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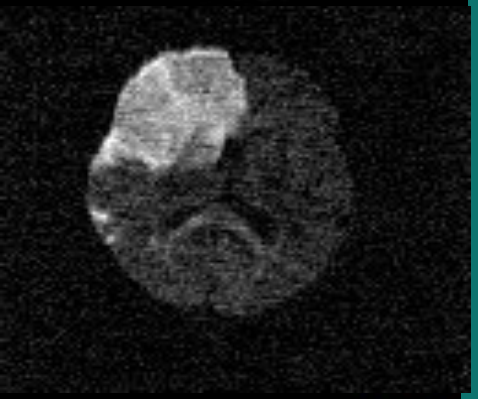
Clínica Alemana

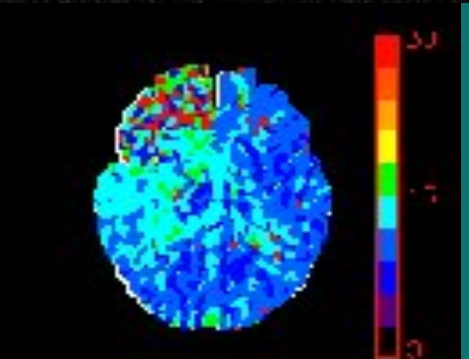
Clinical Applications Of TCD

Alejandro Brunser M.D.
Vascular-Neurology
Neurosonology Laboratory
Clínica Alemana de Santiago
abrunser2002@yahoo.com

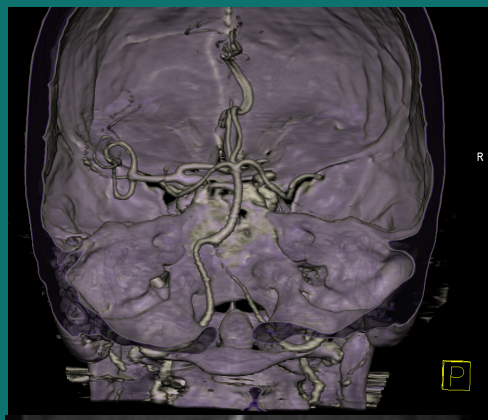
DISCLOSURES
NONE

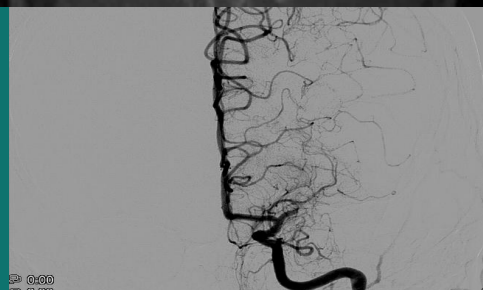
Imaging Techniques in CAS 24/7





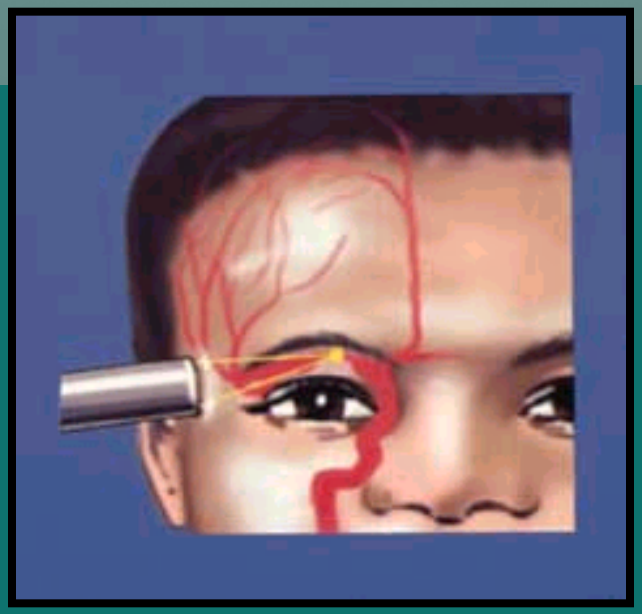
Why TCD ?



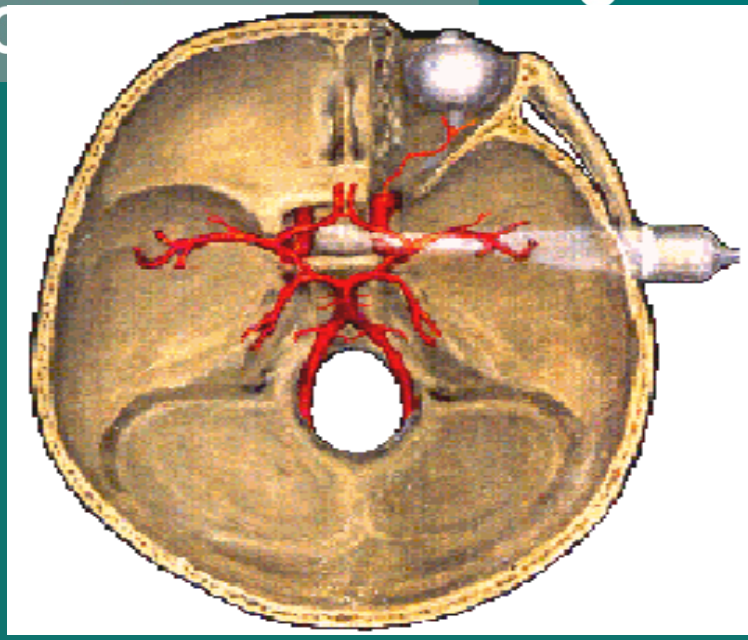


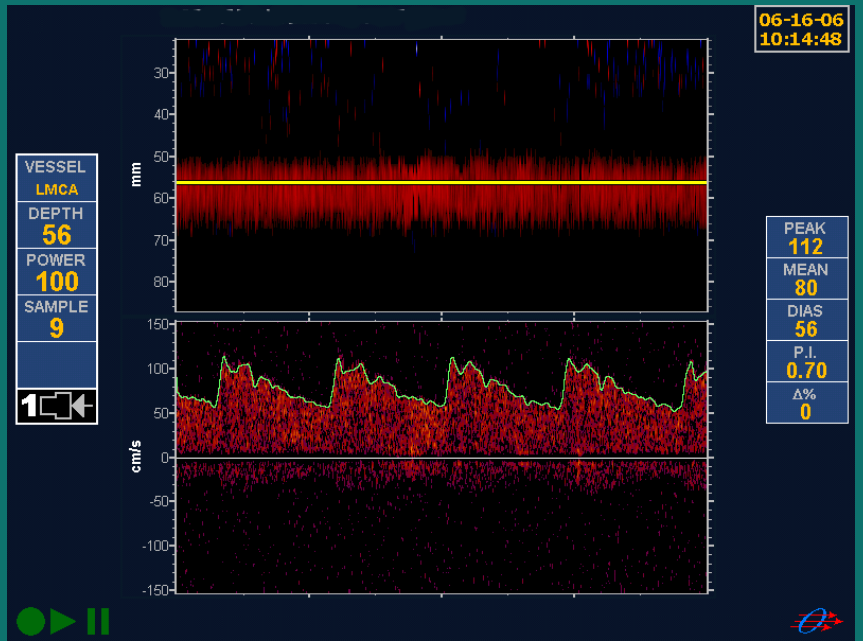
Stroke box on ER of CAS

Special Care Unit, CAS

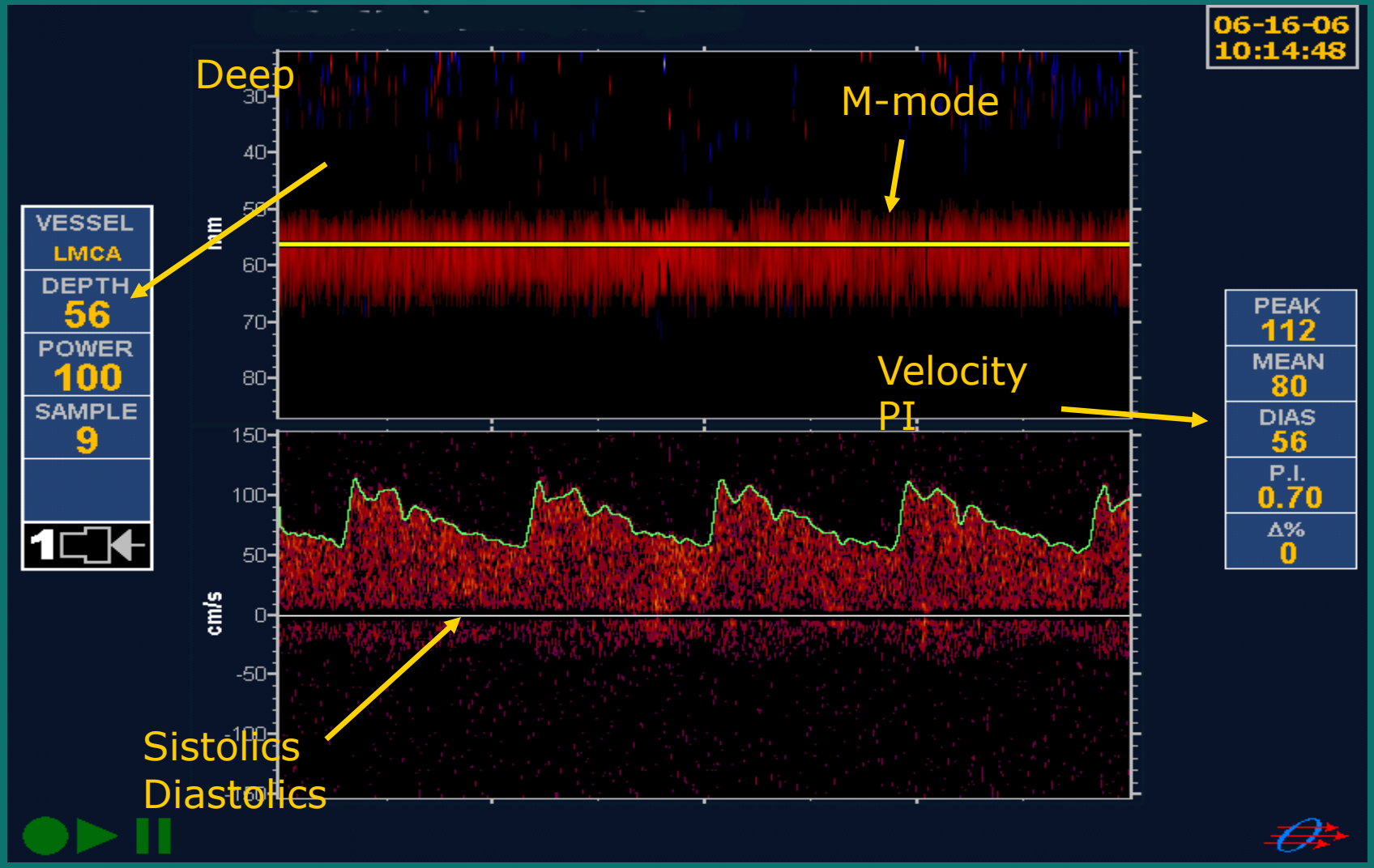


Why?




06-16-06
10:14:48
VESSEL
LMCA
DEPTH
56
POWER
100
SAMPLE
9
mm
cm/s
PEAK
112
MEAN
80
DIAS
56
P.I.
0.70
Δ%
0

What do we see with TCD??



TCD is a useful tool

- Stroke (ischemic)
- Brain trauma
- Brain death
- Subarachnoidal hemorrhage
- Other

TCD
and ischemic stroke

Ischemic stroke with vessel oclussion

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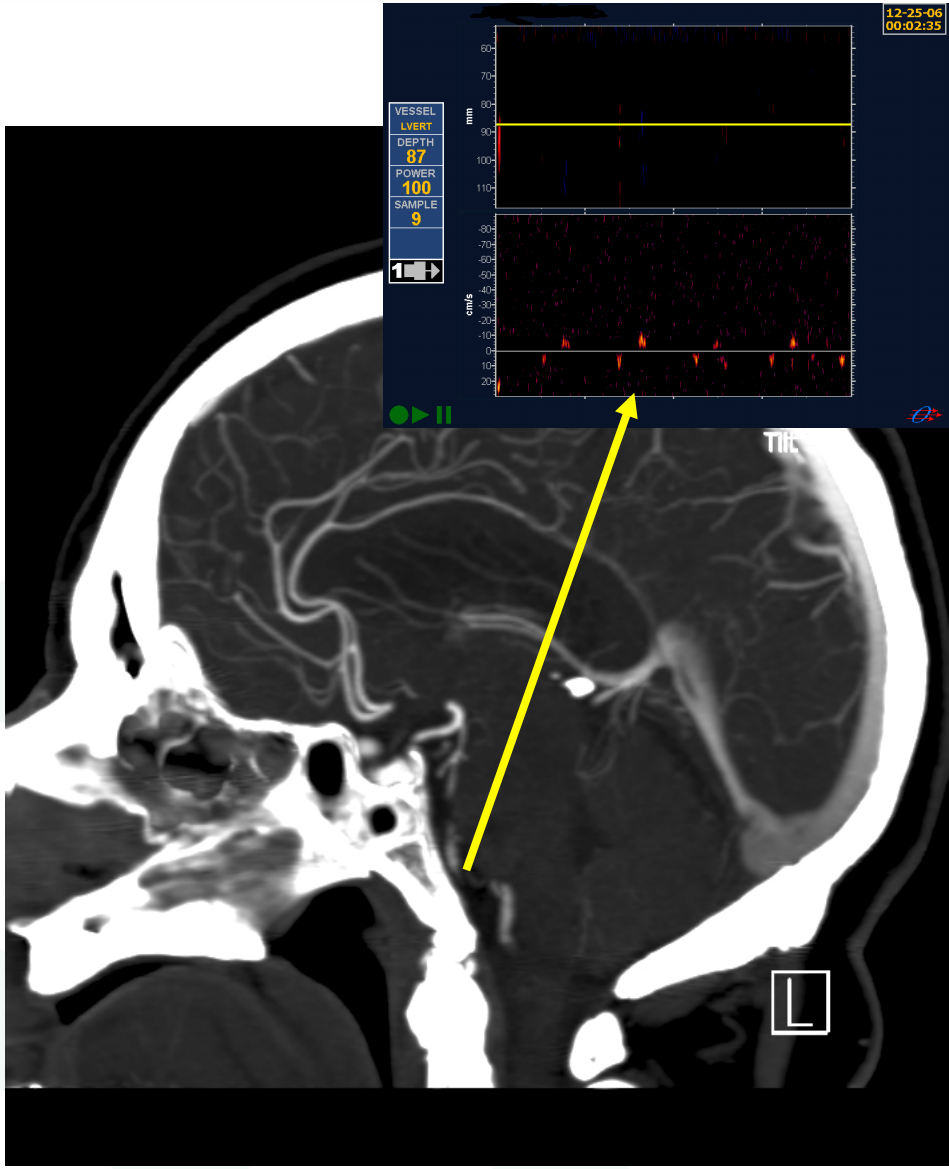
- Responds less to EV rt_PA
- Worse prognosis
- Frequent worsening in the following hours



Advantages of TCD

- ✓ Low cost
- ✓ Does not irradiate
- ✓ Bedside test
- ✓ Its performed by the clinician
- ✓ Can be repeted as necessary
- ✓ Allows monitoring
- ✓ **Good correlation with DSA y CTA**

Site of occlusión	Sensibility	Specificity	VPP	VPN
MCA	93	98	93	98
Distal ICA	81	96	81	96
Proximal ICA	94	97	94	97
Basilar oclussion	60	96	60	96
Vertebral oclussion	55	96	71	92

Demchuk et al. J Neuroimaging 2000

TCD Advantages

Sensitivity, specificity and LHR of TCD compared with CTA, Clínica Alemana de Santiago

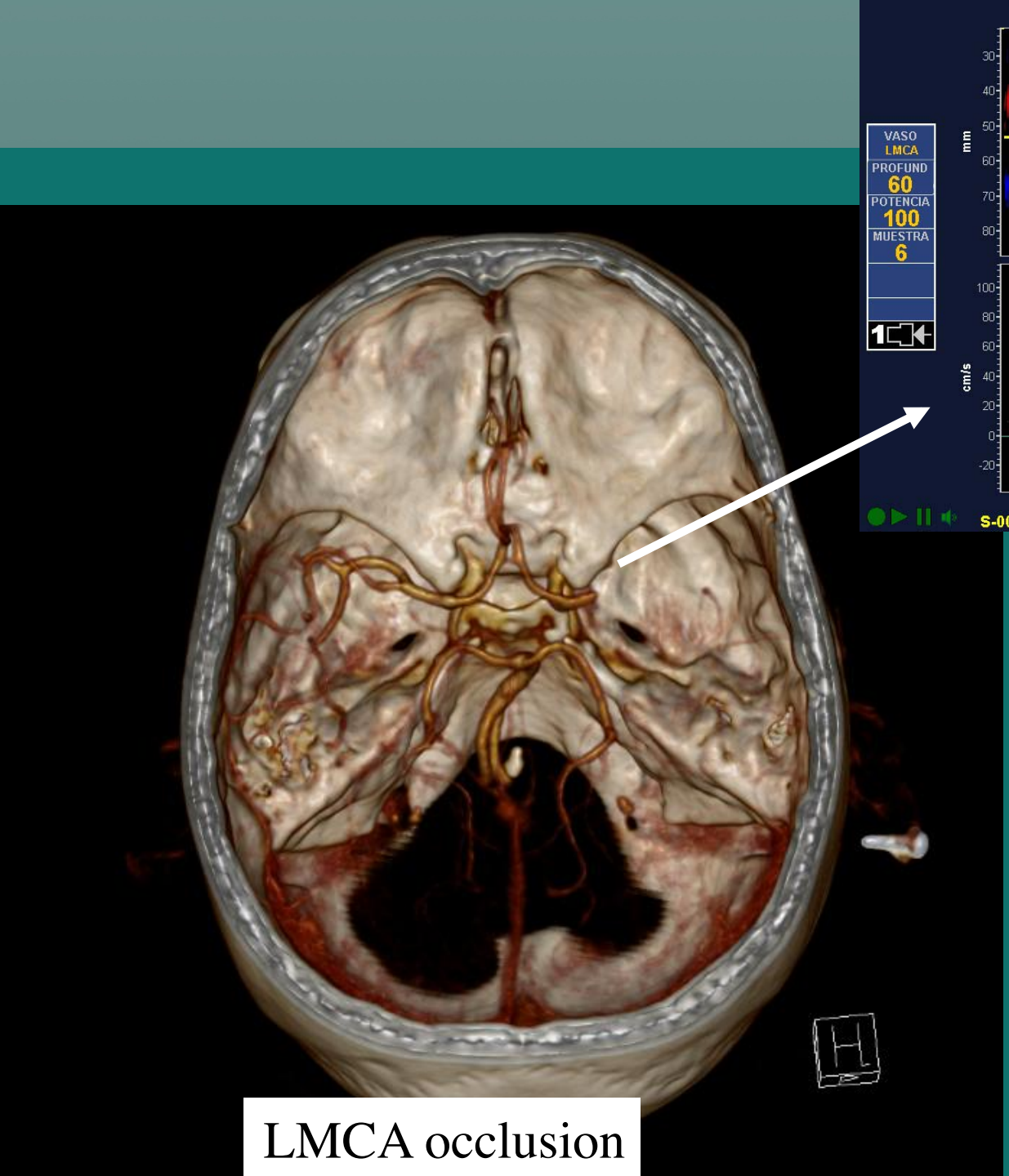
Table 2. PLRs, NLRs, Sensitivities, Specificities, and Diagnostic Accuracy for Each Artery With Corresponding 95% CIs

Artery	PLR (95% CI)	NLR (95% CI)	Se (95% CI)	Sp (95% CI)	Diagnostic Accuracy
Any specific artery	13.7 (5.2–35.9)	0.19 (0.09–0.4)	81.8 (68.7–95.0)	94 (88.3–99.7)	90
MCA	24.6 (8.1–74.7)	0.045 (0.006–0.30)	95.6 (87.3–100)	96.2 (91.7–100)	96
Anterior circulation	18.5 (7.1–48)	0 (0–NA)	100 (100–100)	94.5 (89.4–99.7)	96
Posterior circulation	>1000 (NA–infinity)	0.42 (0.18–1)	57.1 (20.4–93.8)	100 (100–100)	97
Central occlusion	70.3 (10–494.8)	0.08 (0.02–0.3)	91.3 (79.7–100)	98.2 (96.1–100)	97
Any overall artery	15.2 (5.8–38.6)	0.09 (0.03–0.28)	90.9 (81.1–100)	94 (88.3–99.7)	93

NA indicates not applicable.

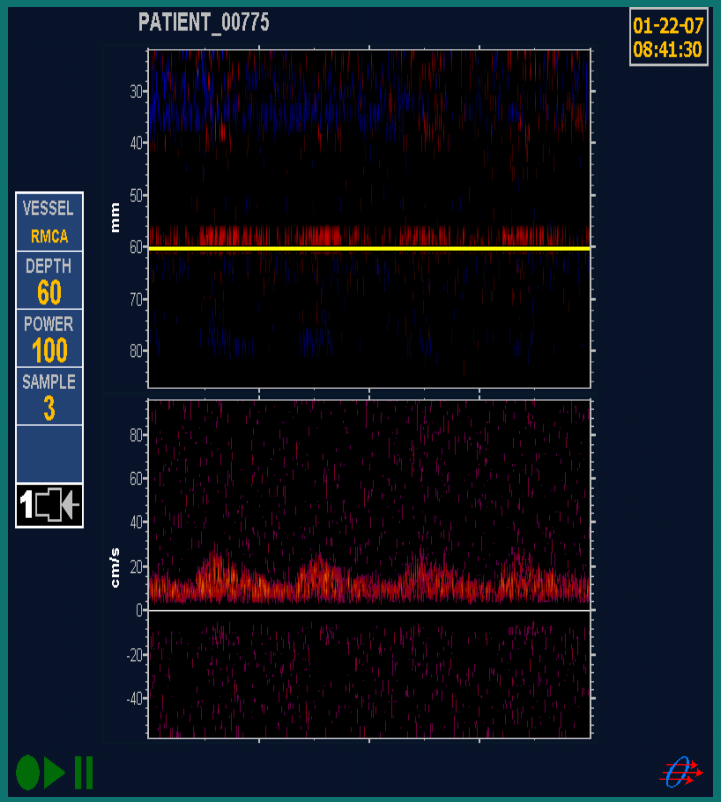
LHR: Likelihood ratio

Brunser AM.Stroke 2009



LMCA occlusion

Recanalization with t-PA related to location of obstruction by TCD

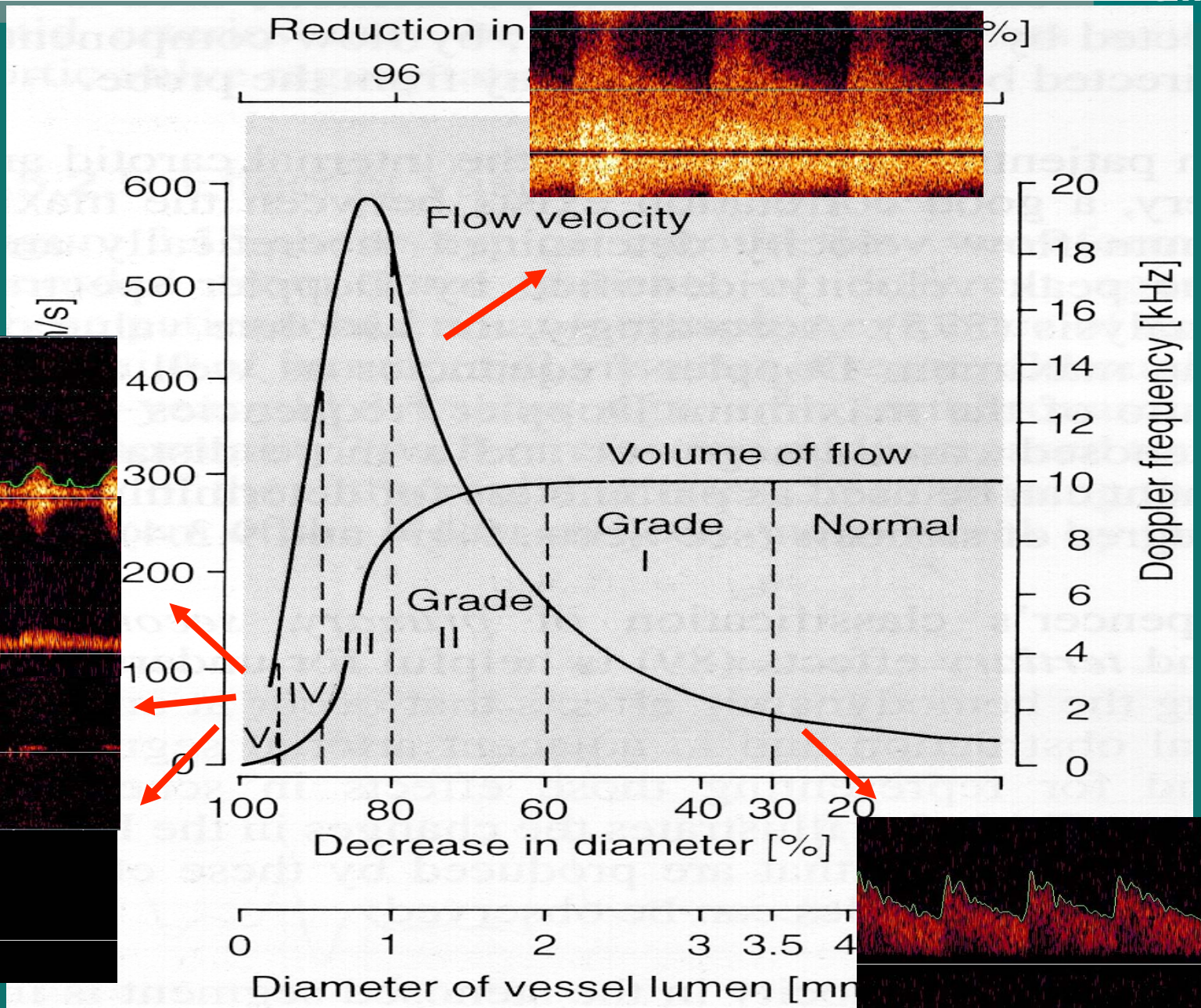


Complete recanalization

- MCA M1: 30%
- MCA M2: 44%
- Tandem:27%
- Terminal ICA 6%
- Basilar:33%

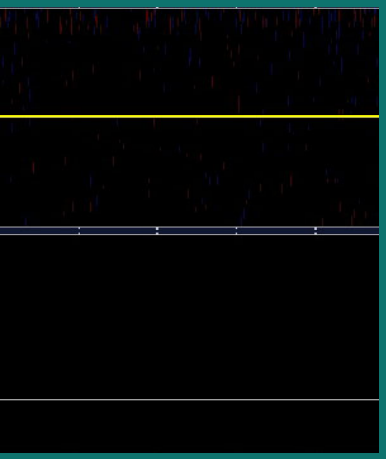
Saqqur.Stroke.2007:38;948-954.

TIBI scale related to Spencer curve



Initial TIBI scale on TCD and reperfusion with t-PA

TIBI 0



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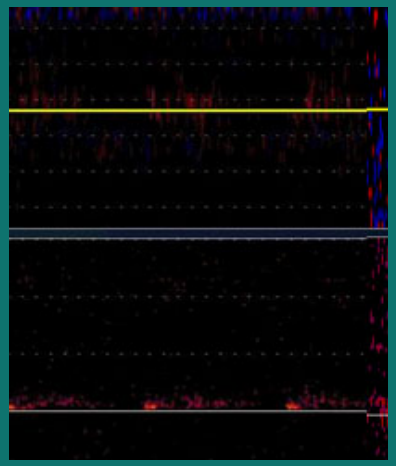
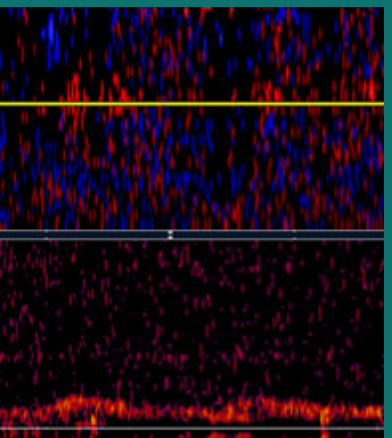
TIBI 1



Demchuck.Stroke**2001;32:89-93.**

35% of complete reperfusion at 2 hours

TIBI 2



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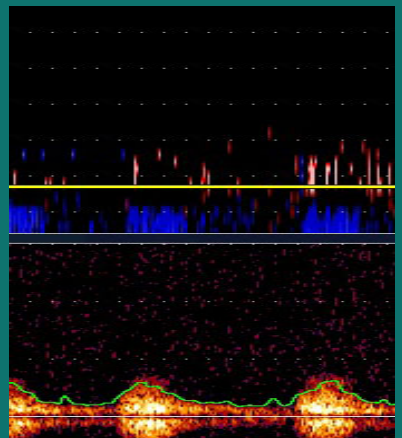
TIBI 3



52%of complete reperfusion at 2 hours

TCD advantages

- 79 patients
- Evaluated in the first 24 hours
  - Brain TC
  - Brain CTA
  - DWI
  - TCD blind

Table 2. Additional information given by TCD on 28 patients

Additional information	
Collateral flow	15 (18.9)
Active microembolism	6 (7.6)
Confirms doubtful CTA in patient with MCA trifurcation	3 (3.8)
Confirms occluded MCA M2 branch	n = 2
Discards occluded MCA M2 branch	n = 1
Detects occlusion first not seen by CTA	2 (2.5)
Subclavian steal	1 (1.3)
Information related to patency of vessels	5 (6.3)
Detects proximal carotid stenosis	2 (2.5)

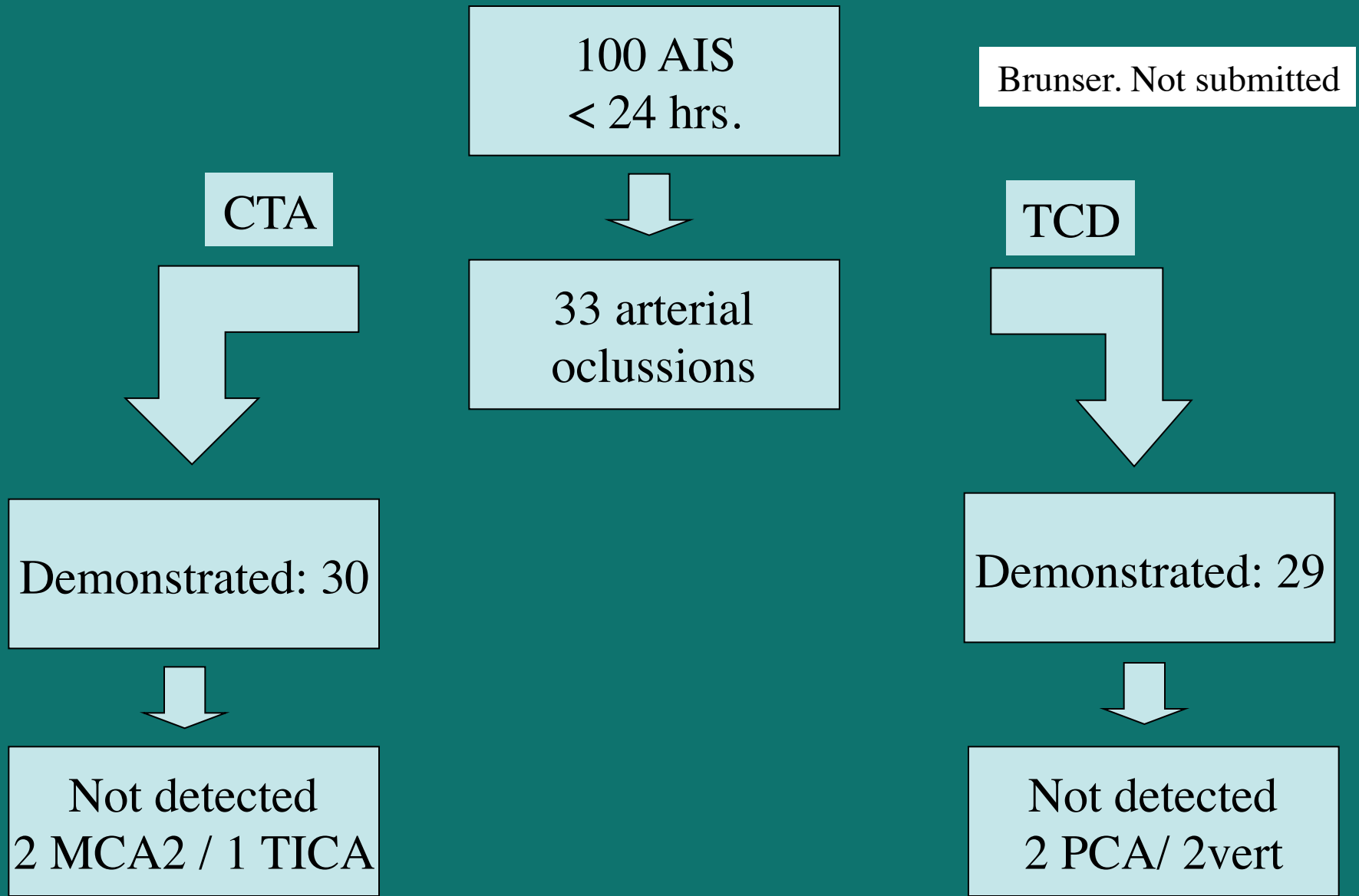
Data shown as number of patients with percent in parentheses.

Additional information
35%
(95% IC 25,7-46,4)

Change in medical managament
9%(95% CI 4.3–17.1)

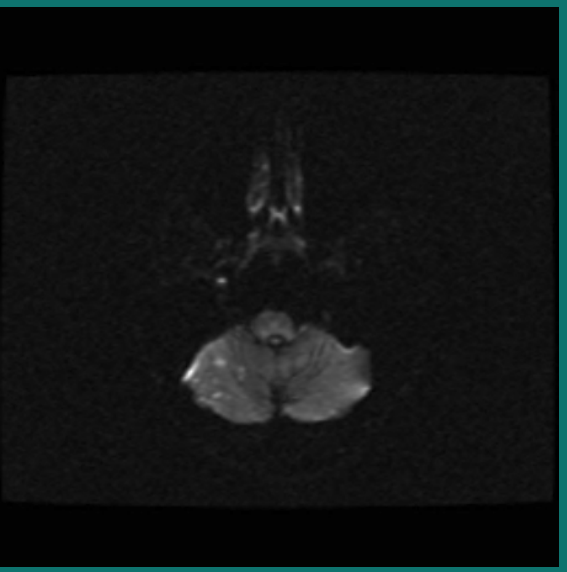
Brunser AM. Cerebrovasc Dis 2010

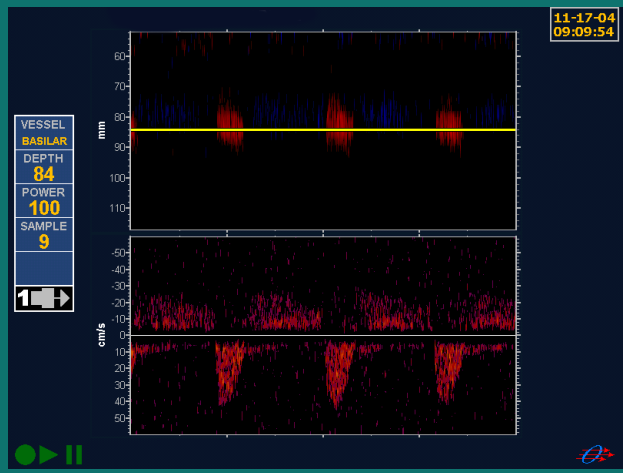
TCD and CTA do complement each other



Additional Information

- Ischemic stroke NIHSS 3, frequent fluctuation of symptoms.





NIHSS: 18

VESSEL RACA
DEPTH 68
POWER 100
SAMPLE 3

PEAK -221
MEAN -159
DIAS -111
P.I. 0.69
Δ% 0

R

VESSEL RPCA
DEPTH 62
POWER 100
SAMPLE 3

PEAK 108
MEAN 71
DIAS 47
P.I. 0.86

VESSEL RMCA
DEPTH 60
POWER 100
SAMPLE 3

P

Changes in management caused by TCD in 79 patients with AIS

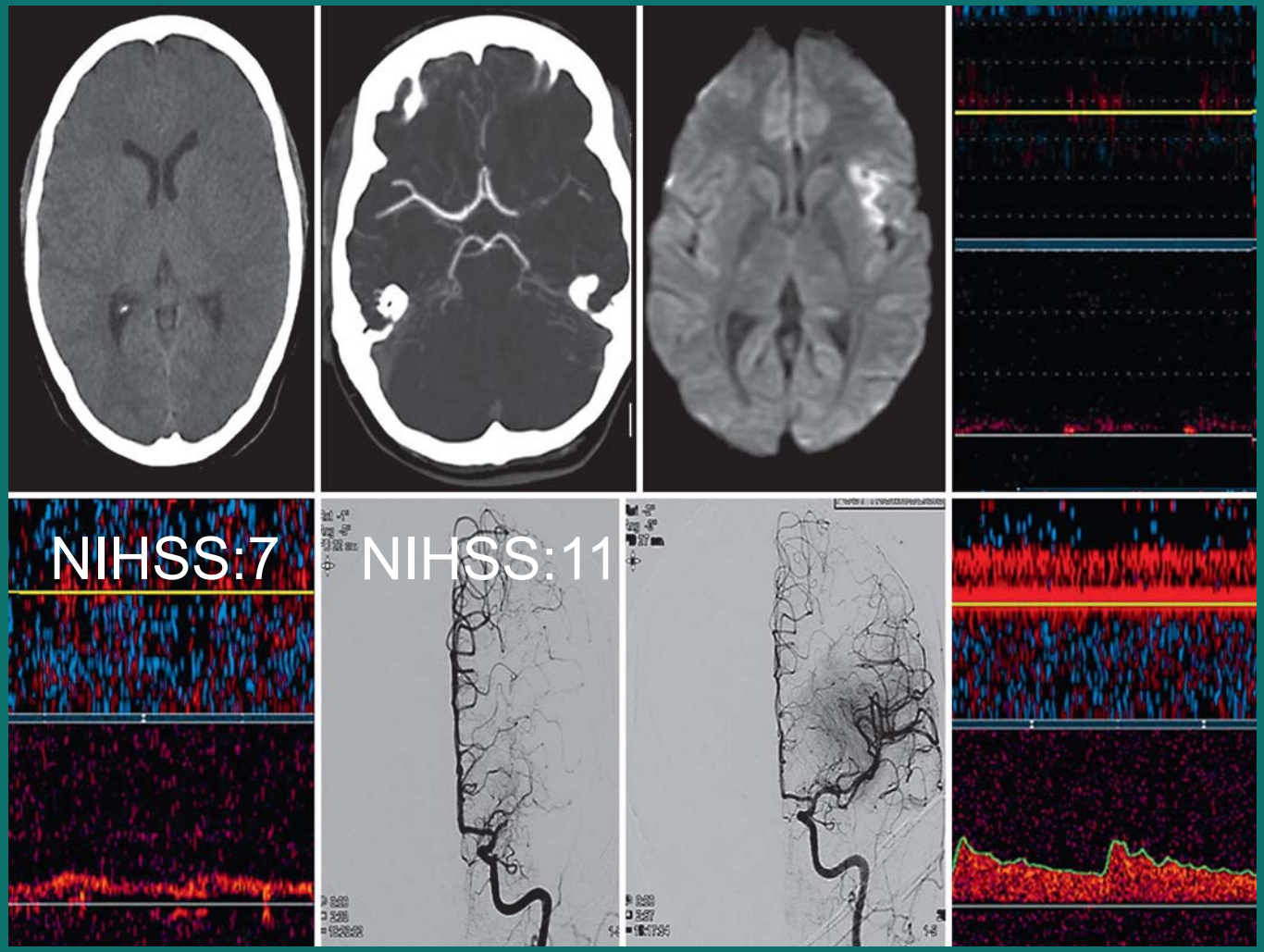
8.8%, 95% CI 4.3–17.1

Case	Sex age, years	NIHSS	ASIP findings	TCD findings	Change in management	mRS 3 months after stroke
11	F 18	9	left stroke MCA occlusion	left MCA occlusion, with no recanalization during i.v. rt-PA	DSA angiography and intra-arterial thrombolysis were performed, with recanalization of the occluded artery	0
12	F 84	14	right stroke MCA occlusion	right MCA occlusion that recanalized during diagnostic TCD; NIHSS score decreased from 15 to 4	planned DSA and intra-arterial thrombolysis were not performed	1
33	M 66	13	right stroke MCA M2 occlusion	right M2 occlusion, with important collateral flow from ipsilateral ACA and PCA	aggressive neurocritical care was started	1
40	M 66	19	left stroke MCA occlusion	left MCA occlusion, with no recanalization during i.v. rt-PA	DSA and intra-arterial thrombolysis were performed, with recanalization of the artery	0
51	F 69	15	left MCA stroke no occlusion on circle of Willis	post-stenotic left MCA flow signal and inverted ophthalmic artery suggest proximal left carotid artery disease	DSA was performed and ICA stenosis was found; intensive secondary prevention was begun	1
67	M 83	11	left stroke, CTA with important movement artifacts, possible left terminal M1 stenosis	normal TCD	planned diagnostic DSA was not performed	1
75	F 66	10	right MCA stroke no occlusion on circle of Willis	post-stenotic right MCA flow signal and inverted ophthalmic artery suggest proximal right carotid artery disease	DSA was performed and ICA stenosis was found; intensive secondary prevention was begun	0

Brunser. Cerebrovasc Dis 2010;30:260–266

Rescue of patients in whom rt-PA failed

NIHSS: 9



What about the hot spot: time < 4.5 hours

- 86 patients
- Evaluated in the first 4.5 hours
  - Brain TC
  - CTA brain and cervical
  - DWI
  - TCD not blinde

Additional information

56.9.4% (95 CI 46.4 -66.9)

Change in medical management

17.4%(95 CI. 9.4-25.5)

Brunser AM,Submitted J. Neuroimaging

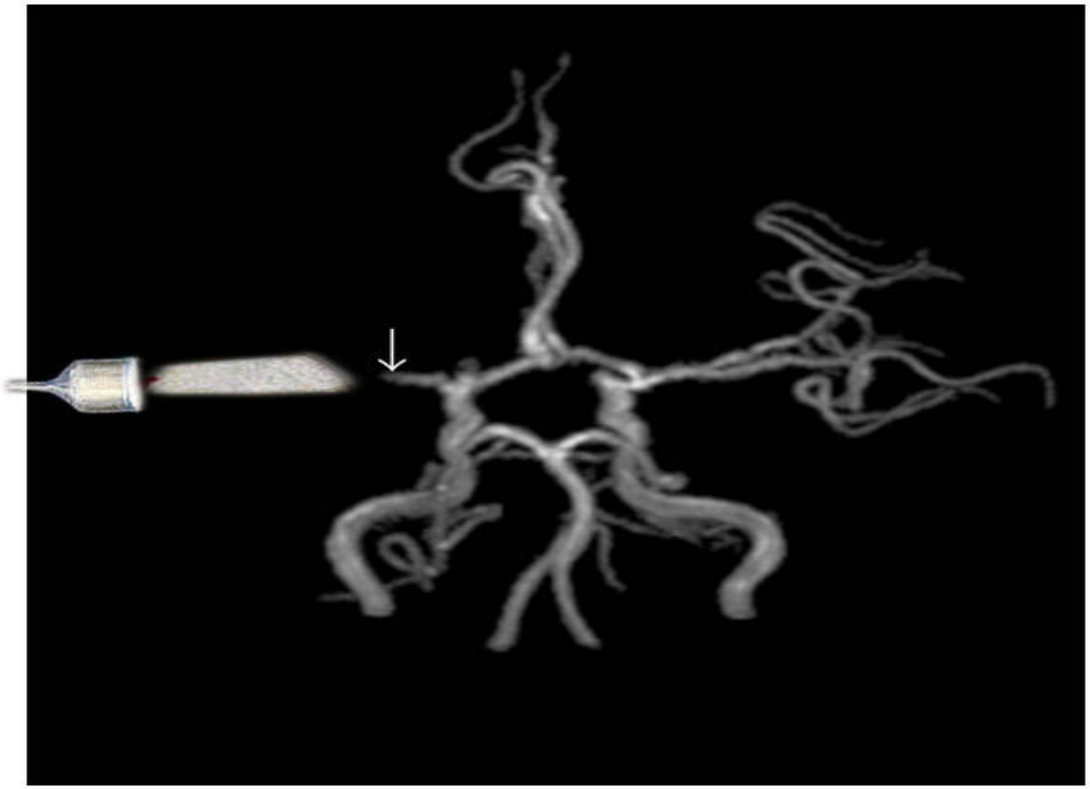
Change in management depends on vessel oclusion on CTA p =0.000

NIHSS 19

NIHSS 9

Brunser. Submitted J. Neuroimaging

TCD increase rt-PA recanalization



Change in the structure of fibrin

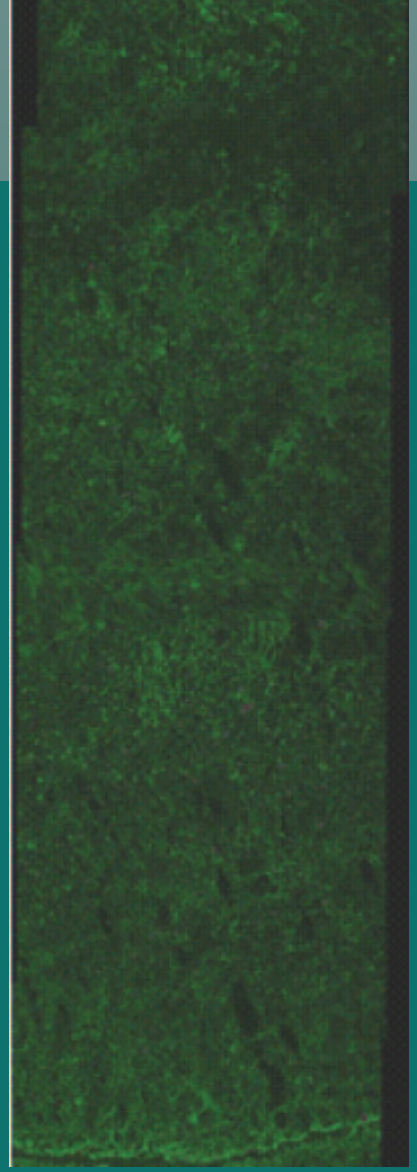
↓

Fissures in the clot through which plasma seeps

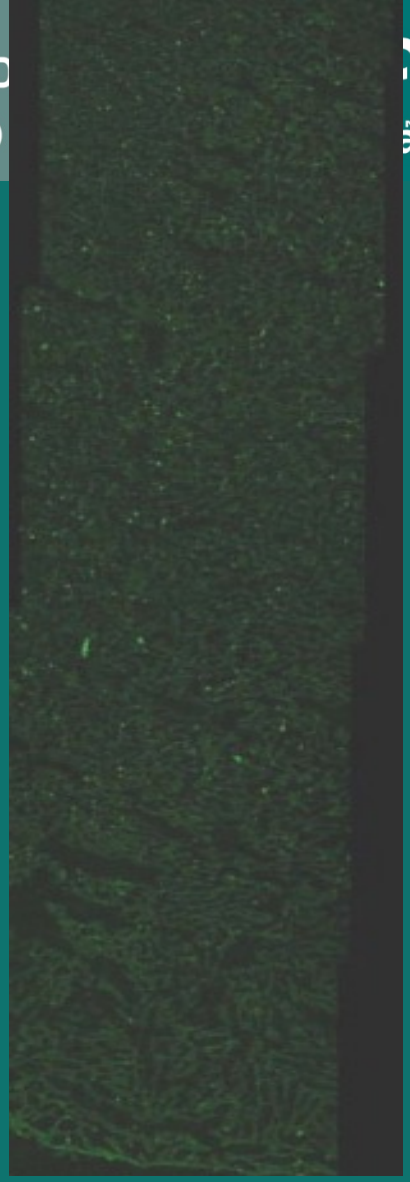
↓

Increased contact between the clot and t-PA

Penetration of t-PA
into a thrombus
during thrombolysis



With Ultrasound



With out Ultrasound

Hichcock Stroke. 2010;41[suppl 1]:S50-S53

Combined Lysis Of Thrombus in Brain ischemia using 2 MHz transcranial Ultrasound and Systemic TPA

CLOTBUST

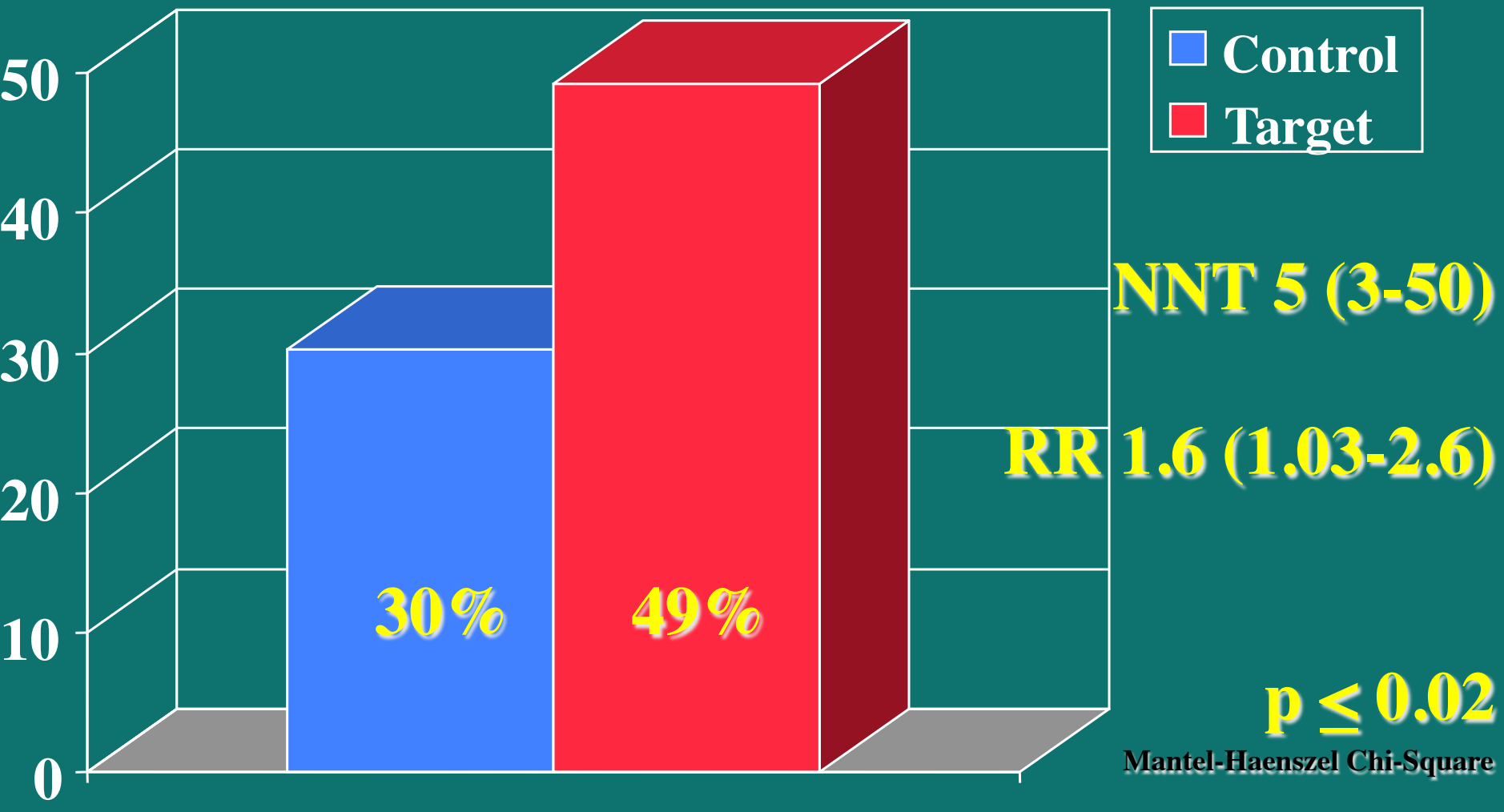
ORIGINAL ARTICLE

Ultrasound-Enhanced Systemic Thrombolysis for Acute Ischemic Stroke

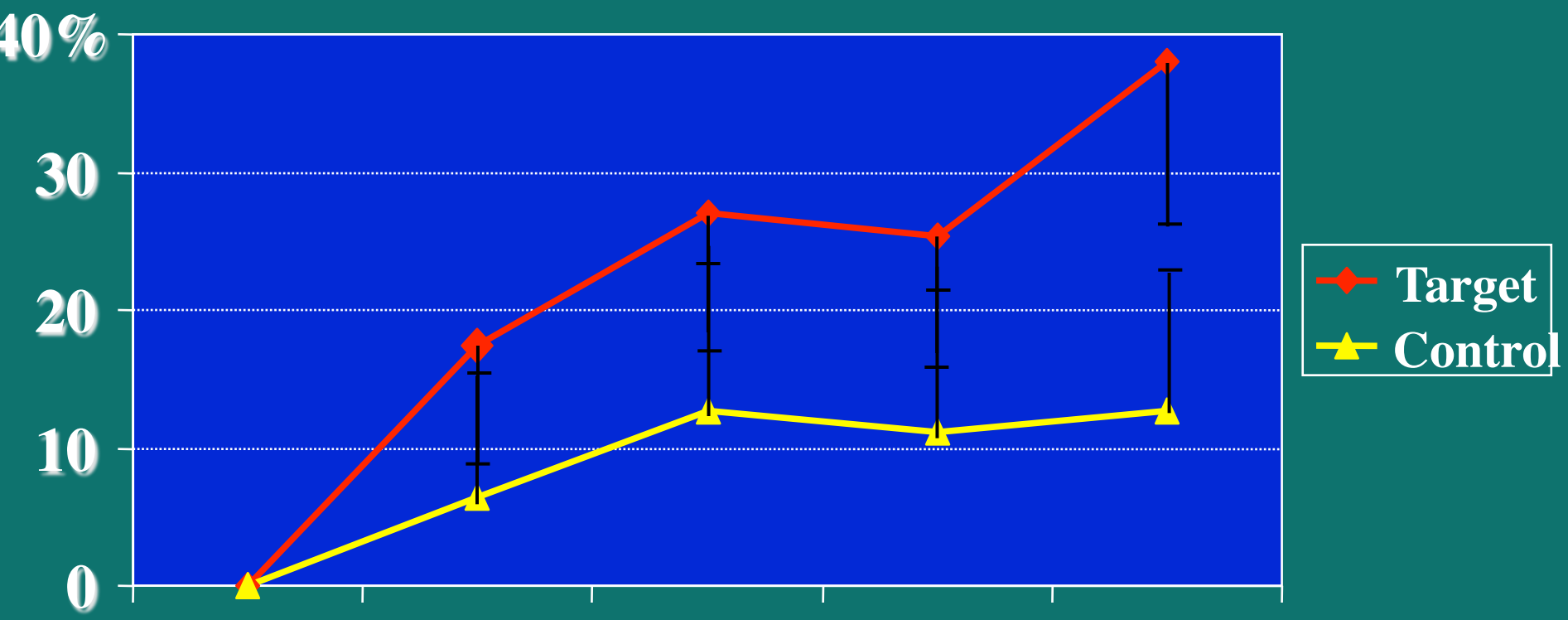
Andrei V. Alexandrov, M.D., Carlos A. Molina, M.D., James C. Grotta, M.D., Zsolt Garami, M.D., Shiela R. Ford, R.N., Jose Alvarez-Sabin, M.D., Joan Montaner, M.D., Maher Saqqur, M.D., Andrew M. Demchuk, M.D., Lemuel A. Moyé, M.D., Ph.D., Michael D. Hill, M.D., and Anne W. Wojner, Ph.D., for the CLOTBUST Investigators*

Primary End-Point: Complete Recanalization OR total NIHSS ≤ 3 OR Recovery by ≥10 NIHSS points

Departamento Científico Docente Alemana



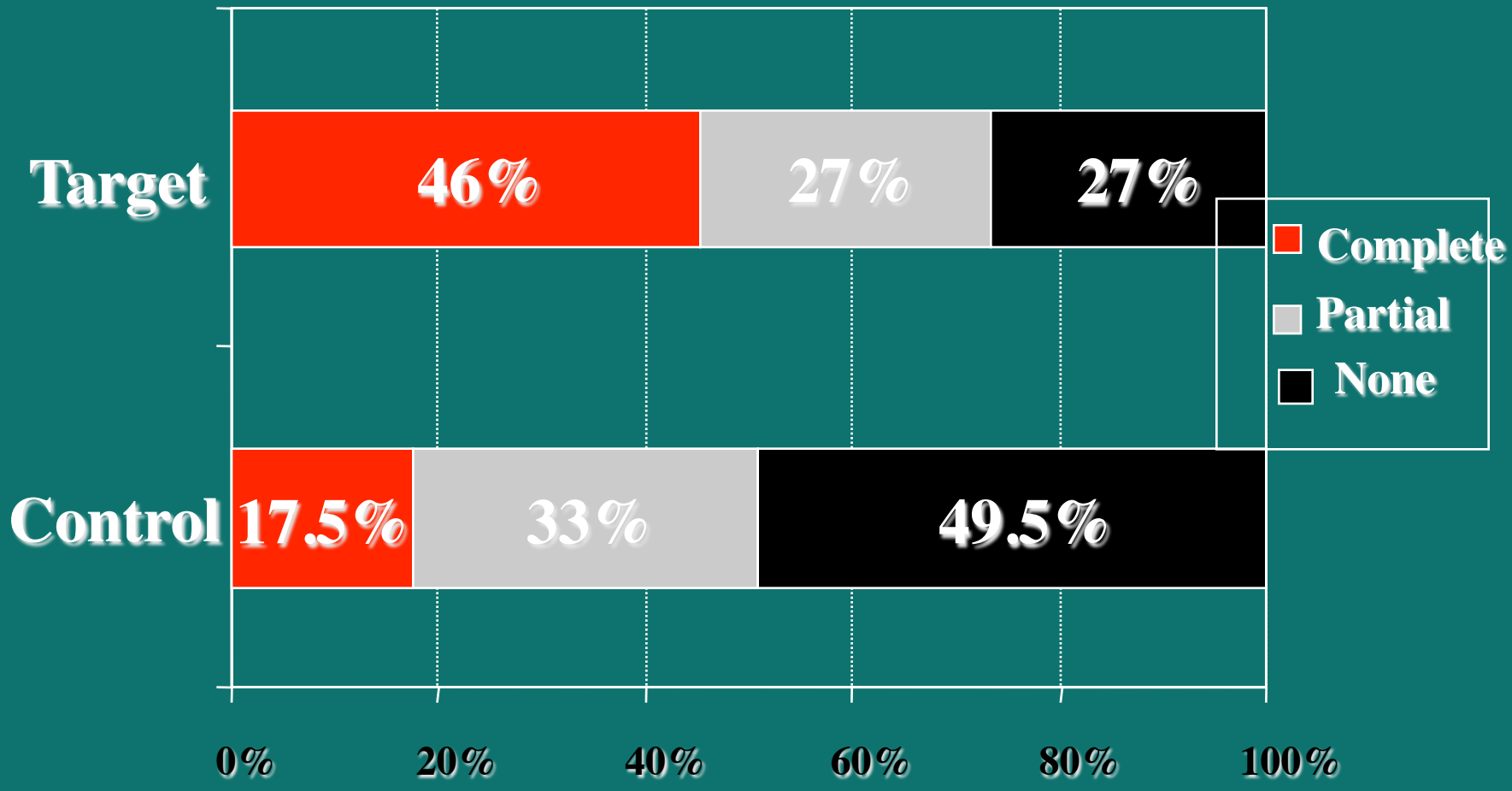
Sustained Complete Recanalization: TCD TIBI 5 Flow at 30 min Intervals



p = 0.003

Fisher's exact test

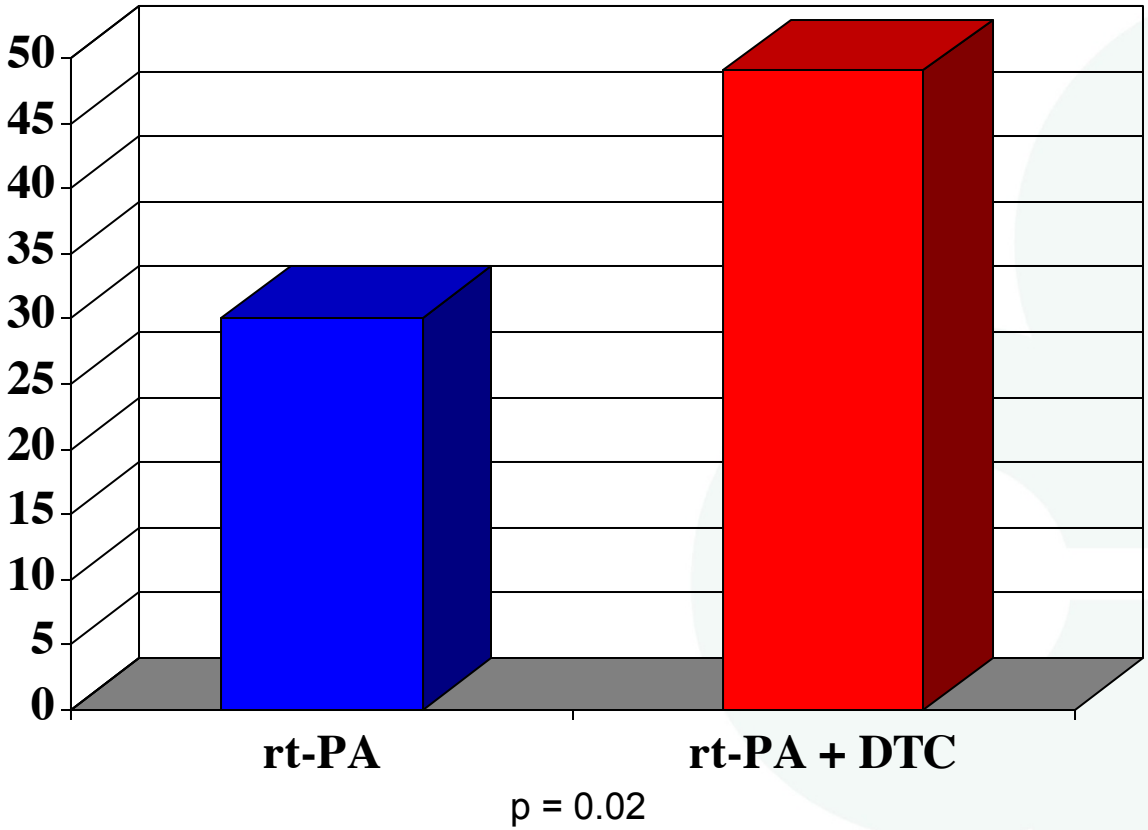
CLOTBUST: Any Early Recanalization on TCD



$p < 0.001$

3x2 Chi-Square

TCD increases the thrombolytic power of rt-PA



Complete arterial recanalization, NIHSS ≤ 3 or ≥10 decrease in NIHSS

NNT 5 (3-50)

RR 1.6 (1.03-2.6)

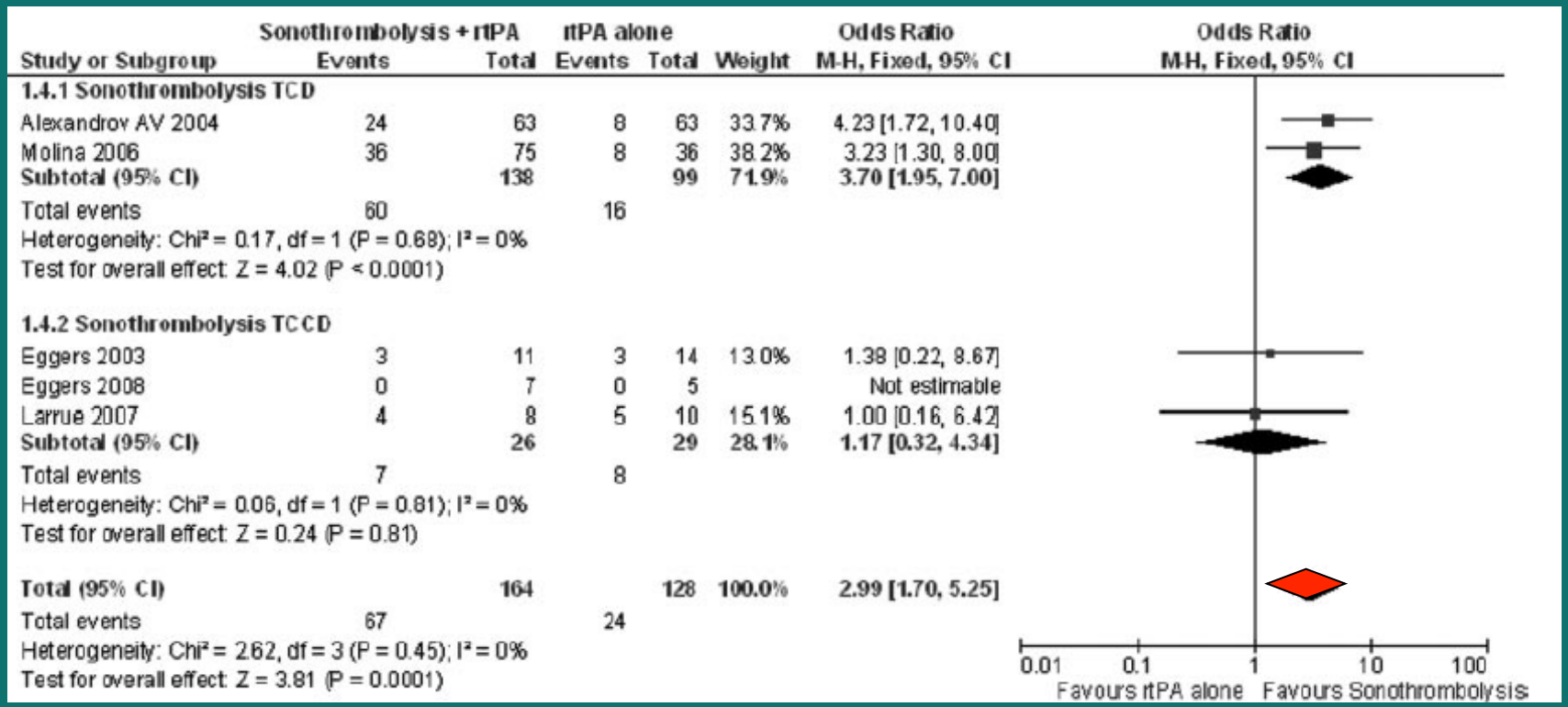
Alexandrov. N Engl J Med. 2004

Sonothrombolysis CAS compared to **CLOTBUST**

	CLOTBUST control (rt-PA)	**CLOTBUST treatment (ST+rt-PA)**	**Clínica Alemana Santiago (ST+rt-PA)**
Patients	63 (49)	63 (53)	61
Age	70 ±13	67 ±12	66±17,6
NIHSS	17	16	14
Time to bolus	130	150	127
MCA occlusion	100%	100%	88,5%
Complete Recanalización TIBI 4-5	17,6%	46%	44,3%
mRS 0-2 at 3 months	36,7 % (IC: 95%; 0,25- 0,51)	50,9% (IC: 95%; 0,38 - 0,64)	60,6% (IC:95%; 48,1-72)
sHIC	4,8% (IC:95%; 1,1-13,6)	4,8% (IC:95%; 1,1-13,6)	9,8% (IC:95%; 4,3-20,2)

Sono-thrombolysis meta-analysis

Recanalization OR 2.99 CI 95 (1.70-5.25)



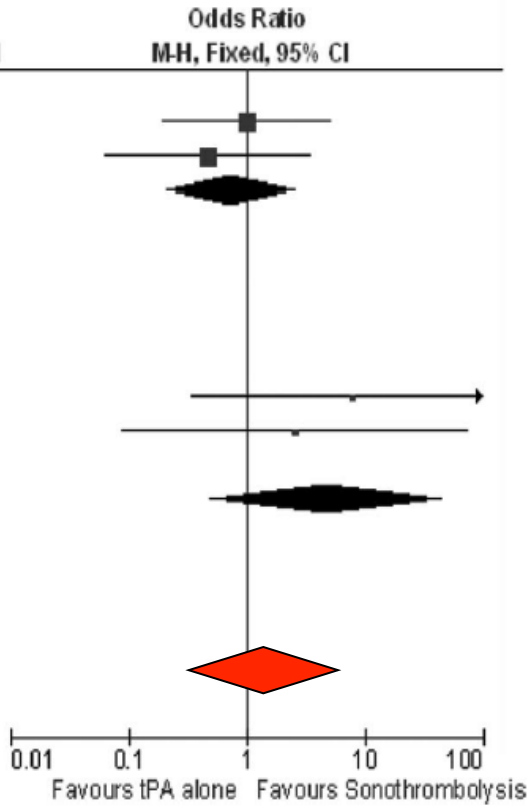
Study or Subgroup	Sonothrombolysis + rtPA Events	Total	rtPA alone Events	Total	Weight	Odds Ratio M-H, Fixed, 95% CI
1.4.1 Sonothrombolysis TCD						
Alexandrov AV 2004	24	63	8	63	33.7%	4.23 [1.72, 10.40]
Molina 2006	36	75	8	36	38.2%	3.23 [1.30, 8.00]
Subtotal (95% CI)		138		99	71.9%	**3.70 [1.95, 7.00]**
Total events	60		16			
Heterogeneity: Chi² = 0.17, df = 1 (P = 0.68); I² = 0%						
Test for overall effect: Z = 4.02 (P < 0.0001)						
1.4.2 Sonothrombolysis TCCD						
Eggers 2003	3	11	3	14	13.0%	1.38 [0.22, 8.67]
Eggers 2008	0	7	0	5		Not estimable
Larrue 2007	4	8	5	10	15.1%	1.00 [0.16, 6.42]
Subtotal (95% CI)		26		29	28.1%	**1.17 [0.32, 4.34]**
Total events	7		8			
Heterogeneity: Chi² = 0.06, df = 1 (P = 0.81); I² = 0%						
Test for overall effect: Z = 0.24 (P = 0.81)						
Total (95% CI)		164		128	100.0%	**2.99 [1.70, 5.25]**
Total events	67		24			
Heterogeneity: Chi² = 2.62, df = 3 (P = 0.45); I² = 0%						
Test for overall effect: Z = 3.81 (P = 0.0001)						

Tsivgoulis. Stroke.2010;41:280=4

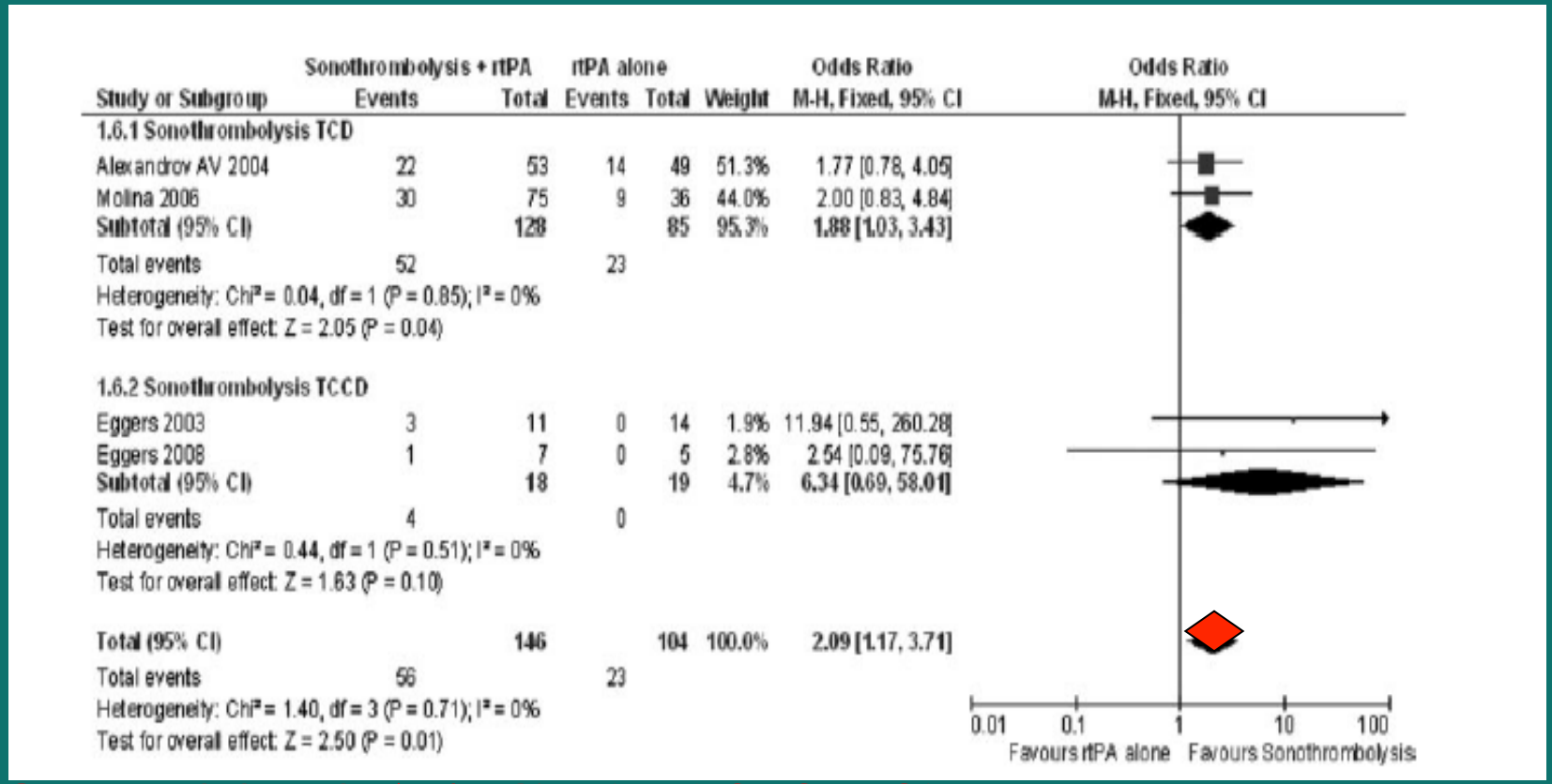
Sono-thrombolysis meta-analysis

RISK of ICH : OR 1.26, 95 CI (0.44-3.6

Study or Subgroup	Sonothrombolysis + rtPA Events	Total	rtPA alone Events	Total	Weight	Odds Ratio M-H, Fixed, 95% CI
1.2.1 Sonothrombolysis TCD						
Alexandrov AV 2004	3	63	3	63	45.3%	1.00 [0.19, 5.15]
Molina 2006	2	75	2	36	41.7%	0.47 [0.06, 3.45]
Subtotal (95% CI)		138		99	87.1%	**0.74 [0.21, 2.64]**
Total events	5		5			
Heterogeneity: Chi² = 0.34, df = 1 (P = 0.56); I² = 0%						
Test for overall effect: Z = 0.46 (P = 0.65)						
1.2.2 Sonothrombolysis TCCD						
Eggers 2003	2	11	0	14	5.6%	7.63 [0.33, 177.14]
Eggers 2008	1	7	0	5	7.4%	2.54 [0.09, 75.76]
Larrue 2007	0	9	0	11		Not estimable
Subtotal (95% CI)		27		30	12.9%	**4.73 [0.49, 45.89]**
Total events	3		0			
Heterogeneity: Chi² = 0.22, df = 1 (P = 0.64); I² = 0%						
Test for overall effect: Z = 1.34 (P = 0.18)						
Total (95% CI)		165		129	100.0%	**1.26 [0.44, 3.60]**
Total events	8		5			
Heterogeneity: Chi² = 2.45, df = 3 (P = 0.48); I² = 0%						
Test for overall effect: Z = 0.43 (P = 0.67)						



Sonothrombolysis-Metaanalysis mRS 0-1 at day 90

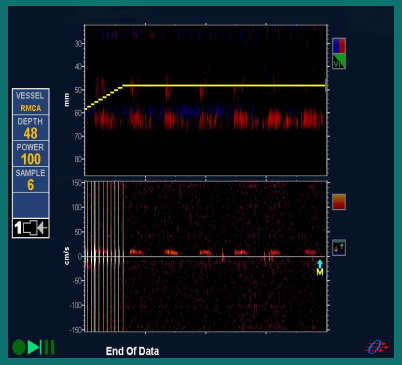


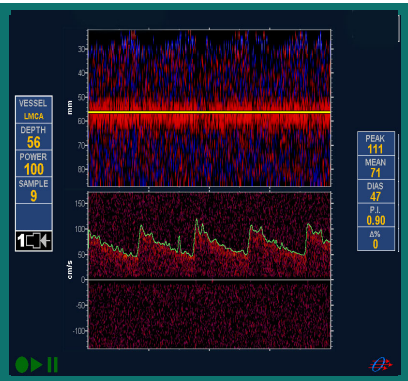
OR 1.88, 95% CI (1.03-3.43)

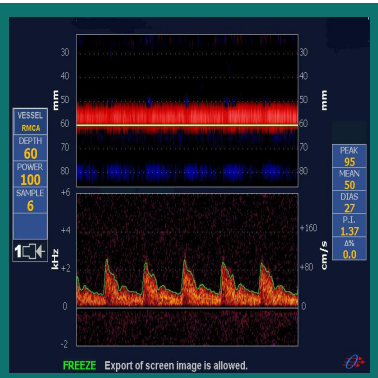
Tsivgoulis. Stroke.2010;41:280-4

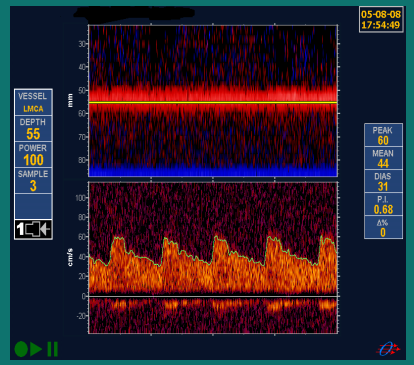
Rescue of endovenous t-PA failure

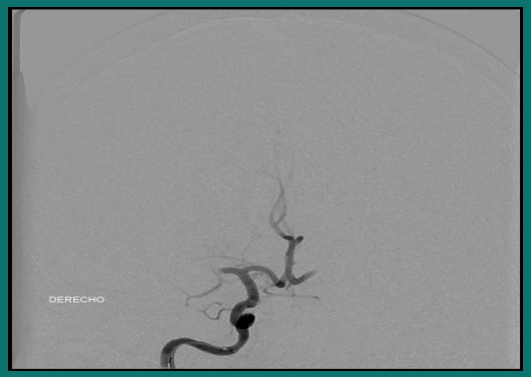
Saqqur.Stroke 2005;36:865-868









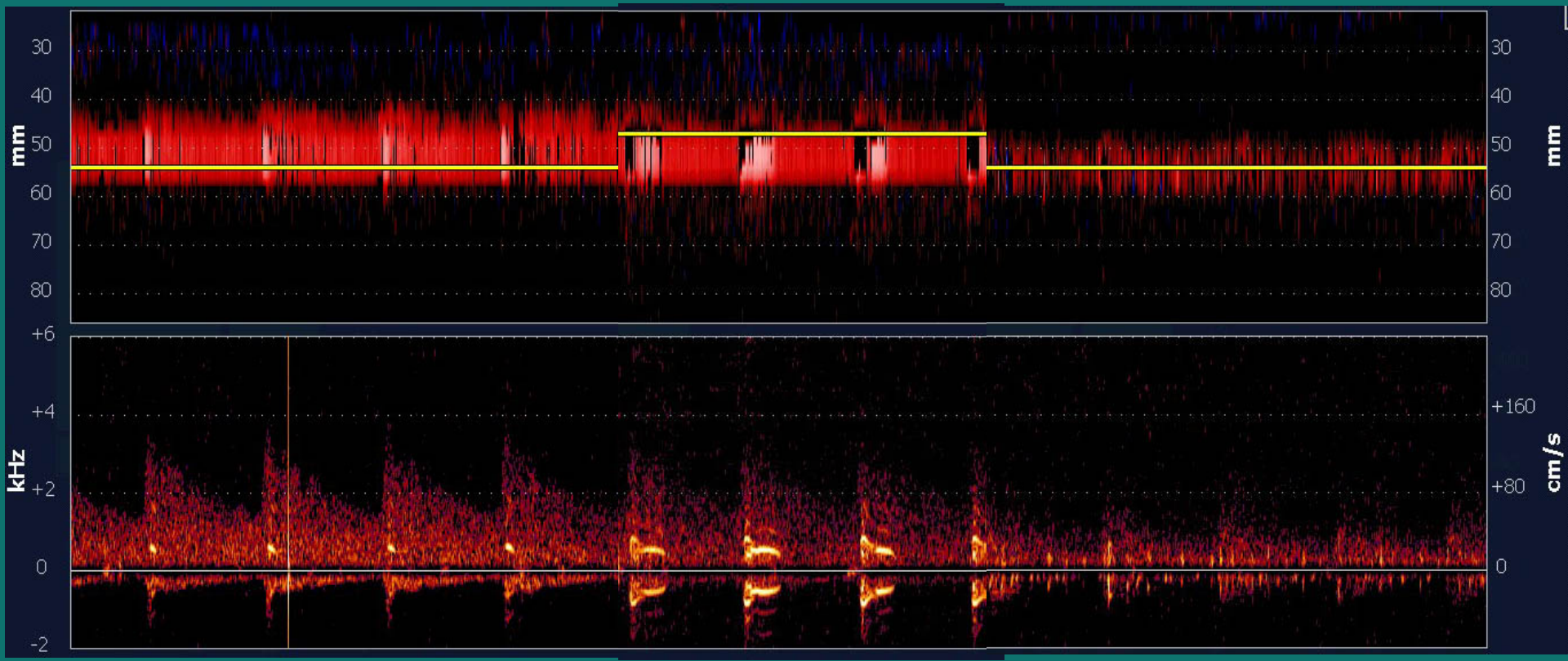


$$\frac{\text{Affected MCA}}{\text{Contralateral MCA}} < 0.6$$

Detection in angiooccclusion
Sensitivity: 94% (63-99)
Specificity 100% (lower 54)

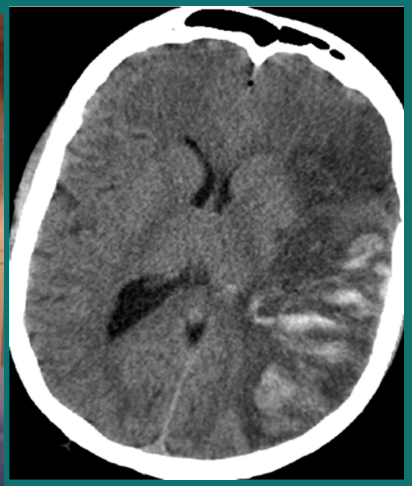
Reocclusion during EV t_PA

NIHSS 4 | NIHSS 10 | NIHSS 19



Min 41 | Min 47 | Min 49

TCD and endovascular theraphy
Accuracy of ultrasound for recanalization



Brain haemorrage risk increases with contrast injection

Accuracy of TCD for recanalization

Sen 88%

Spe 89%

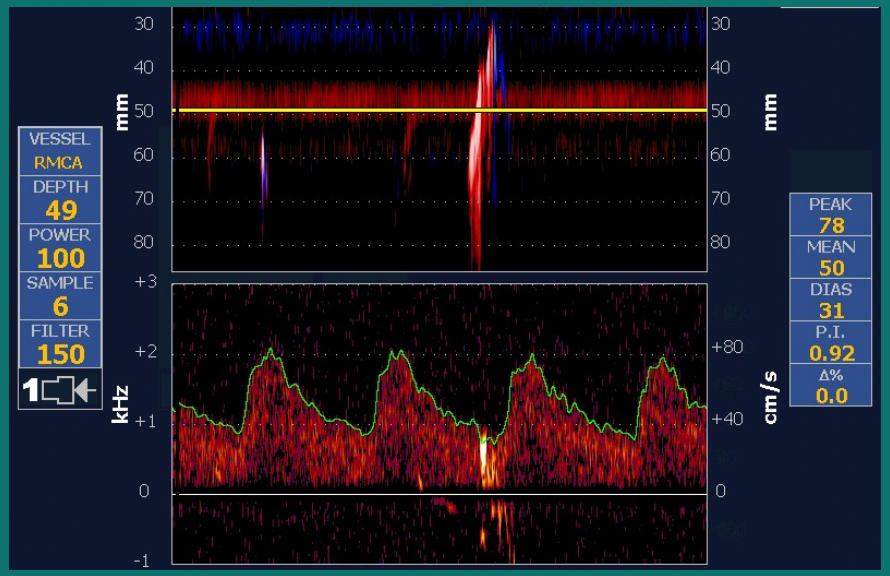
PPV: 81%

NPV:93%

Tsivgoulis. Stroke.2013;44,394-400

TCD and other uses in stroke

Detection of microembolic signs (MES)



- Higher risk of AIS in patients with CAD.

Srinivasan J. Stroke 1996

- Increase risk of AIS.

Iguchi Y.JNNP 2008

Assessment: Transcranial Doppler ultrasonography

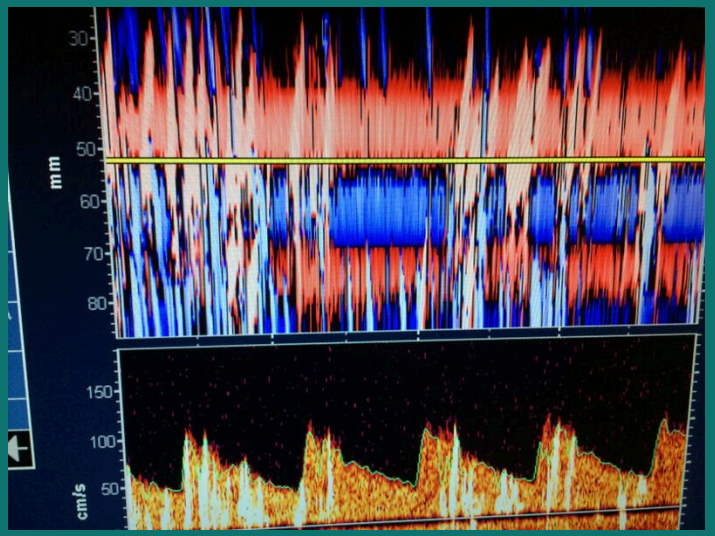
Report of the Therapeutics and Technology Assessment Subcommittee of the American Academy of Neurology*

TCD

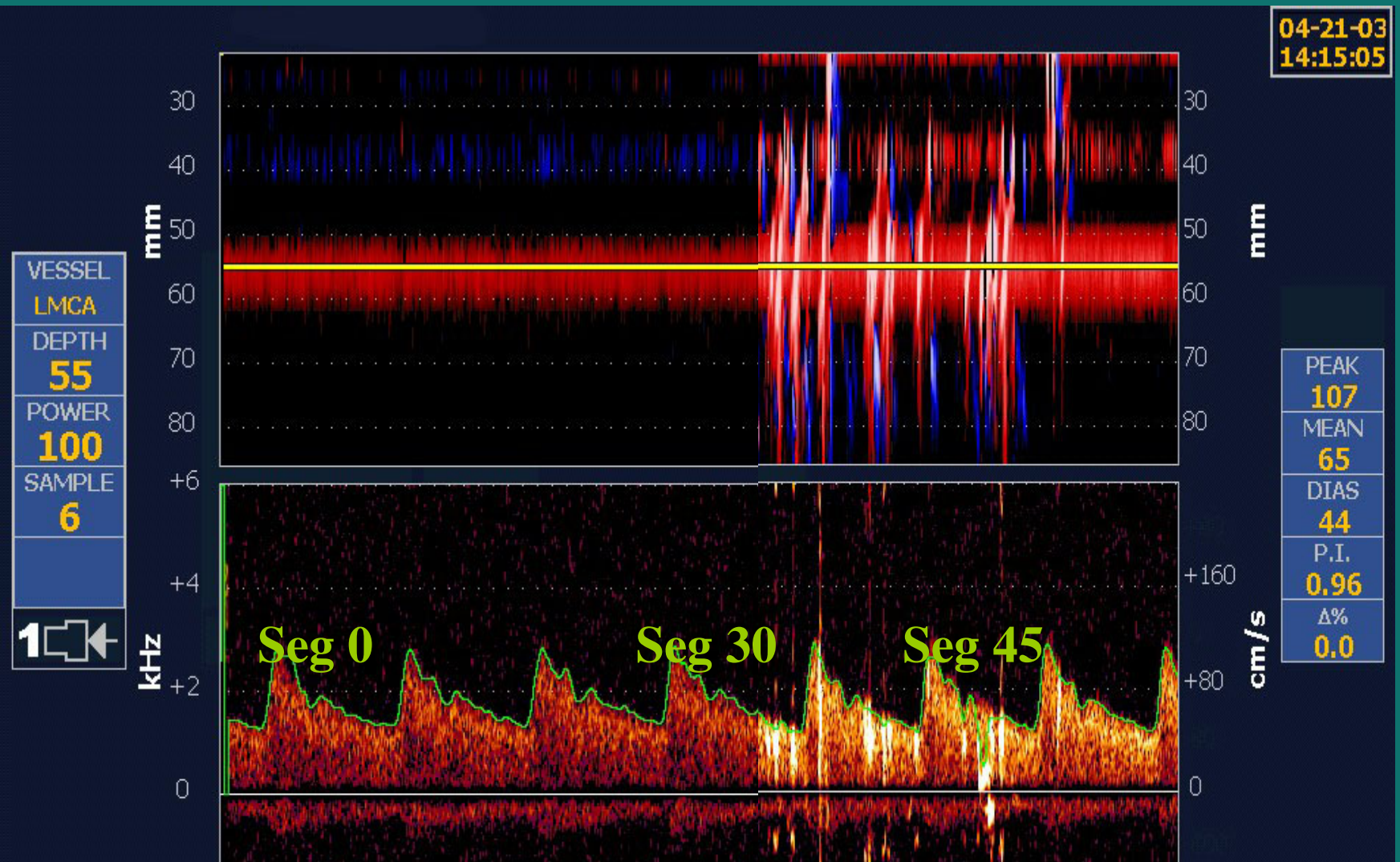
Diagnosis of PFO

Sensitivity 70-100%, Specificity >95%

Superior to Trastoraxic Ecocardiogram

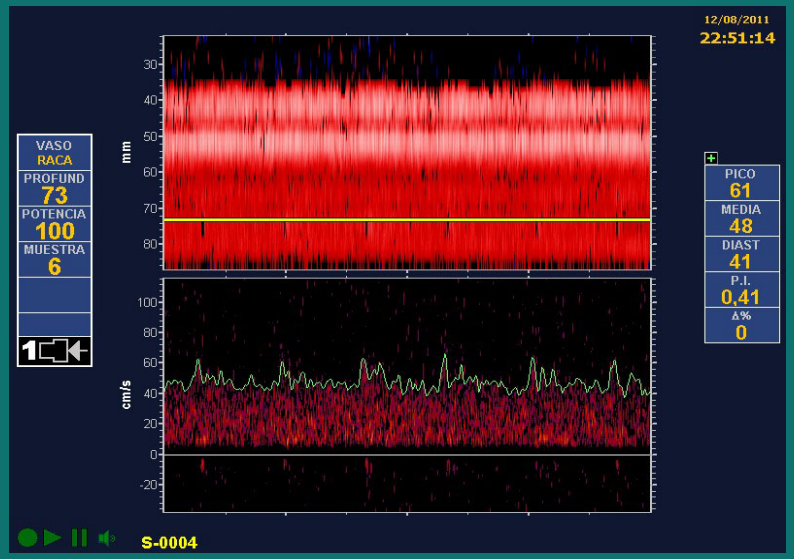


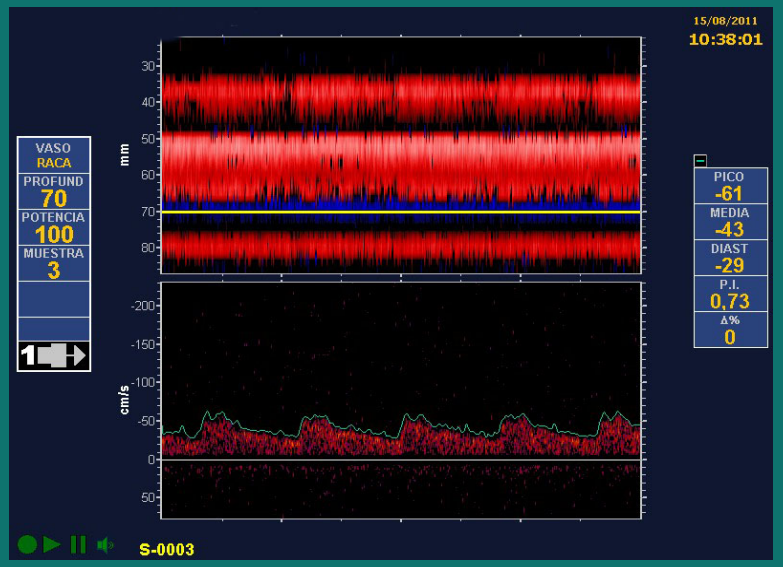
Patient with a cryptogenic AIS and a PFO



TCD allows follow up of changes in flow

43 years, male patient R carotid dissection

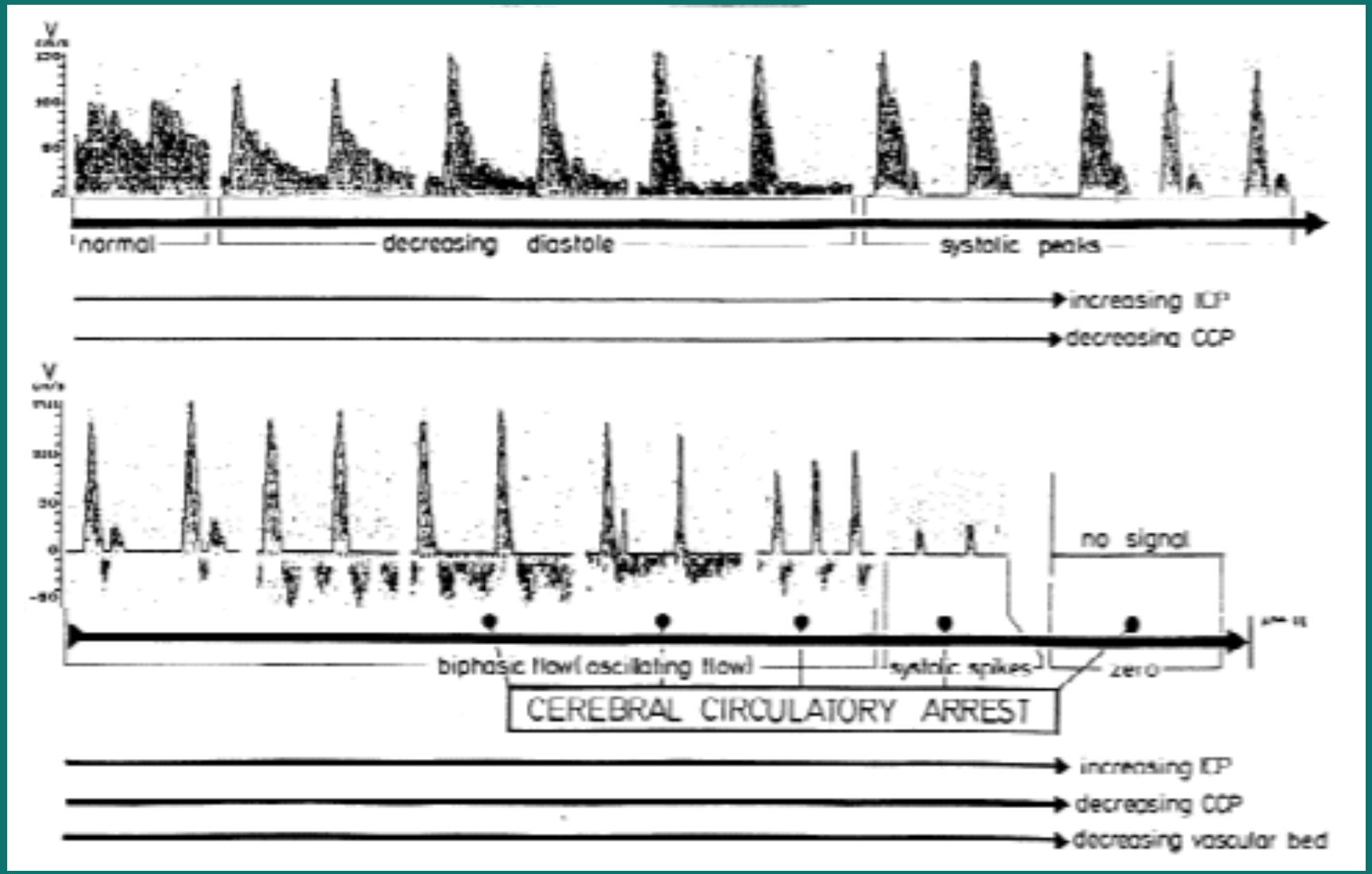




36 hours of aggressive treatment

TCD and brain death / intracranial pressure

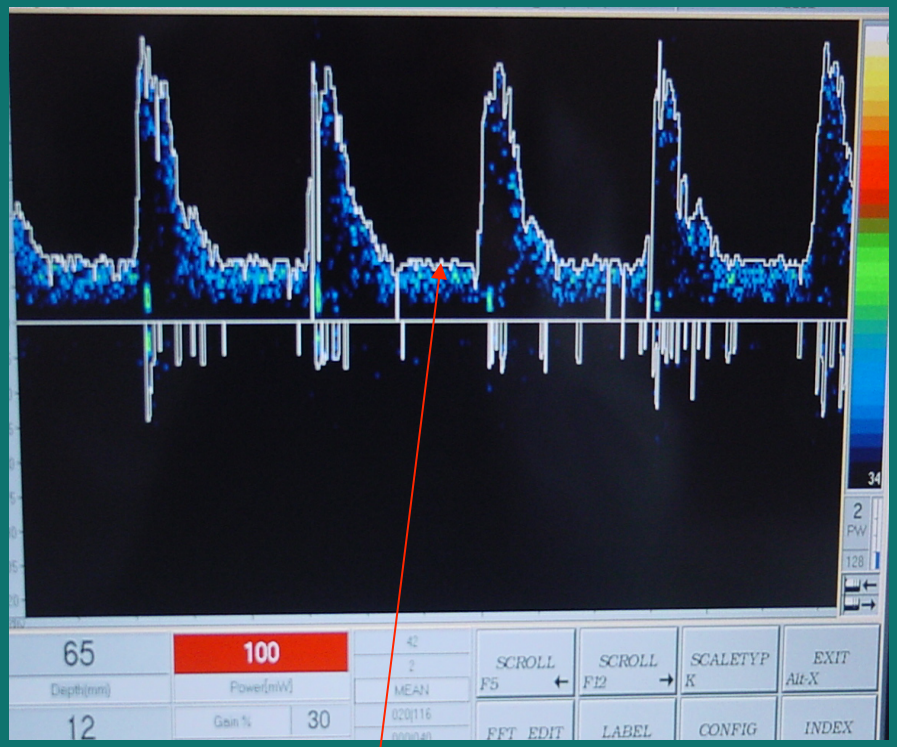
Consensus for the diagnosis of intracraneal hypertension and circulatory arrest using TCD



Journal of the Neurological Sciences 159 (1998) 145–150

TCD and intracranial pressure

MCA velocity=35cm/seg



Low velocities

PI > 1.2

Monitoring head trauma with TCD

- Low velocities:

(<35 cm/seg), High PI (>1.2) first 72 hrs

Acta Neurochir (Wien). 2002;144(11):1141.

- Vasospasm:

ACM (>120 cm/seg, Lind > 3)

J Neurosurg 1992;77:575-3

- Hyperhemia:

ACM (>120 cm/seg ACM, Lin < 3)

J Neurosurg. 2003;98(4):793-9.

- Lost of autoregulation:

(static o dynamic)

Acta Neurochir Suppl. 2002;81:117-9.

- Early ICH

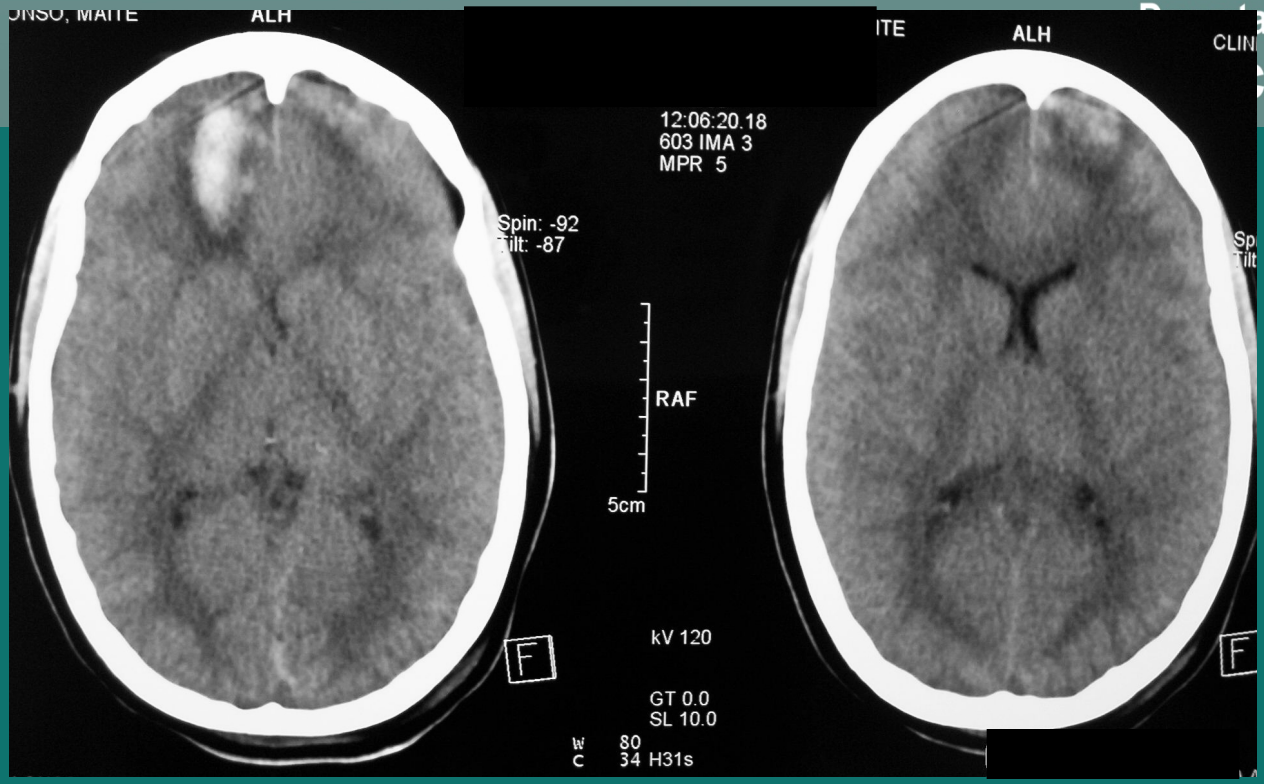
OR 3.2 for bad prognosis

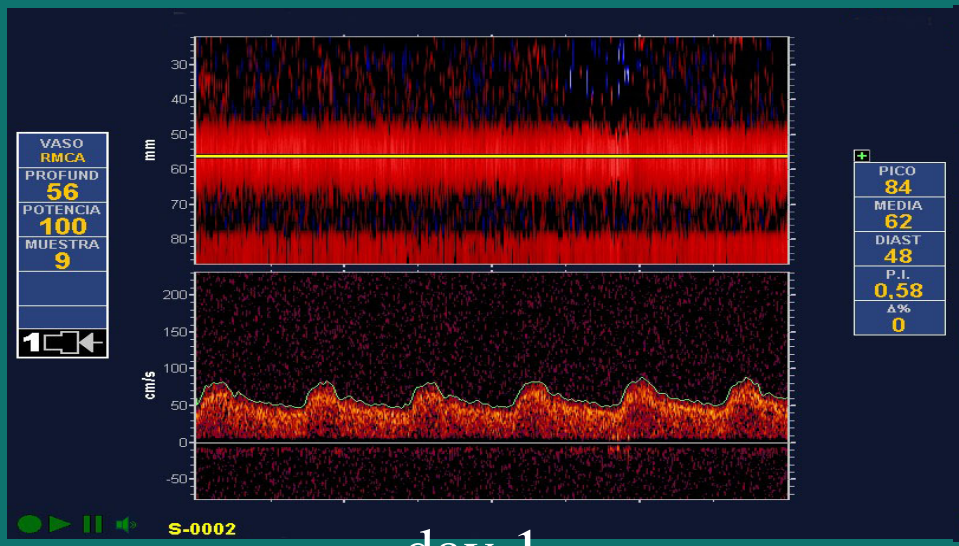
•Associated with traumatic SAH , 27-40% severe head trauma, risk of stroke and bad prognosis.

•Risk of brain edema.

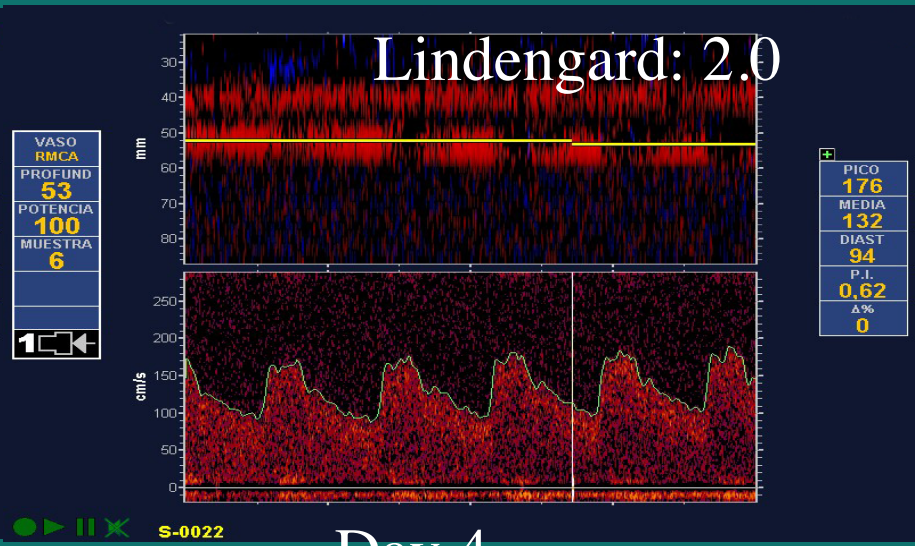
- PPC dependence,

Mortality of 47% vs 11%


ALH
12:06:20.18
603 IMA 3
MPR 5
Spin: -92
Tilt: -87
RAF
5cm
kV 120
GT 0.0
SL 10.0
W 80
C 34 H31s
ALH

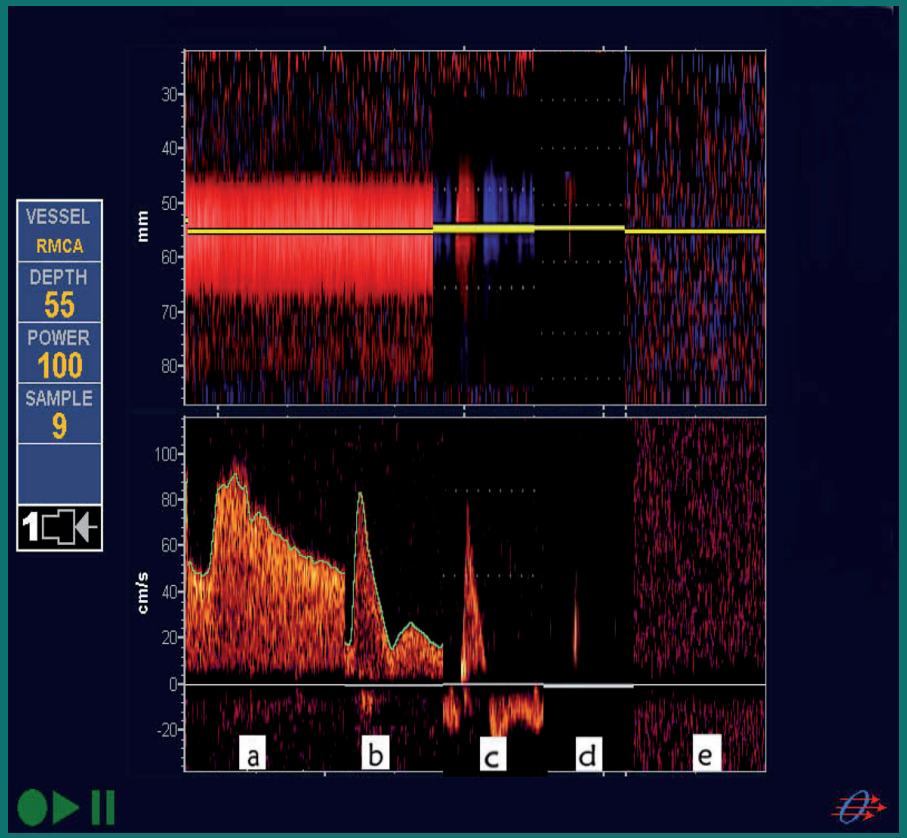

VASO
RMCA
PROFUND
56
POTENCIA
100
MUESTRA
9
mm
cm/s
PICO
84
MEDIA
62
DIAST
48
P.I.
0,58
Δ%
0
S-0002

day 1


Lindengard: 2.0
VASO
RMCA
PROFUND
53
POTENCIA
100
MUESTRA
6
mm
cm/s
PICO
176
MEDIA
132
DIAST
94
P.I.
0,62
Δ%
0
S-0022

Day 4

Accuracy of TCD in the diagnosis of brain dead



- Sensitivity: 100%
- Specificity: 98%
- PPV: 96.1
- NPV: 100

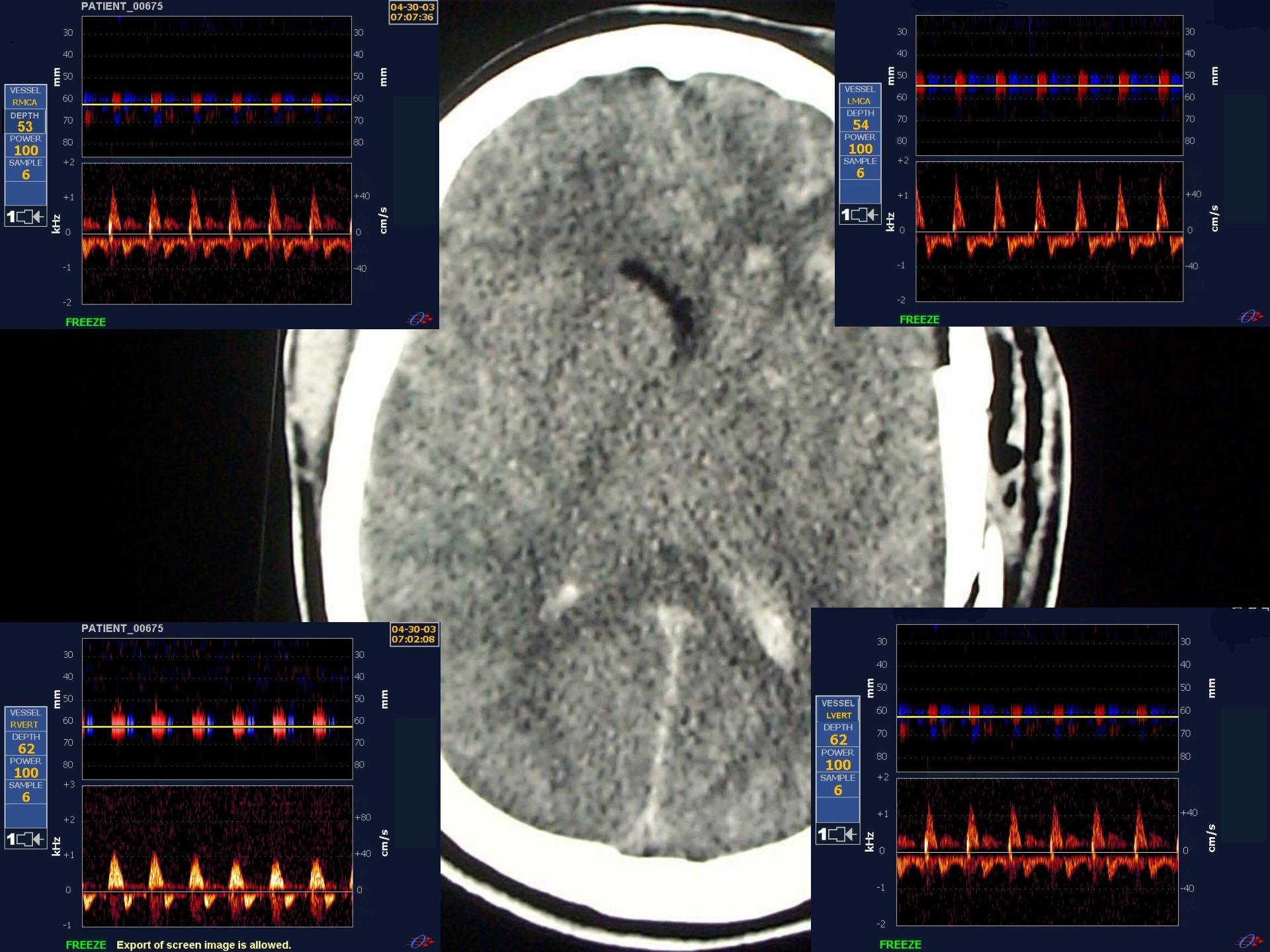
Brunser Rev Méd Chile 2010: 138:406-412

In comparison with EEG

Its not afected by drugs

Patient 33 years, Glasgow 3, intubated and sedated

¿What to do?

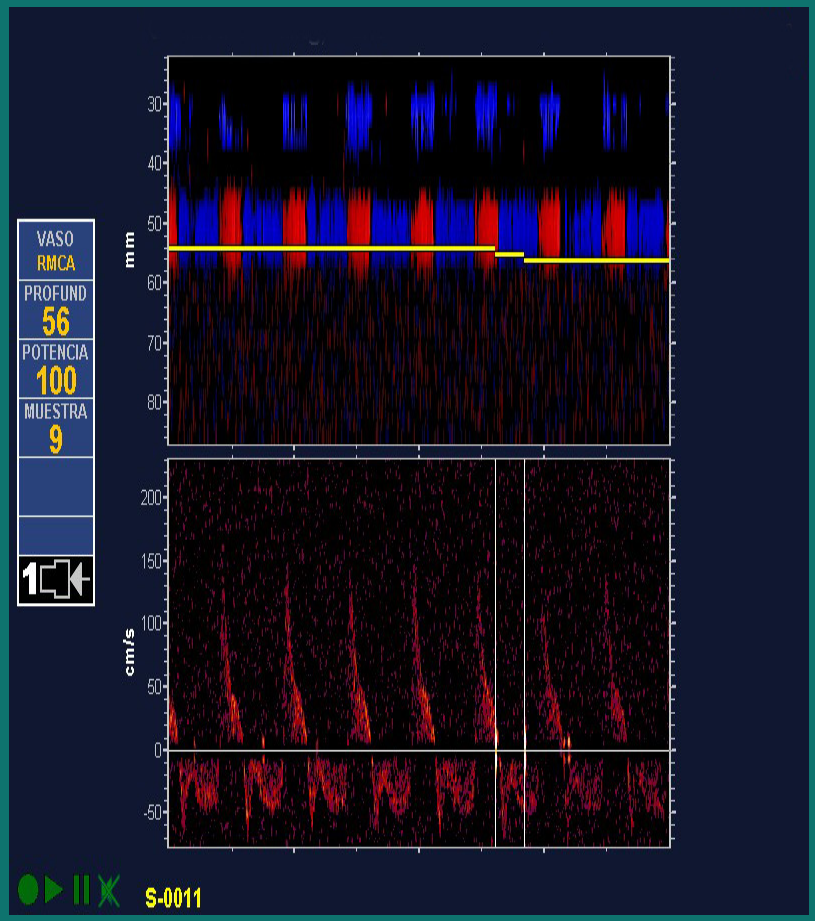

PATIENT_00675
04-30-03
07:07:36
VESSEL
RMCA
DEPTH
53
POWER
100
SAMPLE
6
mm
kHz
cm/s
FREEZE
PATIENT_00675
04-30-03
07:02:08
VESSEL
RVERT
DEPTH
62
POWER
100
SAMPLE
6
mm
kHz
cm/s
FREEZE
Export of screen image is allowed.
VESSEL
LMCA
DEPTH
54
POWER
100
SAMPLE
6
mm
kHz
cm/s
FREEZE
VESSEL
LVERT
DEPTH
62
POWER
100
SAMPLE
6
mm
kHz
cm/s
FREEZE

TCD and brain death

75 patients in coma

Pretest posibility: 40%

- P LHR: 45
- N LHR: 0

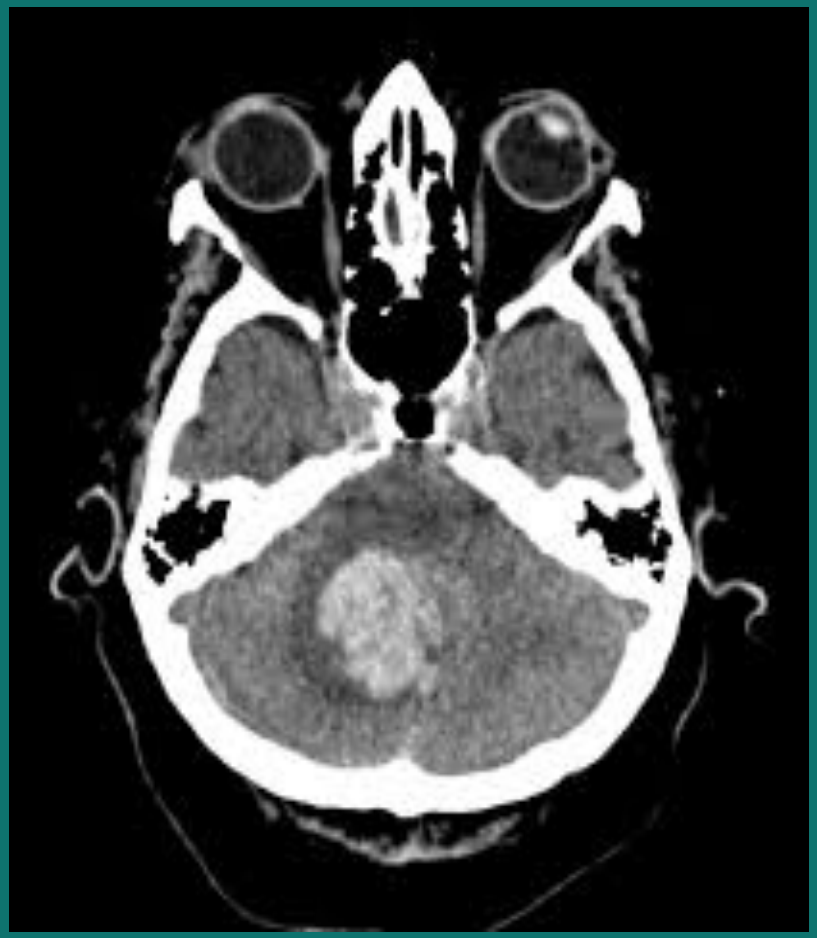


Brunser. JMC 2015:23; 29-33 .

Were are the false negatives?

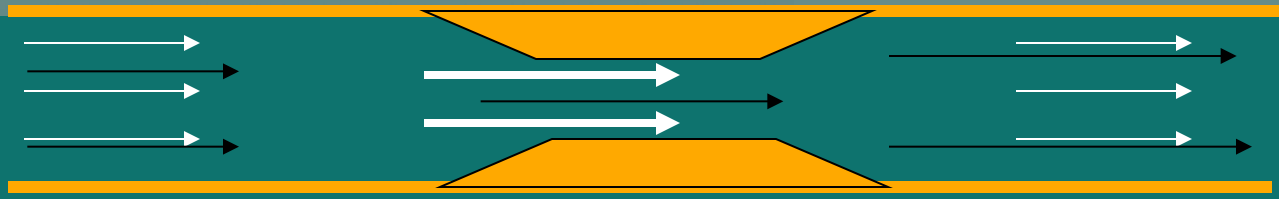
Patients with:

- Ventricular drains
- Skull defects
- Infratentorial lesions



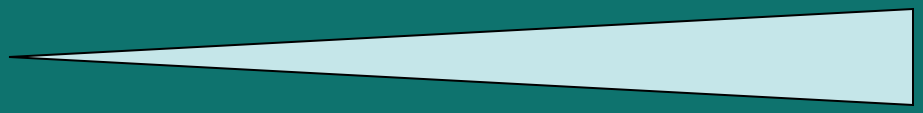
Brunser. JMC 2015;23: 29-33.
Thompson. Crit Care 2014;3:534-8

TCD and subarachnoidal hemorrhage



Flow

Velocity



Vessel

diameter

Acurracy of TCD and angiography for symptomatic vasospasm in anterior circulation .

TCD

Sensitivity: 73%

Angiography

Sensitivity: 80%

Suarez.Critical Care Medicine.2002;30:1348-1355.

Acurracy of TCD and angiography for symptomatic VSP in anterior circulation

TCD

Sensitivity: 73%

Angiography

Sensitivity: 80%

Suarez.Critical Care Medicine.2002;30:1348-1355.

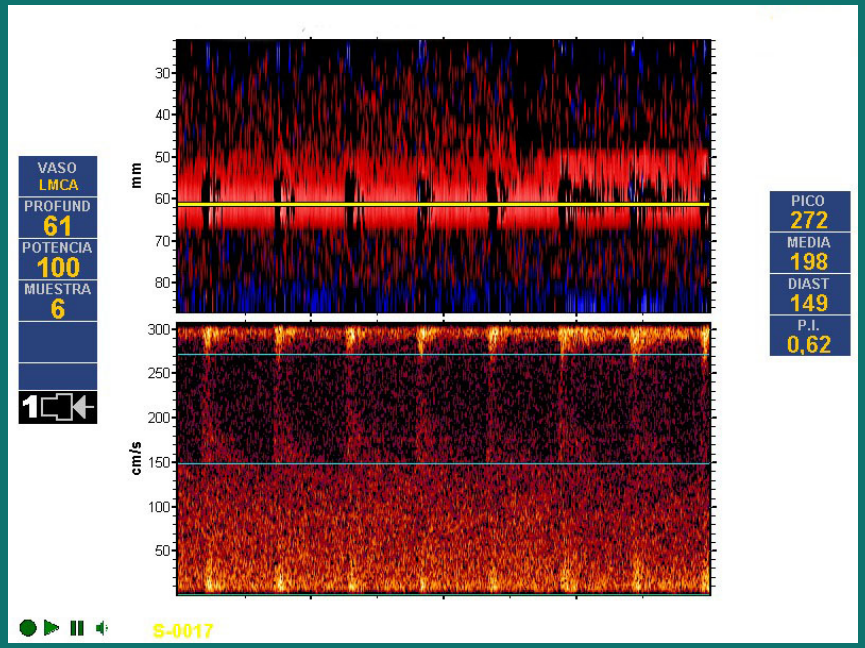
Diagnosis of vasospasm by TCD

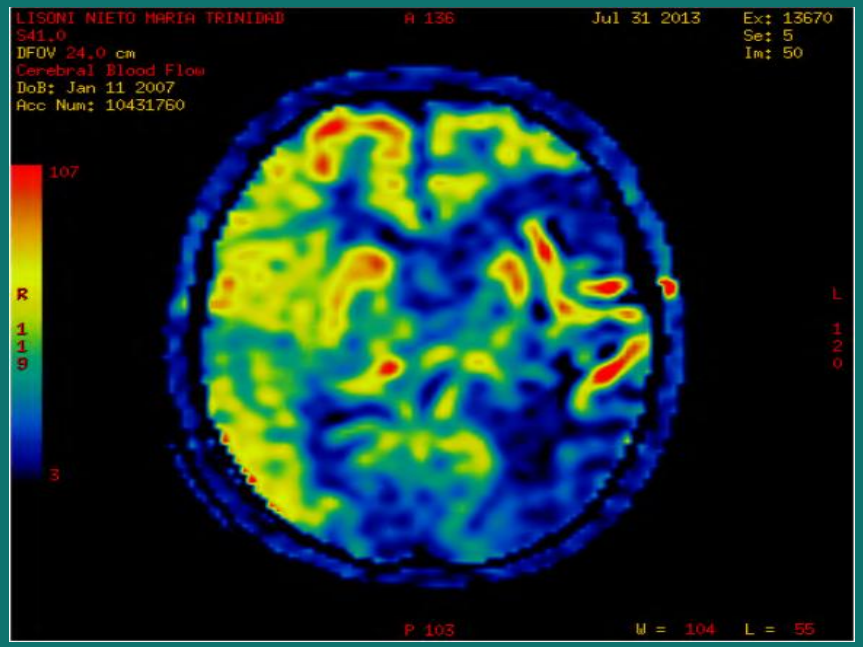
Vasoespasm	ACM/ICA	Velocity
Mild	3-6	100-140 cm/seg
Moderate	3-6	140-200 cm/seg
Severe	> 6	> 200 cm/seg

TCD velocities increase 24-48 horas before clinical deterioration.

Wardlaw. J Neurosurg.1998;88:272-276

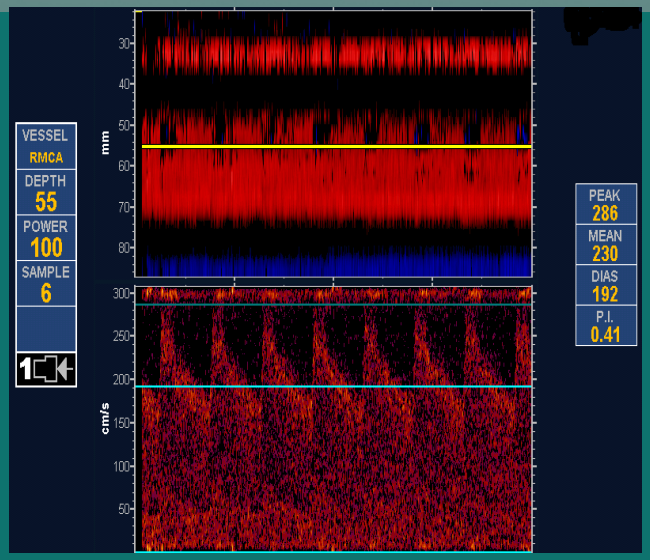
Asymptomatic patient on his day 7 of SAH

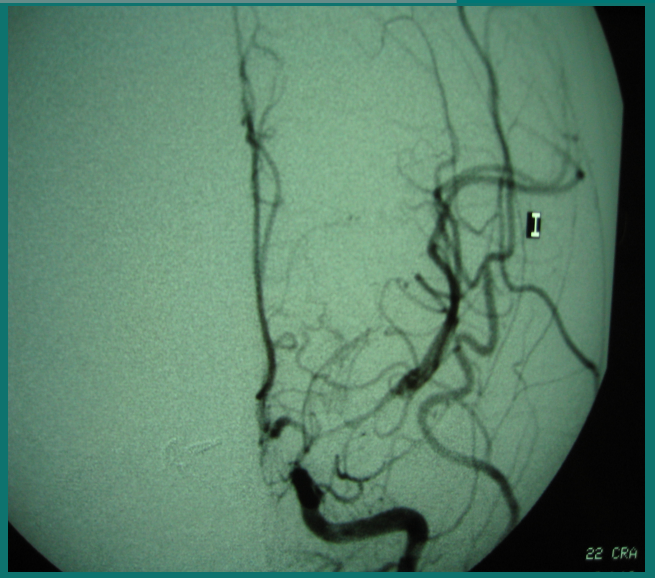


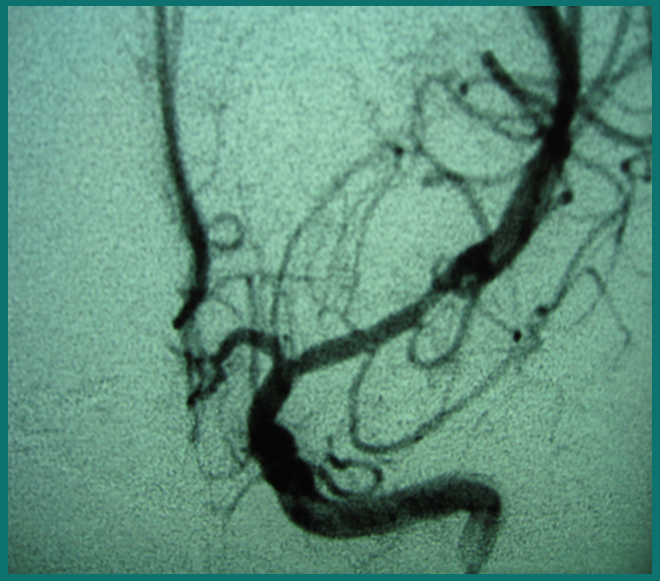


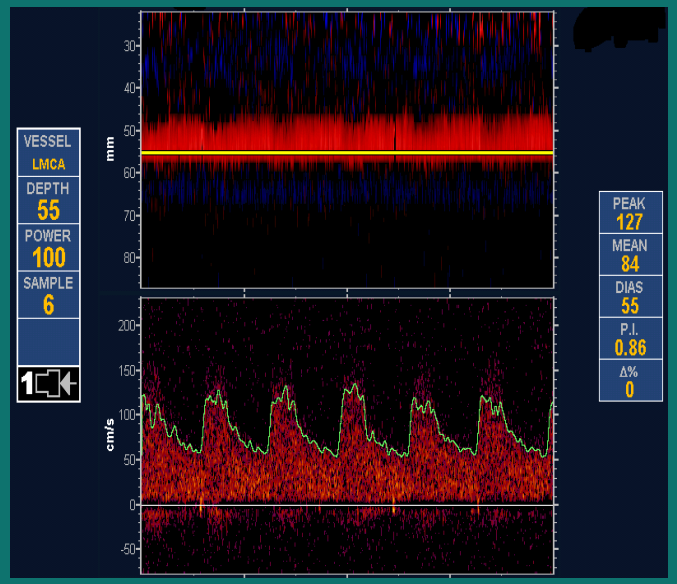
Lindengard: 7.8

TCD allows to control therapies in SAH



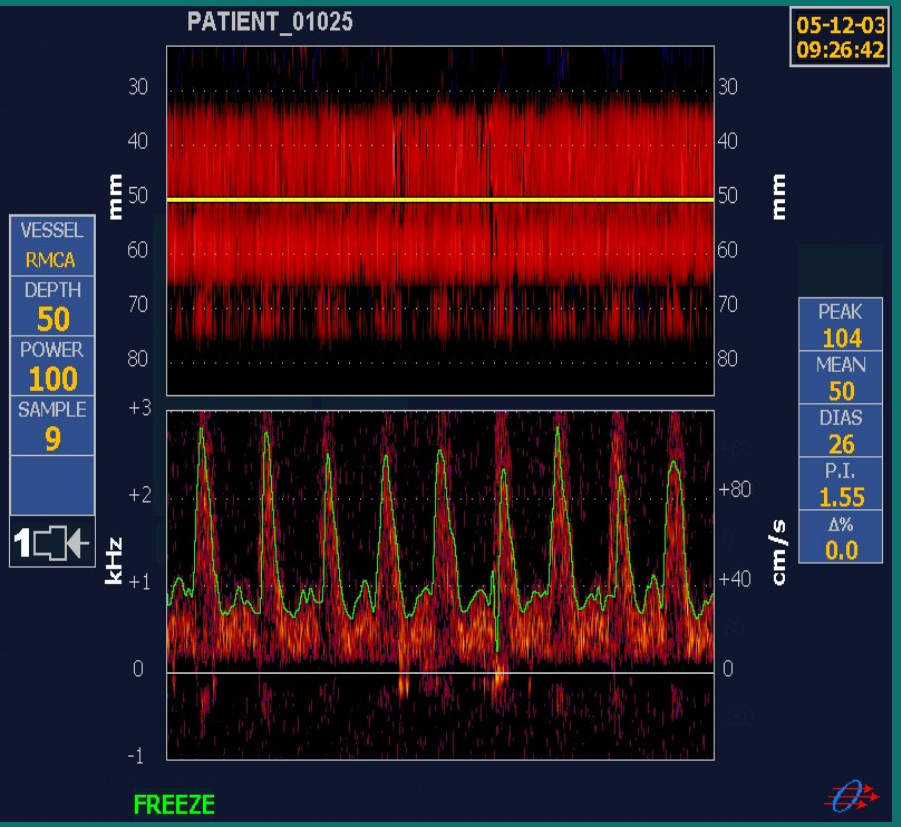


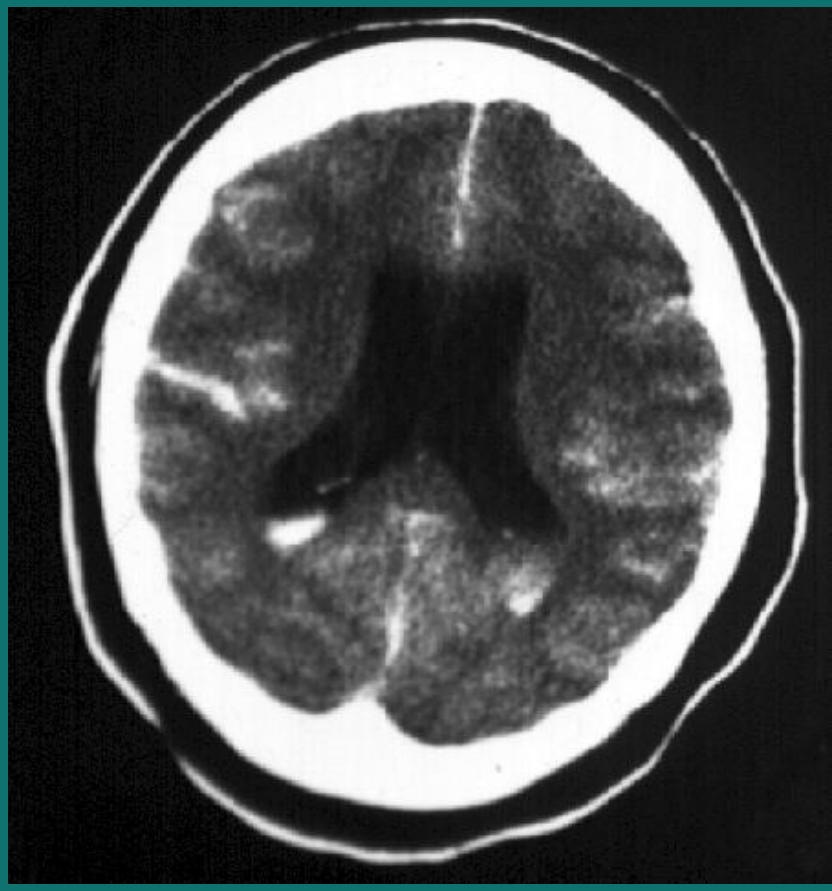




TCD allows to control therapies in SAH

Day 7 , patient with decrease of level of concious

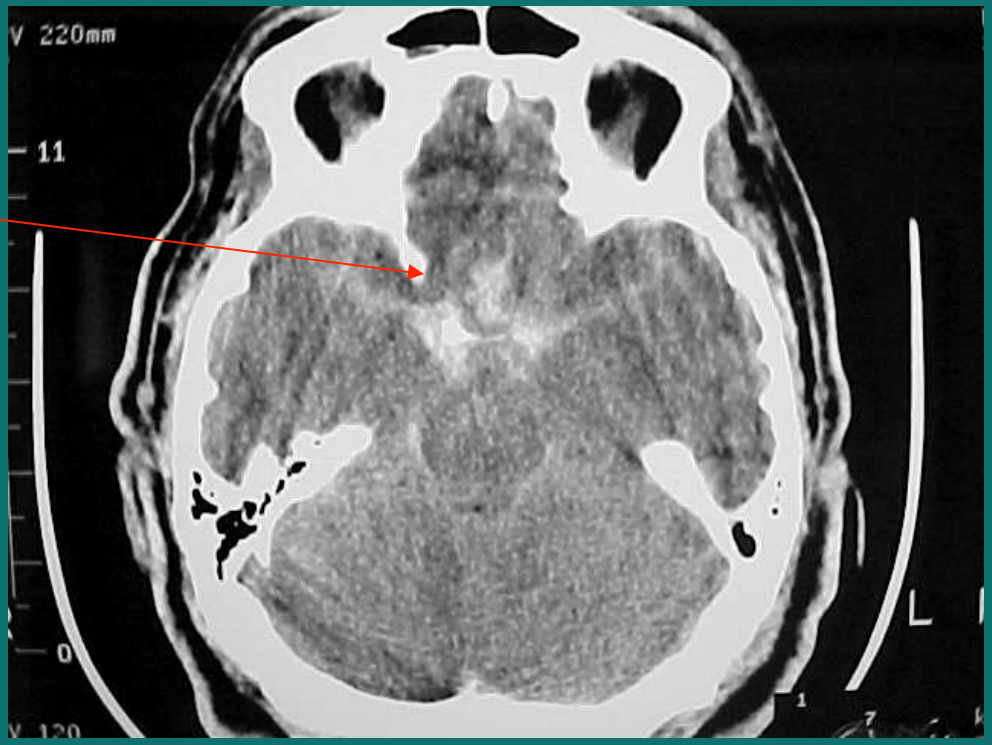


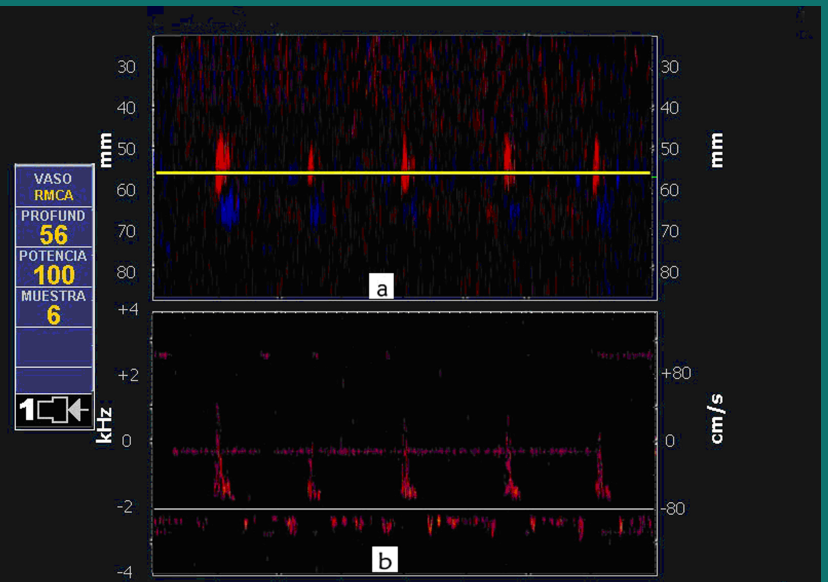


Treatment: external drain

From time to time

85 year woman, SAH
Glasgow 3





Acreditada por
Joint Commission International

TCD in SUC of Clínica Alemana

Clínica Alemana

Experience 2005- 2008

Evaluated:

97 pacients /241 examinations

Diagnosis:

- 26 ischemic strokes
- 21 SHA
- 11 head injury
- 9 ICH
- 5 circulatory arrest
- 24 other

TCD in SUC of Clínica Alemana

Questions to the intensivist:

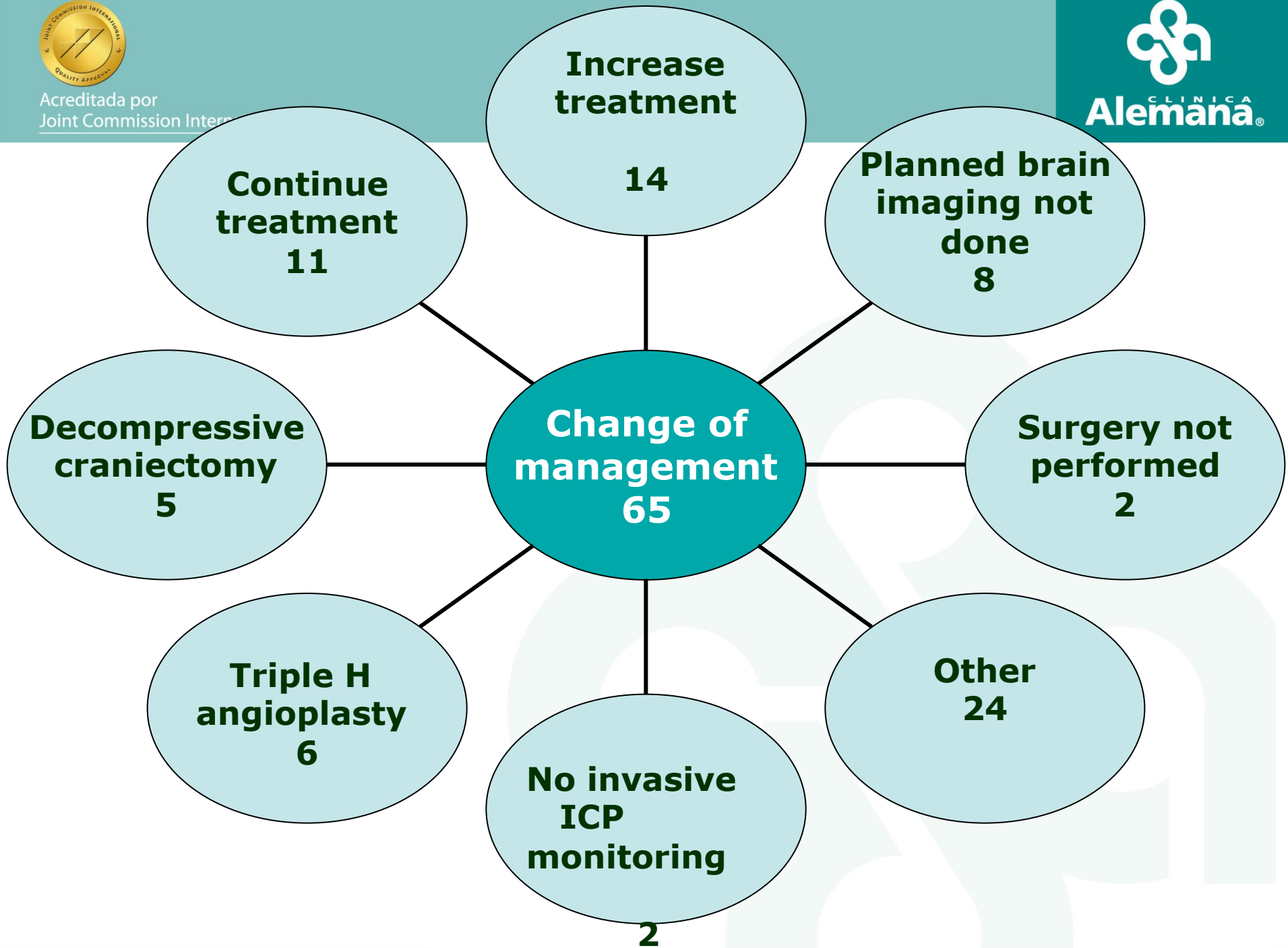
1- Did TCD provide you with usefull information?

2-Are you going to change your treatmen?

3-How?

TCD gives useful information

93/97 patients (96%)


Increase treatment
14
Continue treatment
11
Planned brain imaging not done
8
Decompressive craniectomy
5
Change of management
65
Surgery not performed
2
Triple H angioplasty
6
No invasive ICP monitoring
2
Other
24

Technical limitations

10% Patients with suboptimal windows

Table 4. Regression analysis for a non-ideal temporal window.*

Variable	OR† I.C. 95.0%
Mechanical ventilation	1.4 (0.73-2.822)
Sex	2.3 (1.51-3.45)
Age ≥ 80	N.A. ‡
Age 60-79	1.62 (1.04-2.54)
Age <60	13.87 (7.80-24.64)

*The dependent variable was a non-ideal window. †Odds ratio; ‡Not applicable

Brunser. San Diego.2002 (Texas University)
Brunser. Cape Town South Africa 2004
Brunser A. *Brain and Behavier*