ORIGINAL ARTICLE

ROLE OF HIGH RESOLUTION ULTRASONOGRAPHY IN THE EVALUATION OF POSTERIOR SEGMENT LESIONS OF THE EYE

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ABSTRACT: BACKGROUND: The superficial location of the eye, its cystic composition, and the advent of high-frequency ultrasound make sonography ideal for imaging the eye. Ultrasonography is a simple, readily available, non-invasive, non-ionizing, highly accurate, real time and cost effective modality. **OBJECTIVES:** 1) To evaluate the accuracy of high resolution B-mode ultrasonography in the diagnosis of posterior segment lesions of eye as compared to ophthalmoscopic examination particularly in cases of opaque conducting media. 2) To evaluate sonographic appearances of various posterior segment lesions of the eye. **MATERIALS AND METHODS:** 1) A prospective study was carried out on 62 cases with suspected posterior segment lesions of eye. All patients clinically suspected to have posterior segment lesions in the presence of opaque conducting media were included in the study. Cases suspected to have isolated anterior segmental and extra ocular lesions were excluded. 2) HRUS was performed with Philips IU22 using high frequency probe (5 to 17 MHz) utilizing contact method. 3) Sonological diagnosis was made based on sonographic features such as location, morphology, echo pattern, color Doppler characteristics, kinetics of the lesion with eye movements and acoustic characteristics of the lesion. 4) Subsequent clinical, lab investigations, surgical and histopathological examinations were carried out as applicable and final diagnosis was made which was correlated with the sonological diagnosis. Sonological diagnosis was also compared with ophthalmoscopic diagnosis. **STATISTICAL ANALYSES:** The validities and diagnostic accuracies of high resolution ultrasound and ophthalmoscopic examinations were calculated and compared. **RESULTS AND CONCLUSIONS:** 1) Ultrasound was the initial imaging modality opted in most of the cases as it was readily available, simple and cost effective modality. It establishes the diagnosis in significant number of cases superseding the accuracy of ophthalmoscopic diagnosis with significant difference (p- value < 0.0001). 2) It is particularly well suited in cases of opaque conducting media when direct ophthalmoscopy is not possible. 3) HRUS is a highly sensitive modality and it can reliably differentiate various ocular detachments, vitreoretinal disorders and neoplastic lesions with significant accuracy.

KEYWORDS: Eye; posterior segment; high resolution ultrasound; sonography.

INTRODUCTION: The superficial location of the eye and its cystic composition makes high resolution ultrasonography ideal for imaging.(1) It is a simple, cost effective, rapid, non-ionizing imaging modality and provides detailed cross sectional anatomy with real time display of the moving organ.(2) Recent studies have shown a specificity of 99% and a sensitivity of 93% with the use of non-dedicated eye scanners with high correlation of ultrasound findings and clinico-pathological diagnosis.(3) Vitreoretinal diseases are the most common indication for

ultrasonographic imaging of the posterior segment. It allows for evaluation of the vitreous, retina and choroid in situations where there is media opacity.[4] It is a powerful non-invasive tool for the accurate diagnosis and effective management of intra ocular tumors.[5] It is a critical adjunct in ophthalmology for diagnosis of ocular inflammatory disorders.[6] It contributes more to tissue diagnosis than do CT or MRI as they cannot scan in real time and are not comparable with ultrasound for spatial resolution.[7]

OBJECTIVES:

- To evaluate the accuracy of high resolution B- mode ultrasonography in the diagnosis of posterior segment lesions of eye as compared to ophthalmoscopic examination particularly in cases of opaque conducting media.
- To evaluate sonographic appearances of various posterior segment lesions of the eye.

INCLUSION CRITERIA:

- All patients clinically suspected to have posterior segment lesions in the presence of opaque conducting media.
- Ocular injuries suspected to have posterior segmental lesions.

EXCLUSION CRITERIA:

- Cases suspected to have isolated anterior segmental and extra ocular lesions.
- Cases with external eye injuries where performance of ultrasound was difficult.

MATERIALS:

- A prospective study was carried out on 62 cases with suspected posterior segment lesions of eye.

TECHNIQUE OF ULTRASOUND STUDY[8,9,10]:

- With the patient in supine position, Ultrasound was performed with closed eyelid after application of adequate coupling gel utilizing contact method. Linear high frequency probe (5 to 9 MHz) of PHILIPS IU22 ultrasound system was used for the study.
- Longitudinal and transverse axis scans were performed, both in static and with dynamic movements of eye after instructing the patients. Color Doppler flow imaging was done in all cases.

METHODS:

- The lesions were evaluated in terms of detection, localization and characterization.
- Sonological diagnosis was made based on sonographic features such as location, morphology, echo pattern, color Doppler characteristics, kinetics of the lesion with eye movements and acoustic characteristics of the lesion.
- Subsequent clinical, lab investigations, surgical and histopathological examinations were carried out as applicable and final diagnosis was made which was correlated with the sonological diagnosis.
- Sonological diagnosis was also compared with ophthalmoscopic diagnosis.

STATISTICAL ANALYSES:

- The validities and diagnostic accuracies of high resolution ultrasound and ophthalmoscopic examinations were calculated and compared.

NORMAL SONOGRAPHIC ANATOMY OF EYE[9,10,11] (Fig. 4):

- The eye is the easiest object to visualize within the orbit, as its fluid content and superficial position make it ideal for ultrasound examination.
- **Lens:** It is seen as oval high reflective structure with intralenticular echoes varying from none to highly reflective depending on the amount of cataract.
- **Vitreous:** This is acoustically clear but can show low reflective echoes in older people.
- **Retina, choroid and sclera:** All 3 are seen as a single high reflective structure.
- **The retina:** Its anterior surface is clearly identifiable on ultrasound examination but the posterior surface of the retina merges with the choroid. The thickness is 0.4 mm near the entrance of the optic nerve but reduces to 0.1 mm at the ora serrata.
- **The choroid:** This thin erectile vascular layer which may be upto 1 mm thick.
- **The sclera:** This layer displays a higher reflectivity than the choroid.
- **Optic nerve:** This is seen as a hypoechoic band starting at the sclera zone and extending posteriorly and medially.
- **Retrobulbar fat:** It is hyperechoic compared to other structures and any lesion within the orbit is well demarcated by this fat.

POSTERIOR SEGMENT PATHOLOGIES ENCOUNTERED IN OUR STUDY & THEIR APPEARANCES:

VITREOUS HEMORRHAGE (FIG. 5): was the commonest ocular pathology in our study. Out of 12 cases, one was missed. Ultrasound was 95 % sensitive and 81.8 % accurate in diagnosing VH. Fresh VH is very low reflective. In old vitreous hemorrhage, the dot-like echoes organize to form membranes of varying reflectivity, most dense inferiorly due to gravity.

RETINAL DETACHMENT (FIG. 6): Ultrasound was 100 % sensitive and accurate in diagnosing all 11 cases of RD in our study. It also formed an important tool in following up these cases.

It may be rhegmatogenous, tractional, combined traction-rhegmatogenous or exudative. It appears as thin, continuous, V- shaped membrane separated from globe wall with attachment points at the nasal and temporal ora serrata and at the optic nerve.

POSTERIOR VITREOUS DETACHMENT (FIG. 7) AND VITREOUS FLOATERS: All 6 cases of PVD and 3 cases of VF were correctly diagnosed by ultrasound.

PVD is seen as a freely mobile membranous echo with variable attachments to the optic nerve head or retina. The mobility of the PVD is more than that of RD.

Vitreous floaters appear as discrete mobile point like bright echoes with a clear space between the particles and the posterior globe wall.

RETINOBLASTOMA (FIG. 8): 8 cases of RB were there in our study, all of them in first decade. They formed the most common ocular neoplasm and the commonest ocular pathology to cause proptosis (7%) and leucokoria in our study. All were correctly diagnosed by ultrasound.

It may appear as single or multiple mass lesions in the vitreous cavity arising from the retina with high internal reflectivity. Presence of calcium, seen as high reflective specks or clumps within the lesion, causing orbital shadowing.

CHOROIDAL DETACHMENT: Out of 4 cases in our study, one case was missed due to accompanying vitreous hemorrhage.

It appears as smooth, thick, dome shaped membrane in the periphery with little or no after movement.

PERSISTENT HYPERPLASTIC PRIMARY VITREOUS (PHPV) (FIG. 9): All 3 cases of PHPV were in first decade and were correctly diagnosed with ultrasound, especially with color Doppler which demonstrated flow in posterior hyaloid artery.

PHPV appears as vitreous band of variable reflectivity extends from the lens to the optic disc. Doppler signal from posterior hyaloid artery may be seen within.

CHOROIDAL MELANOMA (FIG. 10): 1 case of choroidal melanoma was noted in our study in 5^{th} decade which was correctly diagnosed.

It classically appears as homogenous solid mass showing internal vascularity. Choroidal excavation produced by the contrast between the normal high reflective choroid surrounding the tumor and the low reflectivity of the densely homogenous tumor mass.

Features to be noted in ocular tumours: Number, shape, surface, location & layer involved, presence, extent & location of RD, reflectivity of lesion compared to sclera, measurements-base-vertical and horizontal, height, presence of extrascleral extension, optic nerve extension & orbital soft tissue involvement, presence of tumor vascularity and associated inflammatory signs.

CHOROIDAL METASTASIS (FIG. 11): 2 cases with primary carcinoma of thyroid presented with gradual loss of vision. Lenticular echogenic lesions arising from choroid showing internal vascularity were noted in both cases.

It appears as irregular solid mass at the posterior pole with or without internal blood flow.

CHOROIDAL OSTEOMA (FIG. 12): Young male patient presented with bilateral diminution of vision. Ultrasound showed curvilinear calcification involving posterior aspect of choroid bilaterally. Very high reflective plaque like lesion with orbital shadowing.

OPTIC DISC DRUSEN (FIG. 13): Young male patient presented with blurring of vision bilaterally. Calcific focus at the optic disc will be seen.

PHTHISIS BULBI (FIG. 14): 2 cases of Phthisis bulbi were correctly diagnosed by ultrasound which showed deformed collapsed globe with curvilinear calcification of the wall of globe.

It appears as collapsed distorted globe with circumferential irregular calcifications.

OBSERVATIONS: Posterior segment pathologies observed in our study were predominant in the 3rd decade (12 cases) with slight male predilection (M:F::1.1:1.0). A slight predilection for involvement of right eye (45%) was noted with 17% of cases having bilateral involvement.

The presenting complaint was predominantly Dimness of vision (24 cases) followed by trauma (14 cases) and leucocoria (13 cases) (Fig. 1). The major indication for HRUS was opaque media (Fig. 2). The commonest posterior segment pathology was vitreous hemorrhage followed by retinal detachment.

Out of 62 cases, 60 were correctly diagnosed by HRUS. One case of retinal detachment and one case of choroidal detachment were missed on HRUS. Of 62 cases, only 38 were correctly diagnosed by ophthalmoscopic examination.

The overall sensitivity, specificity, PPV, NPV and diagnostic accuracy of ultrasound for the diagnosis of posterior segment pathologies were 96.0%, 50.0%, 99.2%, 16.7% and 96.7% (p-value <0.0001) respectively compared to 61.1%, 50.0%, 98.7%, 02.0% and 61.2% for ophthalmoscopic examination (Fig. 3, Tables 1 & 2).

Ultrasound was the initial imaging modality opted in most of the cases as it was readily available, simple, cost effective, non-ionizing, non-invasive and reliable modality. It readily establishes the diagnosis in significant number of cases. It has a higher spatial and temporal resolution compared to both CT and MRI for the diagnosis of ocular pathologies. It superseded the accuracy of ophthalmoscopic diagnosis with significant difference (p- value <0.0001).

Ultrasound diagnosis correlated very well with the final diagnosis. Ultrasound diagnosis formed a major basis for management decisions in significant number of cases. It was a major tool for the follow up of cases.

COMPARISON WITH OTHER STUDIES (TABLE 3):

OP Sharma[2] (2005) conducted a study on 122 cases, the clinical and USG diagnosis were correlated with final diagnosis to infer the accuracy, sensitivity and specificity. Commonest intraocular pathology was vitreous hemorrhage. Retinal detachment showed diagnostic accuracy of 99% but specificity was slight less (98.6%). Ultrasonographic findings well correlated with clinical, operative & histological observation.

Nzeh DA[3] (2007) conducted a retrospective review of 202 eye patients for ultrasonography over a 5-year period using two non-dedicated general purpose US scanners. 179 (88.6%) had agreement between clinical and ultrasound diagnosis. They concluded that in experienced hands, there is a high correlation of findings on US and clinico – pathological diagnosis even in the absence of a dedicated eye scanner.

Ejaz A J et al[12] (2006) conducted B-Scan on 463 eyes and concluded that B-scan was a valuable diagnostic modality in opaque media and had remarkable prognostic importance.

J A Fielding[13] performed 200 consecutive scans on 184 patients through-the-lid with general ultrasound equipment. The examination was simple to perform with production of good

images. It was sensitive (92%) and specific (99%) in the detection and exclusion of intra-ocular disease.

Roger P et al[14] (2004) in a study addressed the impact of echography on the evaluation and management of posterior segment disorders. This study presents the diagnostic findings of 1,000 consecutive patients referred to an ophthalmic echographic specialty practice over a 16-month period. Ophthalmic echography provided essential information about the anterior and posterior segments in eyes.

Fisher Y L et al[15] (1991) investigated the status of the posterior vitreous in 70 eyes to evaluate the diagnostic value of kinetic contact ultrasonography, which provided an extremely accurate method for evaluating the posterior vitreoretinal interface in 69 of the 70 eyes in this study, when compared with all conventional clinical means of examination including slit-lamp biomicroscopy with the Goldmann contact lens and fundus photography with the El Bayadi-Kajiura lens.

Zafar D et al[16] (2008) performed 320 B-scans and concluded that ultrasonography proved to be very helpful method for medical diagnosis in Ophthalmology. Opacities in the vitreous were the commonest problems followed by retinal detachment for which ultrasound was advised.

Scott IU et al[17] (2004) conducted a retrospective, non-comparative, consecutive case series study on 154 eyes of 143 patients, to investigate the impact on patient management of posterior segment echographic evaluation. The final clinical or pathologic diagnosis confirmed the echographic diagnosis in 148 eyes (96%).

Jamil Ahmed et al[18] (2009) conducted a study 73 eyes of 68 patients with vitreous opacities and concluded that B-scan was very useful in detection and evaluation of vitreo-retinal pathologies

Jemeld B et al[19] (1980) examined 93 diabetics (168 eyes) with opaque ocular media and low visual acuity by ultrasonography. The ultrasonic accuracy was checked in 49 eyes at vitrectomy. It was 78% for retinal detachments and 67% for prepapillary and pre retinal proliferations

R Rabinowitz et al[20] (2004) correctly diagnosed all cases of retinal detachment, but less than 50% of retinal tears with ultrasound. A total of 18.9% of the eyes were falsely diagnosed as having retinal detachment.

Verbeek AM et al[21] (1994) analyzed the data on echographic diagnosis of intraocular tumors, using the final diagnosis either from pathology after enucleation or from the confirmed clinical diagnosis. The material consisted of melanomas (n=325), metastases (n=44), hemangiomas (n = 19) and other intraocular tumors (n=16). The best set of echographic parameters in descending order of significance was: reflectivity (A-mode), choroidal excavation (B-mode), shape (B-mode), and regularity (A/B mode). The clinical echographic classification for these cases was 89%, 93% and 99.5%, respectively. The simultaneous differentiation between the three classes was found to yield a correct fraction of 85% by computer statistics and 95% by routine echography.

Byrne SF et al[22] (2002) in COMS conducted a study to describe the methods used by the Collaborative Ocular Melanoma Study (COMS) Echography Center for grading tumor echograms

and to assess reliability of the grading system. The level of agreement (after adjusting for chance agreement) ranged from 'moderate' to 'almost perfect.' Grading for 'confidence of tumor measurement' differed between the original grading and the regrading but there was little difference in the tumor measurements. The COMS Echography Center has demonstrated that its grading protocol is consistent over time.

Collaborative Ocular Melanoma Study Group[23] (2003) in its report 21, a study was conducted to compare pre-enucleation clinical and echographic measurements with postenucleation histopathological measurements of choroidal melanoma of a size and in a location suitable for iodine 125 brachytherapy. The results suggest that tumor measurements made according to COMS protocol were highly reliable in planning radioactive plaque therapy and monitoring changes in tumor size after such treatment.

Boldt HC et al[24] (2008) conducted a retrospective study on 2320 patients to report baseline echographic characteristics of tumors in patients enrolled in the COMS randomized trials, to determine how often these characteristics matched prespecified criteria for choroidal melanoma. 88 % of the tumors in the COMS exhibited features characteristic for melanoma: low to medium reflectivity, the classic mushroom shape, or both. Using additional preset criteria, 96% of tumors exhibited baseline echographic characteristics consistent with the diagnosis of melanoma. Echography graders were able to detect extrascleral nodules > or = 1.5 mm in elevation but not minimally elevated extraocular tumor extension. Clinicians and echographers can use these data to improve their understanding of the echographic features of untreated uveal melanomas.

Varene B et al[26] performed echography on 38 eyes enucleated for suspected retinoblastoma. No errors in diagnosis were made on the 25 eyes considered to be cases of retinoblastoma by echographic criteria.

Roth DB et al[27] (2001) concluded that echography is a useful adjunct to indirect ophthalmoscopy in establishing the diagnosis of retinoblastoma, permits monitoring of treatment response and may aid in detecting recurrent tumor growth or failure to respond to treatment.

Mackeen LD et al[28] (2000) concluded stating High-frequency ultrasound can be reliably used to distinguish characteristic features of PHPV. Furthermore, the presence of a thickened adherent anterior hyaloid face may help explain the well-recognized complications of peripheral retinal tears and retinal detachments during and after surgical intervention.

CONCLUSIONS:

- High resolution ultrasonography is a readily available, non-invasive, non-ionizing, highly accurate and cost effective modality which offers real time scanning with option of color Doppler.
- It is particularly well suited in cases of opaque conducting media when direct ophthalmoscopy is not possible.
- HRUS is a highly sensitive modality and it can reliably differentiate various ocular detachments, vitreoretinal disorders and neoplastic lesions with significant accuracy.

LIMITATIONS OF ULTRASOUND:

- It is operator dependent and requires the knowledge and expertise of a well-trained and skilled operator to obtain accurate, repeatable, high-quality images.
- It has relatively lower sensitivity in the detection of calcification compared to CT.
- It may be difficult to perform in cases with external eye injuries.

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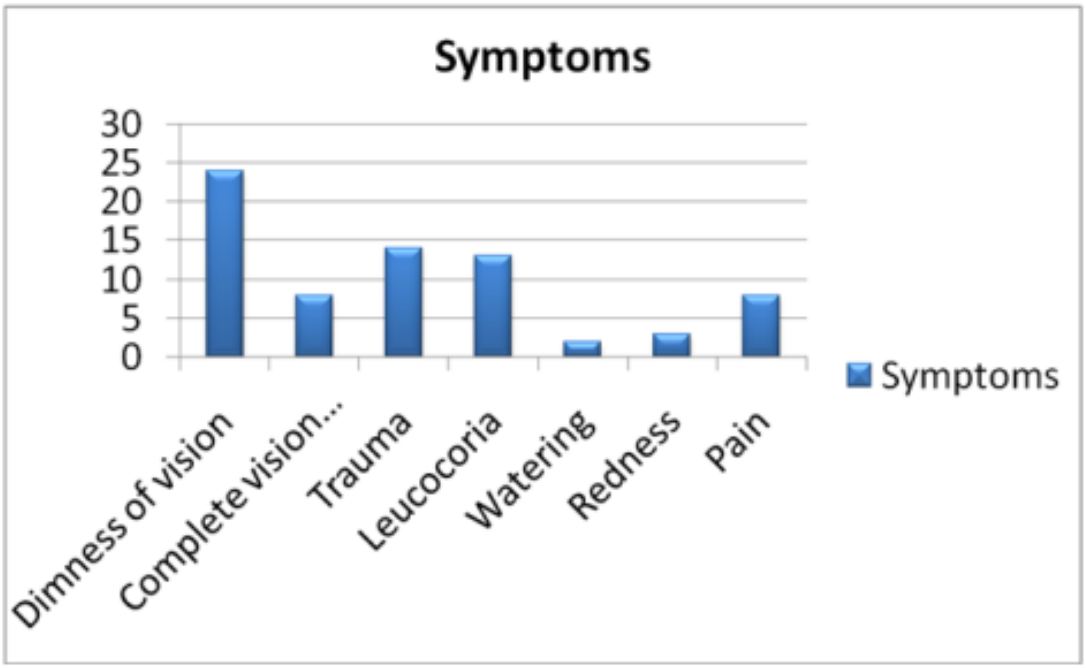

Fig. 1: Frequency of symptoms

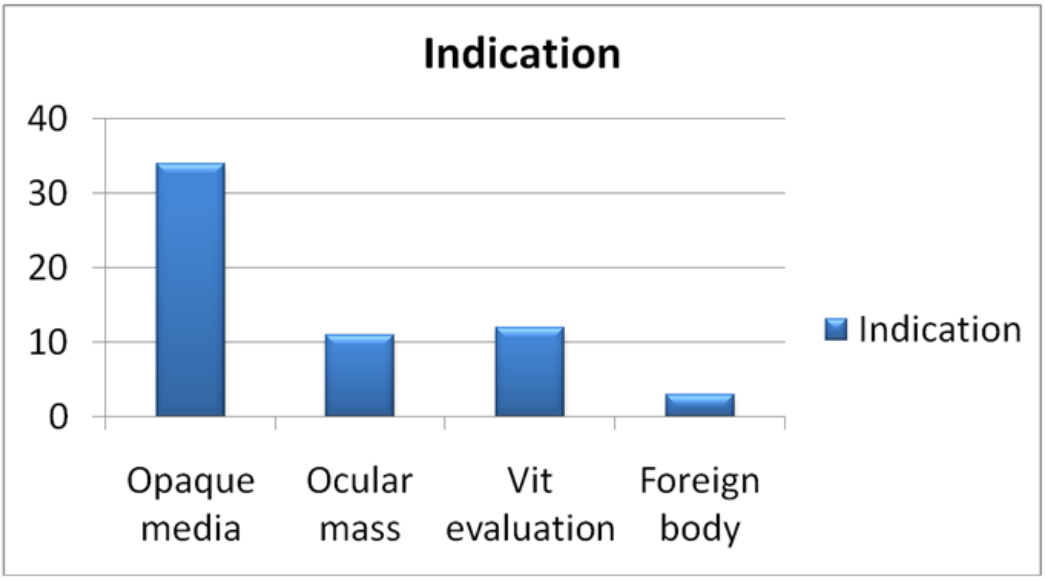

Fig. 2: Indications for HRUS

PATHOLOGY	TOTAL CASES	DETECTION BY OPHTHALMIC EXAMINATION	DETECTION BY HRUS	% ACCURACY IN OPHTHALMIC EXAMINATION	% ACCURACY IN HRUS
VH	12	9	12	75.0	100.0
RD	11	5	10	45.4	91.0
RB	8	5	8	62.5	100.0
PVD	6	2	6	33.3	100.0
VF	4	2	4	50.0	100.0
CH D	4	2	3	50.0	75.0
PHPV	3	2	3	66.7	100.0
CH TH	3	1	3	38.3	100.0
FB	2	1	2	50.0	100.0
CM	2	2	2	100.0	100.0
ODD	2	2	2	100.0	100.0
PHTHI	2	2	2	100.0	100.0
SUB LENS	1	1	1	100.0	100.0
MELAN	1	1	1	100.0	100.0
CH OSTEO	1	1	1	100.0	100.0

Table 1: Distribution of cases with diagnostic accuracies of Ophthalmoscopic and ultrasound diagnosis

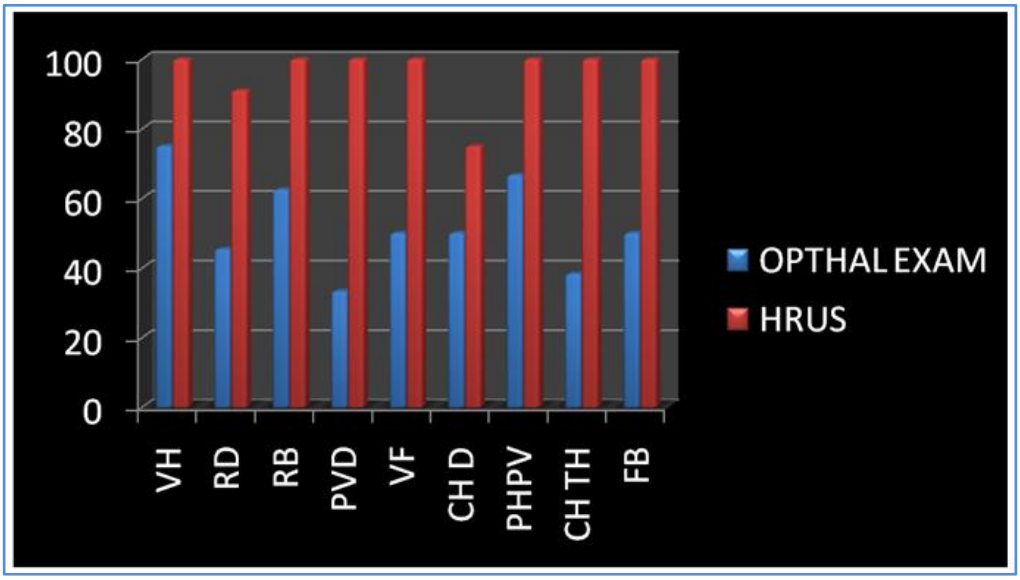

Fig. 3: Comparison of diagnostic accuracies of Ophthalmoscopic and ultrasound diagnosis

	HRUS	OPHTHAL EXAM
SENSITIVITY	96.0 %	61.1 %
SPECIFICITY	50.0 %	50.0 %
PPV	99.2 %	98.7 %
NPV	16.7 %	2.0 %
ACCURACY	96.7 %	61.2 %

Table 2: HRUS versus Ophthalmoscopic examination

VARIABLE STUDIED	PRESENT STUDY	O P SHARMA STUDY	NZEH D A STUDY
AGE	4th decade	4th decade	4th decade
GENDER	M>F	M>F	M>F
COMPLAINTS	DV	DV	Trauma
INDICATION	Opaque media	Opaque media	Trauma
PATHOLOGIES	VH (20%)>RD (18%)	VH (28%)>RD (26%)	RD (26%)>VH(14%)
SENSITIVITY	96.7%	-	93%
DIAG ACCURACY FOR RD	91%	99%	-

Table 3: Comparison with other studies

IMAGES:

Fig. 4: Normal sonographic anatomy of globe: Transverse and longitudinal scan through normal orbit depicting various structures.

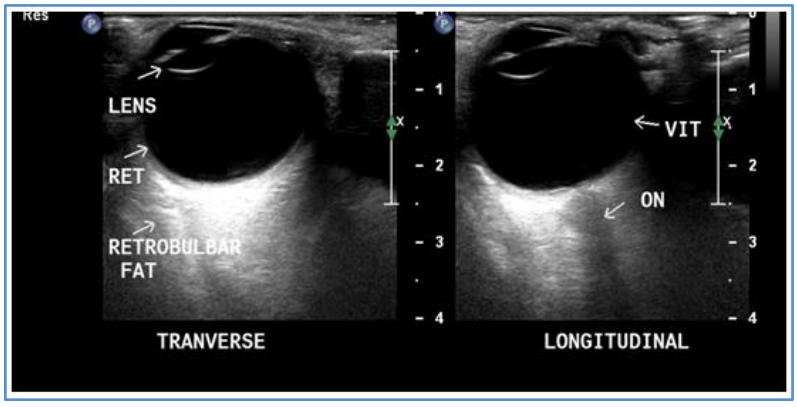

Fig. 4

Fig. 5: Vitreous Hemorrhage: Vitreous Hemorrhage: Low level echoes in the vitreous cavity, predominantly in the dependent portions of the globe.

Fig. 5

Fig. 6: Retinal Detachment: Well defined thick echogenic V- shaped retinal folds attached at the optic disc and ora serrate.

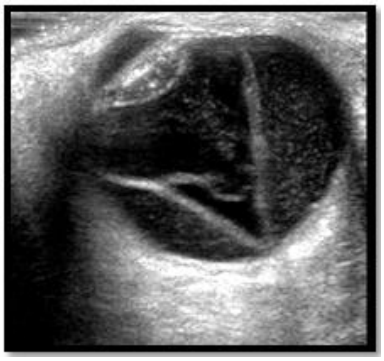

Fig. 6

Fig. 7: Posterior Vitreous Detachment: Posteriorly detached redundant vitreous floating freely.

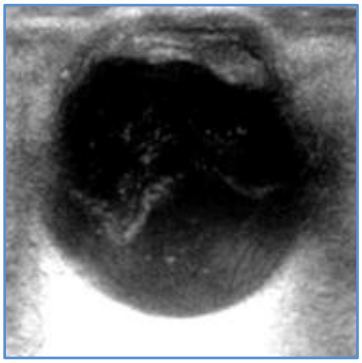

Fig. 7

Fig. 8: Retinoblastoma: Well-defined heterogenous predominantly hyperechoic lesion within the globe showing internal vascularity and calcific foci within.

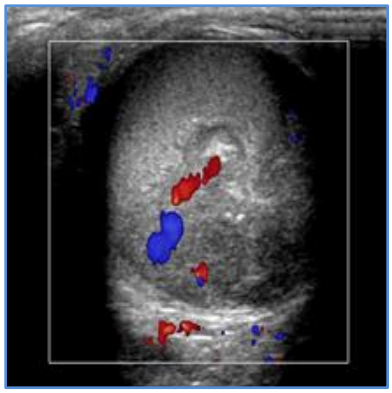

Fig. 8

Fig. 9: PHPV: Irregular echogenic structure extending from the optic disc to posterior surface of lens with Doppler signal from posterior hyaloid artery.

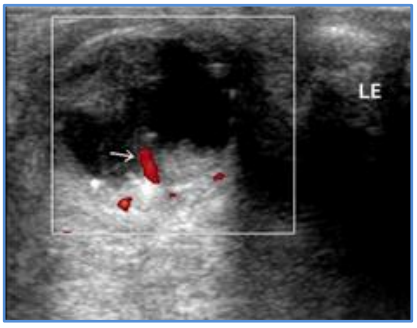

Fig. 9

Fig. 10: Choroidal Melanoma: Well defined echogenic subretinal mass lesion arising from the choroid causing exudative retinal detachment.

Fig. 10

Fig. 11: Choroidal Metastasis: Well defined lenticular echogenic lesion arising from the choroid showing internal vascularity.

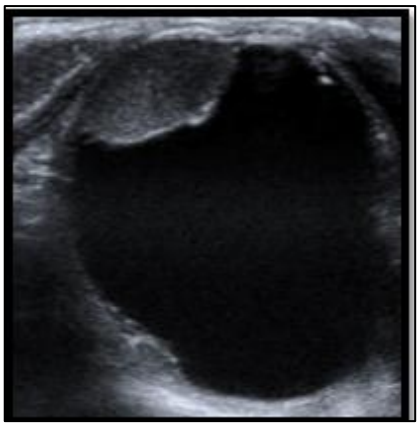

Fig. 11

Fig. 12: Choroidal osteoma: Curvilinear calcification along the choroid.

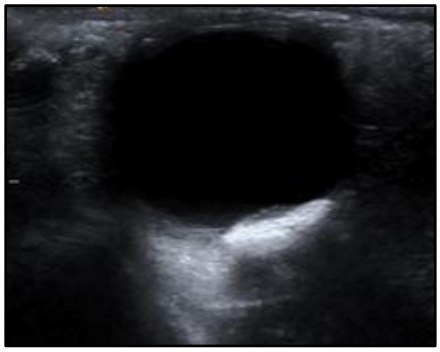

Fig. 12

Fig. 13: Optic Nerve Head Drusen: Calcific focus at the optic nerve head.

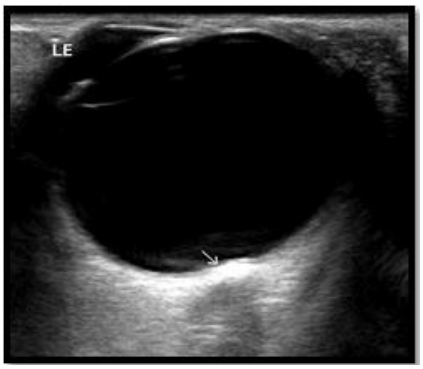

Fig. 13

Fig. 14: Phthisis Bulbi: Irregular deformed globe with curvilinear calcification.

Fig. 14

LIST OF ABBREVIATIONS:

HRUS	-	High resolution ultrasonography,
VH	-	Vitreous hemorrhage,
RD	-	Retinal detachment
RB	-	Retinoblastoma,
PVD	-	Posterior vitreous detachment,
VF	-	Vitreous floater,
PHPV	-	Persistent hyperplasic primary vitreous,
FB	-	Foreign body,
CM	-	Choroidal metastasis,
ODD	-	Optic disc drusen.

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