

Ultrasonographic evaluation of Eyes with Opaque Media

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Abstract :

Aim: To evaluate the role of ultrasonography in the diagnosis of ocular diseases in eyes with opaque media

Settings and Design: Department of Radiology, Tertiary Care Referral Centre in Tamilnadu. Prospective, single institution, Diagnostic case-series.

Materials and Methods: 101 eyes of 82 patients with opaque media were examined with ultrasound and followed up with clinical methods and radiological examinations.

Results: 42 eyes were found to have normal posterior segment. 59 eyes had various posterior segment pathologies either as a single entity or in combination.

Conclusion: Ultrasonography was an indispensable tool in the evaluation of ocular diseases in eyes with opaque media. This report highlights the various advantages of ultrasonography like safety, excellent tissue differentiation, repeatability and accuracy. Combining ultrasonography with other imaging offers better assessment of their pathological characteristics.

Keywords: Ocular ultrasound, eyes with opaque media.

I. Introduction

Ultrasound is a safe non-invasive procedure which can be performed in the outpatient department without any sedation and radiation exposure. Ultrasonography (USG) is an indispensable tool in the evaluation of posterior segment behind an opaque ocular media, which prevents the examination by clinical methods. Hence, the aim of the study is to determine the role of ultrasound in the evaluation of ocular pathologies in eyes with opaque media and also to assess the role of ultrasound as a prognostic indicator for posterior segment examination in eyes with opaque media.

II. Materials and Methods

This study was conducted in Department of Radiodiagnosis, Coimbatore Medical College & Hospital (CMCH), Coimbatore, Tamilnadu during the period December 1st 2013 to September 30th 2015. Our centre serves as a tertiary radiological referral hospital. The study population was made out on the basis of referrals from the Department of Ophthalmology, CMCH, and Coimbatore. 82 patients were selected for the present study by using the simple random sampling method.

An informed consent was obtained from the subjects before the commencement of the investigation. A pro forma was prepared meeting the demands of the study. The clinical diagnosis was recorded as mentioned in the patient referral form. The reports of necessary ophthalmic examinations like visual acuity tests, slit lamp study, tonometry, gonioscopy, direct and indirect ophthalmoscopy and the reports of other laboratory investigations were recorded, as per the protocol.

2.1 Examination technique for B-scan USG of eye

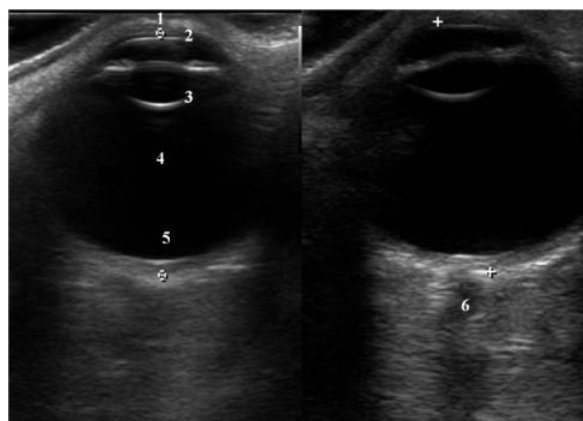
The procedure of ultrasound was explained to the patient. The high resolution images were produced by high resolution ultrasound scanner possessing a short-focus, real-time, 5 MHz to 11 MHz linear small-parts probe. In few situations curvilinear array probe with frequency range of 4 MHz to 8 MHz for endocavitary scanning purpose was also utilized for contact scanning of the eye.

The scanning of the eye was done with the subject lying in the supine position and the eyelid closed, and methyl cellulose 2% as coupling gel was applied over the lid. The subjects were instructed to fix their gaze at the ceiling and scanning was done in the transverse and vertical or cranio-caudal planes of the eye. This is known as the direct contact scanning technique. Frozen images or static scan protocol were taken to enable accurate measurements.

2.2 B-mode ultrasound of the normal eye:

B-scan imaging of the normal eye at high sensitivity reveals the following ^[1].

- a. An echogenic area close to the tip of the probe represents the eye lid.
- b. Normal vitreous produces no echoes however few scattered opacities of very low reflectivity may be detected in the ageing eye ^[2].



B-scan imaging of the normal eye

1. Eye lid, 2. Cornea, 3. Posterior lens capsule, 4. Vitreous gel, 5. Retina, choroid, sclera, 6. Optic nerve

- c. The echogenic area inferiorly represents the retina, choroid, sclera and orbital tissue behind it. The proximal surface is concave and represents the retina.
- d. Optic nerve shadow is noted within the orbital fat whenever it is centered in the ultrasound beam.
- e. The three ocular coats cannot be separated from one another^[3]. Examination of the normal at a decreased sensitivity allows a better evaluation of retina and choroid.
- f. Lens shadow may result in artefacts in the vitreous.

III. Results

A total of 101 eyes of 82 patients were studied from December 1st 2013 till September 30th 2015. The indications, echographic diagnosis and accuracy of ultrasound in eyes with opaque media are discussed as follows.

3.1 Causes of opaque media

101 eyes with opaque media were examined. There were various causes for opaque media like cataract, vitreous haemorrhage, hypopyon and corneal opacity. Among those various causes, cataract was found to be the most common cause for opaque media.

Table 1-Various causes of opaque media

Causes of opaque media	No. of eyes	Percentage %
Corneal leucomatous opacity	09	8.9
Corneal opacity with seclusio pupillae	02	1.98
Total hypopyon / hyphema	09	8.91
Cataractous lens	65	64.35
Vitreous opacities	16	15.84
Total	101	100

3.2 Eyes with history of trauma

On analysis of 39 eyes, with history of blunt trauma to eye, it was found that traumatic cataract was the major cause of opaque media in traumatized eyes. Few other causes that resulted in opaque media in traumatized eyes were vitreous haemorrhage, traumatic hyphema and corneal opacity with seclusio pupillae.

Table 2- Causes of opaque media in patients with history of trauma

Causes of opaque media	No. of eyes	Percentage %
Traumatic cataract	23	48.78
Traumatic hyphema	07	2.4
Vitreous haemorrhage	03	7.3
Corneal opacity with seclusion pupillae	01	2.4
Corneal opacity	05	29.26
Total	39	100

3.3 Analysis in eyes with opaque media

In our study, 101 eyes with opaque media were studied with USG and the various echographic diagnoses in those eyes are tabulated and each diagnosis has been described as percentage of the total 101 eyes.

Table 3- Echographic diagnosis in eyes with opaque media

Sl. No.	Echographic diagnosis	No. of eyes	Percentage
1	Normal posterior segment	42	41.58
2	Dense asteroid hyalosis	03	2.97
3	Vitreous haemorrhage(VH)	13	12.87
4	VH, Posterior vitreous detachment(PVD)	03	2.97
5	VH, Rhegmatogenous retinal detachment(RRD)	02	1.98
6	Intraocular foreign body(IOFB), VH	02	1.98
7	IOFB, vitritis	01	0.99
8	RRD	05	4.95
9	Exudative retinal detachment(ERD)	01	0.99
10	Choroidal detachment	01	0.99
11	Persistent primary hyperplastic vitreous(PHPV)	02	1.98
12	Posterior staphyloma	04	3.96
13	Anterior and posterior staphyloma	01	0.99
14	Posterior scleritis, staphyloma, retinal detachment(RD)	01	0.99
15	Vitreous degeneration	05	4.95
16	Vitritis	05	4.95
17	Endophthalmitis	05	4.95
18	Phthisis bulbi	02	1.98
19	Optic nerve drusen	01	0.99
20	Retinoblastoma(RB)	02	1.98
	Total	101	100

IV. Discussion

In our study, in 101 eyes, 65 eyes (64.35%) had cataract as the cause of opaque media. Our study correlated well with that of O.P Sharma et al ^[4] in that, the cataract was the commonest indication for ocular ultrasound examination. Other major causes of the opaque media were vitreous opacities in 16 eyes (15.84%) and corneal leucomatous opacity in 11 eyes (10.88%). Other important causes in the present study were anterior chamber opacity like total hyphema and hypopyon and corneal opacity with seclusio pupillae.

4.1 Echographic diagnosis in eyes with opaque media:

Accurate detection of vitreoretinal disorders in eyes with opaque media is of utmost importance to decide further management and USG helps in examination of posterior segment in eyes with opaque media ^[2]. Out of 101 eyes studied 42 eyes had normal posterior segment. The other 59 eyes had various echographic diagnoses, which are described in the following paragraphs.

4.1.1 Cataractous lens

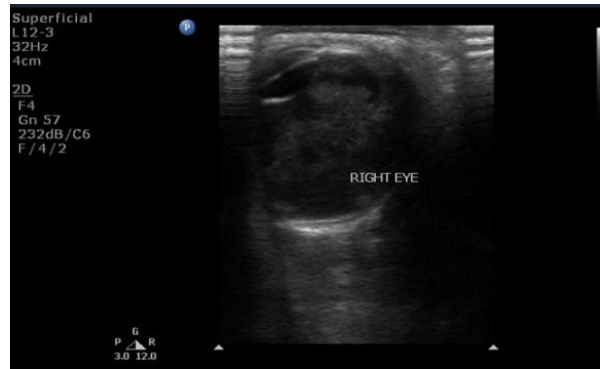
Cataract was found to be the most common cause of opaque media in our study. In immature cataract, the lens shows scattered opacities that are separated by clear media. Mature cataract, appears completely opaque which shows dense shadowing ^[7]. The cataractous lens precludes fundus examination of these eyes and USG is of immense use to evaluate the posterior segment of these eyes.

4.1.2 Vitreous haemorrhage

On ultrasound examination of a normal eye, the vitreous humour appears clear. Ultrasonography yields excellent diagnostic results and is a useful adjunct to clinical examination in cases of vitreous haemorrhage.

The presence of vitreous haemorrhage gives rise to low level internal echoes. These can appear as a localised echogenicity or as diffusely scattered echogenic particles. USG helps to determine type, location, extent and density of haemorrhage, which has prognostic significance ^[5, 6]. In fresh, mild vitreous haemorrhage dot or straight lines are displayed on B-scan. The denser, the haemorrhage becomes the greater the number of opacities and higher their reflectivity and hence better detected by USG ^[2]. This becomes the limitations of USG in the diagnosis of vitreous haemorrhage because unclotted fresh blood may not be picked up by USG, because light, diffuse, unclotted blood produces little or no echo response so that vitreous may appear acoustically clear or 'sonolucent'. In our study, one eye of a patient with history of blunt trauma had mild vitreous haemorrhage which was missed in ultrasound examination. Upon follow up of the patient, this mild haemorrhage was diagnosed by fundus examination. Thirteen eyes with vitreous haemorrhage were diagnosed by ultrasound. In six of these eyes vitreous haemorrhage was detected clinically, by fundus examination, which was later on confirmed on ultrasound examination. In the remaining seven eyes, vitreous haemorrhage could not be detected

on fundus examination due to the presence of cataractous lens, which were diagnosed through ultrasonography. Trauma was found to be the commonest cause of vitreous haemorrhage which correlated well with the earlier studies^[1].



Massive vitreous hemorrhage

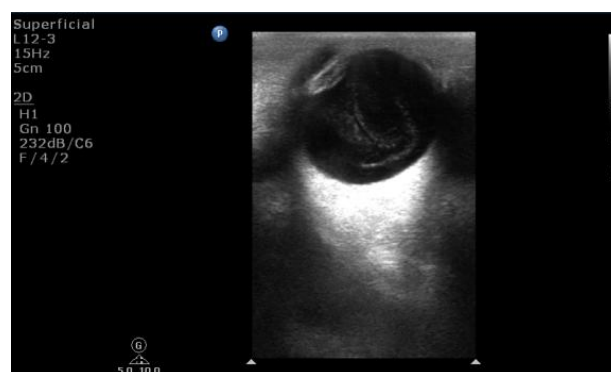
On follow up of these patients, four eyes with mild fresh vitreous haemorrhage were observed without any surgical intervention and there was spontaneous resolution of haemorrhage in these eyes. In three eyes dense organised vitreous haemorrhage with thick membrane formation along with posterior vitreous detachment (PVD) was present. The presence of organization and membranes reduces the visual prognosis^[6], and hence in our study these cases were referred for surgical intervention. Thus USG helped not only in diagnosing vitreous haemorrhage but also helped in planning the management. Another important role of B-scan in eyes with vitreous haemorrhage was to rule out associated abnormalities. In the present study two eyes had tractional retinal detachment and one eye had IOFB along with vitreous haemorrhage.

4.1.3 Dense asteroid hyalosis

Dense asteroid hyalosis was diagnosed in three eyes and is caused due to the calcium soaps in the vitreous, which produce bright points like diffuse or focal echoes on B-scan which are freely mobile. An area of clear vitreous is normally present between the posterior boundary of the opacities on the posterior hyaloids^[1]. In asteroid hyalosis, by a rapid shift of gaze, the vitreous echoes show extremely fast, marked & prolonged after movements after the eye motion has stopped, this sign helps to differentiate it from vitreous haemorrhage.

4.1.4 Posterior vitreous detachment

PVD could occur as a normal ageing phenomenon or may be seen in association with vitreous haemorrhage or inflammation^[8]. PVD could be focal or extensive, or could be associated with vitreoretinal adhesions at the optic disc, or could be seen in association with vitreous haemorrhage.



Posterior vitreous detachment with vitreous hemorrhage

On USG, PVD appears as a smooth, linear, thin membrane with a fluid undulating movement. Weiss ring with two closely spaced opacities at the level of PVD may be seen overlying the optic disc^[1]. In our study, four eyes were found to have Posterior Vitreous Detachment (PVD) on ultrasound examination. In one diabetic patient with proliferative diabetic retinopathy, organized vitreous haemorrhage with tractional retinal detachment was wrongly diagnosed as PVD with thick membrane formation. This highlights the difficulties of differentiating PVD with membrane formation from retinal detachment. In such cases the echographer should carefully search for the insertion of membrane to the optic disc, which is suggestive of retinal detachment.

Membranes on the other hand demonstrate thinning on tracing them superiorly and does not insert into the optic disc^[9].

4.1.5 Vitreous degeneration

This degeneration of vitreous occurs following a longstanding uveitis, vitreous haemorrhage. The vitreous liquefies and contains cholesterol crystals which sink due to gravity. Ultrasonographically these appear as high amplitude echoes in the vitreous, and when the eye is still, these crystals sediment in the liquefied vitreous.

4.1.6 Retinal detachment

Retinal detachment is the separation of the neurosensory retina from the pigmented layer. Retinal detachment is of two types:

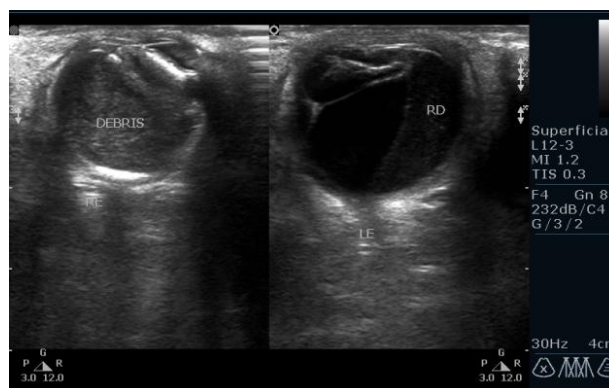
- a) Rhegmatogenous retinal detachment
- b) Non-rhegmatogenous types (exudative and tractional)

Rhegmatogenous retinal detachment appears sonographically as a thin continuous echogenic line separate from the wall of the globe. A total retinal detachment appears as highly elevated, convex white line extending into the globe from the nasal and temporal ora serrata and posteriorly to the optic disc. In Rhegmatogenous retinal detachment, the subretinal fluid appears acoustically clear. But in cases of exudative retinal detachment, which is seen in association with inflammatory conditions^[10], posterior to detached retina, an acoustically opaque mass lesion is seen. For example in malignant melanoma of choroid, tumour mass is seen posterior to the detached retina. The configuration of RD may vary from shallow, flat and smooth to bullous and highly folded. Extensive RD can be funnel shaped and can be open or closed, concave, triangular or T shaped^[4].



Complete rhegmatogenous retinal detachment

The thickness of retinal detachment gives a hint to its age. A freshly detached retina appears as a thin echogenic line and is equal in its entire length. An old retinal detachment appears as a thick membrane and can shrink to form a cord like structure from optic disc to ora serrata.



Exudative retinal detachment

In our present study, retinal detachment was diagnosed on B-scan in 12 eyes with opaque media. Of these 5 eyes were rhegmatogenous retinal detachments. Tractional retinal detachment was diagnosed in three eyes. One eye had exudative retinal detachment secondary to posterior scleritis and the other eye had associated posterior staphyloma and the extent of retinal detachment could be precisely delineated in these eyes^[11], which could not be made out by fundus examination due to cataractous lens.

4.1.7 Endophthalmitis

Endophthalmitis is a dreaded postoperative complication of eye and it can also occur following a penetrating injury to eye. The echographic findings in endophthalmitis include dense vitreous opacities, vitreous membranes, and the presence of retinal detachment, choroidal thickening and choroidal detachment. One case was diagnosed as choroidal detachment with vitreal degeneration but follow up study revealed to be of associated endophthalmitis. This was possibly due to non-specific appearance of the vitreal echoes.

Five eyes of endophthalmitis and five eyes of vitritis were diagnosed, all of which had history of penetrating trauma. On follow up of these patients, after treatment one of them had tractional retinal detachment, which was diagnosed with USG. The presence of tractional retinal detachment was a bad prognostic indicator in endophthalmitis^[12]. USG could pick up tractional retinal detachment in these eyes; hence ultrasound could be used to diagnose endophthalmitis and could also serve as a prognostic indicator in such cases.

4.1.8 Retinoblastoma

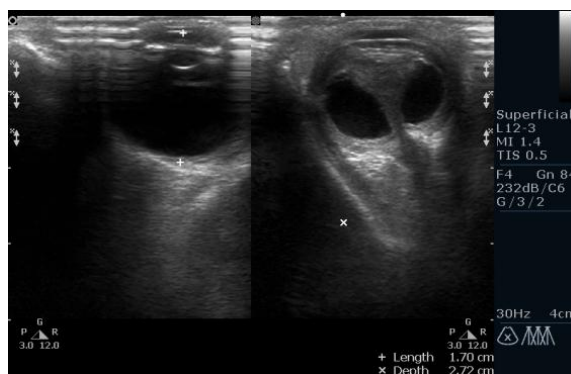
Intra ocular retinoblastoma was suspected clinically in two cases with leukocoria. Ultrasonographically retinoblastoma appears as a heterogeneous soft tissue mass of varying size, which is adjacent to the coats of eye ball. Ultrasound has the ability to show the outline of the mass as dome shape, regular surface or pedunculated mass. Retinoblastoma also contains specks of calcification, which are seen as highly reflective foci. B-scan may help in the detection of extra ocular spread of the tumor, like optic nerve invasion which appears as thickening of the optic nerve.

Both of these patients with leukocoria, were found to have endophytic retinoblastoma on USG and was confirmed after enucleation. This endophytic stage I retinoblastoma showed intra tumoral calcification on B-mode USG and presence of tumoral vascularity on Doppler study, which are significant diagnostic features^[14,15].

B-scan could also be used to screen the fellow eye and also used while follow up to know the response to therapy and to rule out the recurrence.

4.1.9 Persistent primary hyperplastic vitreous

A two month old patient with leukocoria was diagnosed on sonography as persistent hyperplastic primary vitreous with vitreous haemorrhage, which shows that B-scan helps in excluding the intraocular tumour. PHPV is seen as a thin irregular band is seen extending from posterior lens capsule to the optic nerve head with irregularities of the posterior capsule^[16].



Normal right eye and PHPV left eye.

4.1.10 Miscellaneous

Posterior scleritis on USG presents as diffuse or nodular scleral thickening, diffuse retinochoroidal thickening, fluid in Tenon's space, swelling of the optic disc, choroidal folds^[12] and exudative retinal detachments. Eye wall thickness of greater than 2mm is considered abnormal^[17]. When an episcleral inflammation occurs in the peripapillary region it causes distension of sub-Tenon's space producing the "T- sign"^[18]. Thus USG is a helpful ancillary test in the diagnosing posterior scleritis^[18].

Staphyloma is an acquired defect which occurs secondary to weakness and thinning of the scleral uveal coats. It commonly occurs posteriorly, although anterior staphyloma was also observed in our study. Posterior staphyloma defect is often located off-center from the optic disc, typically temporal to the disc^[19]. Progressive myopia, scleritis, necrotizing infection, surgery, and trauma are the common causes of posterior staphyloma. Anterior staphyloma is seen secondary to inflammation or infection of the sclero-corneal lining of the eye. In our study, four eyes with posterior staphyloma were diagnosed by USG, which could not be picked up by fundus examination due to the presence of cataract. One eye had both anterior and posterior staphyloma; it could not be diagnosed by clinical examination because of leucomatous corneal opacity.

The ultrasonographic features include increase in eye size and focal deformity which is seen temporal to optic disc. In our study, two eyes were diagnosed to have phthisis bulbi. It occurs as an end result of long standing inflammation like chronic iridocyclitis, organized haemorrhage. It can also occur following trauma, radiation to the eye. The globe becomes

atrophic and disorganized with thickened and folded sclera, with a calcified cataract. USG aided in diagnosis of this condition and to examine the posterior segment of these eyes.

Drusen of the optic nerve is characterized by the presence of highly reflective focus in the region of optic nerve head [21]. This condition was diagnosed in an eye with USG which could not be picked up on fundus examination due to the presence of cataract.

4.2 Echographic findings in traumatized eyes:

Ultrasound is a useful imaging modality for examination of the globe in patients with ocular trauma. Fifty cases (51 eyes) with history of trauma underwent ultrasound examination. The echographic findings of the traumatized eyes were correlated well with that of the study by Sharma O.P et al [4]. In traumatized eyes traumatic cataract was observed to be the most common cause for opaque media and vitreous haemorrhage was found to be the most common posterior segment abnormality. Traumatic hyphema was found in seven eyes corneal leucomatous opacity was found in five eyes and corneal opacity with seclusio pupillae was present in one eye. In all the above mentioned conditions USG was used to evaluate the posterior segment.

Two cases of IOFB were diagnosed on B-scan in cases with ocular injury. Ultrasound could precisely localise the foreign body [20]. Of these one was radiopaque and the other was not visualised on radiography. Later these were confirmed surgically to be tiny piece of metal and sharp wooden stick respectively. Thus B-scan not only helped in the detection of IOFB but also in determining the nature. One case of intraocular air bubble was wrongly diagnosed as an IOFB, as the air bubble also appeared echogenic that resembled a foreign body.

V. Accuracy Of Ultrasound

5.1 Accuracy in eyes with opaque media

Out of 101 eyes with opaque media which were included in the study and evaluated using the ultrasound 10 patients (10 eyes) were lost for follow-up and hence were not included in the estimation of accuracy (Validity) indices.

Table-4- Accuracy of ultrasound in the diagnosis of posterior segment pathologies in Opaque media

USG Diagnosis	Confirmed diagnosis		Total
	Normal posterior segment	Abnormal posterior segment	
Normal posterior segment	42	00	42
Abnormal posterior segment	00	49	49
Total	42	49	91

All 42 cases diagnosed as having normal posterior segment on ultrasound examination, on follow up were confirmed to have normal posterior segment. Thus, ultrasound had 100% sensitivity and 100% specificity in diagnosis of normal posterior segment. This was of significant importance, as the abnormalities of posterior segment were diagnosed prior to cataract extraction. Thus USG was of major use in ensuring the presence of normal posterior segment in eyes undergoing cataract surgery.

5.2 Accuracy in diagnosis of vitreous haemorrhage

Ultrasound was found to have a sensitivity 95.23 % and specificity 100% in diagnosis of vitreous haemorrhage, because one eye of patient with history of blunt trauma had mild vitreous haemorrhage which was missed in ultrasound examination.

Table-5- Accuracy of ultrasound in the diagnosis of Vitreous haemorrhage

USG Diagnosis	Confirmed diagnosis		Total
	Vitreous haemorrhage	No vitreous haemorrhage	
Vitreous haemorrhage	20	00	20
No vitreous haemorrhage	01	70	71
Total	21	70	91

5.3 Accuracy in diagnosis of retinoblastoma

USG had 100% sensitivity and 100% specificity in the diagnosis of retinoblastoma, correctly diagnosing two eyes with the condition. Three patients with leukocoria were referred for USG, among them two patients were diagnosed to have retinoblastoma and one eye was found to have PHPV. We observed that USG could rule out the presence of an intraocular mass.

Table-6- Accuracy of ultrasound in the diagnosis of Retinoblastoma

USG Diagnosis	Confirmed diagnosis		Total
	Retinoblastoma	No Retinoblastoma	
Retinoblastoma	2	00	2
No Retinoblastoma	00	89	89
Total	2	89	91

5.4 Accuracy in diagnosis of intraocular foreign body

In our study USG had a sensitivity 100%, specificity 97.72% in diagnosing IOFB. Totally three eyes were diagnosed to have IOFB on B-Scan. Two of these were found to be radiolucent IOFB and confirmed surgically. One eye with a history of penetrating history air bubble in the anterior chamber which was mistaken for an IOFB on USG. The air bubble was confirmed on CT scan. The sensitivity was 100% and the specificity was 97.72%.

Table-7- Accuracy in diagnosis of intraocular foreign body

USG Diagnosis	Confirmed diagnosis		Total
	IOFB	NO IOFB	
IOFB	2	01	3
NO IOFB	00	43	43
Total	2	44	46

VI. Conclusion

Ultrasound is an ideal diagnostic tool and prognostic indicator in the evaluation of eyes with opaque media where fundus examination has failed to visualize the posterior segment. Ultrasound is also extremely useful to rule out posterior segment pathologies in eyes with cataract. It is also accurate in the detection, differentiation and localization of intraocular tumours and also aids in staging the tumour. In the detection and localization of intraocular foreign bodies, ultrasound should be used as a supplement and not as a substitute to other radiological methods and clinical examination.

Hence due to its accuracy, cost effectiveness, safety, repeatability, absence of radiation exposure, excellent tissue differentiation and non-invasive in nature, ultrasound is an indispensable tool in the evaluation of ocular diseases especially in eyes with opaque media.

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