Detached retina vs. dense fibrovascular membrane

A-scan and B-scan signs for the differential diagnosis with

Standardized Echography

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1. INTRODUCTION

In eyes with opaque ocular media, especially in those with dense vitreous and subvitreal hemorrhages forming membraneous structures within the vitreous cavity the differentiation between a detached retina and a dense fibrovascular membrane often is a difficult challenge to the echographer. Yet the (early and reliable) diagnosis of retinal detachment in eyes with opaque media is of paramount importance, especially in eyes that have suffered severe trauma as well as in eyes with severe proliferative vitreoretinopathy, i.e., in eyes where timely vitrectomy and retinal re-attachment surgery often decide the outcome and are the only way for recovery of useful vision.

When real-time contact B-scan echography became popular in the 1970's, and more so, when B-scan resolution improved dramatically in the 1980's it was thought that B-scan would readily solve the challenge of correctly differentiating fibrovascular membranes from retinal detachments. Kinetic B-scan, in particular, was expected to help in this differentiating process simply on the basis that posterior vitreous detachments most closely resembling retinal detachments morphologically are, in contrast to retinal detachments, very mobile and show incomparably more extensive aftermovement than the typically limited, undulating aftermovement known from large rhegmatogenous retinal detachments.

However, this clear-cut kinetic difference holds true only for large surfaces separated widely from the fundus and not complicated by any fibrotic changes. But in cases with opaque ocular media (with the exception of plain cataracts), i.e., vitreous hemorrhages, such fibrotic changes occur rather regularly often rendering the kinetic B-scan information worthless. The denser a vitreous membrane is, the more sluggish becomes its aftermovement which then may not be detected by B-scan any longer. Conversely, detached retinas also become less mobile with progressing fibrotic changes so that both detached retinas and fibrovascular membranes become similar (if not immobile) as far as B-scan kinetic evaluation is concerned. In contrast, A-scan kinetic evaluation still shows typical aftermovement in retinal detachments regardless how severe the proliferative changes are.

The custom of calling a membraneous structure which is 360° continuous with surrounding attached retina or which inserts in a more or less funnel-shaped fashion into the optic disc (as evidenced by B-scan) automatically a "detached retina" and of calling a membraneous structure automatically a "membrane" when it seems to by-pass the optic disc on B-scan or when B-scan fails to easily demonstrate a 360° continuity of its signals with those from surrounding fundus is a wide-spread and popular simplification which leads to misdiagnoses and is therefore diagnostically unacceptable. Especially in eyes with severe proliferative vitreoretinal changes caused by diabetes or trauma vitreous membranes easily mimic detached retina. At times retinal detachments cannot be recognized as such as they mimic membranes. When considering all types of retinal detachments and vitreous fibrovascular membrane formations the B-scan effectiveness in differentiating between the two does not look good. 36% of retinal detachments in this study were not positively diagnosed by the combined effort of using all four B-scan criteria (see Table 3A). Almost as often false-positive diagnoses of retinal detachment resulted from such illicit simplification as has been shown in our study even if sophisticated B-scan techniques are applied. One can imagine what happens when overly simplified B-scan techniques (e.g., "free-style" B-scanning applied through closed lids) are applied. In contrast, Standardized Echography (using combined standardized A-scan and B-scan instrumentation and techniques) allows more than 99% of the cases to be reliably and clearly differentiated using a number of A-scan and B-scan criteria to arrive at a "hard" differential diagnosis (see Table 3B).

Since the 1960's, specific A-scan and B-scan criteria for retinal detachment vs. dense fibrovascular membranes were incorporated into Standardized Echography. Since about 1980 a fixed set of 4 A-scan and 4 B-scan criteria was successfully used by us to achieve a differential diagnosis between retinal detachments and vitreous membranes (or other strongly reflecting surfaces mimicking retinal detachments such as the surfaces of posterior hyphemas or of pools of Fluorocarbon liquids) close to a 100% sensitivity and specificity [1,2]. In an 18-month period between January 1987 and June 1988 we performed a study to test each of these echographic criteria for their sensitivity, specificity, and positive as well as negative predictive values, and graded them according to their availability and to the ease as well as quickness of their application.

2. A-SCAN AND B-SCAN CRITERIA

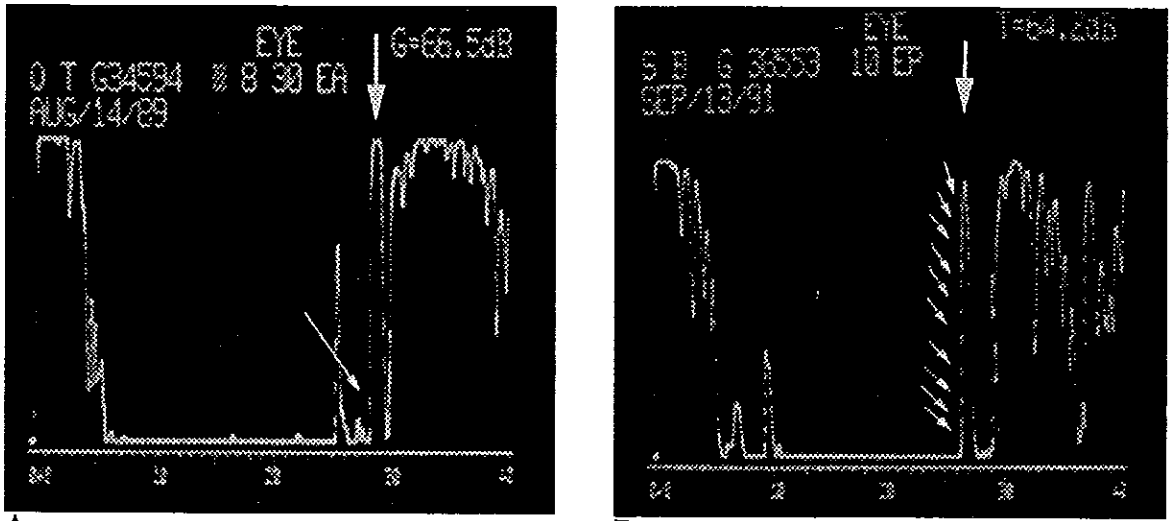
Four A-scan and four B-scan criteria are useful in the diagnosis of retinal detachment and its differentiation from simulating surfaces such as the surfaces of fibrovascultar membranes, of posterior vitreous detachment enhanced by hemorrhage, of posterior hyphemas etc.

A_1 (Figure 1): this A-scan sign is positive for retinal detachment when the maximized surface spike is 100% high at Tissue Sensitivity of the instrument showing a sharply rising left limb with very few (usually less than 3) high-frequency nodules between base and peak ("Quantitative Echography I" [3]).

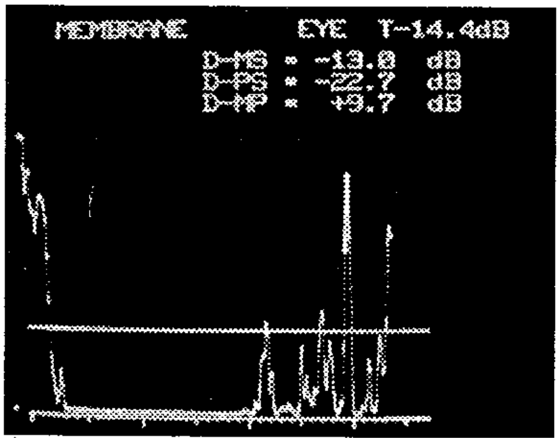
The A_1 sign is positive for retinal detachment, when the spike height is 100% of the display height and the left limb is extremely smooth (fewer than 3 high-frequency nodules between base and peak). It is negative for retinal detachment, when the left limb shows more than 4 high-frequency nodules or the height is less than 97% (when maximized!). This sign is equivocal, when 3 high-frequency nodules are seen along the left limb or the spike height is about 99%. It is also considered equivocal, when a typical retinal signal can only be obtained in one single beam direction although the surface is very large.

In order to be able to use this highly sensitive and specific sign the A-scan instrument must be standardized. To date, the **B-scan S**, the **Mini A-scan**, the **Ophthascan S**, the **Sonokretz**, and the **Kretztechnik 7200 MA** are the only instruments offering standardized A-scan; no other instrument can be used for this differentiation.

Fig. 1. A. Positive A_1 sign (retinal detachment-large arrow). *B.* negative A_1 sign (membrane-large arrow). Small arrows point out high-frequency nodules on left limb of retinal and membrane spikes.

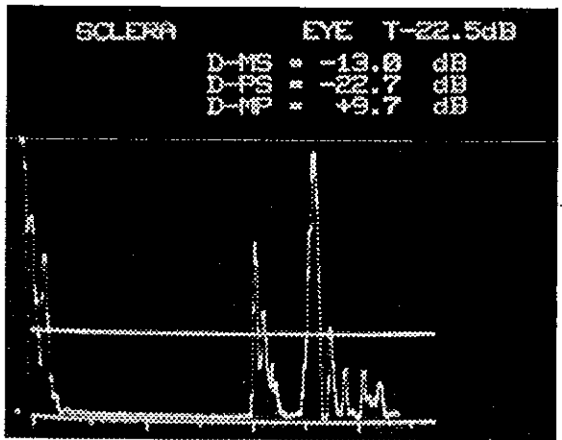


A B

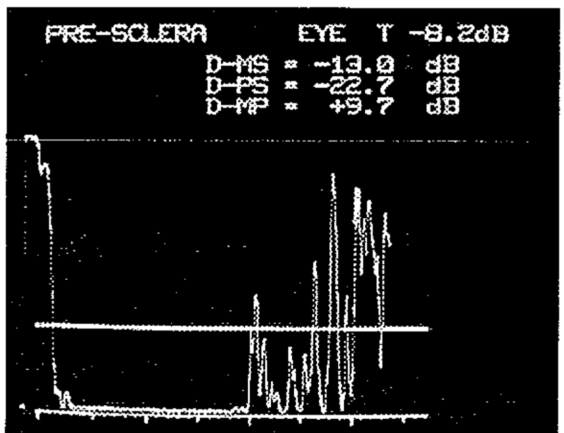


A

Fig.2. Maximal Signals from detached retina (*A*), sclera (*B*), and "presclera" (*C*) as memorized by the instrument (B-scan S - BVI) are highlighted by electronic gates. The difference in decibels between the maximal signals from "membrane" (detached retina in this case) and sclera (D-MS = -13.0 dB), between "presclera" and sclera (D-PS = -22.7 dB), and between "membrane" and "presclera" (D-MP = +9.7 dB) are displayed: **Positive A_4.**



B



C

A_2: this A-scan sign is positive for retinal detachment when the surface spike remains high (at least 95% display height) or becomes that high when the beam is shifted anteriorly toward the ora serrata. This phenomenon was first described by Freyler [4]. Again, a standardized A-scan instrument is required for a useful application of this sign (see above).

A_3: this A-scan sign is positive for retinal detachment when the surface spike shows minimal, trembling, vertical, brief aftermovement following each of the minimal inadvertant corrective movements of the patient's eye while fixating a stable target [5]. This sign is better appreciated when using low "Measuring Sensitivity" of a Standardized A-scan instrument.

A_4 (Figure 2): this A-scan sign results from a quantitative measurement of the reflectivity of the surface in question ("Quantitative Echography II" [3,6]). During this evaluation, the maximal signal from the surface is displayed and compared with the maximal signal from the sclera of the same eye being used as reference [7]. A difference between the maximal surface and scleral signals of 15 db or less indicates retinal detachment whereas a difference of 17 db and above proves membrane. A difference of 16 db is borderline and can still be resolved by including the maximal signal from the prescleral surface. In the case of retinal detachment, this surface is pigment epithelium and reflects less strongly than when the retina is attached and the prescleral surface is retinal surface. A difference of 12 db or less between the maximal scleral and prescleral surfaces indicates attached retina while a difference of 14 db or more is consistent with retinal detachment.

This acoustic criterion too requires the use of a Standardized A-scan instrument to be reliable and useful (see above). The latest model of a Standardized A-scan instrument, i.e., the *B-scan S* (BVI), acting like a Maximum (-minimum) Thermometer and memorizing the maximal signals regardless of the instrument sensitivity used has made this Quantitative Echography II incomparably less time-consuming and much easier to perform than previous instruments (as had been used for this study).

B_1(Figure 3): this B-scan sign represents shapes of surface signals that are specific for retinal detachment and not produced by fibrovascular membranes or other surfaces that may mimic retinal detachment. The most commonly seen typical shape is an "angled" surface line representing detached retina which is subjected to traction. Figure 3A illustrates such angling (arrows) in a total funnel-shaped retinal detachment ("triangular" detachment; Fuller [8]) and Figure 3B shows it in localized, tent-like tractional detachments.

Another typical shape is caused by cyst formation which too is specific for retina. In order to safely differentiate a retinal cyst from a large retinal fold, the cyst pattern must be shown in two echographic planes that are perpendicular to each other and thus reveal the 3-dimensional character of a cyst and dispel the possibility that a 2-dimensional fold is the cause for the pattern. Figures 3C and 3D show a tranverse and a longitudinal section from such a retinal cyst proving its 3-dimensional character.

B_2: this B-scan sign is caused by smooth "macro-folds" of a large surface. Only those portions of the surface reached by an approximately perpendicular sound beam produce echoes while those portions reached by an oblique beam reflect all the energy away from the probe and thus remain "anechoic" (mirror-like reflection on large smooth interface). This results in an interrupted echo line. The individual short echo lines originate only at the tiny point-like portions of the smooth surface, which are reached by a perpendicular beam. These lines are longer or shorter depending on the echo intensity. Moreover, these lines are oriented perpendicular to the direction of the sound beam and not according to the course of the large surface (Figure 3A, small arrows).

Fig. 3 Total funnel-shaped retinal detachment (*A*) and tractional retinal detachments (*B*) showing phenomenon of "angling" (large arrows). Smooth macrofolds are also present (small arrows). Transverse (C) and longitudinal (D) scans of retinal cyst (arrows point at signals from posterior cyst wall).

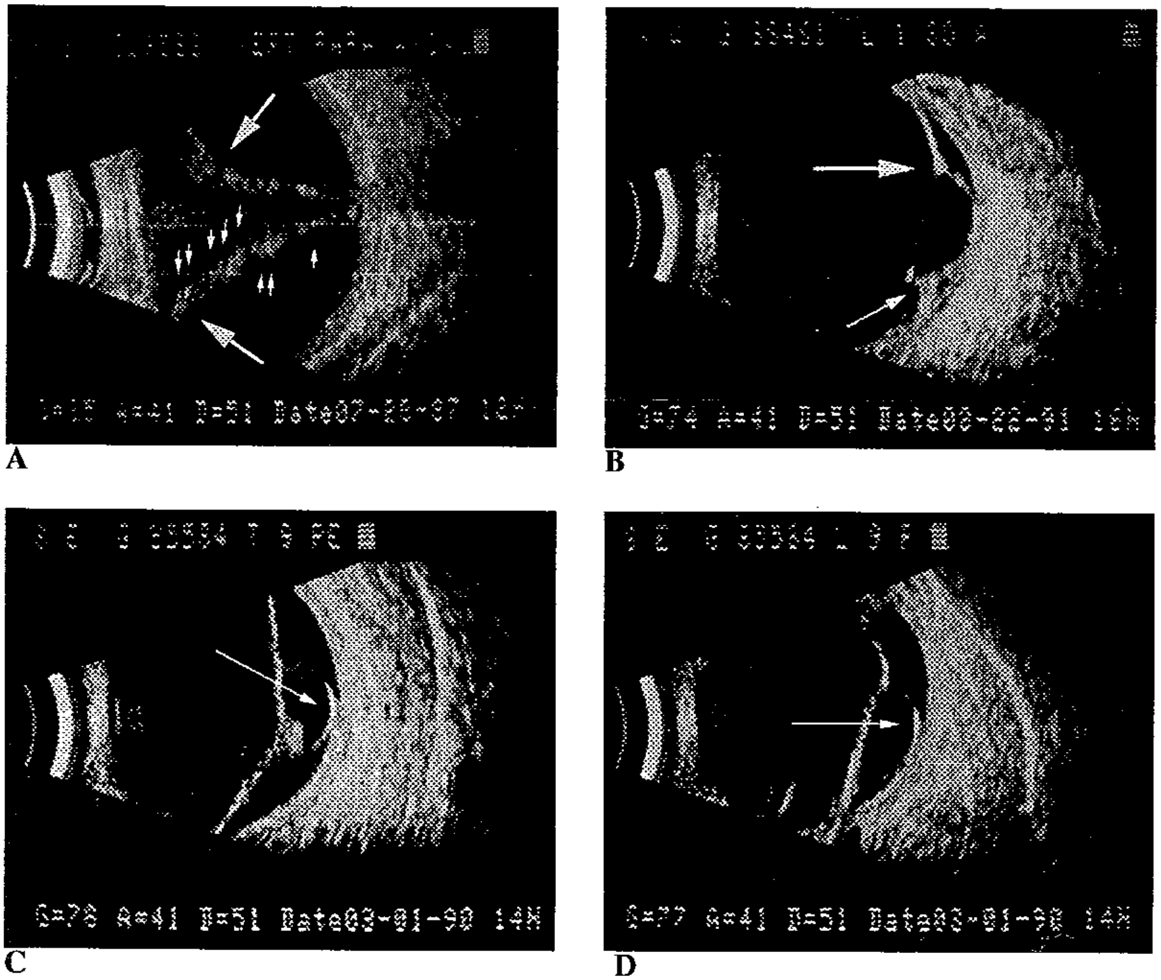
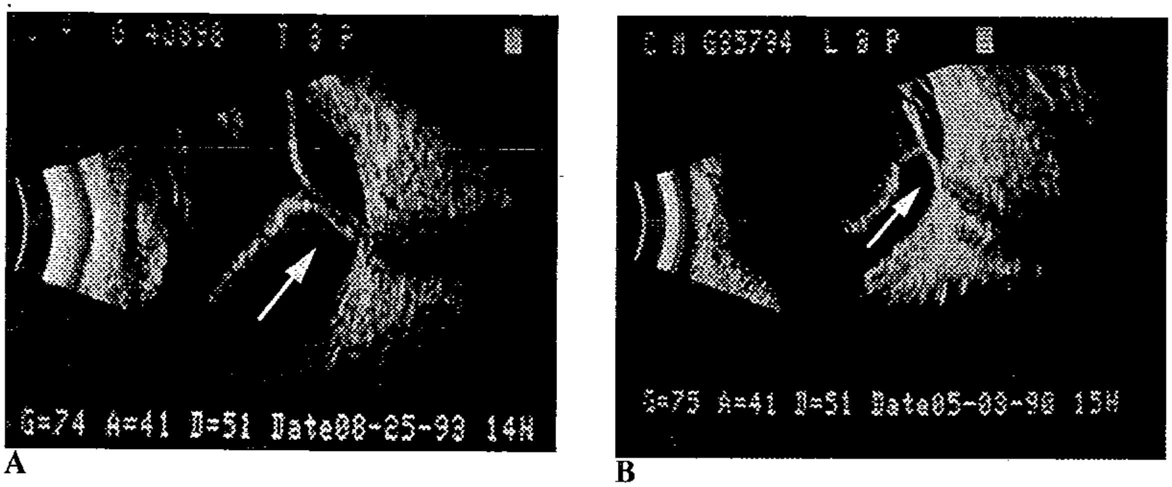


Fig. 4 *A:* total funnel-shaped retinal detachment showing separate insertion (arrow) of the two retinal leaves into the disc [positive B_3]. *B:* funnel-shaped fibrovascular vitreous membrane inserting into disc with common stalk (arrow) of the two membrane leaves [negative B_3].



B_3 (Figure 4): this B-scan sign is positive for retinal detachment when a funnel-shaped surface structure inserts into the optic disc with clear separation of its two leaves in the B-scan section. One often has to search for an optimal scanning approach to clearly displaythe B_3 sign. In Figure 4A this was achieved through a longitudinal scan of the optic disc area.

A retinal detachment is unlikely when the two leaves of the funnel-shaped surface structure are seen to insert into the disc with one common stalk (Figure 4B). Only a clear-cut separation or a distinct common stalk of the two leaves at their optic disc insertion allow a useful application of the B_3 sign. Often the insertion of a detached retina or a funnel-shaped membrane show neither clear-cut type of insertion into the disc and thus offer no unequivocal B_3 sign that would be useful for the differential diagnosis.

B_4: this sign may be applicable in partial retinal detachments. When the echo line obtained from the detached portion can be followed clearly into the attached area and thus both the detached and attached portions of the echo line are clearly continuous the B_4 sign is positive for retinal detachment. While inserting membranes usually do not show this sign, a partially detached vitreous with its posterior surface being enhanced by hemorrhage may simulate retina in this regard. However, such non-membraneous posterior vitreous surface behaves very differently from detached retina in quantitative and kinetic terms. Also, the direction in which the fusion occurs in large surfaces is clearly opposite in detached retina vs. vitreous: the attached portion is seen only peripherally in detached vitreous whereas it is located either both peripherally and posteriorly or only posteriorly (when the retina is detached to the ora).Since the posterior surface of a detached vitreous (even if it is acoustically enhanced by dense vitreous hemorrhage) reflects clearly less than a detached retina the B_4 sign should be recruited as additional help for the diagnosis of detached retina only after a positive A_1 sign has been established first.

3. THE STUDY

In a clinical study we tested the usefulness of the four A-scan and four B-scan criteria by determining their availability, (general and particular) sensitivity, (general and particular) specificity, and their (general and particular) positive as well as negative predictive values. We also determined the ease (vs. difficulty) of applying each of the acoustic criteria, and the time required for their application (qickness vs. slowness of procedure).

The study originally involved all patients seen consecutively in our Echography Service between January of 1987 and June of 1988 because of densely opaque ocular media. All those patients who had only a plain cataract with or without a rhegmatogenous retinal detachment, or only a simple vitreous or subvitreal hemorrhage without proliferative complications were excluded from the study. Further more, all those patients were excluded from the study, in whom a verification of the real status of the retina could not be obtained within 10 days of the echographic examination. After the exclusion of these cases the study included a total of 61 eyes in 58 patients (55% males, 45% females). All of these eyes had densely opaque ocular media and strongly reflective "membraneous" structures within the vitreous cavity (most of them as a consequence of severe proliferative diabetic retinopathy or severe ocular trauma).

In all but two of the eyes verification of the echographic diagnosis was obtained through a vitrectomy. In one case a vitreous hemorrhage cleared enough in time to allow ophthalmoscopic verification. In another case histologic verification was obtained following enucleation. In 48 (79%) of the eyes included in the study the "membraneous structure" which had been evaluated with the acoustic criteria for retinal detachment, was confirmed to be detached retina. Conversely, fibrovascular membranes were confirmed in the remaining eyes.

Availability of an acoustic criterion is the percentage of all eyes studied, in which a particular criterion could be applied whether the result was unequivocal for the diagnosis of retinal detachment and its differentiation from a dense fibro-vascular membrane, or not. If the availabity, for instance, was 98%, the criterion was available in all but one of the 61 cases.

The A-scan and B-scan criteria basically fall into two categories. Category 1 includes those criteria (i.e., A_1, B_1, and B_2),.which by nature are always available, though not always diagnostic. The maximal height of a surface spike at Tissue Sensitivity and the smoothness of its left ascending limb (A_1), for instance, can always be evaluated. Typical shapes (B_1) such as angling of an echo line and cyst patterns may or may not be present but can always be looked for, in a B-scan. These typical shapes may also be present but equivocal and misleading. The same holds true for smooth macrofolds (B_2).
Category 2 includes those criteria (i.e., A_2, A_3, A_4, B_3, and B_4) which if available may be either positive, negative or equivocal. On the other hand these criteria may not be available for reasons extrinsic to the study. They then are useless for the diagnosis but at least cannot be misleading as the equivocal criteria are. A_2, for instance, is only available to begin with if a large surface extends to the ora (or vitreous base). It cannot be used when the large surface is limited to a more posterior fundus area. The A_3 sign may be impossible to evaluate in a patient who continuously moves the eyes as subtle those movements may be. An A_4 sign may not be available if an eye is extremely soft for lack of standard scleral signals. The B_3 sign may be out of order because the surface structure is neither funnel-shaped nor inserting into the disc. The B_4 sign finally cannot be included when a retinal detachment or simulating surface structure is total. In all these instances, these particular criteria cannot be used but also cannot mislead the diagnostician. For this reason particular (not only general) sensitivities etc..were determined for the category 2 criteria (see below).

Sensitivity of a criterion indicates how reliable it is in detecting retinal detachment. It is the probability or percentage of true positives. This is the rate that a true detached retina will be identified as such. Any misinterpretation in this regard is a false-negative diagnosis. If, for instance, the sensitivity of the A_1 criterion in the study was 98%, then it was positive in all cases of retinal detachment but one.

Specificity of a criterion is the probability (or percentage) of true negatives. This is the rate that a normal (not detached) retina will be identified. Any misinterpretation in this regard is a false-positive diagnosis. If, for intance, the specificity of the A_1 criterion in the study was 100%, then it was not positive for retinal detachment when there was no retinal detachment. It never indicated detached retina when the retina was attached.

There are two ways to look at the sensitivity and specificity of an acoustic criterion for the diagnosis of a retinal detachment vs. a dense fibrovascular membrane. In a general sense, the sensitivity is the percentage of correct calls in the total group of retinal detachments (i.e., 48 cases in the study). Any such diagnosis not indicated by the criterion is a false-negative regardless of whether the criterion was negative for retinal detachment or was not even available for use. In this report such a sensitivity is called "general" sensitivity. In the same way, the specificity is called general, when all the true negatives are counted against the criterion being negative for retinal detachment regardless of whether the criterion was indeed negative or was not even used for the diagnosis because it was not available. This general consideration of a criterion's sensitivity and specificity is important to evaluate the value of the criterion in the differential diagnosis of retinal detachment vs. dense fibrovascular membrane.

For the clinician in clinical practice this general sensitivity and specificity of a criterion, however, are much less important than what - in a narrower definition - is called "particular" sensitivity and "particular" specificity: it is the percentage of correctly diagnosed true positives and true negatives, respectively among those cases for which the criterion was available. If, for instance, the A_3 sign was available only in 92% of all 48 cases of true retinal detachment but correctly indicated retinal detachment in all these cases, the particular sensitivity of the A_3 sign is 100% whereas its general sensitivity is only 92%. For the clinician, however, it is important to knowthat this criterion is available in 92 % of all cases and that it is 100% reliable in detecting retinal detachment in the cases where it is available.

Positive Predictive Value of a criterion is the probability (or percentage) that a positive outcome of the test will actually be a detached retina.

Negative Predictive Value of a criterion is the probability (or percentage) that a negative outcome of the test will actually be an attached retina.

To both the positive and negative predictive values the the definitions of a general and a particular kind were appliedas outlined for the sensitivity and specificity above. Again, the particular values are more interesting to the echographer than the general ones since the echographer does know when a test cannot be applied and therefore a conclusion is not possible. On the other hand the echographer needs to know how reliable a criterion is once it is available.

Ease: Another important factor in choosing and weighing various criteria for the differentiation between detached retina and dense fibrovascular membranes are the skill and effort thee echographer needs to apply to get a useful result. Usually the easier and faster techniques are applied first and the more difficult procedures are left for later if needed. For the evaluation in this study, the easier techniques were given a ++ and the more difficult tests were rated as **--**.

Time: Similarly, the value of a criterion was also judged by the length of time needed to get a useful result. Again the speediest procedures were rated with a ++, wheras the more time-consuming evaluations were given a **--**.

4. THE RESULTS

The results of the study are presented in Tables 1-3. Table 1A tabulates the percentages of the availability of each of the eight acoustic criteria (both for the entire group of patients [bold numbers] and for the 48 eyes with subsequently proven retinal detachment [numbers in parenthesis]). The particular sensitivities and specificities as well as positive and negative predictive values are highlighted to stress their greater importance for the clinician. The general and particular indicators are illustrated side by side in the bar charts (Tables 1B-E).

Table 1A

Results of the four A-scan and four B-scan criteria used in the diagnosis of **Retinal Detachment** and its differentiation from dense **Fibrovascular Vitreous Membranes** according to their Availability (**AV**), General Sensitivity (**S_G**), Particular Sensitivity (**S_P**), General Specificity **SP_G**), Particular Specificity (**SP_P**), General Positive Predictive Value (**$+Pred_G$**), Particular Positive Predictive Value (**$+Pred_P$**), General Negative Predictive Value (**$-Pred_G$**), Particular Negative Predictive Value (**$-Pred_P$**), Ease vs. Difficulty of application (**Ease**), and Quickness vs. Slowness of procedure (**Time**):

% of	AV(av)	S_G	S_P	SP_G	SP_P	$+Pred_G$	$+Pred_P$	$-Pred_G$	$-Pred_P$	Ease	Time
A_1	100 (100)	98	98	100	100	100	100	93	93	++	++
A_2	69 (67)	67	100	62	89	86	97	33	100	+	+
A_3	92 (92)	92	100	92	100	98	100	75	100	±	++
A_4	77 (71)	65	91	92	92	97	97	41	80	--	--
B_1	100 (100)	44	44	85	85	91	91	29	29	+	++
B_2	100 (100)	75	75	38	38	82	82	29	29	±	++
B_3	44 (42)	25	60	31	67	57	86	10	33	-	±
B_4	57 (60)	40	66	15	33	63	83	6	17	-	-

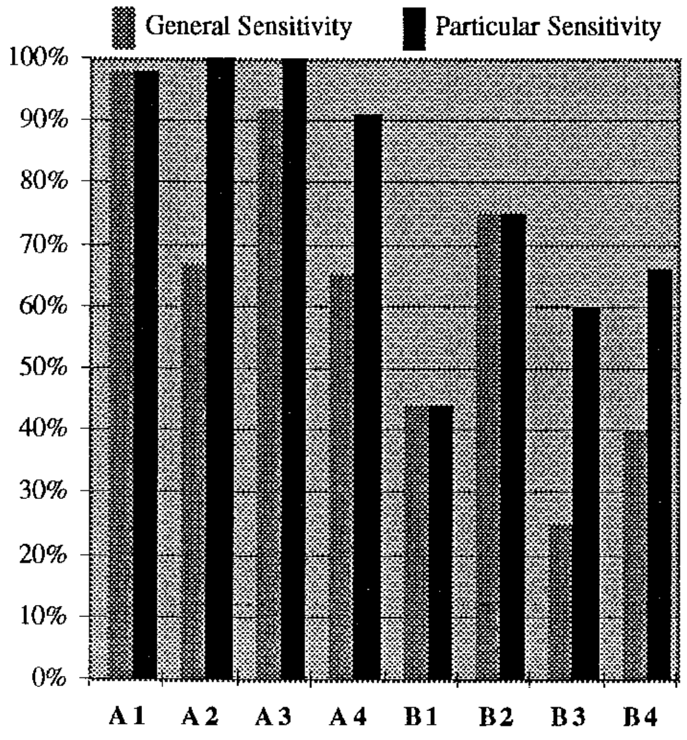


Table 1B

Illustration of the (General and Particular) Sensitivities of the four A-scan and the four B-scan criteria used in the Study for the diagnosis of Retinal Detachment

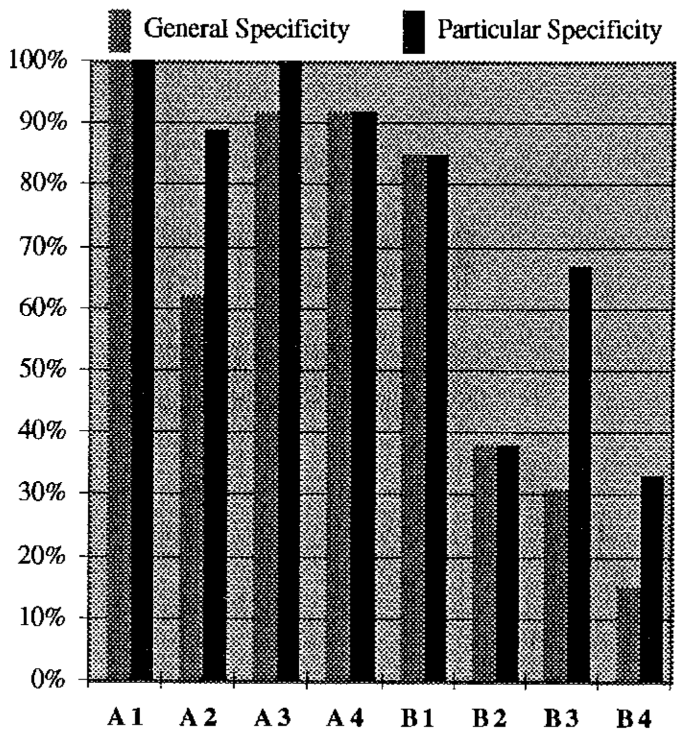


Table 1C

Illustration of the (General and Particular) Specificities of the four A-scan and the four B-scan criteria used in the Study for the diagnosis of Retinal Detachment.

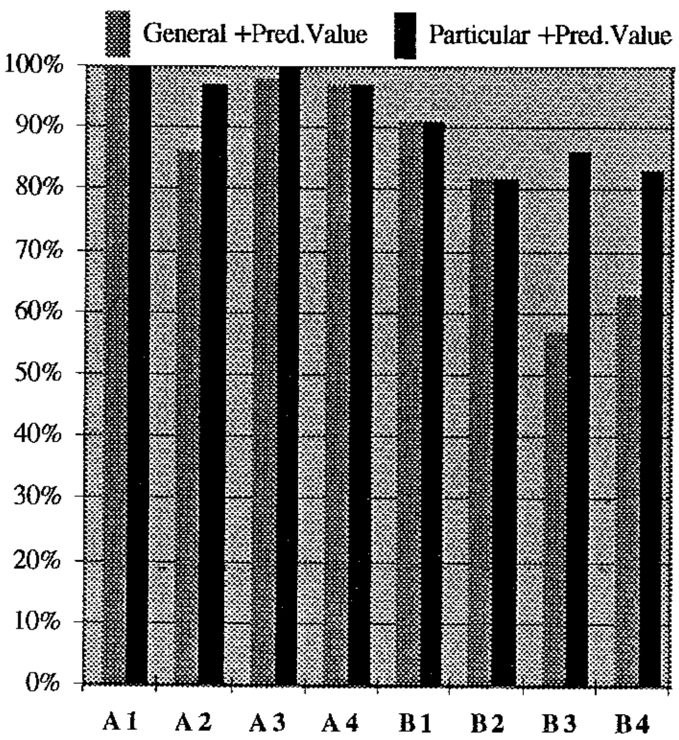


Table 1D

Illustration of the (General and Particular) Positive Predictive Values of the four A-scan and the four B-scan criteria used in the Study for the diagnosis of Retinal Detachment.

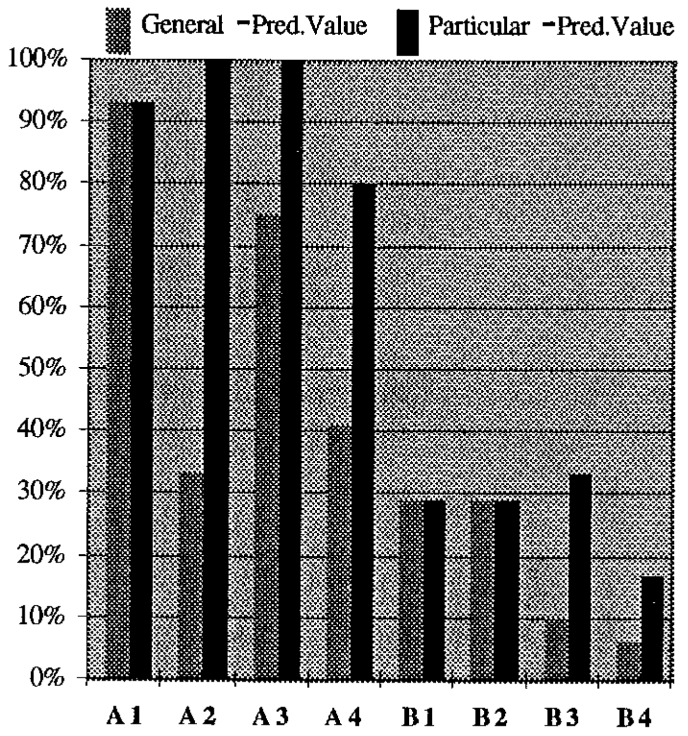


Table 1E

Illustration of the (General and Particular) Negative Predictive Values of the four A-scan and the four B-scan criteria used in the Study for the diagnosis of Retinal Detachment.

Table 2 lists the ranking of the 4 A-scan and 4 B-scan criteria in regard to the various indicators listed in Table 1A. As can be seen, the A-scan criteria (especially the A_1 sign) clearly lead the B-scan criteria in all indicators. Among the B-scan signs the B_1&B_2 signs rank first. Those criteria which ranked higher than 90% are highlight4ed in Table 2; so are the indicators of greater importance.

Table 2

Ranking of Differential Criteria (from left to right) according to:

Availability:	$\mathbf{A_1\&B_1\&B_2}$, A_3, A_4, A_2, B_4, B_3
Sensitivity (General):	$\mathbf{A_1}$, $\mathbf{A_3}$, B_2, A_2, A_4, B_1, B_4, B_3
Sensitivity (Particular):	$\mathbf{A_2\&A_3}$, A_1, $\mathbf{A_4}$, B_2, B_4, B_3, B_1
Specificity (General):	$\mathbf{A_1}$, $\mathbf{A_3\&A_4}$, B_1, A_2, $B_2\&B_3$, B_4
Specificity (Particular):	$A_1\&A_3$, $\mathbf{A_4}$, A_2, B_1, B_3, B_2, B_4
Positive Predictive Value (General):	$\mathbf{A_1}$, $\mathbf{A_3}$, $\mathbf{A_4}$, B_1, A_2, B_2, B_4, B_3
Positive Predictive Value (Particular):	$A_1\&A_3$, $\mathbf{A_2\&A_4}$, $\mathbf{B_1}$, B_4, B_2, B_3
Negative Predictive Value (General):	$\mathbf{A_1}$, A_3, A_4, A_2, $B_1\&B_2$, B_3, B_4
Negative Predictive Value (Particular):	$\mathbf{A_2\&A_3}$, A_1, A_4, B_3, $B_1\&B_2$, B_4
Ease of Operation:	A_1, $A_2\&B_1$, $A_3\&B_2$, $B_3\&B_4$, A_4
Swiftness of Operation:	$A_1\&A_3\&B_1\&B_2$, A_2, B_3, B_4, A_4

The clinically most important parameters and the percentages which are ≥ 90 are printed in bold letters.

Table 3A

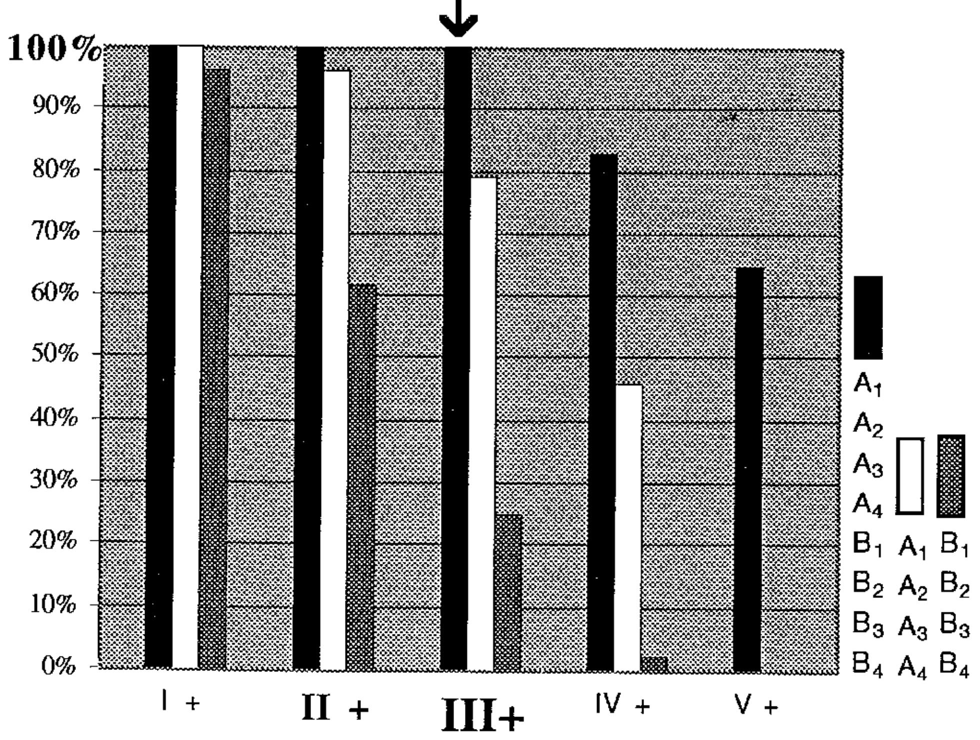
Effectiveness of various combinations of Diagnostic Criteria in positively diagnosing Retinal Detachment (at least two positive criteria required):

Among the 48proven Cases of Retinal Detachment were **AT LEAST** Acoustic Citeria **Positive** for **Retinal Detachment:**	(ONE)	TWO	**THREE**	FOUR	FIVE
$A_1\&A_2\&A_3\&A_4\&B_1\&B_2\&B_3\&B_4$	(100%)	**100%**	**100%**	83%	65%
$A_1\&A_2\&A_3\&B_1\&B_2\&B_3\&B_4$	(100%)	**100%**	98%	79%	42%
$A_1\&A_2\&A_3\&A_4\&B_1\&B_3\&B_4$	(100%)	**100%**	98%	71%	48%
$A_1\&A_2\&A_3\&A_4\&B_1\&B_2\&B_4$	(100%)	**100%**	98%	85%	65%
$A_1\&A_2\&A_3\&A_4\&B_1\&B_2\&B_3$	(100%)	**100%**	98%	79%	60%
$A_1\&A_2\&A_3\&A_4\&B_2\&B_3\&B_4$	(100%)	**100%**	96%	77%	56%
$A_1\&A_3\&A_4\&B_1\&B_2\&B_3\&B_4$	(100%)	**100%**	96%	77%	48%
$A_2\&A_3\&A_4\&B_1\&B_2\&B_3\&B_4$	(100%)	**100%**	90%	60%	40%
$A_1\&A_2\&A_3\&A_4\&B_1\&B_2$	(100%)	**100%**	96%	77%	56%
$A_1\&A_2\&A_4\&B_1\&B_3\&B_4$	(100%)	**100%**	96%	73%	48%
$A_1\&A_3\&B_1\&B_2\&B_3\&B_4$	(100%)	**100%**	92%	58%	19%
$A_1\&A_2\&B_1\&B_2\&B_3\&B_4$	(100%)	98%	89%	40%	17%
$A_2\&A_3\&B_1\&B_2\&B_3\&B_4$	(100%)	98%	81%	44%	17%
$A_2\&A_4\&B_1\&B_2\&B_3\&B_4$	(100%)	90%	71%	42%	10%
$A_1\&A_2\&A_3\&B_1\&B_2$	(100%)	**100%**	92%	63%	19%
$A_1\&A_2\&A_3\&A_4\&B_1$	(100%)	**100%**	85%	65%	15%
$A_1\&B_1\&B_2\&B_3\&B_4$	(100%)	96%	62%	21%	-
$A_2\&B_1\&B_2\&B_3\&B_4$	(98%)	90%	44%	19%	2%
$A_2\&A_4\&B_1\&B_3\&B_4$	(100%)	77	50%	13%	
$A_1\&A_2\&A_4\&B_1$	(100%)	**100%**	85%	65%	15%
$A_1\&A_3\&B_1\&B_2$	(100%)	**100%**	83%	25%	-
$A_1\&A_2\&A_3\&A_4$	(100%)	96%	79%	46%	-
$A_1\&A_4\&B_1\&B_3$	(100%)	83%	46%	2%	-
$B_1\&B_2\&B_3\&B_4$	(96%)	62%	25%	2	-
$A_1\&A_3\&A_4$	(100%)	96%	60%	-	-
$A_1\&A_2\&A_3$	(100%)	94%	60%	-	-
$A_1\&A_4\&B_1$	(100%)	81%	25%	-	-
$A_1\&A_2\&A_4$	(98%)	83%	48%	-	-
$A_1\&A_3$	(100%)	90%	-	-	-
$A_1\&A_4$	(98%)	65%	-	-	-
$B_1\&B_2$	(92%)	29%	-	-	-
$B_1\&B_3$	(58%)	10%	-	-	-

Table 3A lists the diagnostic effectiveness of various combinations of A-scan and B-scan criteria in terms of their overall sensitivities. Table 3B shows a bar chart illustrating the differences in this group effectiviness between a diagnostic pool of all eight criteria and a combined effort of all A-scan and all B-scan criteria, respectively. While the combined pool of all eight criteria harvested at least 3 positive criteria in each single case of retinal detachment and thus provided a "hard" correct diagnosis in 100% of the proven cases of retinal detachment, the success rate of the combined effort of all A-scan criteria was only 79% in achieving at least 3 positive criteria, and that of all B-scan criteriawas only 25%

Table 3B

Comparison of results (in %) when using $A_1\&A_2\&A_3\&A_4+B_1\&B_2\&B_3\&B_4$, $A_1\&A_2\&A_3\&A_4$, and $B_1\&B_2\&B_3\&B_4$ echographic criteria and harvesting at least one **(I +)**, at least two **(II +)**, at least three **(III +)**, four **(IV +)** and five **(V +)** **criteria positive for retinal detachment** in the 47 cases (100%) of proven retinal detachment in the Study.



5. DISCUSSION

When scrutinizing the performance of each of the acoustic differential criteria as indicated in the Tables 1A-E, it becomes evident that no single acoustic criterion can give an entirely satisfying result. Each of the criteria has its strengths and weaknesses though to quite different degrees.

The A_1 sign offers a perfect specificity and positive predictive value, but its sensitivity is slightly less than perfect. The A_2 sign offeres a 100% sensitivity and negative predictive value, at least regarding the 69% of the true retinal detachments where it is available. Its specificity, however, is only 89% and, besides, it was not available in a third of the cases. The A_3 sign appears to be the best of all with a 100% record for all the particular indicators and an availability of 92%. It is, however, a highly subjective sign and requires a good deal of experience before it can be trusted completely. For the experienced examiner it is a pearl. The A_4 sign shows another excellent but less than perfect performance. In particular, its poor time performance and demand on the skills of the examiner hampered its use (availability only 77%) in severely injured eyes. However, this A-scan criterion has been improved tremendously since the study was performed through the use of software programs available nowadays with the *B-scan S* (BVI). It now may be considered an equal partner with the other A-scan criteria. It does offer the great advantage of providing a truly quantitative measure.

The B_1 sign performed best among the B-scan criteria. Its specificity of 85 % comes close to that of the A-scan criteria, but its sensitivity is very low. The reason for this is the relative rarety of typical shapes occurring in retinal detachments across the board. The B_2 sign, by contrast, offers a much higher though still not ideal sensitivity while being not at all specific. The characteristics of the B_2 sign, however, are better understood today than at the time of the study, so that clearly better results can be expected from its use. The same holds true of the B_3 sign: when accepting only clear-cut cases of separate insertion of the two leaves of a funnel-shaped surface structure into the disc, the rate of false-positives is likely to drop further; at the same time, however, false-negatives are likely to increase as a consequence of more equivalent outcomes. A major weakness of both the B_3 and the B_4 signs has been and continues to be their low availability rates (44% and 57%, respectively).

As the study clearly shows, none of the acoustic criteria is always available and sensitive enough to diagnose each case of retinal detachment. Moreover, the specificities of some of the criteria are so poor that one cannot trust them even though their sensitivity may be high. The solution is to use a pool of several criteria and attempt to harvest at least 2 positive ones to make the diagnosis of retinal detachment a safe one. If one of the two successful criteria has a poor specificity record a third positive criterion has to be added to make the diagnosis "hard". As the study shows, only the utilization of the entire pool of A-scan and B-scan criteria has a chance to achieve this goal in all cases (see Tables 3A and 3B). Combinations of only seven, and in some instances even of fewer than seven A-scan and B-scan criteria may be successful to get at least 2 positive hits, and in the majority of cases even 3 positive answers (Table 3A). But such a limited approach risks misdiagnoses and does not offer a significant shortening of the examination times needed. It is definitely better to always use the entire pool of eight acoustic differential criteria. The question remains of how to apply the various A-scan and B-scan criteria successively in order to save time and effort and still obtain the hard diagnosis desired.

Experience has shown that the B_1 sign, followed by the B_2 and B_3 signs, and then by the A_1&A_2&A_3 group leads to a hard diagnosis quickly. Since the B-scan basic examination usually detects a large surface suspicious of being a retinal detachment, it is quite natural to first look at the presence of smooth macro-folds and typical shapes. If the surface structure inserts into disc in a funnel-shaped fashion, this insertion would be scrutinized next (B_3). Since none of these B-scan signs has a good specificity record, they are not sufficient to safely diagnose retinal detachment even if 2 of them should be positive. It is always an easy and very safe approach to quickly add the A_1&A_2&A_3 signs to secure the diagnosis of retinal detachment. Should the absolutely required number of two positive signs or the always preferable minimal score of three clearly positive answers still not be achieved by this approach, one will add the somewhat more time-consuming and difficult A_4 and B_4

evaluations. Ever since the software program for Quantitative Echography II has become available with the *B-scan S* instrument (BVI), the A_4 sign can be mastered in a very short time. We use the A_4 sign regularly in many cases of retinal detachment, simply because it is next to the A_1 sign the only objective quantitative measurement available and gives the diagnosis the extra security.

6. CONCLUSION

The safe diagnosis of retinal detachment in eyes with dense vitreous and/or subvitreal hemorrhages and with proliferative complications requires the use of all eight A-scan and B-scan criteria of Standardized Echography. Any shortcuts trying to use fewer acoustic criteria softens the diagnosis considerably and fails to come up with a solid diagnosis in every single case. The use of B-scan signs alone misses on a large scale and the exclusive use of A-scan signs is also insufficient.

When utilizing the entire pool of all eight A-scan and B-scan criteria the echographer is guaranteed to safely diagnose retinal detachment even under the most adverse circumstances as found in severe cases of trauma and vitreoretinal proliferative disease. However, not all criteria need to be applied in all cases. To economize their usage time- and effort-wise, the examiner is recommended to apply them in a certain order until at least 3 clearly positive criteria are obtained. If one or the other of these positive criteria has a poor specificity record it will be wise to safeguard the diagnosis with one of the two quantitative criteria (i.e., A_1 and A_2).

The recommended order of application is this: B_2, B_1, B_3 A_1, A_2, A_3, A_4, and B_4. Even if it should be necessary to apply all eight criteria in a rare case, the total evaluation time should not exceed 10 minutes in the hand of an experienced echographer. The reward for utilizing this approach well will be a nearly 100% diagnostic record.

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