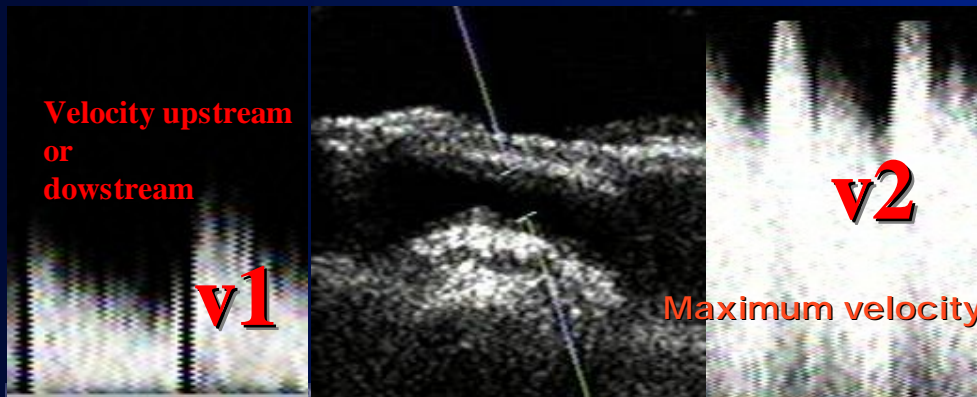
STENOSIS?

HOW AND WHERE TO QUANTIFY

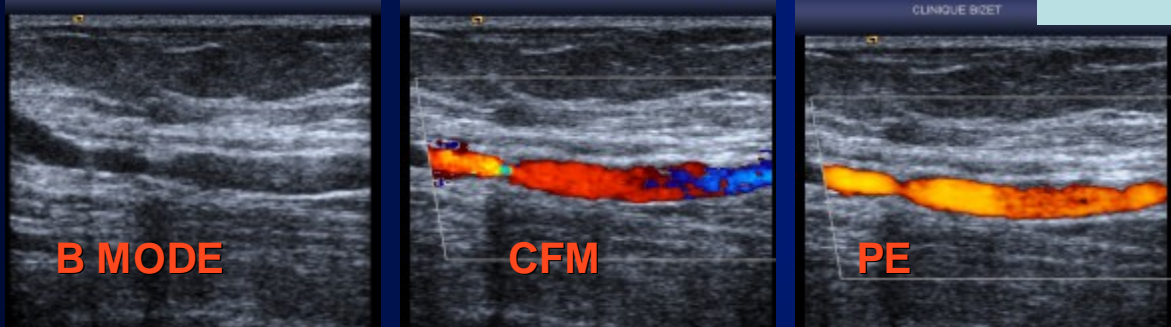


STENOSIS

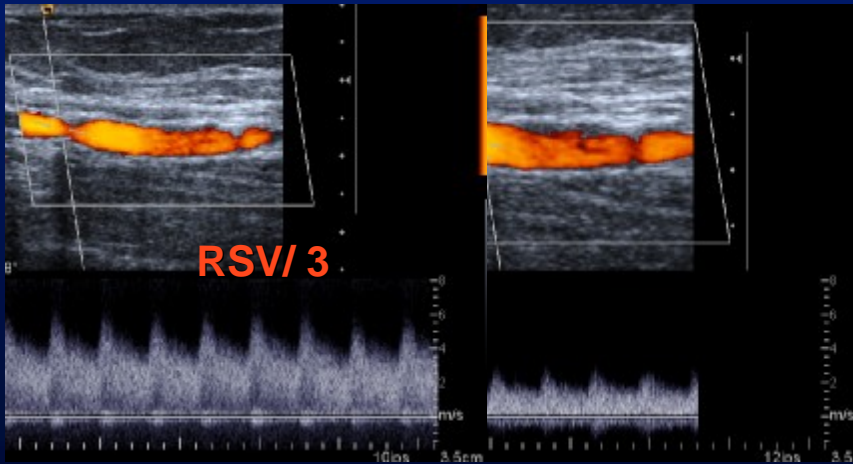
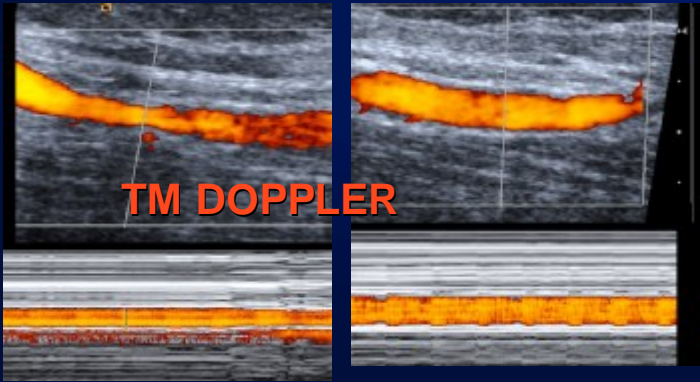
Diagnosis and Quantification



CONTINUITY EQUATION:
 $S1 * V1 = S2 * V2$
 $\% \text{ of stenosis} = 1 - V1/V2 * 100$
RSV > 3 : significant sténosis >50%

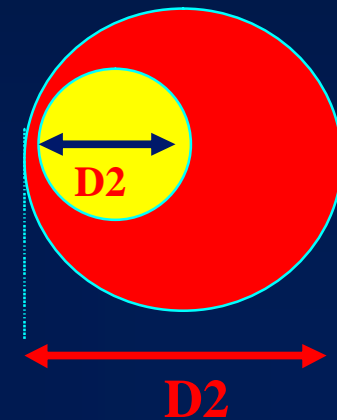
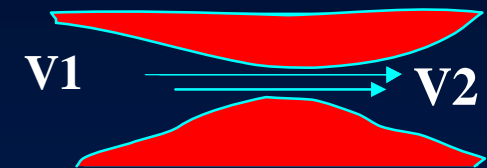


50% STENOSIS



RELATION TO %STENOSIS / VELOCITY /PRESSURE DROP

V2 max m/s	Pressure drop $4v^2_{max}$: mmHg	RATIO V2/V1	% STENOSIS $1-V1/V2*100$
1	4	1	0
2	16	2	50%
3	36	3	66%
4	64	4	75%
5	100	5	80%
6	144	6	83%



PSV RATIO AND SIGNIFICANT STENOSIS

Peak systolic velocity ratio (SVR)

- $\geq 2:1$ detect $\geq 50\%$ stenosis involving arterial inflow and venous outflow
- $\geq 3:1$ or PVV $> 3\text{m/s}$ to detect $\geq 50\%$ anastomotic stenosis

Tordoir JH, J Vasc Surg. 1989

Chao A., J Vasc Technol. 2001

- These widespread criteria in literature lead to a too high number of diagnosis of critical stenoses in patent AVFs using CDU surveillance.
- Using these criteria only 26% of the patent primary AVF were perfectly normal and 54% had hemodynamically significant stenosis

Grogan JJ Vasc Surg. Jun 2005

- Need to more precise threshold: residual lumen
- Critical stenosis :3 mm

Strandness DE ,Summer DS. Vasc Surg 1989

Diapositive 11

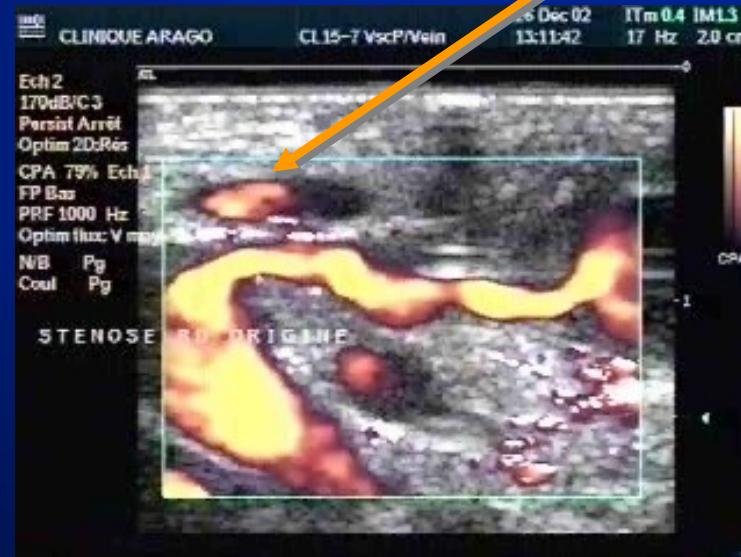
- F18 CDUS with variance analysis enable very fast detection of the areas with high turbulences relative to venous or arterial stenosis. Velocities of the areas upstream and downstream can be recorded. Peak systolic velocity ratios (SVR) can thus be calculated, enabling stenosis quantification according to the following continuity equation: $S1.V1 = S2.V2$. give the theoretical percentages of stenosis .the relationships between the velocities resulting from the continuity equation give surface ratio stenosis which are intellectually much more satisfying for stenosis quantification than the diameter ratio obtained by angiography. A correction coefficient should be applied to render the equivalent in terms of diameter reduction. In the literature a SVR of $\geq 2:1$ are used to detect $\geq 50\%$ stenosis involving arterial inflow and venous outflow, whereas an SVR of $\geq 3:1$ are used to detect $\geq 50\%$ anastomotic stenosis. These widespread criteria in literature lead to a too high number of diagnosis of critical stenosis in patent AVF. The latter parameter must be compared to the flow parameter because a high flow generates high velocities, and any anatomic singularity, leads to functional stenosis.

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PROXIMAL STENOSIS OF RA

RA

RI >0.5
VARIANCE ++
↑ VELOCITY AND FREQUENCIES <0



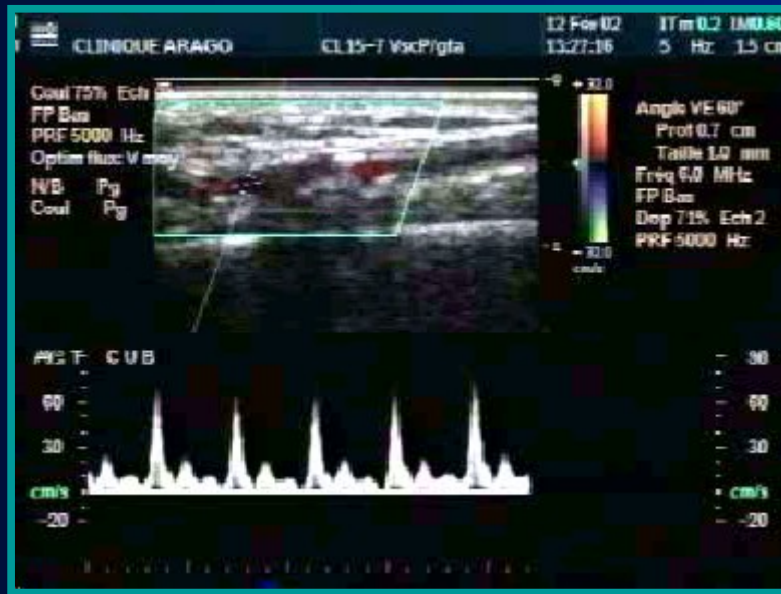
RADIAL AVF AT FOREARM

STENOSE SERREE DES ARTERES DE L'AVT BRAS

IR >0.5

VARIANCE ++

↑ VITESSES ET FREQUENCES <0

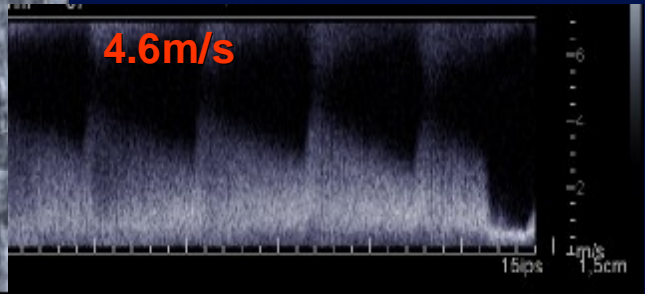
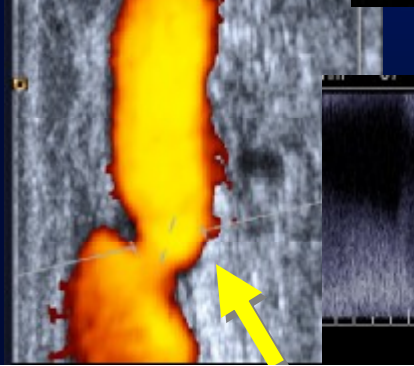
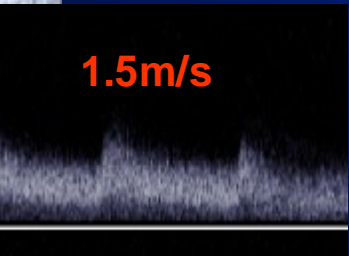
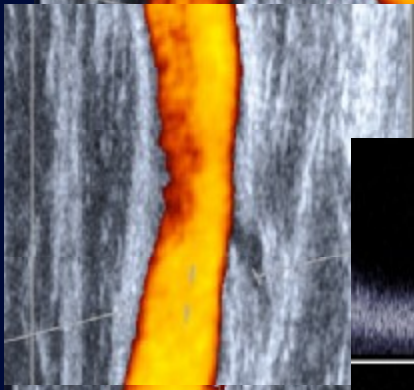
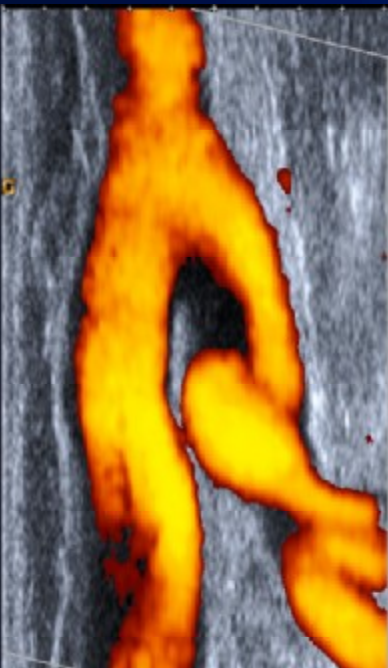


CUBITALE



RADIALE

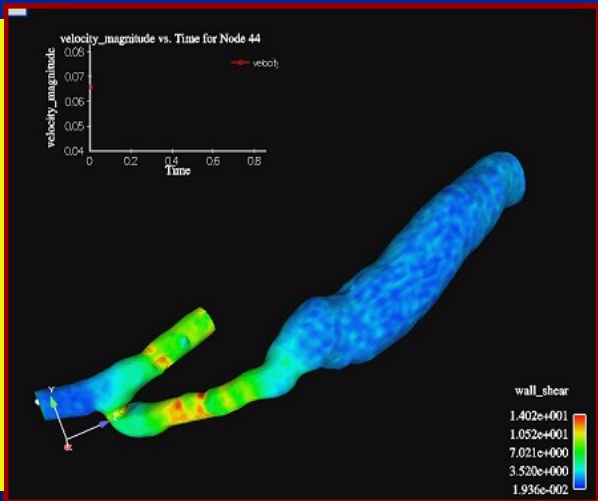
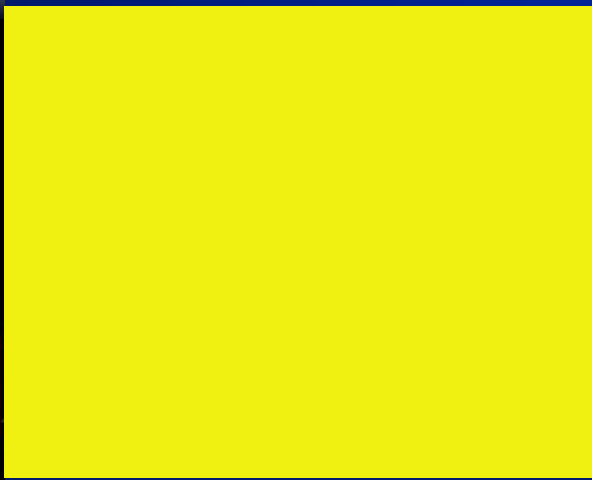
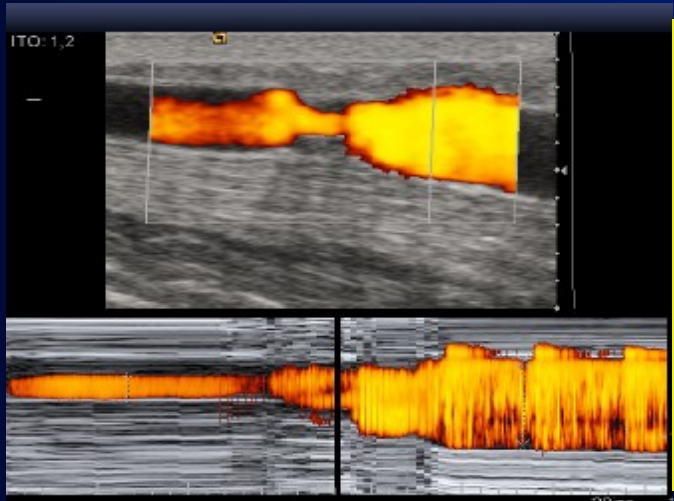
**AVF AT WRIST
PERFORATOR IS THE ONLY DRAINAGE
FLOW :780 ml/mm
RSV:3
MILD RADIAL STENOSIS**



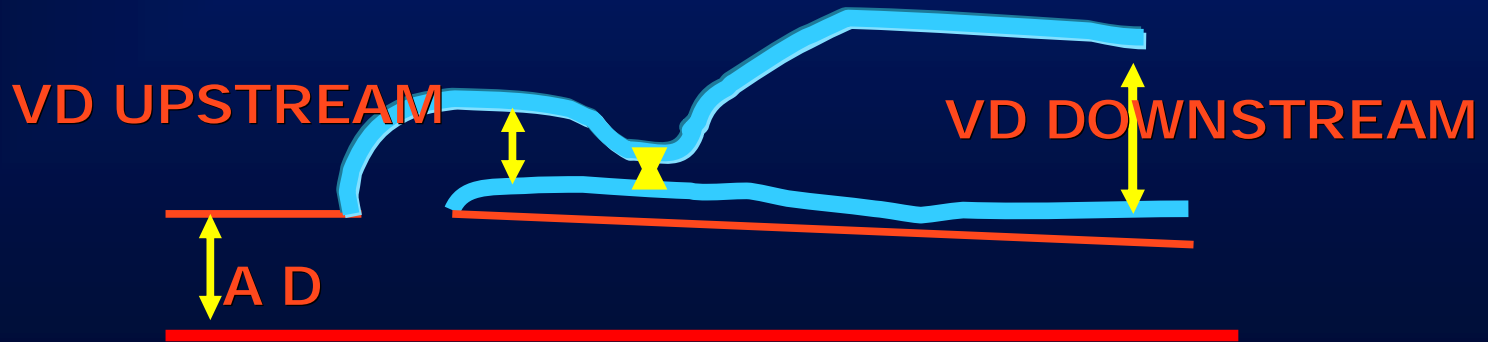
VENOUS STENOSIS

- **LOW FLOW / LATE MATURATION**
- **INCREASED VENOUS PRESSURE**
- **BLEEDING**
- **OEDEMA**
- **HEMATOMA**
- **PAIN**

TM DOPLER COULEUR AND ENERGY



RESIDUAL LUMEN



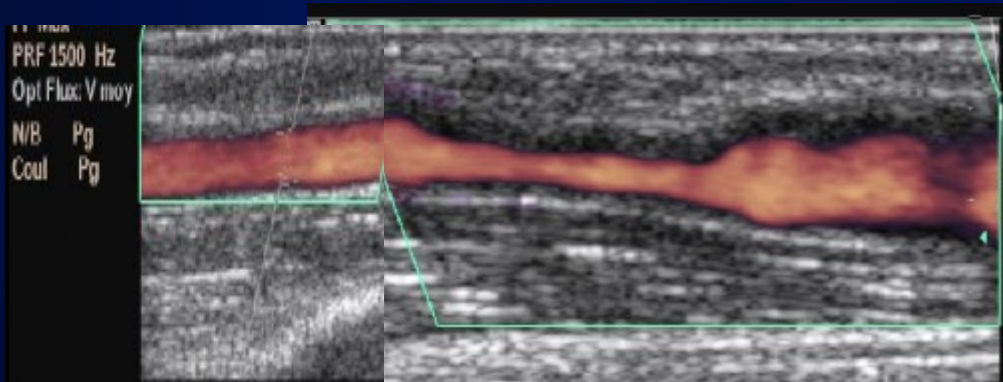
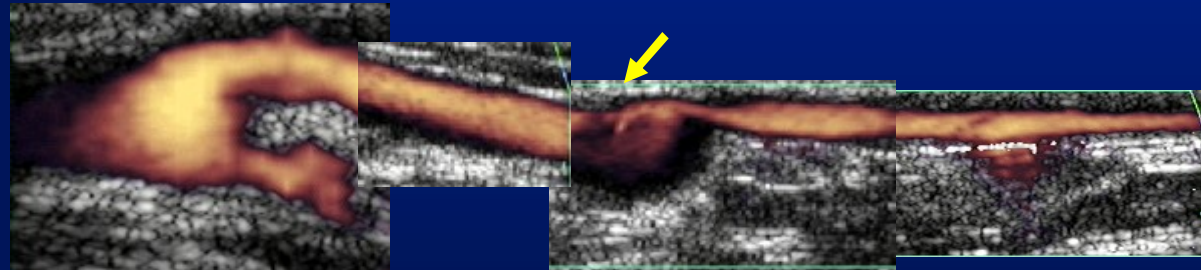
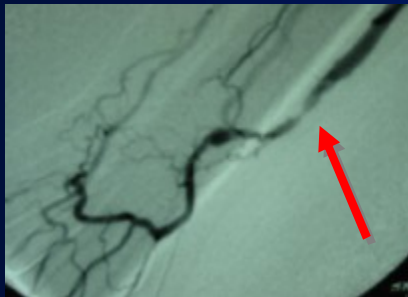
Diapositive 16

F9

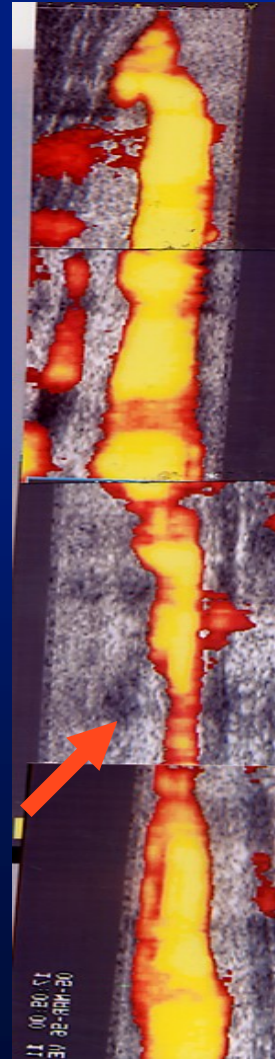
Power Doppler is up to five times more sensitive in detecting blood flow than color Doppler and allows better display of the vessels..Combined with TM mode the calculation of stenosis percentage become more accurate and furthermore estimates the resistance and compliance of stenosis. These features make understand why in many cases a recoil happens after balloon dilatation.

FRANCO; 08/06/2007

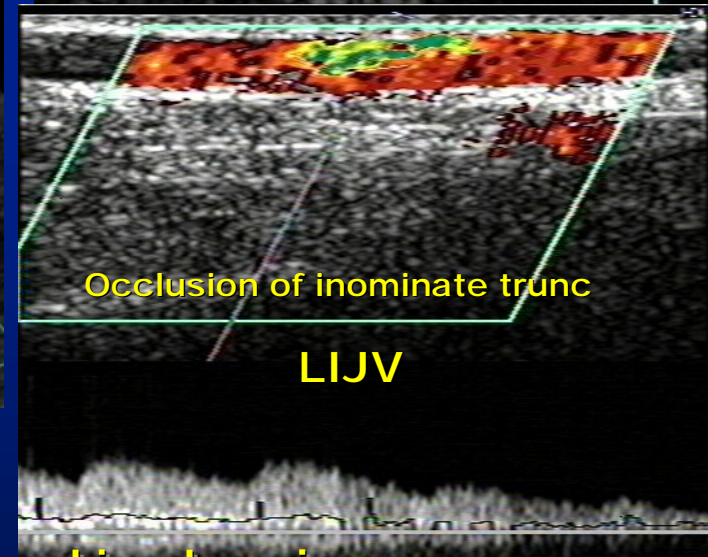
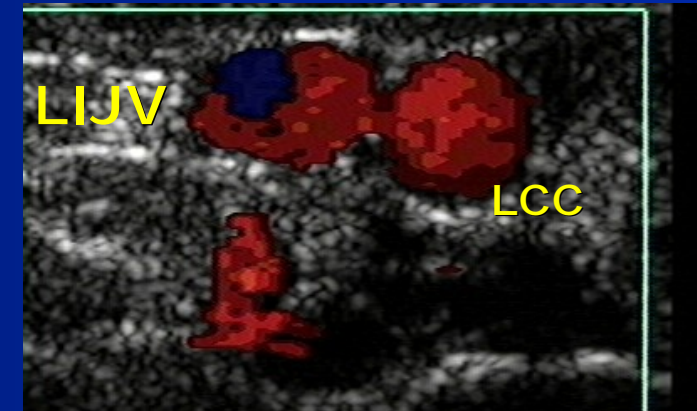
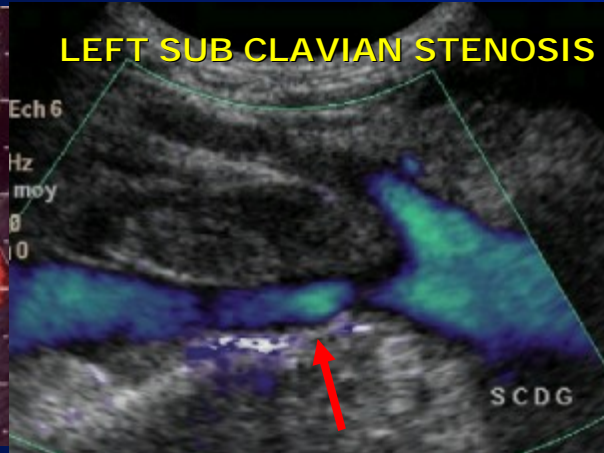
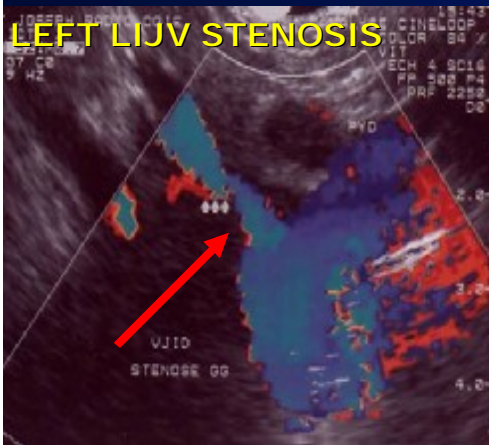
VENOUS OUT FLOW STENOSIS AT FOREARM



VENOUS OUT FLOW STENOSIS AT THE ARM



LIMITATIONS: CENTRAL VEINS

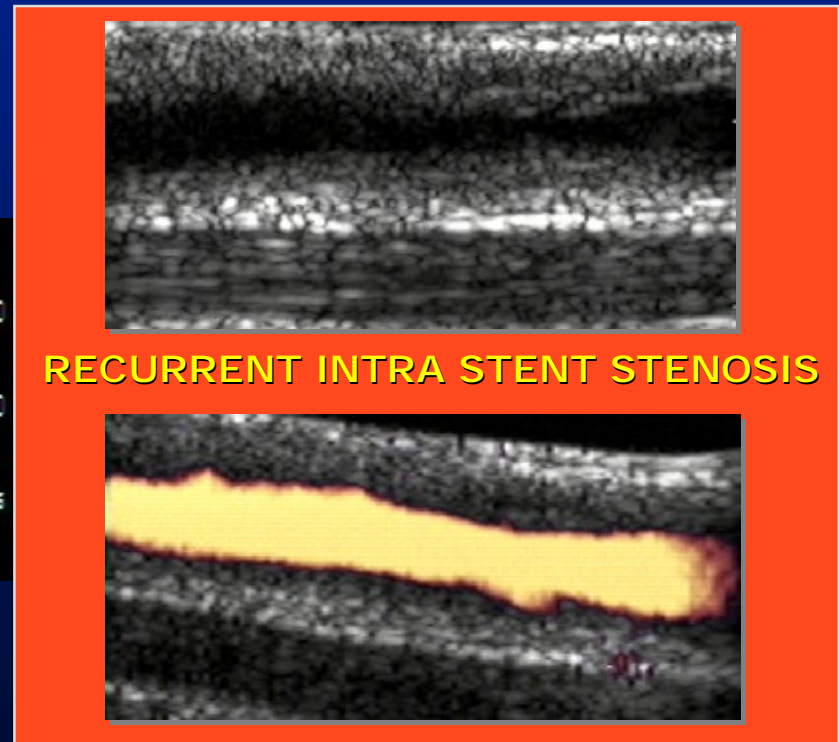
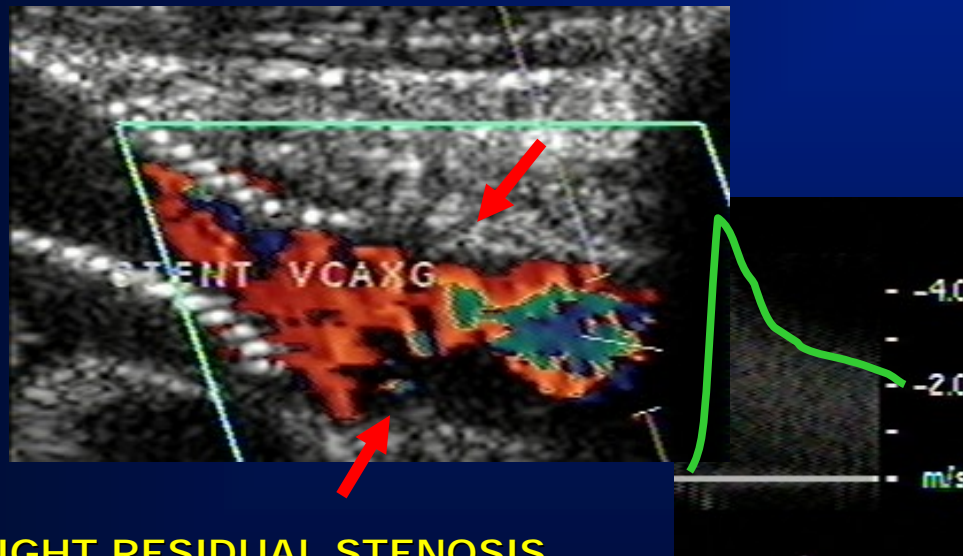
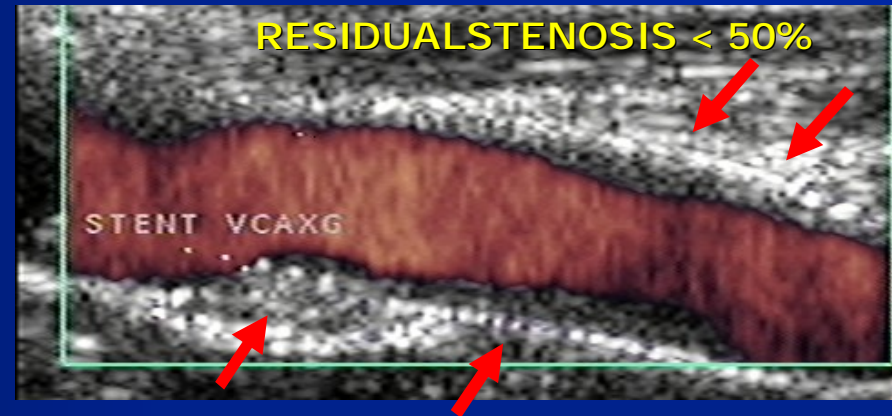


significant stenosis of central veins :

- active side branches and flow reversal in the internal jugular vein
- disappearance of variations of flow and of vessels size with respiration
- combined with dilatation upstream.

BUT
venography remain more accurate in some situations

CONTROL POST BALLOON DILATATION



STENOSIS DETECTION CDUS/ ANGIOGRAPHY

	N	Sens %	Spec %
PASSMANN <i>J Vasc surg 1998</i>	51	85	97
GADALLAH <i>Am J Kidney Dis 1998</i>	38	100	100
ROBIN <i>Radiology 1998</i>	219	95	89
DOELMANN <i>J Vasc surg 2005</i>	91	91	95

DIFFICULT PUNCTURE

Many lesions can make puncture of the AVF difficult

or

dialysis ineffective

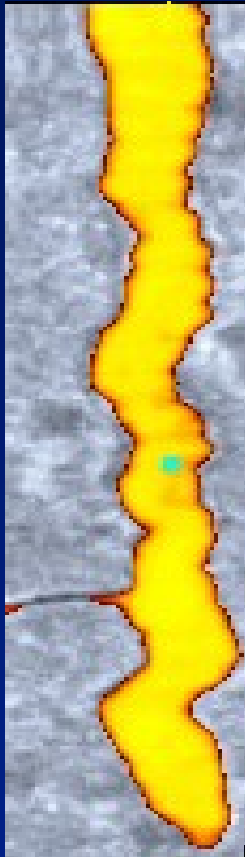
If

the needle drive in a clot

in a dead end

or

in the channel of dissection



F28



MOVING CLOT AND WAL THROMBUS WITHIN VENOUS ANEURISM

Diapositive 23

F28

Many lesions can make puncture of the AVF difficult or the dialysis ineffective
If the needle drive in a clot in a dead end or the channel of a dissection

FRANCO; 08/06/2007

SEROUS PERI GRAFT EXTRAVASATION



**VENOUS DISSECTION
WITH
DOUBLE CHANNEL**

**DIFFICULTES
DE
PONCTION/DEBIT
DISSECTION VEINEUSE**

ARTERIAL STEAL / DIGITAL ISCHEMIA

- Reversal of flow in the RA beyond the anastomosis is common
- Digital-brachial index < 0.6 , often < 0.3 is an interesting sign of ischemia but it could be falsely good when the vessels are very calcificated.
- In case of proximal or distal arterial obstruction or the both such steal can be a critical factor of ischemia increasing the distal drop of pressure and velocity non reversible after manual closure of the AVF
- Association of high flow rate and high grade stenosis of the forearm arteries increase the consequences of the steal syndrome
- CDUS show significant improvement of distal flow:
after therapeutic as balloon dilatation of stenosis
elimination of steal by ligation of the distal radial artery
reduction of high flow
DRIL

Diapositive 26

F22

Several types of case may occur, as follows:

The distal flows are normal, when AVF is open, and possible distal ischemia can be ruled out.

The distal flows are degraded or absent, which is compatible with an ischemia which probably worsens during dialysis sessions. In that case, either manual compression of the AVF makes the flows reappear and one can conclude that ischemia with steal is present, and as the permeability of the axes downstream of the AVF is not involved, it is important in such cases to search for a high flow whose correction may be efficient to reduce the steal and improve the symptoms, or else AVF compression does not lead to the reappearance of distal flows and one may conclude that the steal is accompanied by significant arterial lesions, which may be located upstream or downstream of the AVF anastomosis. A careful search must be made for the seat of the lesions in order to determine the radiologic or surgical treatment.

FRANCO; 08/06/2007

UPPER LIMB ISCHEMIA

Acute ischemia with sensorimotor deficiency

Monomelic neuropathy with severe sensory and motor nerve dysfunction

Chronic ischemia, with or without trophic disorders

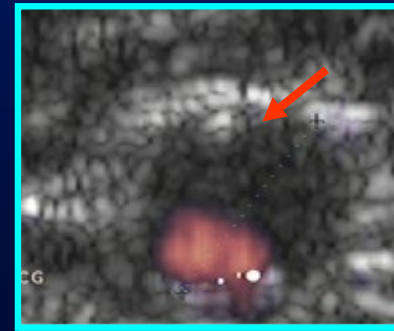
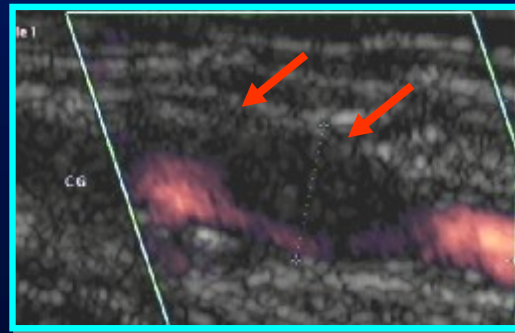
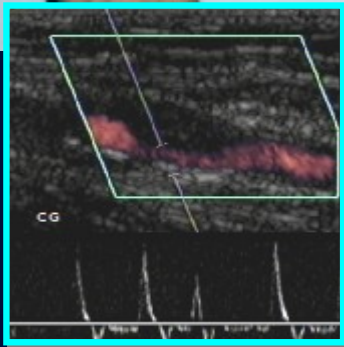
Ischemic syndrome and oedema: venous etiology.

Embolic causes: source of migration.

Arterial aneurysm

or

Occluded AVF stump with a thrombus, a possible



ULNAR ANEURYSM

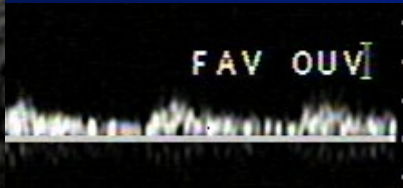
Diapositive 27

F24

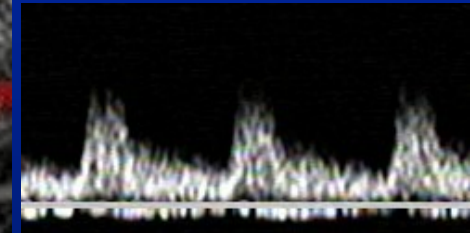
Distal ischemia is a severe complication of vascular hemodialysis access. Its mechanisms are complex. A thorough knowledge of these mechanisms is indispensable for pre-treatment diagnosis and to guide the choice of treatments. Interventional radiology is often efficient, mostly by performing angioplasty in patients with severe or extensive disease, and can also enable steal to be reduced by arterial occlusion. Several often intricate mechanisms are at the origin of this problem, which may be urgent, especially if it occurs soon after AVF creation.

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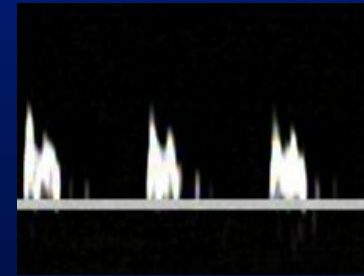
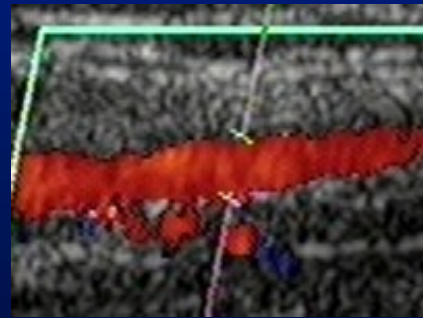
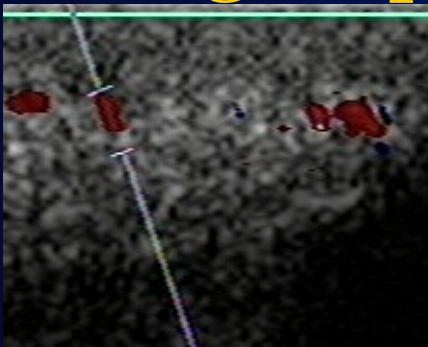
Distal steal without digital ischemia



Digital pulp



Radial artery



Result of FAV compression on distal flow

Diapositive 28

F23

Doppler shows the presence of a continuous flow along the forearm axes.

Manual compression of the fistula at the level of the anastomosis leads to the immediate disappearance of the steal.

The flow level is an important factor to be taken into account.

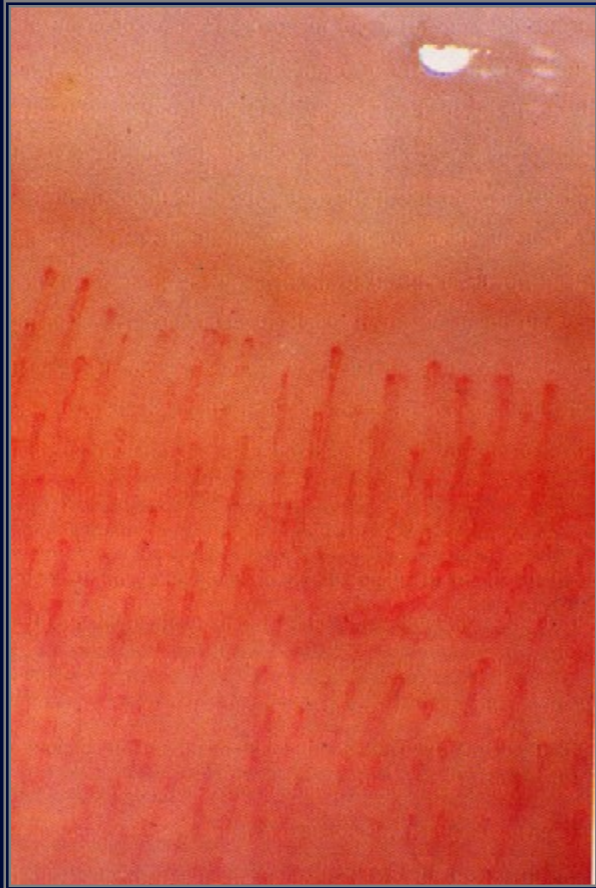
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INTERMITTENT DISTAL STEAL

LENGTH
OF
RETROGRADE FLOW > ANTEGRADE FLOW



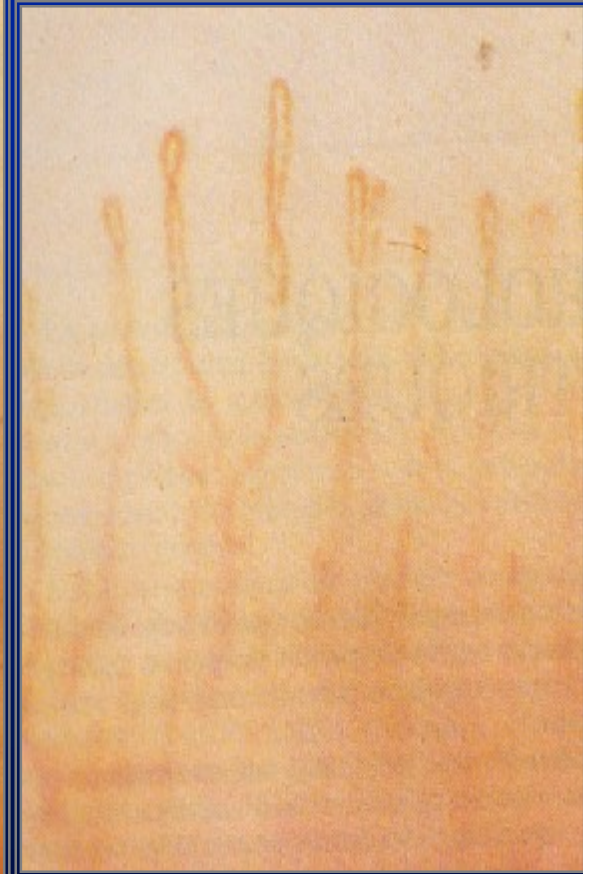
CAPILLAROSCOPIE



Capillaroscopie normale



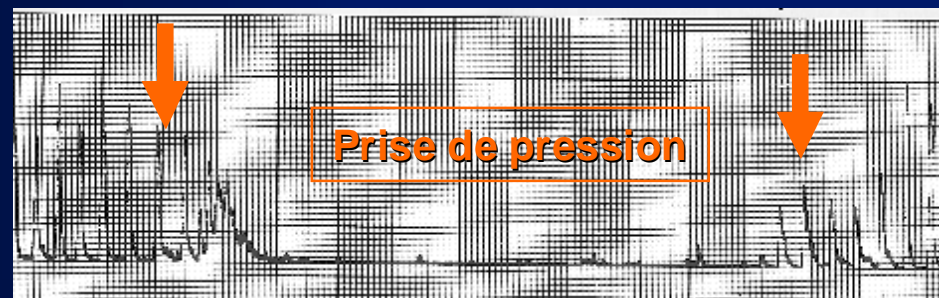
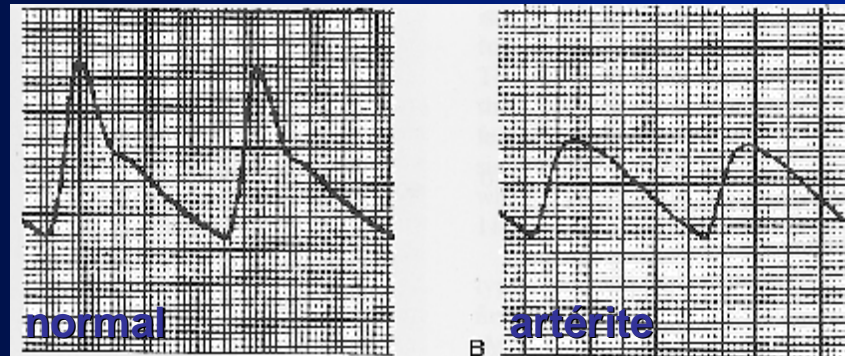
Vascularite



Hypohemie

PLETHYSMOGRAPHIE

PHOTOPLETHYSMOGRAPHIE



MANAGING VASCULAR ACCESS

PROLONGATION OF ACCESS LIFE :

**Detection of stenosis and prevention of thrombosis is valuable
Reduction of thrombotic events reduces loss of access patency.**

When

**CDUS indicates the likely presence of a tight stenosis
fistulography and angioplasty should be performed**

BUT

surveillance technique for detecting anatomic stenosis

ALONE

without concomitant functional assessment has not been established.

Stenotic lesions should not be repaired merely because they are present.

**If such correction is performed
measurement of flow or intra-access pressure MUST demonstrate a functional improvement**



IMAGE CARRIES ONLY THE MEANING THAT YOU GIVE IT

FAV RADIALE / Q° = 1250 ml/mm

