

# **ECO DOPPLER**

## **principi fisici**

**e**

## **principali applicazioni cliniche**

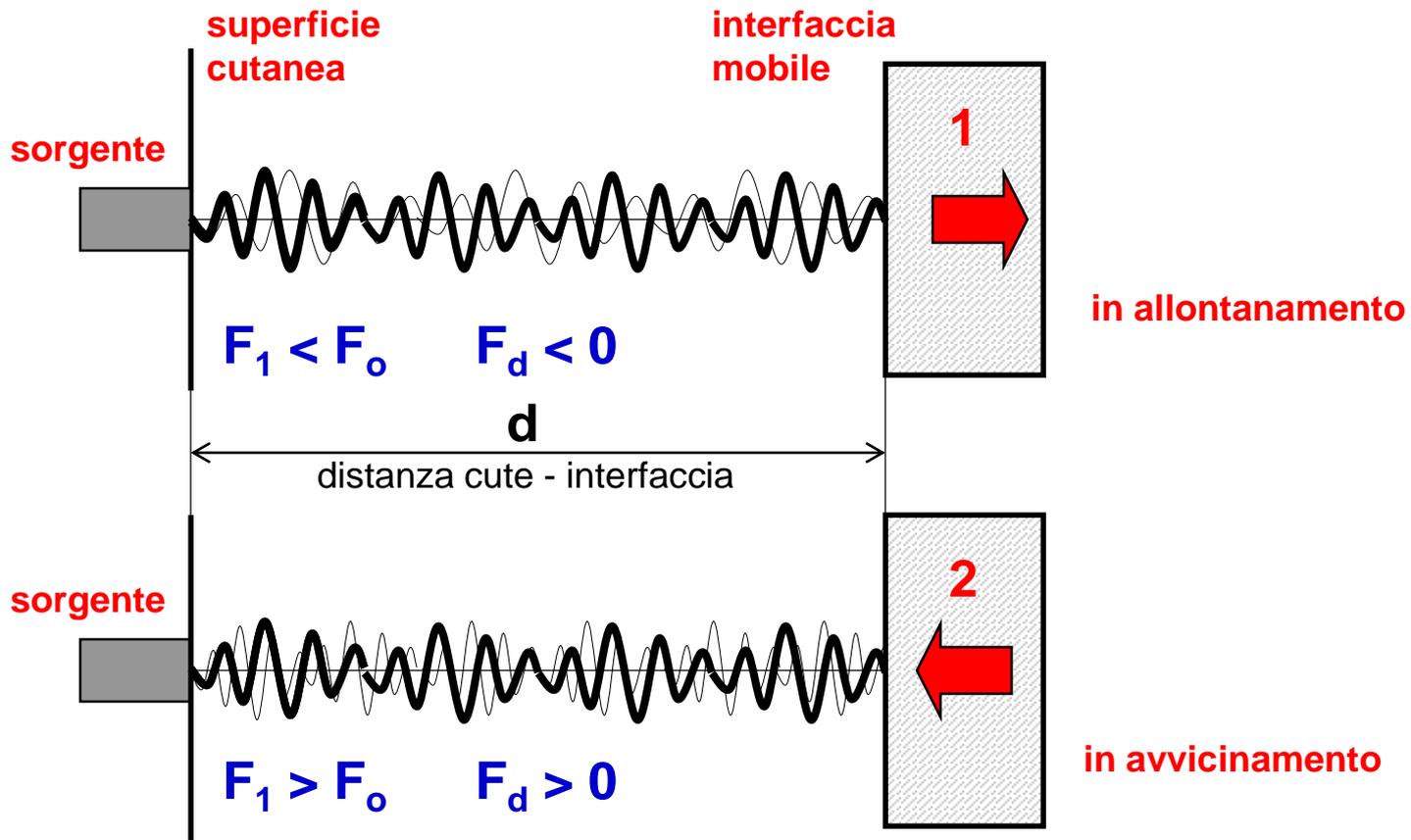


**G. Zironi**

# ANDREAS CHRISTIAN DOPPLER

(29.11.1803 - 17.3.1853)

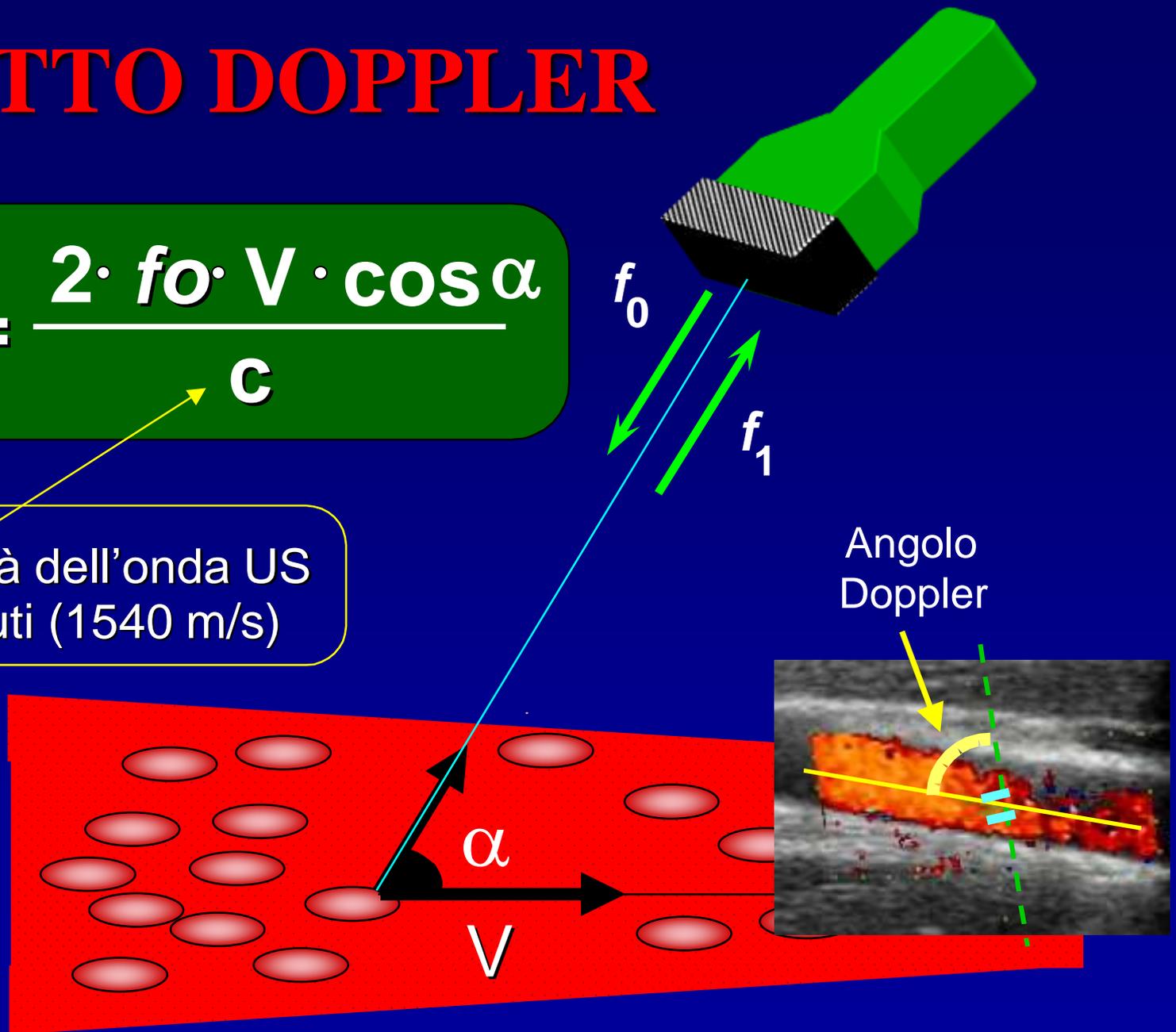




# EFFETTO DOPPLER

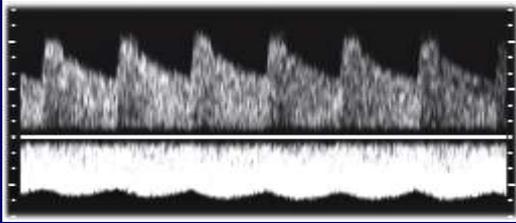
$$f_D = \frac{2 \cdot f_0 \cdot V \cdot \cos \alpha}{c}$$

$c$  = velocità dell'onda US nei tessuti (1540 m/s)



$$\cos 0^\circ = 1; \cos 90^\circ = 0$$

## DOPPLER CONTINUO



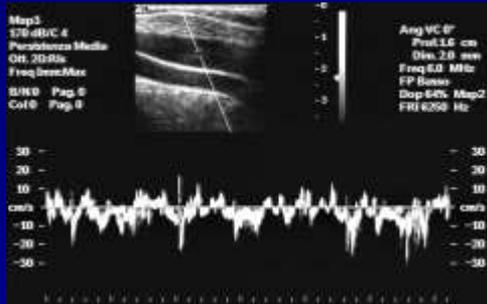
Due cristalli continuamente attivi.

Emissione e ricezione continua

**Vantaggio: nessun limiti di velocità di flusso rilevabile**

**Svantaggio: assenza di risoluzione spaziale**

## DOPPLER PULSATO



Un singolo cristallo che emette/riceve alternativamente.

Il numero di volte nell'unità di tempo in cui il ciclo emissione-ricezione viene ripetuto è definito PRF (Pulse Repetition Frequency)

**Vantaggio: risoluzione spaziale**

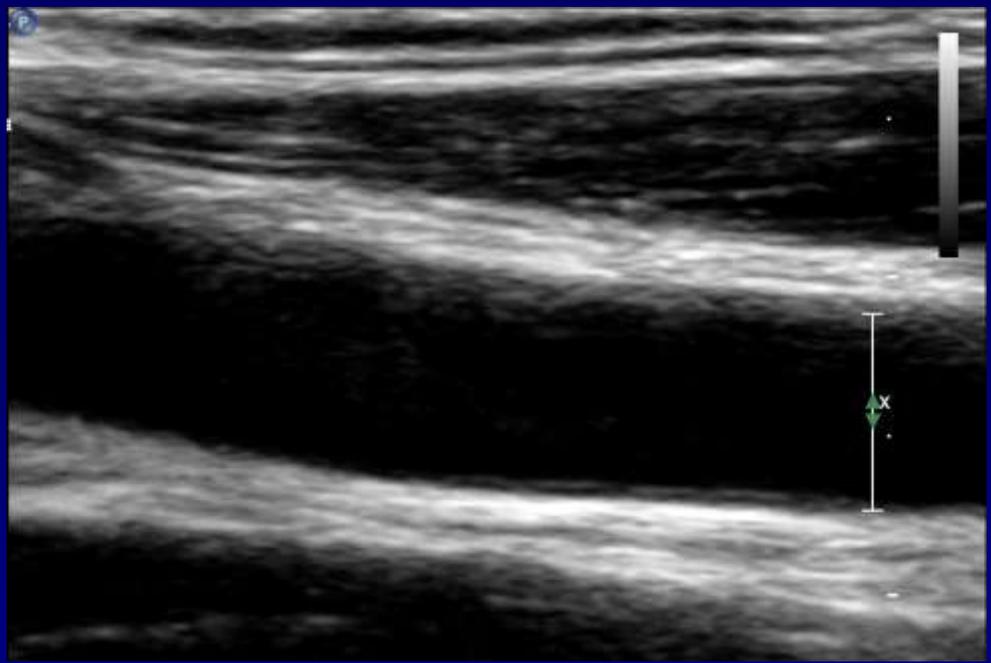
**Svantaggio: limitazione nella velocità di flusso rilevabile**

## COLOR DOPPLER

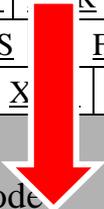


Una mappa relativa alle velocità di flusso (in codice cromatico) viene sovrapposta all'immagine ecografica relativa alle strutture (in scala di grigi).

**Vantaggi/Svantaggi: gli stessi del Doppler pulsato**



Q W E R T Y U I O P  
 A S F G H J K L  
 Z X V B N M ; .



Mode

M B C P  
 Pw TH

Doppler

Gain  
 Angolo  
 Steering  
 PRF

Misurazioni

+...+  
 Area  
 Menu'

Fuochi

↑ ↓  
 n

Preset



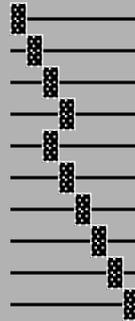
Sonde

DEPTH

↕ ↕

zoom

TGC

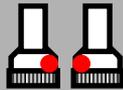


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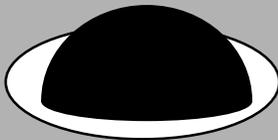
Orientamento



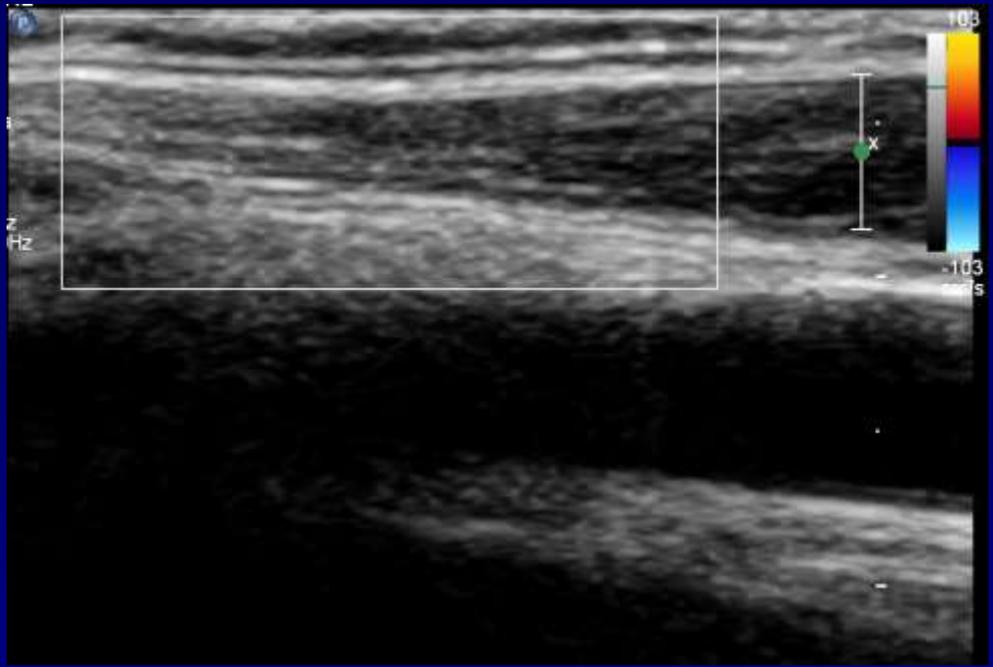
Immagine



Sonda



Freeze



Q	W	E	R	T	Y	U	I	O	P
A	S	D	F	G	H	J	K	L	
Z	X	C	V	B	N	M	.	:	

Mode

M	B	C	P
Pw	TH		

Doppler

Gain

Angolo

Steering

PRF

Misurazioni

+...+
Area
Menu'

Fuochi

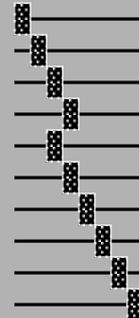
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Preset

Sonde

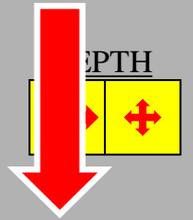


TGC



On  
Off

DEPTH



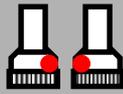
zoom



Orientamento

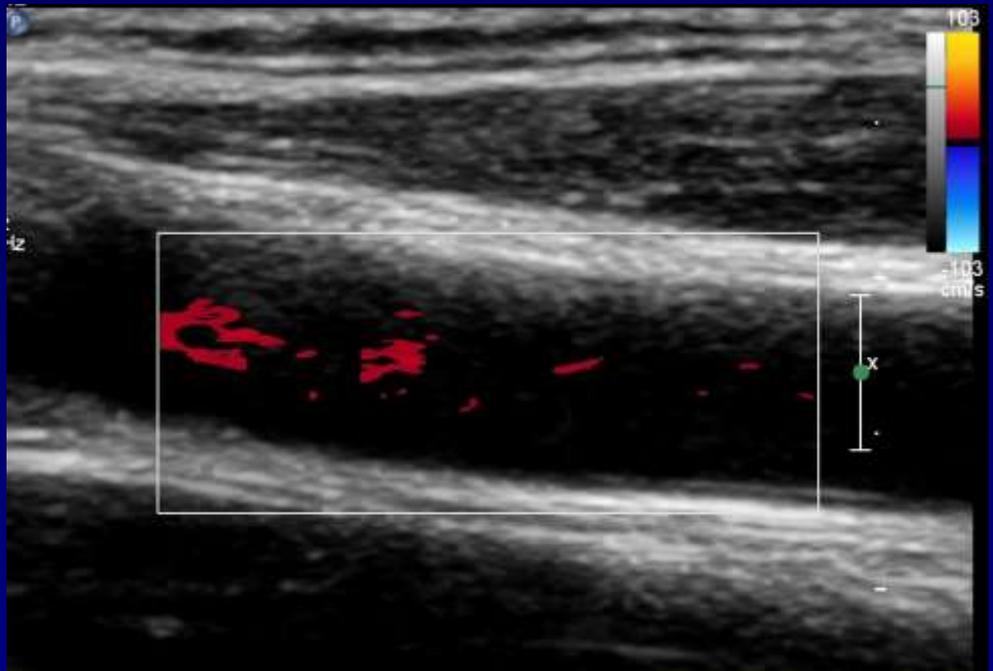


Immagine



Sonda

Freeze



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Fuochi

↑ ↓  
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Preset

Sonde

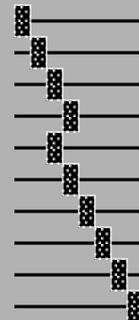


DEPTH

↕ ↔

zoom

TGC

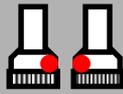


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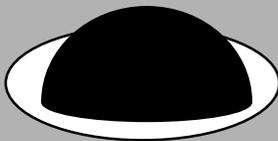
Orientamento



Immagine



Sonda

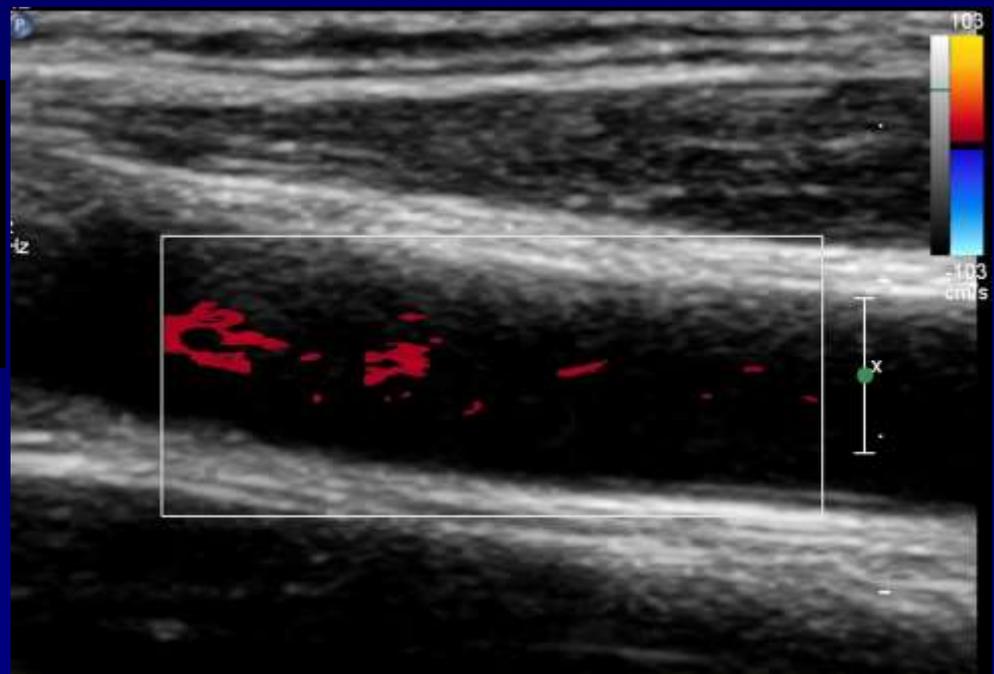


Freeze

$$F_d = \frac{2 \times F_0 \times V \times \cos a}{c}$$

$$\cos 0^\circ = 1$$

$$\cos 90^\circ = 0$$



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Preset

Sonde



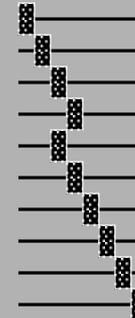
DEPTH

↕ ↕

zoom

GAIN

TGC

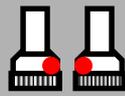


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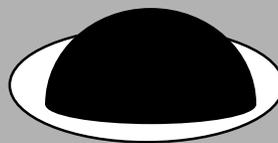
Orientamento



Immagine

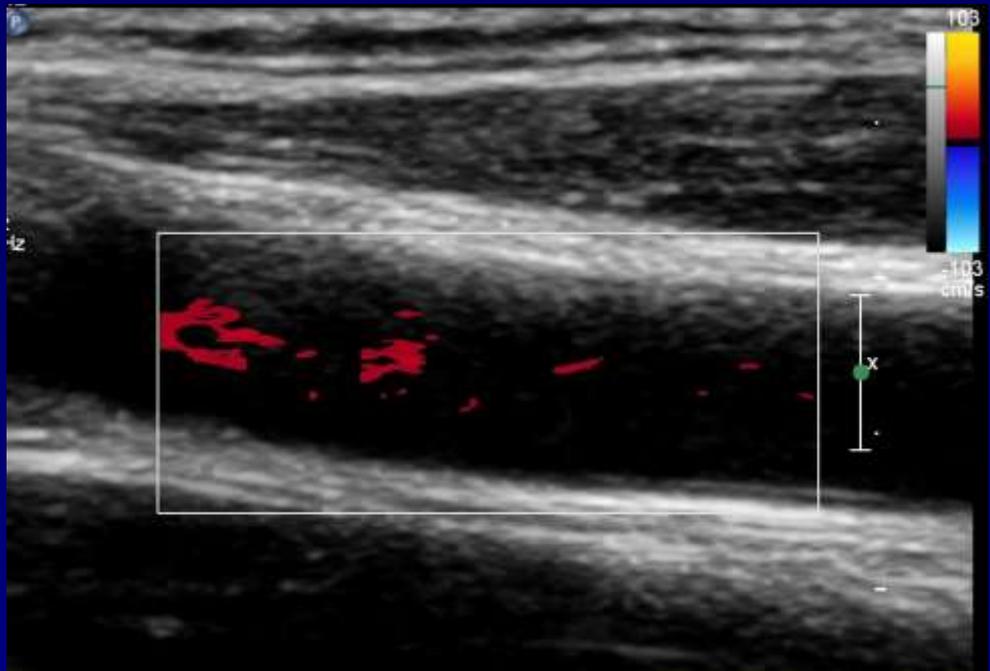


Sonda



Freeze





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Preset

Sonde

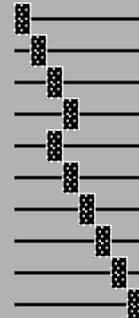


DEPTH

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zoom

TGC

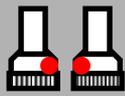


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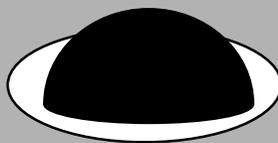
Orientamento



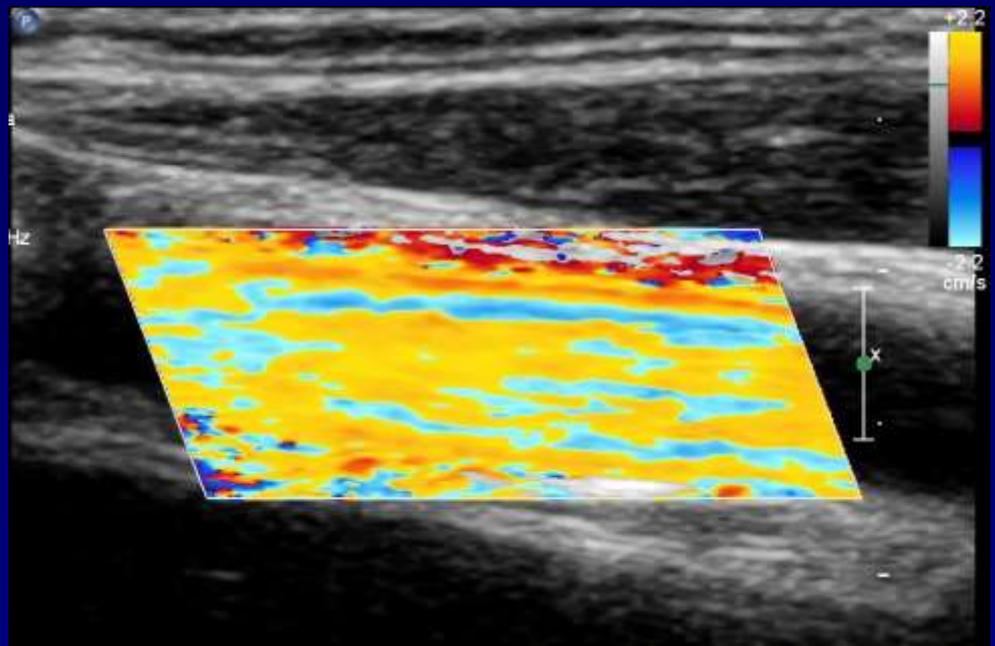
Immagine



Sonda



Freeze



Q W E R T Y U I O P  
 A S D F G H J K L  
 Z X C V B N M ; .

Mode

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 Angolo  
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↑ ↓  
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Preset

Sonde

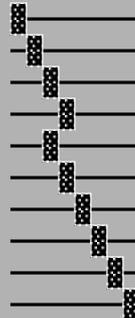


DEPTH

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zoom

TGC

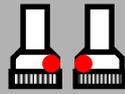


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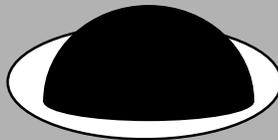
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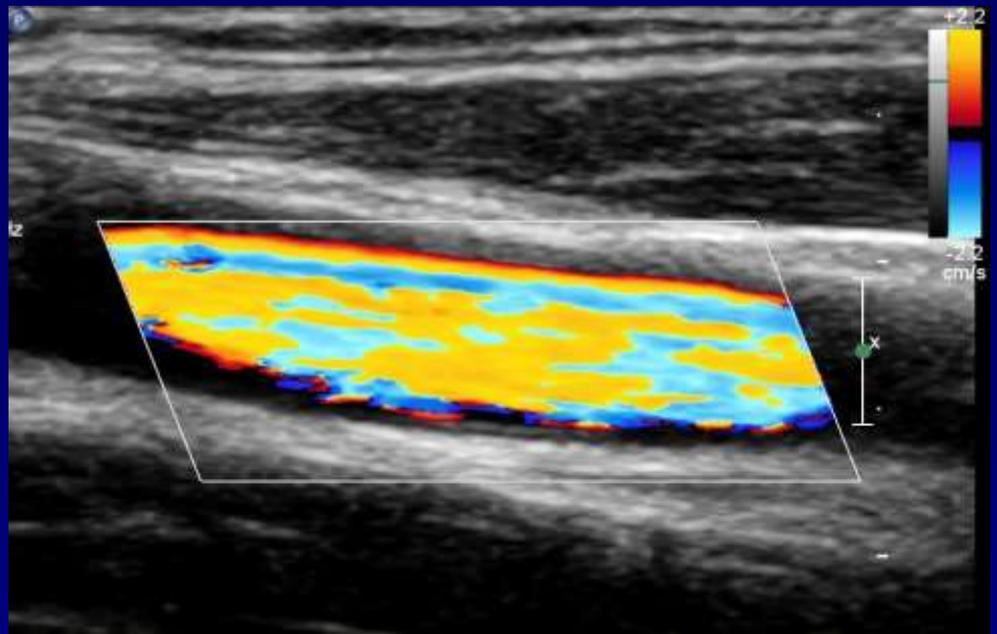
Immagine



Sonda



Freeze



Q W E R T Y U I O P  
 A S D F G H J K L  
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Mode

M B C P  
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Doppler

Gain  
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Misurazioni

+...+  
 Area  
 Menu'

Fuochi

↑ ↓  
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Preset

Sonde

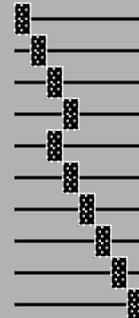


DEPTH

↕ ↕

zoom

TGC

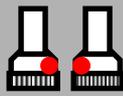


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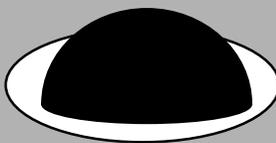
Orientamento



Immagine



Sonda



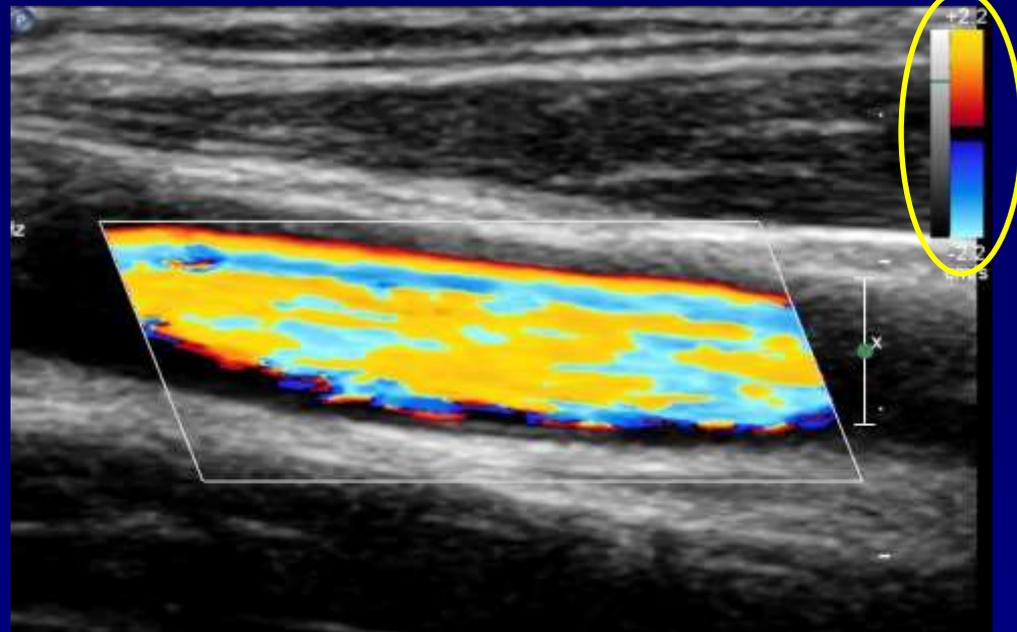
Freeze

## Scala colore

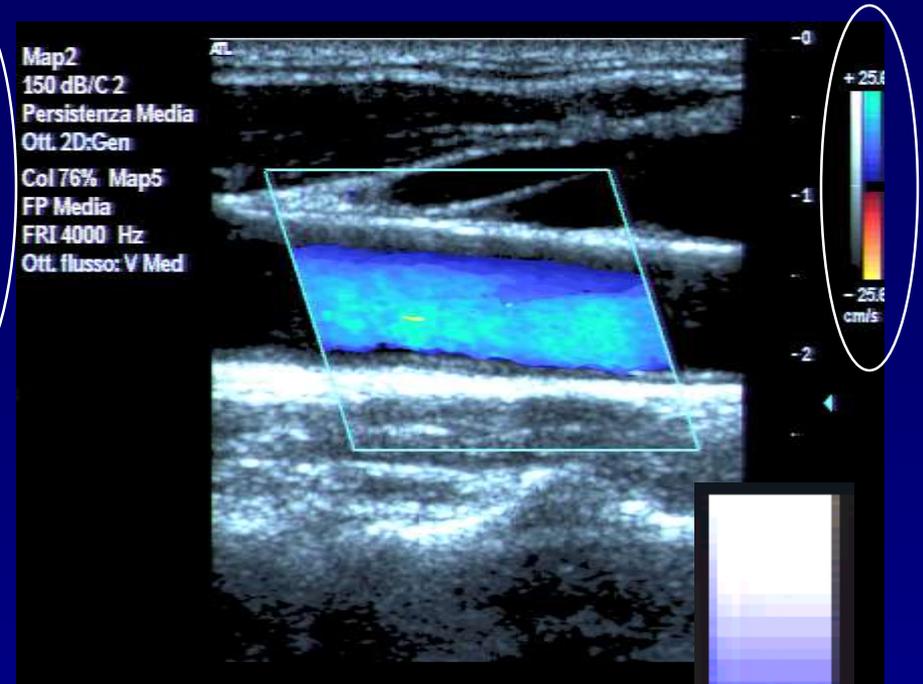
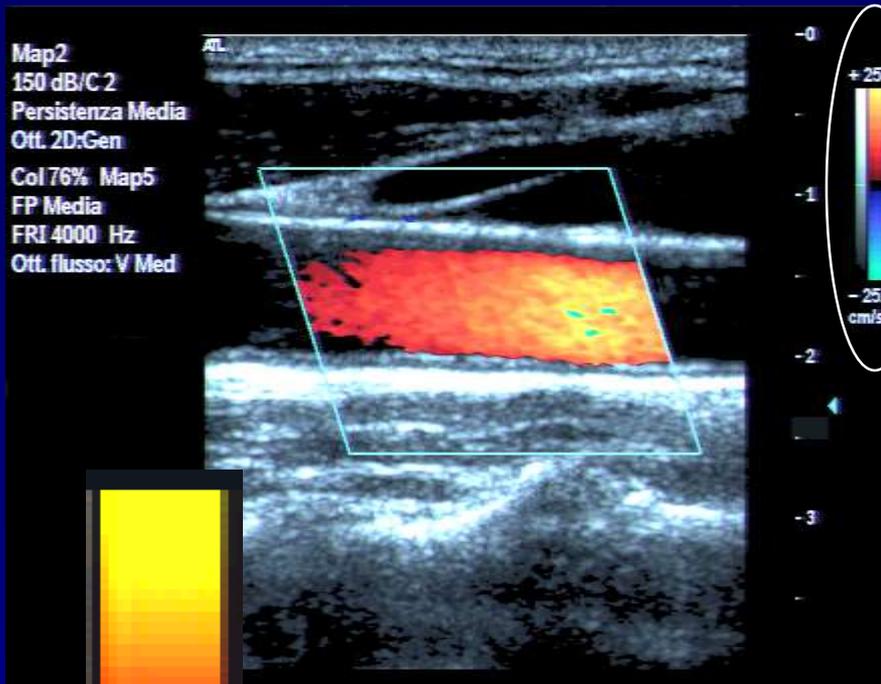


I colori dal rosso al  
giallo rappresentano  
flussi in  
**AVVICINAMENTO**  
alla sonda

I colori dal blu al  
bianco rappresentano  
flussi in  
**ALLONTANAMENTO**  
dalla sonda



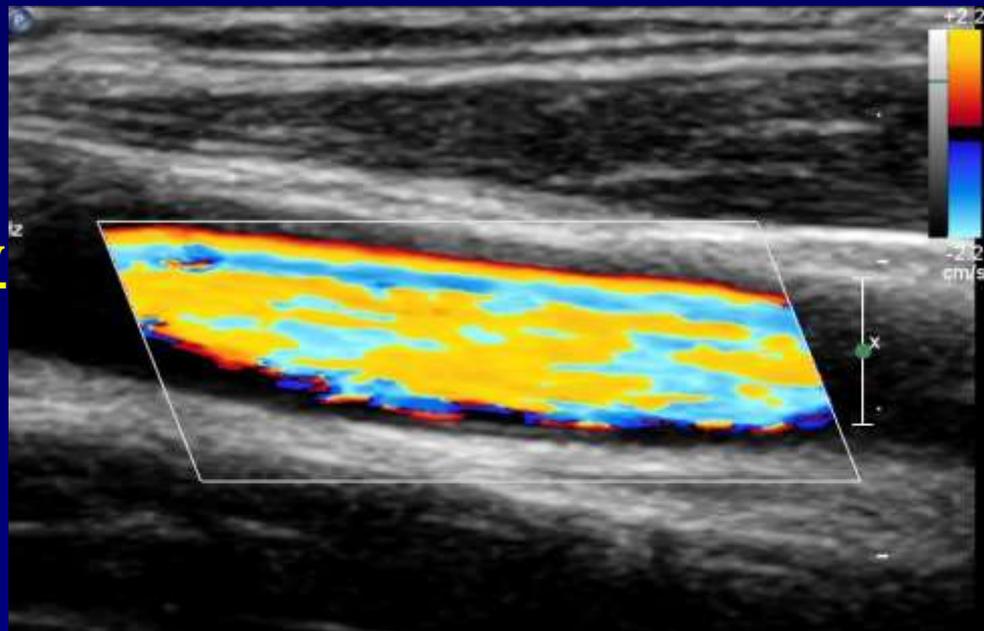
**BART**



**SOPRA** alla linea zero: flusso in **avvicinamento**

**SOTTO** alla linea zero: flusso in **allontanamento**

PRF: pulse repetition frequency  
ALIASING



Q	W	E	R	T	Y	U	I	O	P
A	S	D	F	G	H	J	K	L	
Z	X	C	V	B	N	M	.	:	

Mode

M	B	C	P
Pw	TH		

Doppler

Gain

Angolo

Steering

PRF

Misurazioni

+...+
Area
Menu'

Fuochi

n

Preset

Sonde

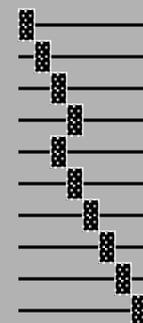


DEPTH

zoom



TGC

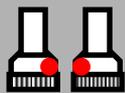


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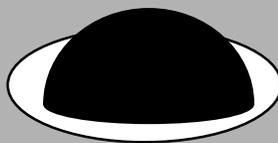
Orientamento



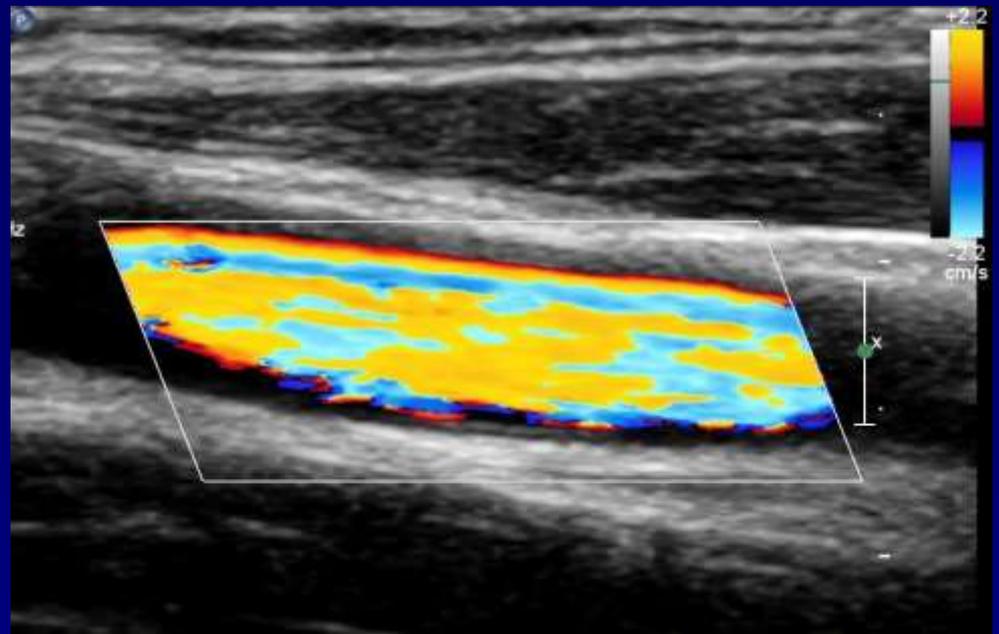
Immagine



Sonda



Freeze



Q W E R T Y U I O P  
 A S D F G H J K L  
 Z X C V B N M ; .

Mode

M B C P  
 Pw TH

Doppler

Gain  
 Angolo  
 Steering  
 PRF

Misurazioni

+...+  
 Area  
 Menu'

Fuochi

↑ ↓  
 n

Preset

Sonde

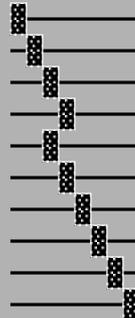


DEPTH

↕ ↗

zoom

TGC

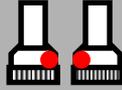


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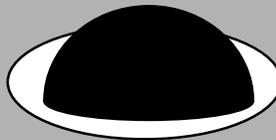
Orientamento



Immagine

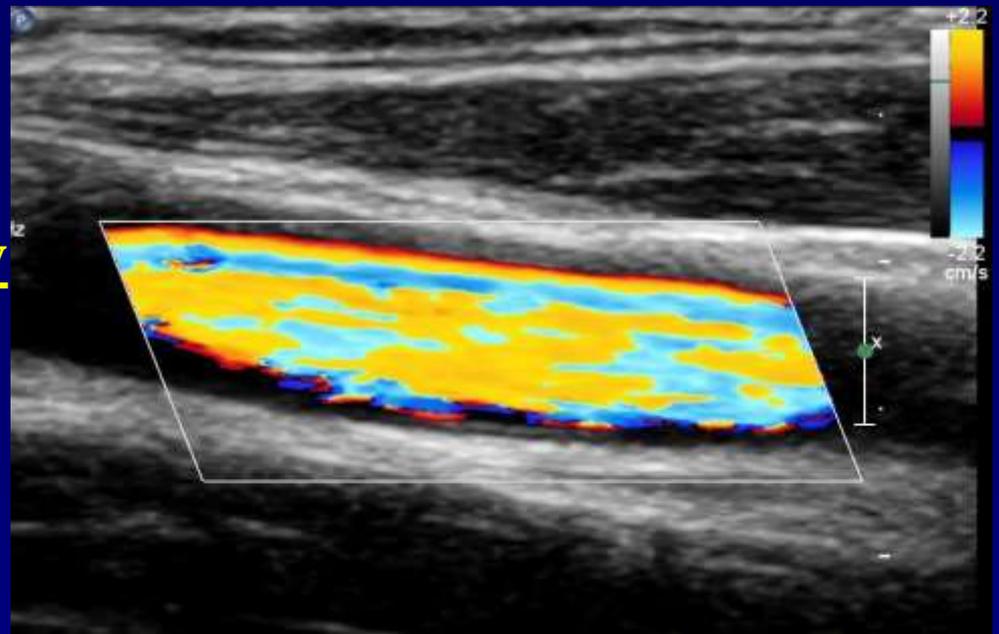


Sonda



Freeze

PRF: pulse repetition frequency  
ALIASING



Q	W	E	R	T	Y	U	I	O	P
A	S	D	F	G	H	J	K	L	
Z	X	C	V	B	N	M	.		

Mode

M	B	C	P
Pw	TH		

Doppler

Gain  
 Angolo  
 Steering  
**PRF**

Misurazioni

+...+
Area
Menu'

Fuochi

n

Preset

Sonde

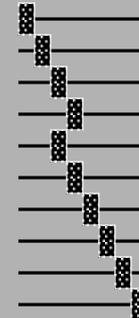


DEPTH

zoom

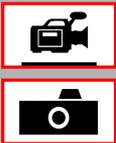


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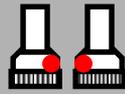


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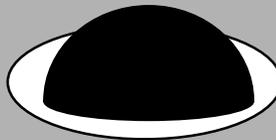
Orientamento



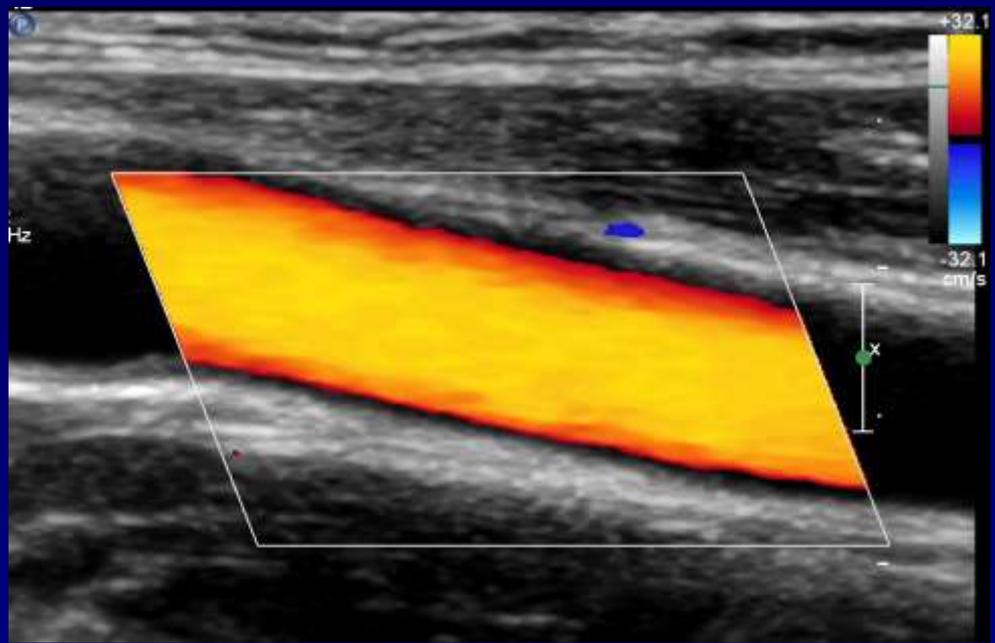
Immagine



Sonda



Freeze



**Q W E R T Y U I O P**  
**A S D F G H J K L**  
**Z X C V B N M .**

**Mode**  
**M B C P**  
**Pw TH**

**Doppler**  
**Gain**  
**Angolo**  
**Steering**  
**PRF**

**Misurazioni**  
**+...+**  
**Area**  
**Menu'**

**Fuochi**  
**↑ ↓**  
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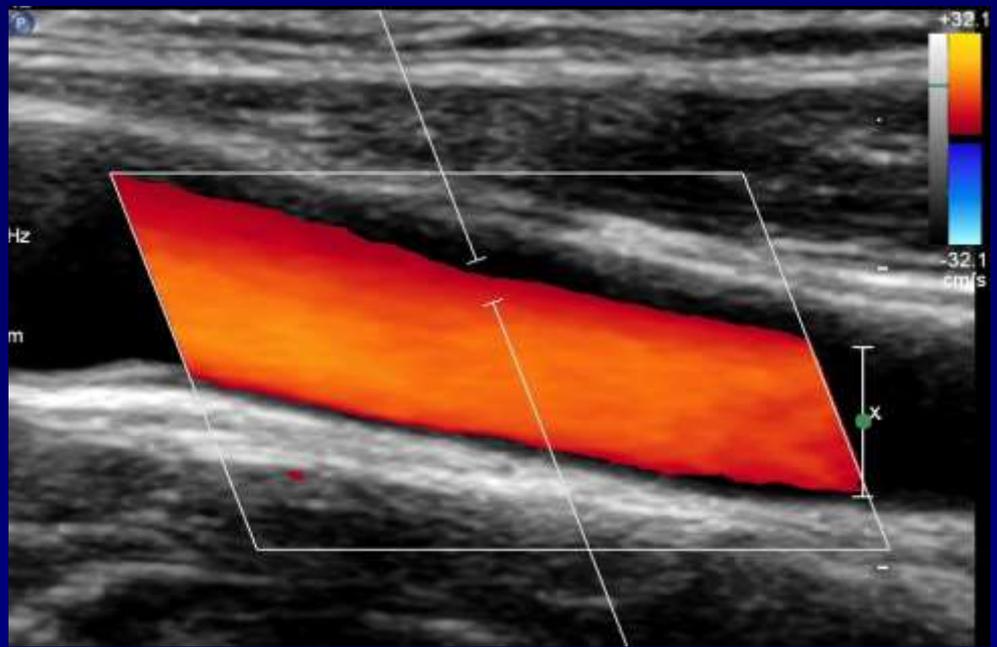
**DEPTH**  
**zoom**

**Preset**  
**Sonde**

**TGC**  
**On**  
**Off**

**Orientamento**  
**Immagine**  
**Sonda**

**GAIN**  
**Freeze**



Q W E R T Y U I O P  
 A S D F G H J K L  
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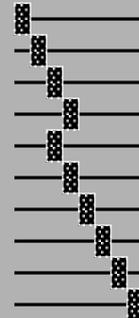
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Preset

Sonde

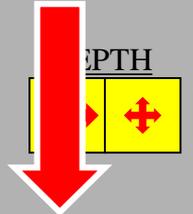


TGC



On  
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DEPTH

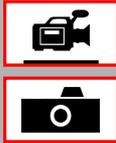


zoom

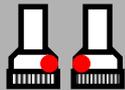


Freeze

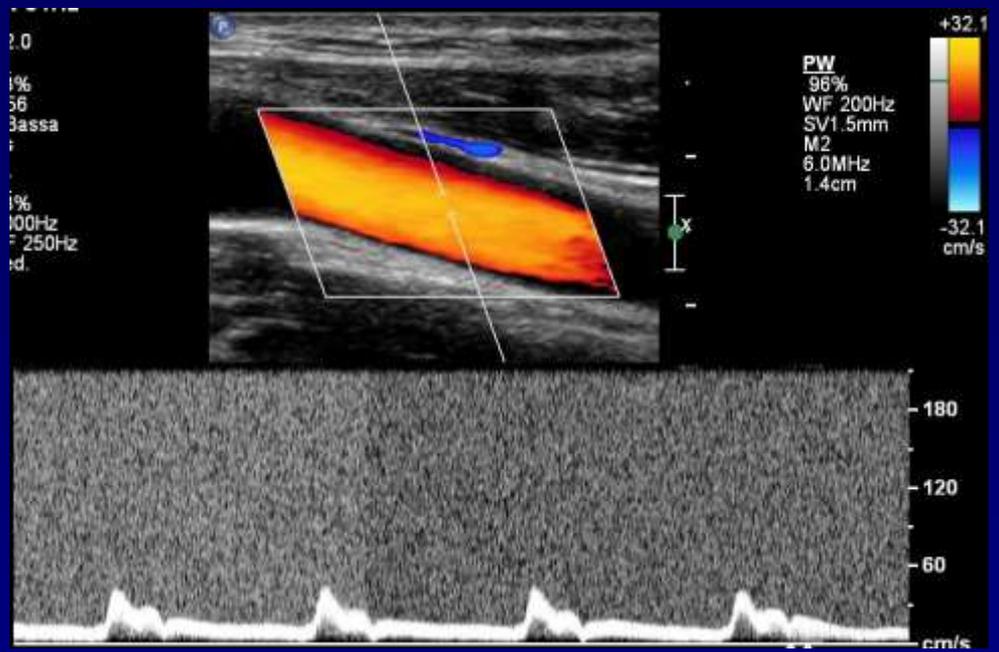
Orientamento



Immagine



Sonda



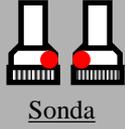
Q W E R T Y U I O P  
 A S D F G H J K L  
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Mode  
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 Pw TH



Immagine

Doppler  
 Gain  
 Angolo  
 Steering  
 PRF



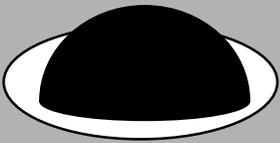
Sonda

+...+  
 Area  
 Menu'

Misurazioni

Fuochi  
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DEPTH  
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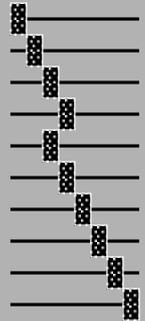


Preset  
 Sonde

zoom

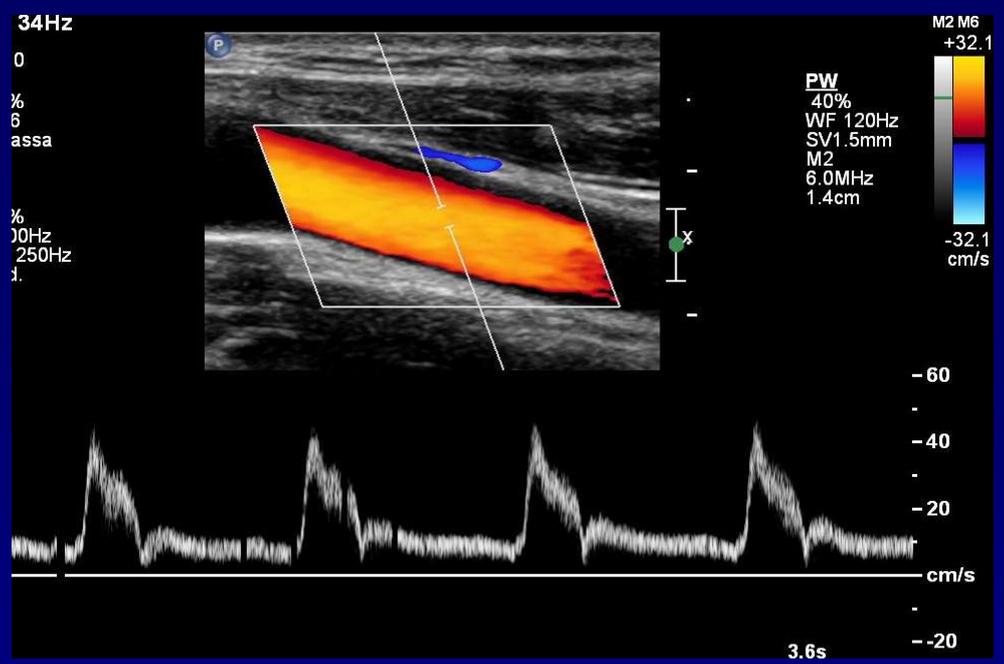


TGC



On  
 Off

Freeze



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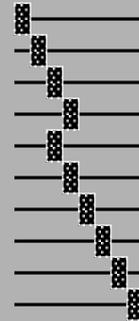


DEPTH

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zoom

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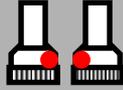


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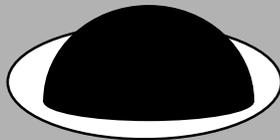
Orientamento



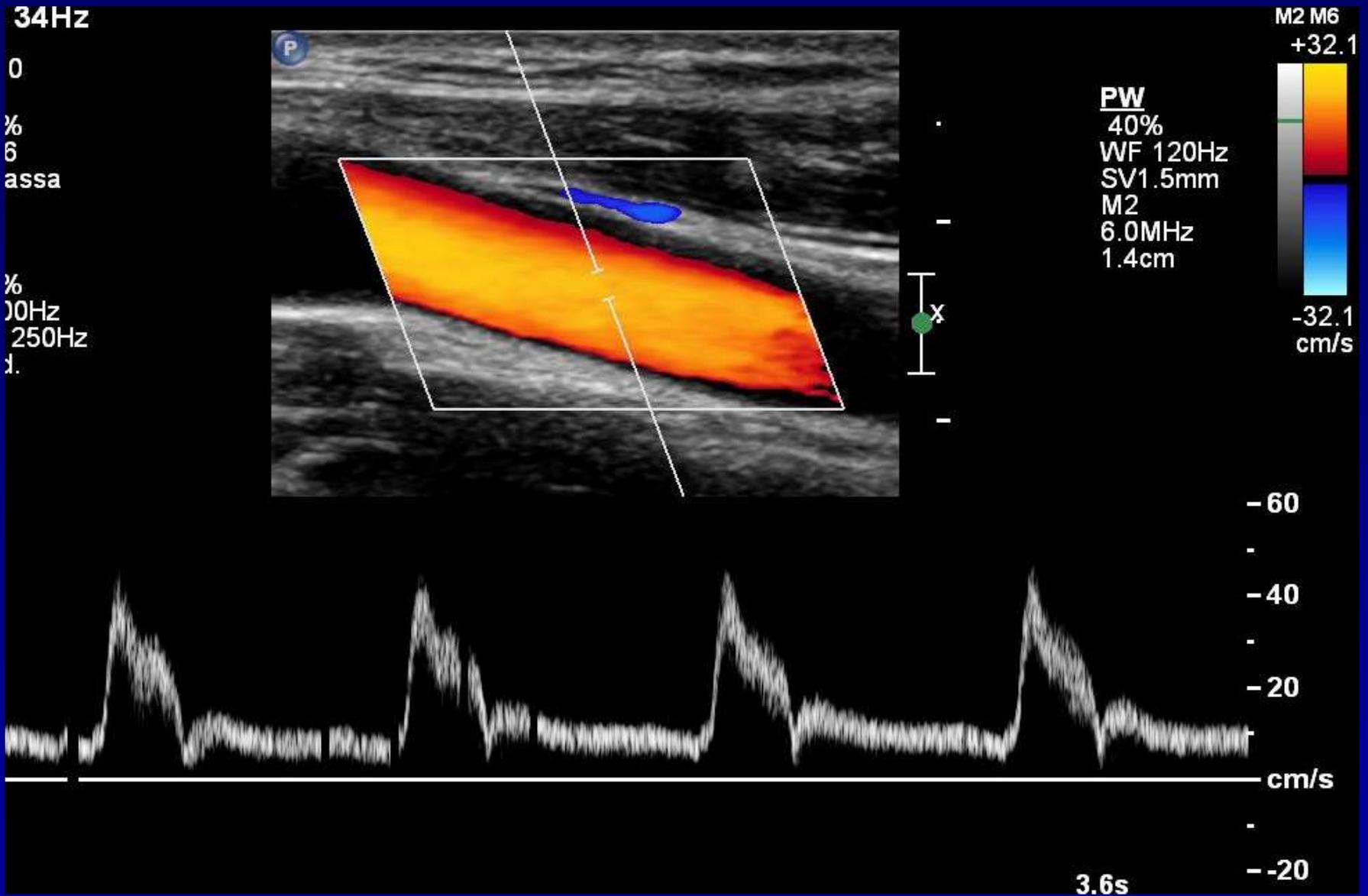
Immagine



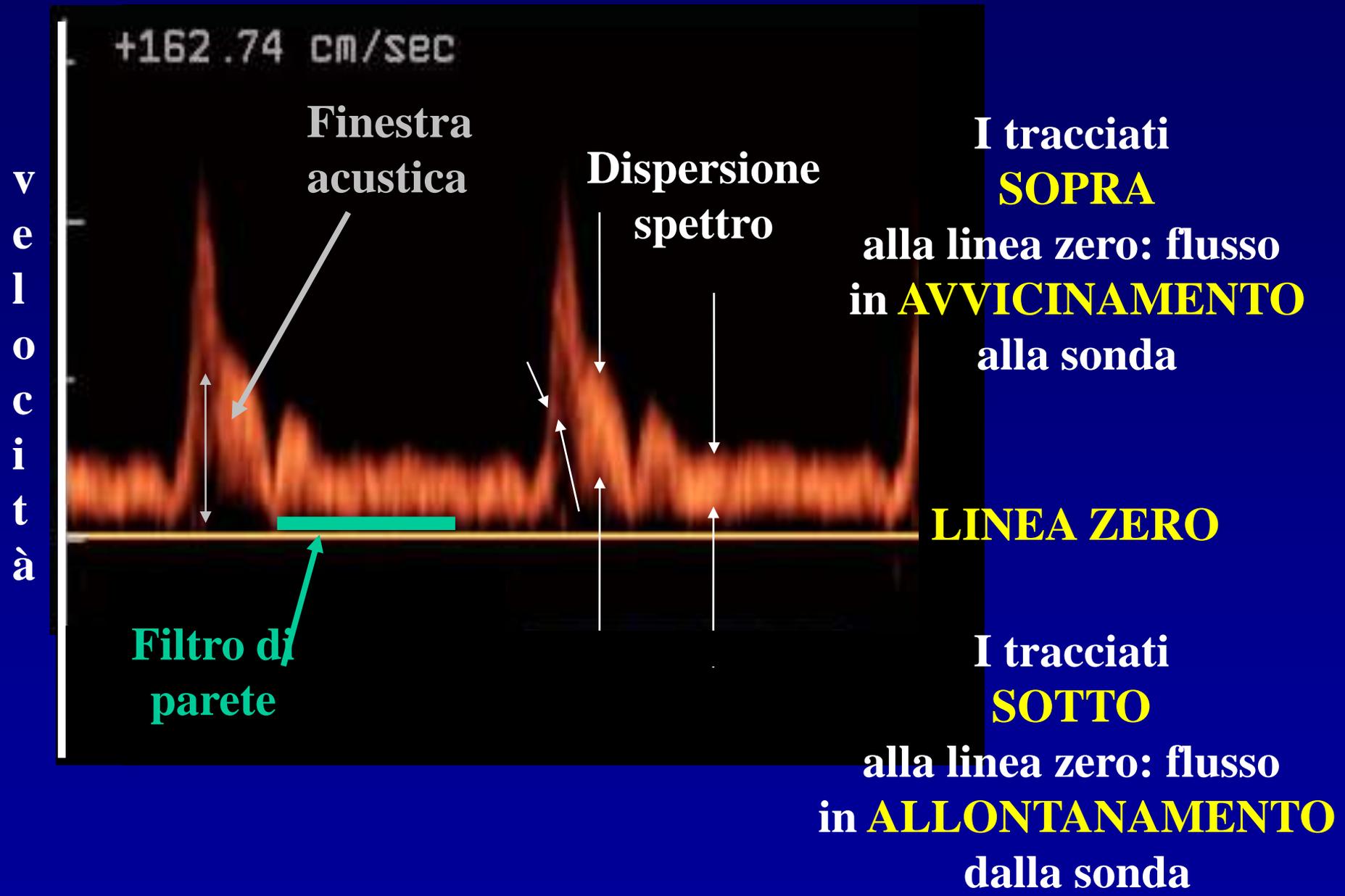
Sonda



Freeze



# ANALISI SPETTRALE



**QUALITATIVE**

**presenza flusso  
direzione flusso  
caratteristiche flusso**

**QUANTITATIVE**

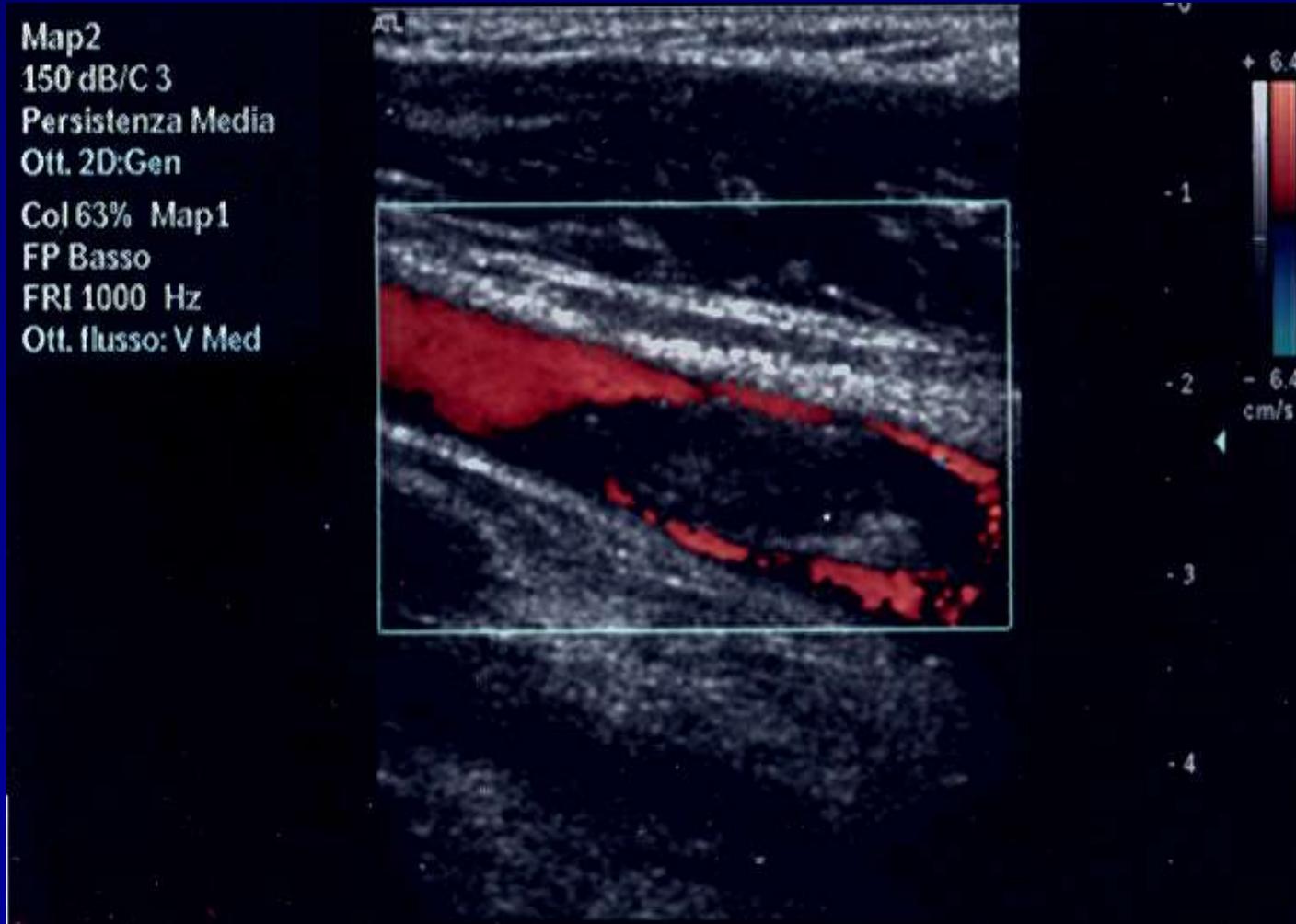
**velocità di flusso  
volume di flusso**

**SEMI-  
QUANTITATIVE**

**indici d'impedenza  
congestion index**

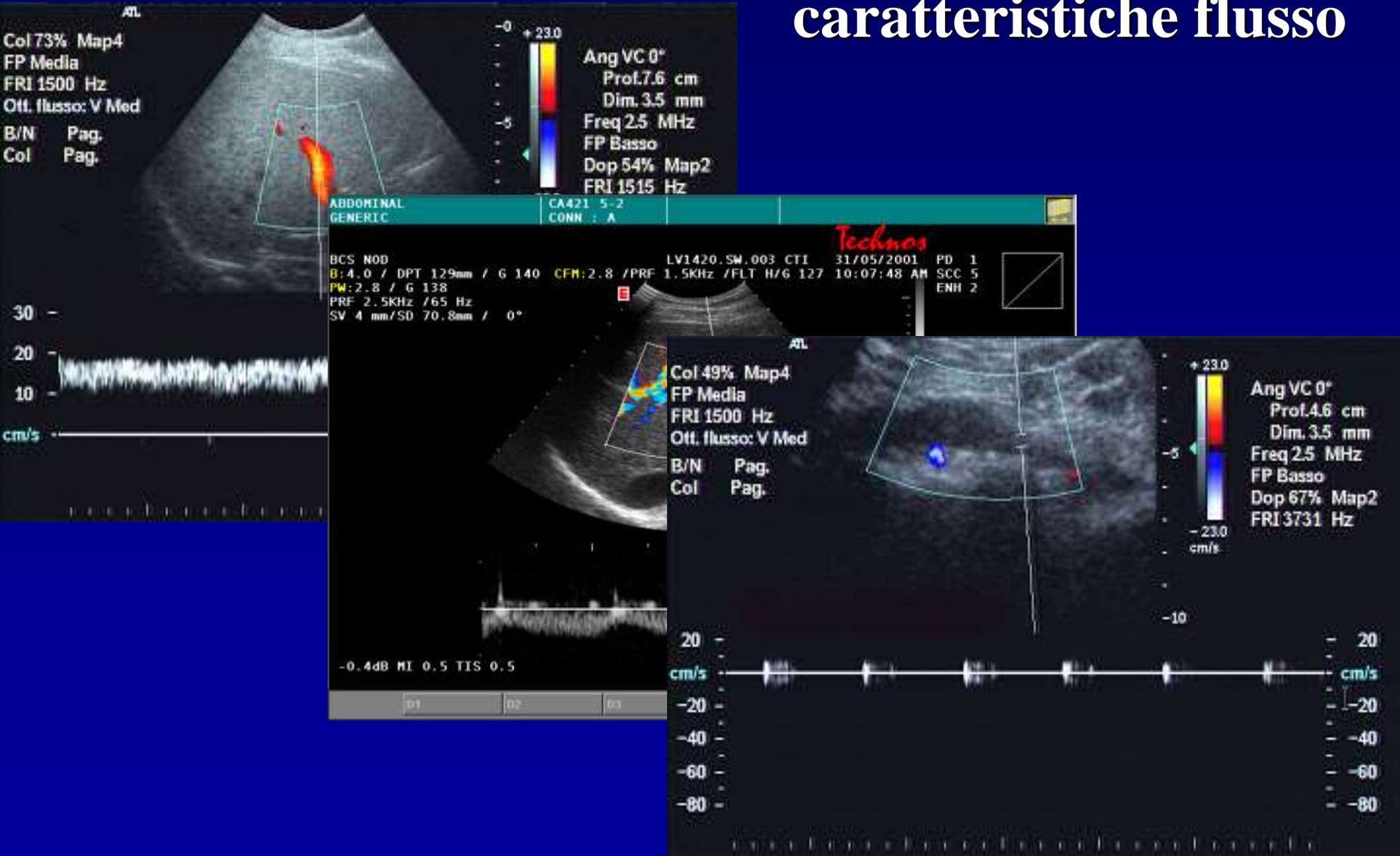
# QUALITATIVE

presenza flusso  
direzione flusso  
caratteristiche flusso



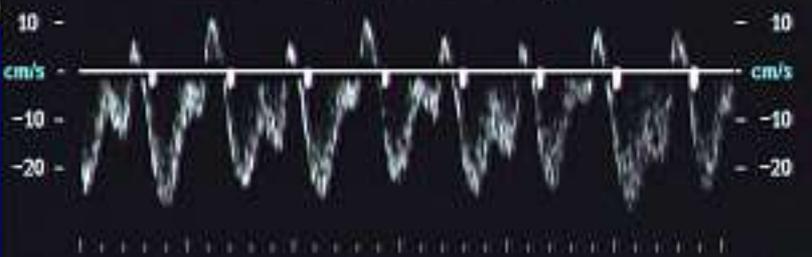
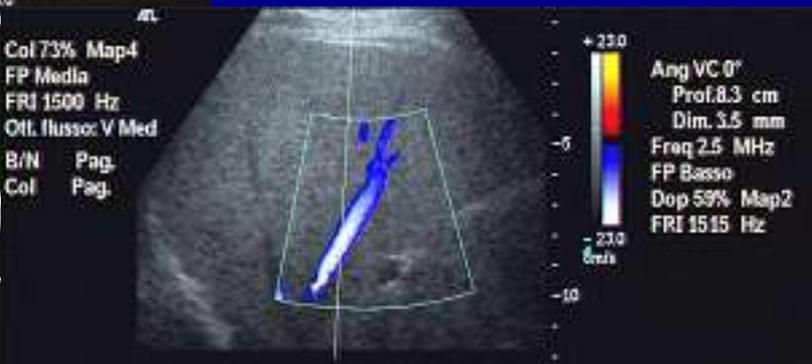
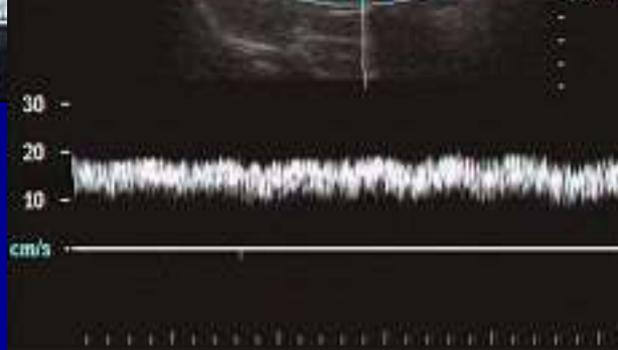
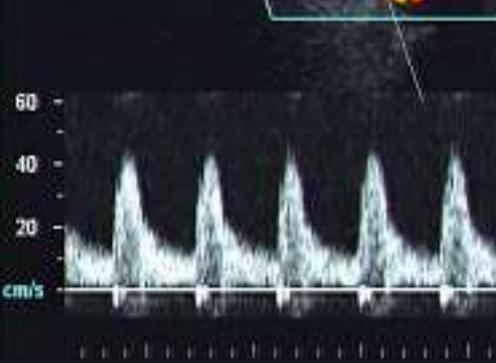
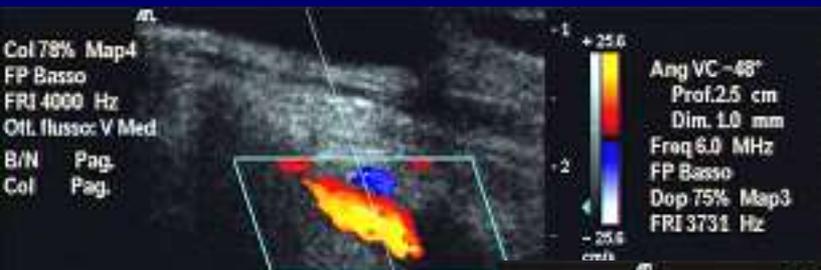
# QUALITATIVE

presenza flusso  
direzione flusso  
caratteristiche flusso



# QUALITATIVE

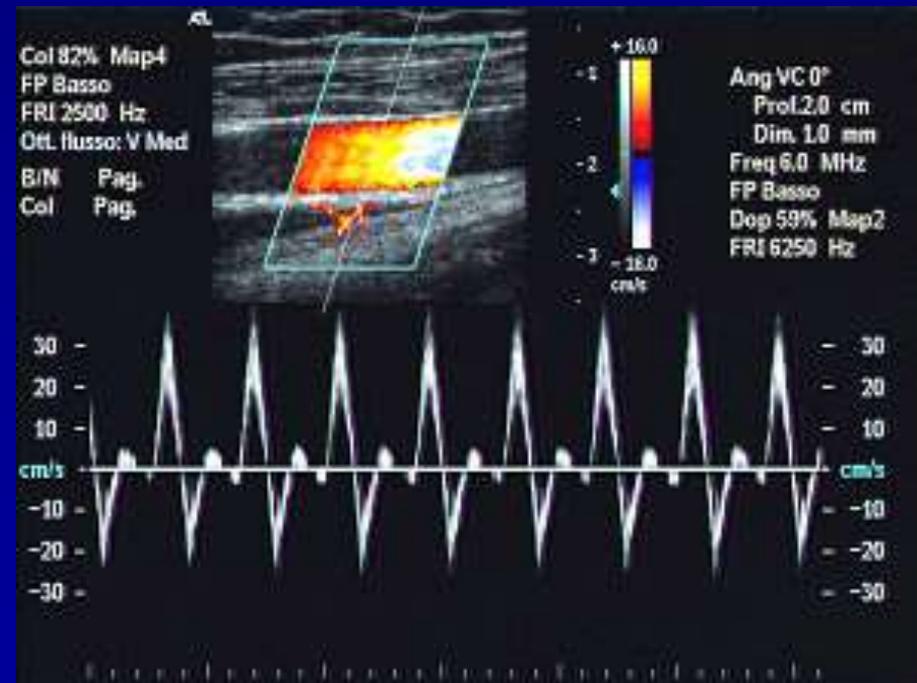
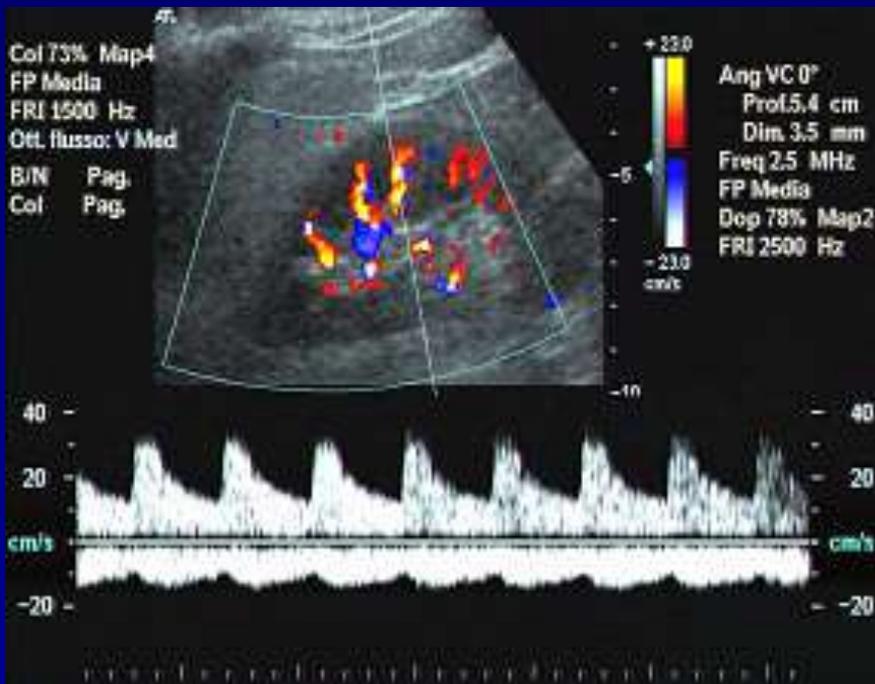
presenza flusso  
direzione flusso  
caratteristiche flusso



# QUALITATIVE

presenza flusso  
direzione flusso  
caratteristiche flusso

Tipo di parenchima irrorato  
e stato funzionale organo



**QUALITATIVE**

**presenza flusso  
direzione flusso  
caratteristiche flusso**

**QUANTITATIVE**

**velocità di flusso  
volume di flusso**

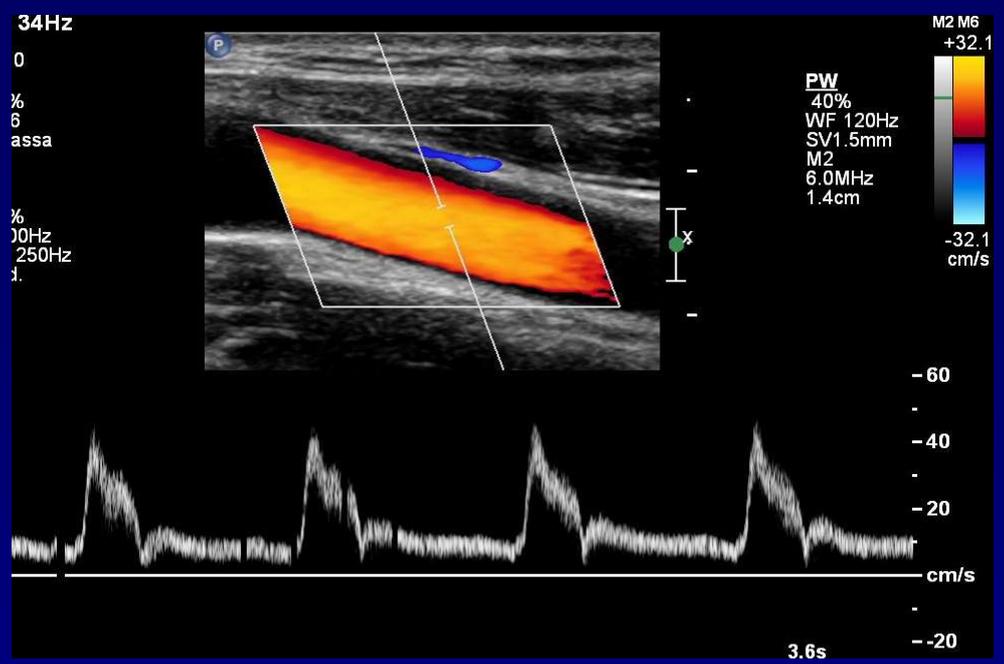
**SEMI-  
QUANTITATIVE**

**indici d'impedenza  
congestion index**



$$f_D = \frac{2 \cdot f_0 \cdot V \cdot \cos \alpha}{c}$$

$$V = \frac{f_D \cdot c}{2 \cdot f_0 \cdot \cos \alpha}$$



Q W E R T Y U I O P  
A S D F G H J K L  
Z X C V B N M ; .

Mode  
M B C P  
Pw TH

Doppler  
Gain  
Angolo  
Steering  
PRF

Correzioni  
+...+  
Area  
Menu'

Fuochi  
↑ ↓  
n

Preset  
Sonde

DEPTH  
↑ ↓ ← →

zoom

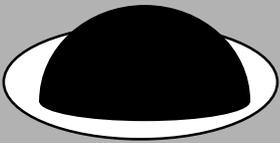
TGC

On  
Off

Orientamento

Immagine

Sonda



Freeze





Q W E R T Y U I O P  
 A S D F G H J K L  
 Z X C V B N M ; .

Mode

M B C P  
 Pw TH

Doppler

Gain  
 Angolo  
 Steering  
 PRF

Misurazioni

+...+  
 Area  
 Menu'

Fuochi

↑ ↓  
 n

Preset

Sonde

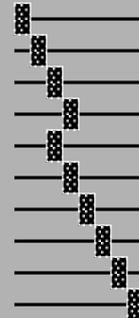


DEPTH

↑ ↓  
 ← →

zoom

TGC

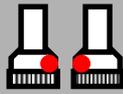


On  
 Off

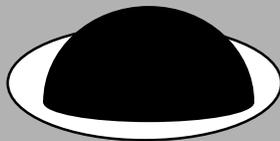
Orientamento



Immagine

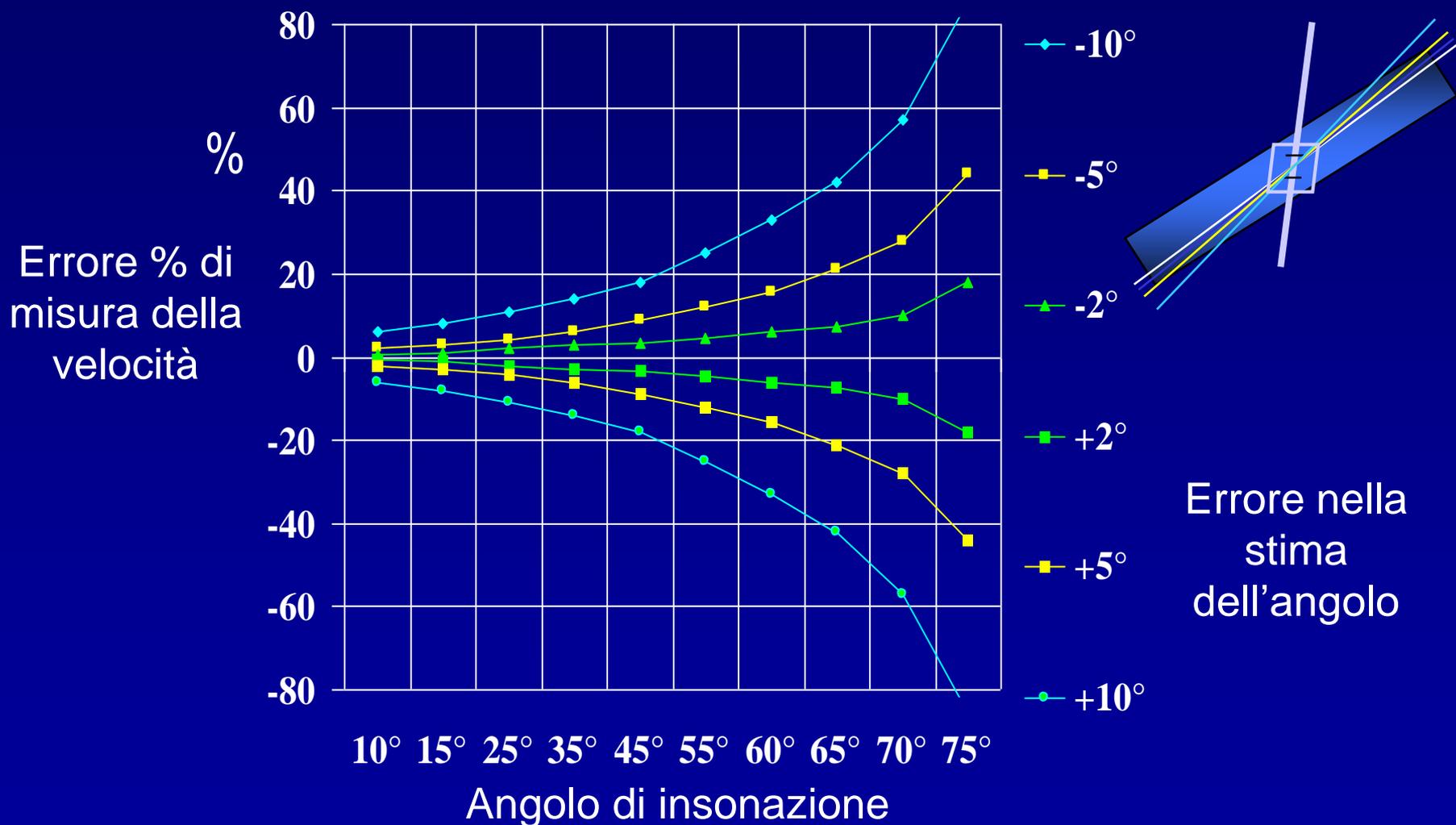


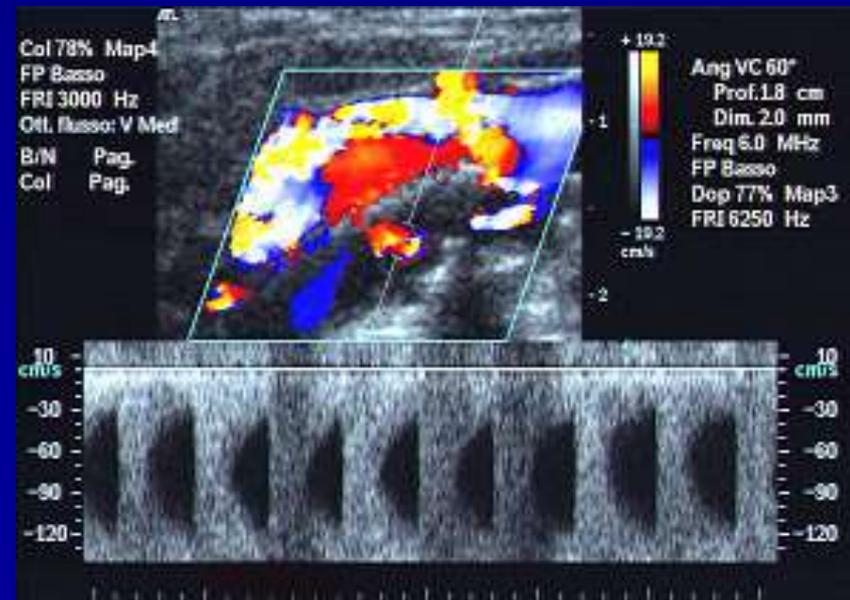
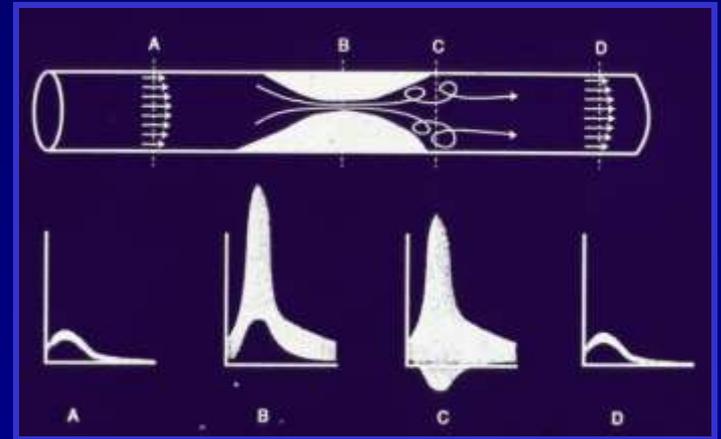
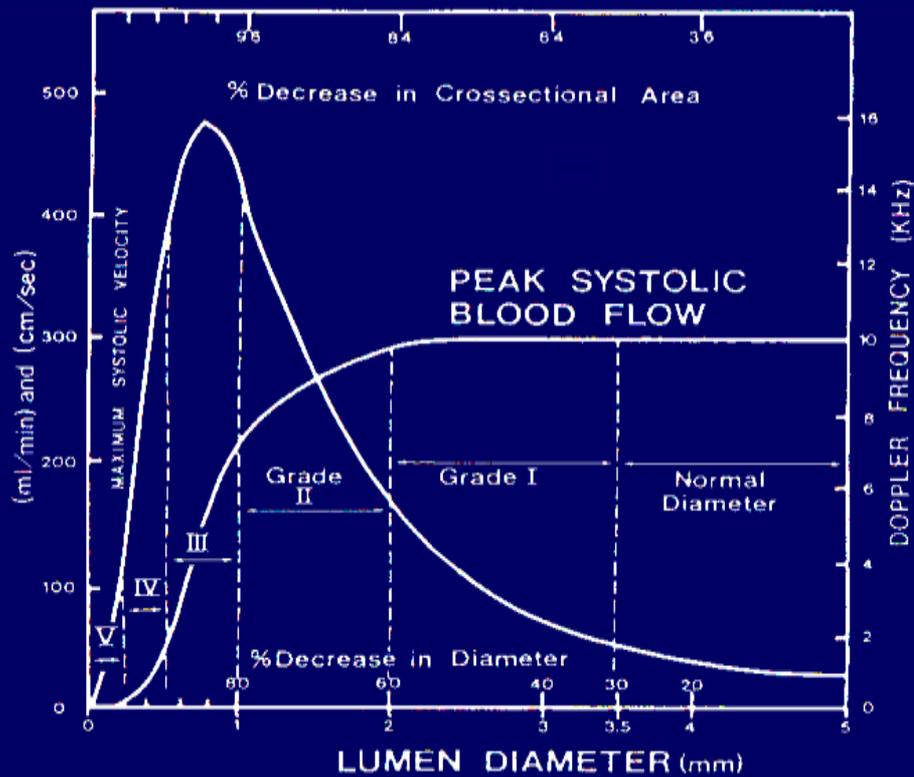
Sonda



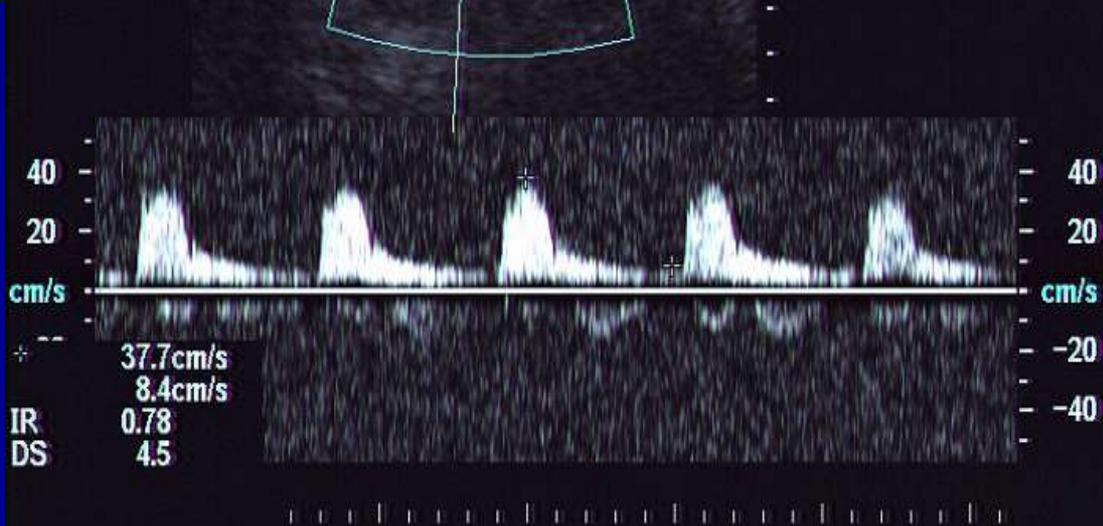
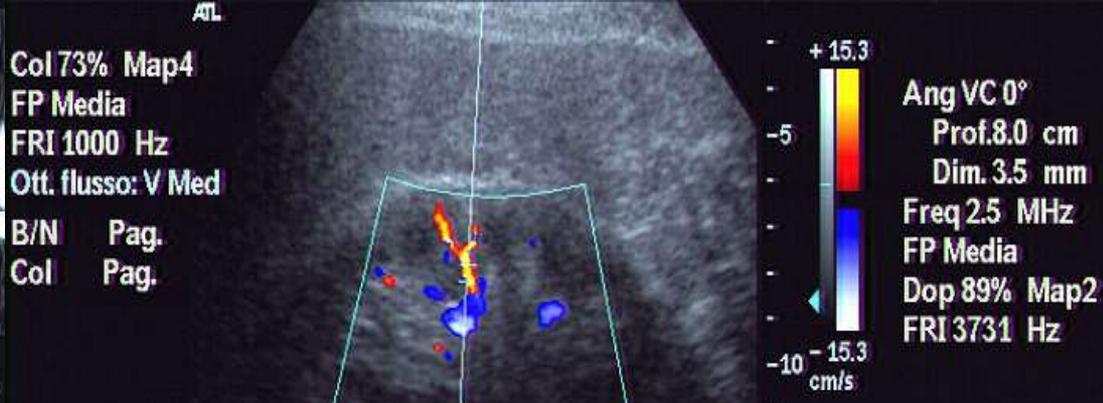
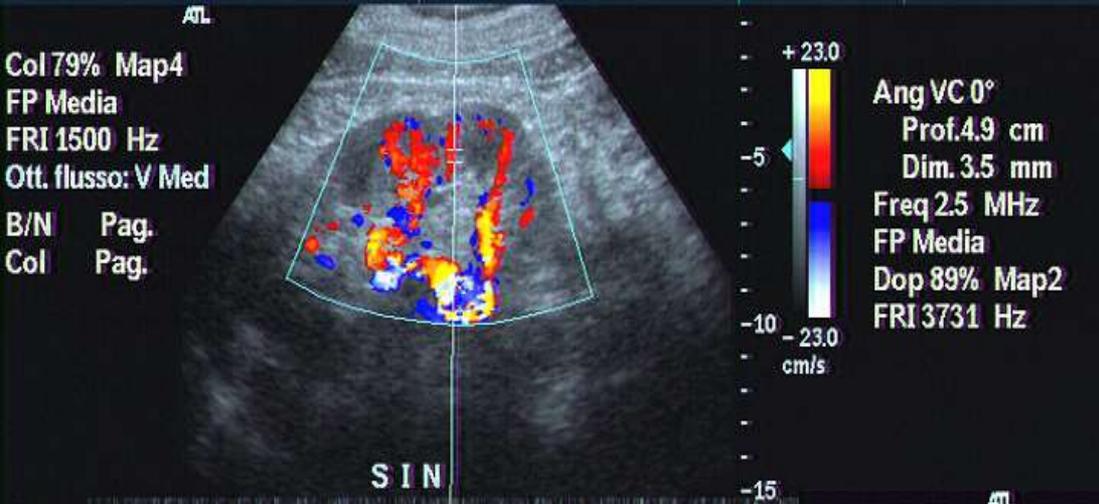
Freeze

# ERRORE DI STIMA DELL'ANGOLO DI INSONAZIONE E ACCURATEZZA DELLA MISURAZIONE DELLA VELOCITÀ DI FLUSSO





**Aliasing** →



**QUALITATIVE**

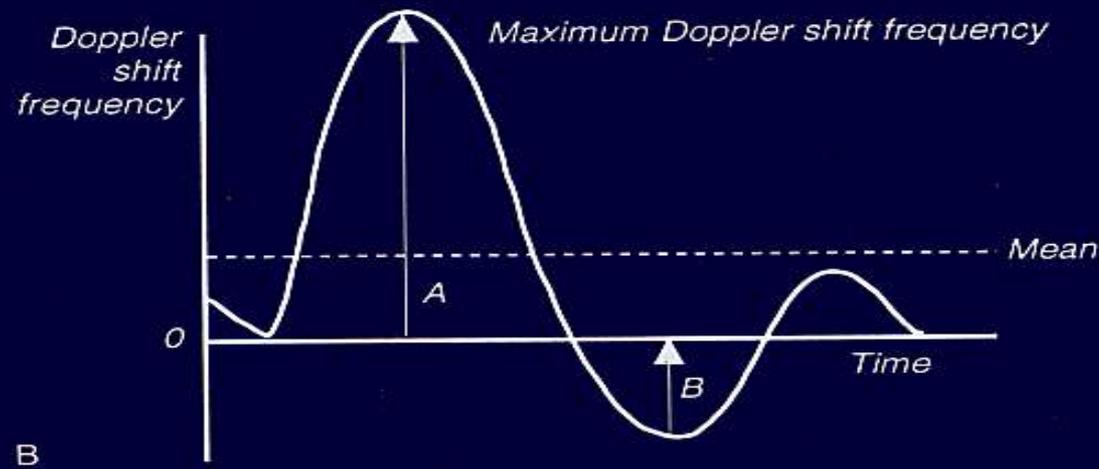
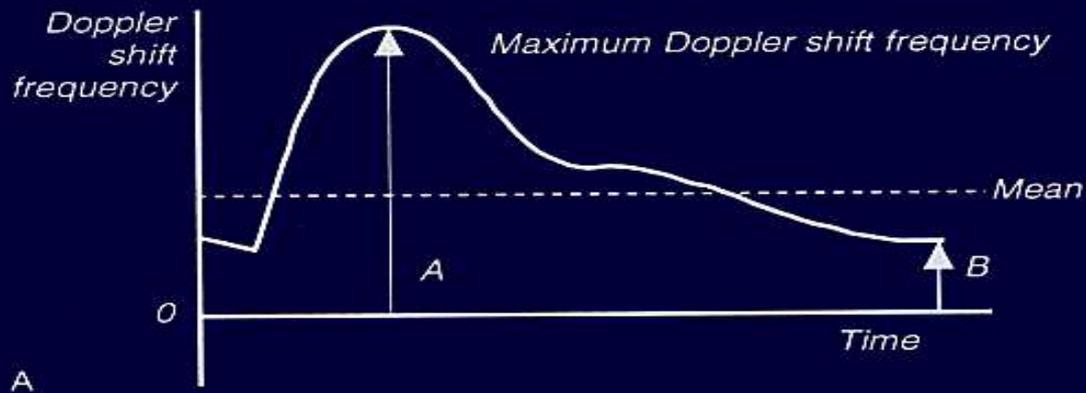
**presenza flusso  
direzione flusso  
caratteristiche flusso**

**QUANTITATIVE**

**velocità di flusso  
volume di flusso**

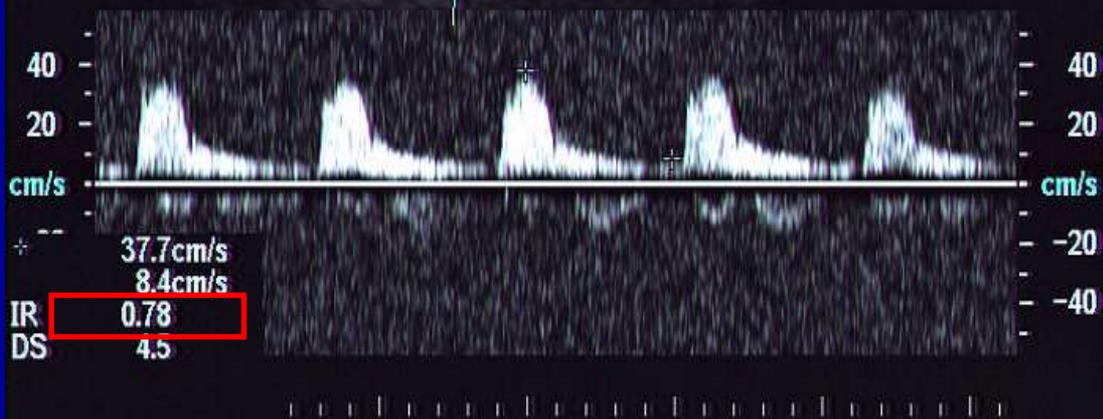
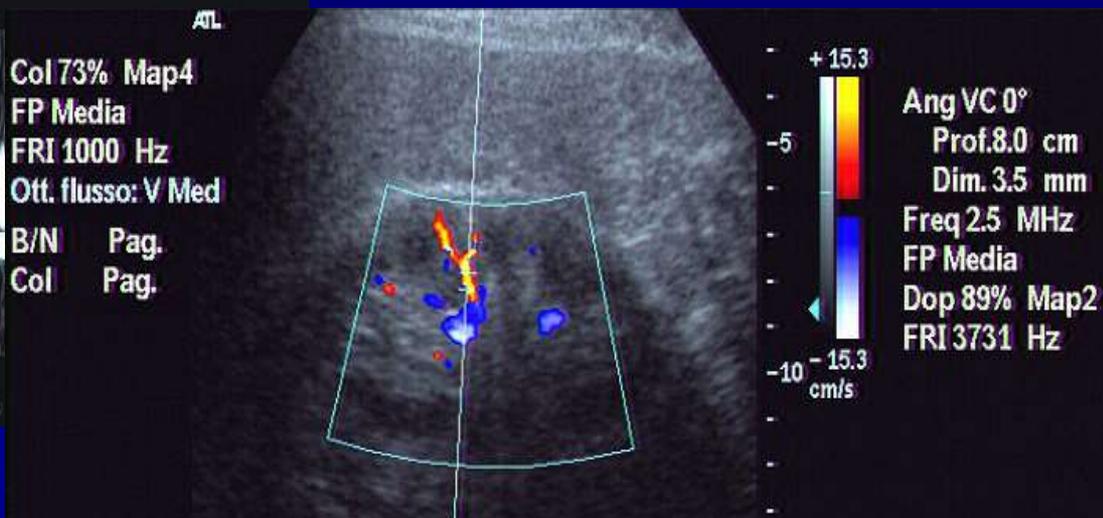
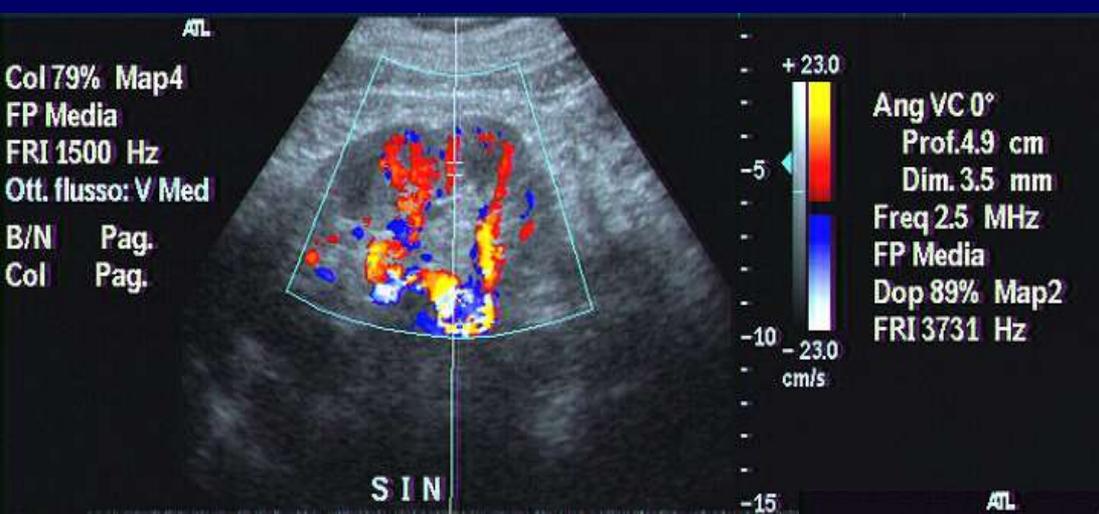
**SEMI-  
QUANTITATIVE**

**indici d'impedenza  
congestion index**



$$\text{Pulsatility index} = \frac{A - B}{\text{mean}}$$

$$\text{Resistance index} = \frac{A - B}{A}$$



# ECODOPPLER

## principali applicazioni cliniche

**Neurologia:** malattie cerebrovascolari, ricerca pervietà forame ovale, vasospasmo post-ESA  
Ipertensione endocranica, morte cerebrale, MAV cerebrali, monitoraggio intraoperatorio  
chirurgia vascolare (TEA) cardiocirurgia (CEC)

**Oculistica:** occlusioni arteria/vena centrale della retina, arteriti, neuropatia ottica ischemica, patologia carotidea,  
Vascularizzazione tumori oculari/dell'orbita, alterazioni emodinamica oculare nel diabete e nel glaucoma

**Angiologia:** patologia arteriosa/venosa TSA, arti superiori e inferiori, TVP

**Reumatologia:** vascularizzazione entesiti/connettivopatie

**Cardiologia:** valvulopatie (native, protesiche), valutazione ipertensione polmonare, cardiac output, cuore fetale

**Endocrinologia:** patologia tiroidea (neoplastica e non)

**Gastroenterologia:** ipertensione portale e complicanze, neoformazioni apparato digerente, trapianto fegato,  
Malattia ischemica intestinale, diverticolite, IBD, Budd-Chiari

**Nefro/urologia:** occlusioni/stenosi arteria/vena renale, trapianto renale, colica renale, varicocele, torsione testicolare,  
deficit erettile, neoformazioni apparato genito-urinario

**Ginecologia/ostetricia:** caratterizzazione formazioni utero/annessiali, gravidanza (feto/placenta), eclampsia



