TRANSCRANIAL DOPPLER ULTRASOUND

THIS IS A STAT EXAMINATION. PLEASE GENERATE A PRELIMINARY REPORT ON THE HOSPITAL PROGRESS RECORD & HAND TO THE SONOGRAPHER FOR PLACEMENT IN CHART. IF POSSIBLE PLEASE ALSO DICTATE A REPORT.

GENERAL CRITERIA FOR GRADING VASCULAR VELOCITIES

(1) MIDDLE CEREBRAL ARTERY VELOCITY & MCA/ICA RATIO

MEAN VEL	≥ 120 ,	MCA/ICA RATIO 3-4	POSSIBLE MILD	VASO-SPASM
"	≥ 120 ,	" >4-6	MODERATE	VASO-SPASM
"	≥ 180	" >6	MODERATE TO SEVERE	VASO-SPASM
"	≥ 200	" ≥	SEVERE	VASO-SPASM

ANY VELOCITY (EVEN ≥ 200) WITH MCA/ICA RATIO < 3 NO VASOSPASM

(2) CHANGE IN VELOCITY FROM LAST EXAM

(3) ACA

POSSIB	VASOSPASM	>90
PROB	VASOSPASM	>110
DEFINITE	VASOSPASM	>120

(4) BCA

POSSIB	VASOSPASM	>60
PROB	"	>80
DEFIN	"	>90

(5) BA

Table 4. Predictors of Adverse Outcomes in Patients with SAH: TCD Findings Indicating Vasospasm Progression and ICP Changes.

Parameter	Values
Velocity	Early appearance of MCA MFV ≥ 180 cm/sec
	rapid (> 20% or + >65 cm/sec) daily MFV raise during critial days 3-7
Ratio	MCA / ICA ratio ≥ 6
Pulsatility	Abrupt appearance of high resistance PI ≥ 1.2 Due to increased ICP (hydrocephalus)
	Appearance of PI ≥ 1.2 due to distal spasm

Data modified from references 14, 19 and Alexandrov AV (STAT Neurosonology Service Criteria).

Other intracranial arteries: see Table 5. Grading vasospasm severity in the arteries other than the MCA is difficult. Sloan (19) suggested reporting vasospasm as possible, probable, and definite. The key indicator of a significant vasospasm is a focal, asymmetrical and disproportionate velocity increase which may occur in an artery distant from the aneurysm site. The differential diagnosis includes hyperemia and its combination with vasospasm in these arteries.

Individual correlation of digital subtraction angiography with same day TCD findings may improve the accuracy of TCD to detect vasospasm onset. A focal and disproportionate to therapy increase in MFV's indicates the development of vasospasm. For example, an MCA MFV increase by +50 cm/sec may indicate 20% diameter reduction of the vessel, and since FV is inversely proportionate to the vessel radius, a 30% diameter reduction usually doubles the velocity on TCD (19-21). Therefore TCD is more sensitive to intracranial artery diameter changes than angiography. Since TCD is a screening tool, the criteria should be adjusted to a higher sensitivity to detect any degree of vasospasm in order to institute HHH therapy. At the same time, higher specificity threshold should be used for severe vasospasm to minimize the number of false-negative angiograms.

Table 5. Optimized Criteria for Grading Vasospasm in Intracranial Arteries.

Artery / MFV	Possible VSP*	Probable VSP*	Definite VSP*
ICA	> 80	>110	> 130
ACA	> 90	>110	> 120
PCA	> 60	> 80	> 90
BA	> 70	> 90	> 100
VA	> 60	> 80	> 90

* After hyperemia has been mostly ruled out by the focal velocity increase and by the Intracranial Artery / Extracranial ICA ratio ≥ 3 except for posterior circulation vessels. Optimized criteria were modified from Sloan MA, 1996 (19).

Arterial Vasospasm and Hyperemia

Arterial vasospasm (VSP) is a complication of subarachnoid hemorrhage (SAH), which becomes symptomatic in more than 25% of patients leading to the delayed ischemic deficit (DID) (19-21). DID usually occurs when VSP results in a severe (≤ 1 mm) intracranial arterial narrowing producing flow depletion with extremely high velocities (19-21). It may affect the proximal stem and distal branches of intracranial arteries. VSP may coexist with hydrocephalus, edema, and infarction. The differential diagnosis with TCD should always consider the hyperdynamic state to which we will refer to as ***hyperemia***. Hyperemia may be induced by spontaneous cardiovascular responses to SAH or induced by the hypertension-hemodilution-hypervolemia (HHH) therapy. Although inadequate, the term "hyperemia" is widely accepted in the literature describing velocity changes on TCD. The flow velocity measured by TCD is not a direct measurement of cerebral blood flow volume. However, focal or global velocity changes can help differentiate between spasm and hyperemia. Both conditions may coexist since most SAH patients with spasm routinely receive HHH therapy.

Although quantitative criteria have been studied extensively (14, 19), grading VSP severity is difficult, and the interpretation of TCD findings should be individualized. Daily TCD's may detect considerable velocity/pulsatility changes which should be related to the patient condition, medications, BP, time after onset, and ICP findings.

Proximal vasospasm in any intracranial artery results in a focal or diffuse elevation of mean flow velocities without parallel FV increase in the feeding extracranial arteries (intracranial / extracranial vessel ratio ≥ 3). **Distal vasospasm** in any intracranial artery may produce a focal pulsatile flow (PI ≥ 1.2) indicating increased resistance distal to the site of insonation. No MFV increase may be found. ***Additional findings*** may include daily changes in velocities, ratio's and PI's during the first two weeks but particularly pronounced during the critical days 3-7 after the onset of SAH.

MCA-specific criteria: see Table 3. The differential diagnosis includes hyperemia, combination of vasospasm and hyperemia in the same vessel, residual vasospasm and hyperemia. Prognostically unfavorable signs are summarized in Table 4 (14, 19).

Table 3. Criteria for grading M1 MCA vasospasm with or without hyperemia (14, 19-21).

Mean Flow Velocity	MCA/ICA MFV ratio	Interpretation
< 120	≤3	Hyperemia
> 80	3 – 4	Hyperemia + possible mild spasm
≥ 120	3 – 4	Mild spasm + hyperemia
≥ 120	4 – 5	Moderate spasm + hyperemia
> 120	5 – 6	Moderate spasm
≥ 180	6	Moderate-to-severe spasm
≥ 200	≥ 6	Severe spasm
> 200	4 – 6	Moderate spasm + hyperemia
> 200	3 – 4	Hyperemia + mild (often residual) spasm
> 200	< 3	Hyperemia