Pattern of Pathologies on B-Mode Ocular Ultrasound: An Observational Study

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Abstract: ***The superficial location of the eye, its cystic composition, and the advent of high-frequency ultrasound make sonography ideal for imaging the eye. Ultrasonic imaging of the eye has been undergoing progressive development for over a half century. Ocular B-mode ultrasonography (USG) is an essential adjuvant for evaluation of ocular diseases. This is not unconnected with the anatomic accessibility of the eye. The cystic nature of the eye also made it a good candidate for sonographic evaluation, a modality that is based on high frequency sound waves. But the beauty of ocular ultrasonography is its role as a substitute to ophthalmoscopy or as an ancillary to some ophthalmoscopic limitations. Direct visualization of the retro-bulbar pathologic lesions with ophthalmoscope is also not possible even with clear media. This therefore calls for a substitutive imaging modality like B-scan ocular ultrasonography that will readily characterize most ocular lesions. These lesions range from lens pathology to posterior eye segment pathologies. Materials & Methods: The study was conducted in the Department of Radiodiagnosis and Imaging, Sher-I-Kashmir Institute of Medical Sciences (SKIMS), Medical College and Hospital Srinagar, on patients referred from the Department of Ophthalmology, SKIMS Medical College and Hospital Srinagar. It was a cross-sectional study performed at SKIMS Medical College and Hospital. Diagnostic ultrasound was performed using a high resolution and high-frequency probe on the affected eye. A data collection sheet was used to record the ultrasound findings. Ocular findings were stratified by sex, age group and affected eye. Findings were presented in the form of tables, charts and graphs. The study was conducted over a period of one and a half year in the Department of Radiodiagnosis and Imaging on all patients referred for Ocular Ultra sound. Diagnostic ultrasound was performed with a high frequency (10MHz) linear transducer. The examination was performed in brightness (B-mode) with the patient in the supine position and the eyes closed, slightly resting the transducer on both eyelids, after application of 4% topical lignocaine and coupling gel. Axial images were acquired from the lower to the upper limits of the entire globe followed by sagittal images from the nasal to the temporal side. All patients referred for ocular ultrasound were recruited into the study after consenting to the study and meeting the inclusion criteria. The principal investigator interviewed the patient and document the patient's biodata and presenting complaints in the data collection tool. Diagnostic ultrasound was then performed on the affected eye by an experienced ocular sonographer and the principal investigator and images displaying pathology were acquired and printed. Specific diagnoses were made according to criteria set out in Diagnostic Imaging of the Eye. Results: Majority of the age distribution of the study population belonged to the 30–49-year age group i. e., 56 (51.88 %) followed by 11–29-year age group i. e., 19 (17.92 %) and >50 years i. e., 19 (17.92%). There were 12 (11.32%) patients who aged between 1-10 years. There were 66 (64.85%) males and 39 (37.15%) females in our study. Right eye involvement was observed in 49 (46.67%) patients, 42 (40%) patients had left eye involvement and 14 (13.33%) had bilateral eye involvement. On ultrasonography, retinal detachment was the most common finding in 28 (26.66%) followed by vitreous hemorrhage in 24 (22.85%), vitreous detachment in 18 (17.14%). Most common symptom at presentation was decreased vision followed by leukocoria in 42.57%, trauma in 20.43%, pain and redness in 15.71%, discharge in 3.78% and exophthalmos in 4.32% patients. The study demonstrated that at least half of the ocular pathologies result in diminution of vision and hence the importance of ultrasound as a diagnostic tool in the evaluation of ocular pathologies. The low volume of patients with orbital pathologies is due to referring clinicians preferring CT scan of the orbits over ultrasound for evaluation of the orbit. Vitreous hemorrhage was the USG finding observed in 16 males and 8 females, vitreous detachments in 13 and 5 males and females respectively, retinal detachments in 17 and 11 males and females respectively, retinal metastasis and slow flow vascular malformation were not seen in any male patient but in 1 female patient each. Vitreous hemorrhage and vitreous detachment were significantly more common in 30–49-year group. Vitreous hemorrhage accounted for 57.1% (p 0.05). The distribution of sonographic diagnoses for males and females were not significantly different. Conclusion: Ultrasonography is readily available, simple, cost effective, non-ionizing, non-invasive and a reliable imaging modality for posterior segment ocular pathologies. It readily establishes the diagnosis in significant number of cases. The superficial location of the eye, its cystic composition, and the advent of high-frequency ultrasound make sonography an ideal imaging modality for imaging of the eye. 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). Even though for most orbital pathologies, it needs additional investigations (CT, MRI, histopathology) for confirming the diagnosis, ultrasound proves a useful imaging tool and correlates very well with the final diagnosis.***

Keywords: Ocular; Ultrasound; Imaging; Pathology

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1. Introduction

The superficial location of the eye, its cystic composition, and the advent of high-frequency ultrasound make sonography ideal modality for imaging the eye [1]. The use of ultrasound for diagnostic imaging of the eye originates with the work of Mundt and Hughes [2] (A-scan) & Baum and Greenwood [3] (B-scan) in the 1950s. Ocular B-mode ultrasonography (USG) is an essential adjuvant for evaluation of ocular diseases. The cystic nature of the eye also makes it a good candidate for sonographic evaluation, a modality that is based on high frequency sound waves. But the beauty of ocular ultrasonography is its role as a substitute to ophthalmoscopy or as an ancillary to some ophthalmoscopic limitations. For example, it gives instantaneous information on lesions in eyes with opaque ocular media [1, 3, 4]. This opaque medium would ordinarily have conferred some hindrances to adequate ophthalmoscopic visualization of the posterior segment of the globe. Direct visualization of the retro-bulbar pathologic lesions with ophthalmoscope is also not possible even with clear media [1]. This therefore calls for a substitutive imaging modality like B-scan ocular ultrasonography that will readily characterize most ocular lesions. These lesions range from lens pathology to posterior eye segment pathologies. Ultrasound is a valuable tool to evaluate the eye, particularly when direct examination and fundoscopy is not sufficient [5]. MRI and CT have also been utilized to evaluate the eye; however, they are costlier and less available compared to the ultrasound [6]. In 1972, Bronson and Turner [7] described the first contact B-Scan making ultrasound an easy and patient friendly imaging modality. This, and other significant work by Purnell [8] and Coleman et al [9] laid to major expansion and popularization of B-Scan. In 1990, Pavlin and colleagues described the first high frequency ultrasound (50-100MHz) in Ophthalmology [9]. B-Mode ultrasound has allowed us to investigate subtypes of glaucoma, lesions in the iris, ciliary body, sclera, and pars plana [10]. Now ultrasound is considered an essential tool in the investigation and management of many ocular and orbital disorders [11, 12]. The evaluation of eyes with opaque ocular media is one of the primary indications for the use of ocular ultrasonography [13, 14]. Ultrasound is a valuable tool to evaluate the eye, particularly when direct examination and fundoscopy is not sufficient [15] Sonography demonstrates the eye as a circular hypoechoic cystic structure. The vitreous chamber contains hypoechoic fluid. The retina and choroid cannot be separated sonographically. The optic nerve is demonstrated as a hypoechoic linear structure extending posteriorly from the globe [4]. Retinoblastoma and choroidal melanoma are the most frequent intraocular tumors. In the orbit, common pathologies include orbital pseudotumor, Grave's orbitopathy, and retro-orbital hematoma. All these pathologies can be sufficiently evaluated with ultrasound [16-21]. From anterior to posterior, the anterior eye segment consists of cornea, anterior chamber, iris, ciliary body, posterior chamber and lens. These are structures that rarely require ultrasonography, as they are readily assessed by clinical evaluations, ophthalmoscopy, slit-lamp examination, and ultrasound bio microscopy. The later uses frequencies as much as 35-50 MHz to evaluate abnormalities like ocular trauma, foreign bodies and opaque elements in the anterior segment [22-25]. Notwithstanding the core utility of ultrasonography in posterior eye segment evaluations, it has also been used to localize intra-ocular foreign body (IOFB) in the anterior chamber thereby defining the size, shape and nature of the IOFB [26]. On US, small metallic IOFB in the anterior eye segment will appear as a markedly echogenic short linearity that cast comet tail artefact. Cataract is defined as any opacity of the lens that results in significant variations in the refractive index of the lens over distances like the wavelength of transmitted light. Common causes of cataract include long-term exposure to the sun's ultraviolet light, aging, inherited disorders, diabetes mellitus and trauma [27, 28].

On ophthalmoscopy, cataract is seen as a white reflection with an opaque lens called leukocoria. B-scan is important in cataracts as it evaluates the posterior eye segment which may be difficult with ophthalmoscopy. On B-scan, features of cataracts range from completely opaque hyperechoic lens cortex, intra-lenticular echoes, reflective material beneath the lens capsule, thick hyperechoic posterior capsule of the lens and combined thick hyperechoic anterior and posterior lens capsules. In immature cataracts, scattered opacities are separated by clear zones whereas in mature cataract, the thick echogenicity on the posterior capsule of the lens is a continuous plaque [23]. Lens dislocation could be traumatic, spontaneous or it could originate from hereditary or connective tissue diseases. Examples of the last etiologies are Marfan's syndrome, congenital aniridia, congenital glaucoma, Ehlers –Danlos syndrome, homocystinuria and molybdenum cofactor deficiency [29]. The commonest cause is trauma. Here, blunt force in anterior-posterior direction leads to globe equatorial expansion leading to zonular fibers disruption and lens dislocation [30-32]

In partial dislocation, the crystalline lens remains partially attached to one ciliary body and has an oblique axis. The delayed complications of lens dislocation include secondary or phacolytic glaucoma, delayed retinal detachment, allergic uveitis, proliferative vitreoretinopathy, cataract and vision loss [29]. Treatment of choice for lens dislocation is surgical repair, repositioning, explanting, or exchanging the displaced intraocular lens [31]. The vitreous fluid is an acellular viscous fluid with 99% water content and the rest consists of type 2 collagen fibrils and hyaluronic acid [23]. However, due to ageing, liquefaction of the vitreous called syneresis occurs. This will lead to ultrasonographic detection of few low-amplitude punctate and linear mobile echoes floating within the vitreous chamber, often referred to as "floaters" [23, 33, 34].

Vitreous hemorrhages are caused by trauma, proliferative vascular retinopathies, coagulopathies, age related macular degenerations, retinal breaks, retinal microaneurysms, posterior vitreous detachment (PVD) and neoplasia. On USS, they appear as reflective intra-gel mobile dot echoes that are dependent and freely moves with dynamic scan. Acute bleed will appear as echo lucent or low reflective echoes. These hemorrhages may clear in 2-4 weeks or become chronic. When hemorrhages become chronic, the dot-like echoes get organized to form fibrinous vitreous membranes of varying reflectivity and devoid of anatomic attachment [23, 34, 35].

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Asteroid hyalosis is an asymptomatic degenerative condition resulting from calcium soaps accumulation on vitreous fibrils in the eye [34]. It is usually unilateral, and the cause is unknown, but it is common in diabetes mellitus. On USS, the vitreous cavity shows a variable number of discrete mobile bright echoes (reminiscent of the particles in a snow globe) with a classical space between the particles and posterior globe wall [23, 25]. PVD is an-age related phenomenon whereby the posterior vitreous capsule or hyaloid detaches from the underlying retina [23]. On USS especially on dynamic scan, it characteristically shows as an undulating membrane that moves freely and should swirl away from the region of the optic disc in cases of complete posterior vitreous detachment [23]. It can also be due to vitreoschisis which is splitting of the posterior cortical vitreous, common in diabetic retinopathy [34].

On ultrasonography, retro-hyaloid hemorrhages appear as multiple low reflective dot echoes posterior to PVD which may demonstrate layering of echoes with a straight surface but moves with head movement [34].

Retinal detachment (RD) is the detachment of the inner sensory layer of the retina from the outer pigmented layer called retinal pigmented epithelium [23, 34]. The classical USS features of total RD is a "V" shape echogenic lesion in the vitreous cavity with anterior attachment to the ora-serrata and posterior attachment to the optic nerve head [23, 30]. On the other hand, partial RD will show as an intra-vitreal linear echogenic membrane extending to the optic nerve head, but not across it [23, 34]. The leaflets of the membranes in acute RD are thinner and more mobile than in chronic RD. Thus, Chronic RD is often seen as a rigid "triangle sign" [23, 31]. Causes of sub-retinal hemorrhages are trauma, age related macular degeneration, intra-papillary hemorrhages, diabetes mellitus, retinal tear, RD and ocular tumors [33]. On USS, sub-retinal hemorrhages present as echogenic debris beneath an elevated retina. This debris has variable reflectivity due to clotted or lysed blood. It tends to change contour and reduction in height with time due to resolution or breakthrough vitreous hemorrhage [33]. Retinoblastoma is the commonest childhood malignant ocular tumor. The tumor arises from the retina and could be exophytic (subretinal) or endophytic (growing towards the vitreous cavity) [33]. On US, it could present as a single or multiple solid mass with irregular high internal reflectivity due to presence of calcium [33].

2. Materials & Methods

The study was conducted in the Department of Radiodiagnosis and Imaging, Sher-i-Kashmir Institute of Medical Sciences (SKIMS), Medical College and Hospital Srinagar, on patients referred from the Department of Ophthalmology, SKIMS Medical College and Hospital Srinagar. The present cross-sectional study was performed over a period of one and a half year at SKIMS Medical College and Hospital ultrasound room on all patients referred for Ocular ultrasound. Diagnostic ultrasound was performed using a high resolution and high-frequency probe (10MHz) on the affected eye. A data collection sheet was used to record the ultrasound findings. Ocular findings were stratified by sex, age group and affected eye. The examination was performed in brightness (B-mode) with the patient in the supine position and the eyes closed, slightly resting the transducer on both eyelids, after application of 4% topical lignocaine and coupling gel. Axial images were acquired from the lower to the upper limits of the entire globe followed by sagittal images from the nasal to the temporal side. All patients referred for ocular ultrasound were recruited into the study after consenting to the study and meeting the inclusion criteria.

The principal investigator interviewed the patient and document the patient's bio data and presenting complaints in the data collection tool. Diagnostic ultrasound was then performed on the affected eye by an experienced ocular sonographer and the principal investigator and images displaying pathology were acquired and printed. Specific diagnoses were made according to criteria set out in Diagnostic Imaging of the Eye. Statistical analysis was done using SPSS version 21. Categorical variables such as sex and presenting complaints were summarized into percentages and continuous data such as age was presented as means and standard deviations. Ocular findings were analyzed as proportions and presented with 95% confidence intervals. Stratification of ocular findings was done by sex, age group and affected eye and associations tested using Chi square test. Statistical tests were interpreted at 5% level of significance (p value less or equal to 0.05). Findings were presented using tables and graphs.

3. Results

Majority of patients belonged to the 30-49-year age group i. e., 56 (52.84%) followed by 11-29 and >50 i. e., 19 (17.92%). There were 12 (11.32%) patients who aged between 1-10 years. There were 66 (64.85%) males and 39 (37.15%) females in our study. Right eye involvement was observed in 49 (46.67%) patients, 42 (40%) patients had left eye involvement and 14 (13.33%) patients had bilateral eye involvement. Most common symptom at presentation was decreased vision in 56.32% patients followed by leucocoria in 42.57%, trauma in 20.43%, pain and redness in 15.71%, discharge in 3.78% and exophthalmos in 4.32% patients. On ultrasonography retinal detachment was the most common finding in 28 (26.66%) followed by vitreous hemorrhage in 24 (22.85%), vitreous detachment in 18 (17.14%).

Similar findings were observed by Gathogo Martin M (2016) [35] where the age ranged from two months to eighty-seven years with a mean age of 30.6 years and a median age of 29.5 years. Males (69%) were more than females (31%) and this correlated with previous studies by Hemang DC et al (2013) [36] and Sharma OP (2005) [37]. Table.3 depicts involvement of eye in the studied population. Right eye involvement was seen in 49 (46.67%) patients while as 42 (40%) patients had left eye involvement and 14 (13.33%) had bilateral eye involvement. Similar studies were observed by Gathogo Martin M (2016) [35] wherein the left eye (39.3%) was slightly more affected followed by the right eye (36.9%) and both eyes (23.8%) respectively. This was also observed in prior studies by various authors. Most common symptom at presentation was decreased vision in 56.32% patients followed by leucocoria in 42.57%, trauma in 20.43%, pain and redness in 15.71%,

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discharge in 3.78% and exophthalmos in 4.32% patients. Gathogo Martin M (2016) [35] conducted a study in which the most common presenting complaints were reduction in vision (52%) and trauma (27%) while the least common presenting complaint was discharge (2.4%).

This correlated well with a study done in India by Sharma et al in which reduction in vision and trauma accounted for 49% and 27% respectively [7]. The study demonstrated that at least half of the ocular pathologies result in diminution of vision and hence the importance of ultrasound as a diagnostic tool in the evaluation of ocular pathologies. On ultrasonography retinal detachment was the most common finding in 28 (26.66%) followed by vitreous haemorrhage in 24 (22.85%), vitreous detachment in 18 (17.14%).

Gathogo Martin M (2016) [35] studied that 84 patients who were assessed, ocular pathologies accounted for 69.0% while orbital pathologies accounted for 2.4%. The low volume of patients with orbital pathologies is due to referring clinicians preferring CT scan of the orbits over ultrasound for evaluation of the orbit. In our study, vitreous haemorrhage was the USG finding observed in 16 males and 8 females, vitreous detachments in 13 and 5 males and females, retinal detachments in 17 and 11 males and females, retinal metastasis and slow flow vascular malformation were not seen in any male patient but in 1 female patient each. Gathogo Martin M (2016) [35] conducted a study in which the most common sonographic diagnoses were vitreous haemorrhage, vitreous detachment and retinoblastoma which accounted for 21%, 16% and 15% respectively.

This correlated well with studies by Hemang DC et al (2013) [36] and Sharma OP (2005) [37] that demonstrated vitreous haemorrhage as the most common sonographic diagnosis which accounted for 20% and 28% respectively [5, 7]. Vitreous haemorrhage and vitreous detachment were significantly more common in 30-49-year-old. Vitreous haemorrhage accounted for 57.1% ($p<0.001$) while vitreous detachment accounted 38.1% ($p=0.010$). This is explained by the higher incidence of ocular trauma in this age group. Trauma is the most common cause of vitreous haemorrhage and detachment.

Retinoblastoma occurred exclusively in patients below 10 years old ($p<0.001$). Retinoblastoma is rare above 10 years of age. All the other diagnoses were not significantly associated with age of the patients ($p>0.05$). The distribution of sonographic diagnoses for males and females were not significantly different.

4. Conclusion

Ultrasonography is readily available, simple, cost effective, non-ionizing, non-invasive and a reliable imaging modality for posterior segment ocular pathologies. 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). Even though for most orbital pathologies, it needs additional investigations (CT, MRI, histopathology) for confirming the diagnosis, ultrasound proves a useful imaging tool and correlates very well with the final diagnosis.

Declaration

The authors declare that there are no potential financial or non-financial conflicts of interest.

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Table 1: Age distribution of study population

Age in Years	Number of Patients	Percentage
1-10	12	11.32
11-29	19	17.92
30-49	55	51.88
≥50	19	17.92
Total	105	100.00

Table 2: Gender distribution of study population

Gender	Number of Patients	Percentage
Males	66	64.85
Females	39	37.15
Total	105	100.00

Table 3: Laterality of pathologies

Laterality	Number of Patients	Percentage
Left Eye	42	40.00
Right Eye	49	46.67
Bilateral	14	13.33
Total	105	100.00

Table 4: Symptoms at presentation

Symptoms	Percentage
Decreased vision	56.32
Leucocoria	42.57
Trauma	20.43
Pain and redness	15.71
Discharge	03.78
Exophthalmos	04.32

Table 5: Ultrasound Findings

USG Findings	Number of Patients	Percentage
Vitreous hemorrhage	24	22.85
Vitreous detachments	18	17.14
Choroid detachments	4	3.80
Retinal detachments	28	26.66
Posterior uveitis	5	4.76
Persistent hyperplastic primary vitreous	3	2.85
Endophthalmitis	3	2.85
Retinoblastoma	3	2.85
Lens dislocation	2	1.90
Foreign body	3	2.85
Optic nerve glioma	2	1.90
Posterior staphyloma	2	1.90
Retrobulbar hematoma	3	2.85
Thyroid orbitopathy	3	2.85
Retinal metastasis	1	0.95
Slow flow vascular malformation	1	0.95

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Table 6: Ultrasonographic findings with gender

USG Findings	Male		Female	
Vitreous hemorrhage	16	24.24%	8	20.51%
Vitreous detachments	13	19.69%	5	12.82%
Choroid detachments	3	4.54%	1	2.56%
Retinal detachments	17	25.75%	11	28.20%
Posterior uveitis	3	4.54%	2	5.12%
Persistent hyperplastic primary vitreous	2	3.03%	1	2.56%
Endophthalmitis	2	3.03%	1	2.56%
Retinoblastoma	2	3.03%	1	2.56%
Lens dislocation	1	1.51%	1	2.56%
Foreign body	2	3.03%	1	2.56%
Optic nerve glioma	1	1.51%	1	2.56%
Posterior staphyloma	1	1.51%	1	2.56%
Retrobulbar hematoma	2	3.03%	1	2.56%
Thyroid orbitopathy	1	1.51%	2	5.12%
Retinal metastasis	0	0%	1	2.56%
Slow flow vascular malformation	0	0%	1	2.56%
Total	66	100%	39	100%

Table 7: Relationship of ultrasound findings with age (in years)

USG Findings	1-10	10-29	30-49	≥50
Vitreous hemorrhage	1	4	14	6
Vitreous detachments	1	2	11	4
Choroid detachments	0	0	3	1
Retinal detachments	2	2	18	6
Posterior uveitis	1	2	2	0
Persistent hyperplastic primary vitreous	3	0	0	0
Endophthalmitis	0	1	2	0
Retinoblastoma	3	0	0	0
Lens dislocation	0	1	1	0
Foreign body	0	2	1	0
Optic nerve glioma	1	1	0	0
Posterior staphyloma	0	0	1	1
Retrobulbar hematoma	0	2	1	0
Thyroid orbitopathy	0	2	1	0
Retinal metastasis	0	0	0	1
Slow flow vascular malformation	0	0	1	0

Legends

Fig.1 Clinical image of proptosis (A) with Ultrasound images showing retrobulbar slow flow vascular malformation (B & C).
Fig.2 Ultrasound image showing retinal detachment (A) with posterior detachment (B).
Fig.3 Imaging showing Optic nerve glioma (A) with image (B) showing retrobulbar hematoma.
Fig.4 Ultrasound images showing retinal detachment (A) with vitreous detachment and vitreous haemorrhage (B).
Fig.5 clinical picture showing Leucocoria (A) with corresponding ultrasound images showing retinoblastoma (B & C).

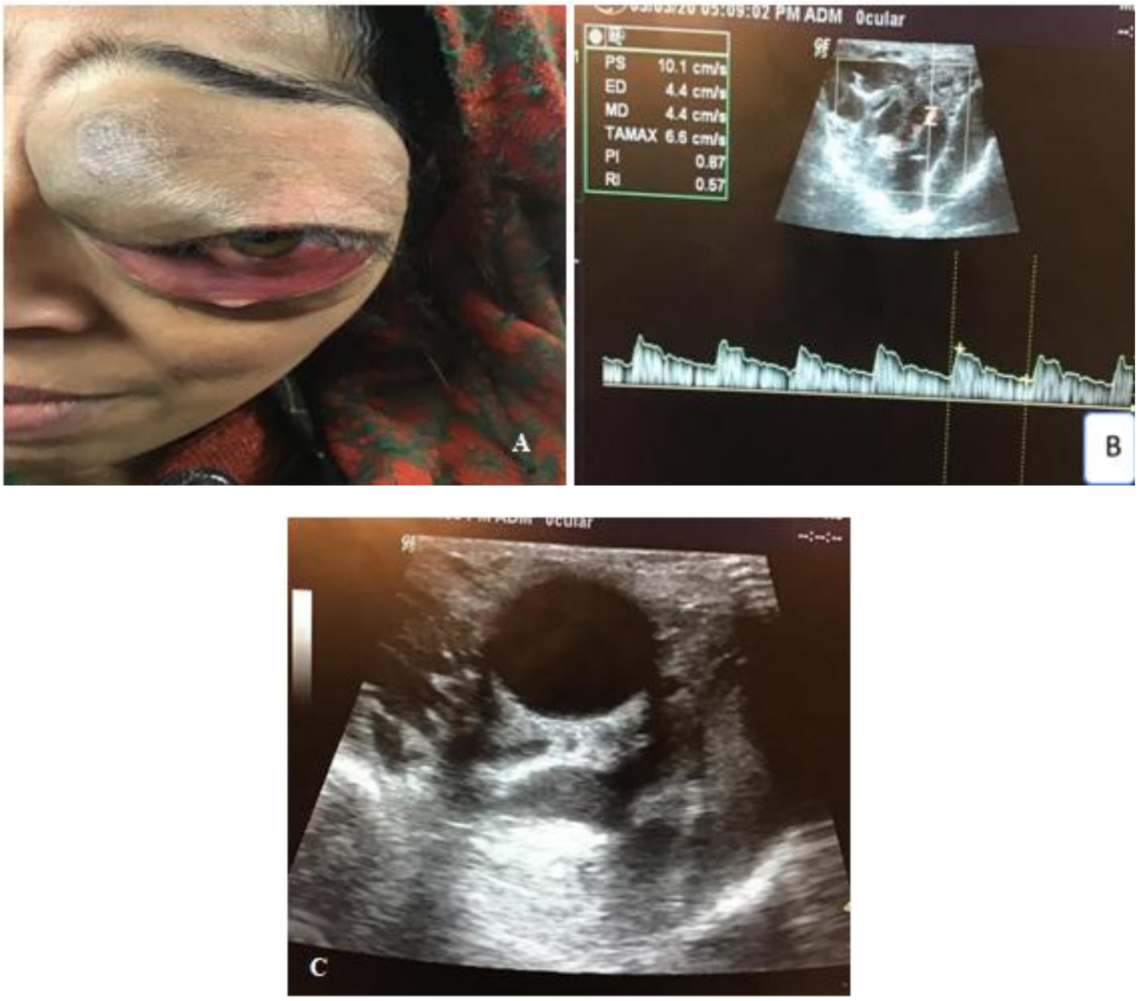

Figure 1

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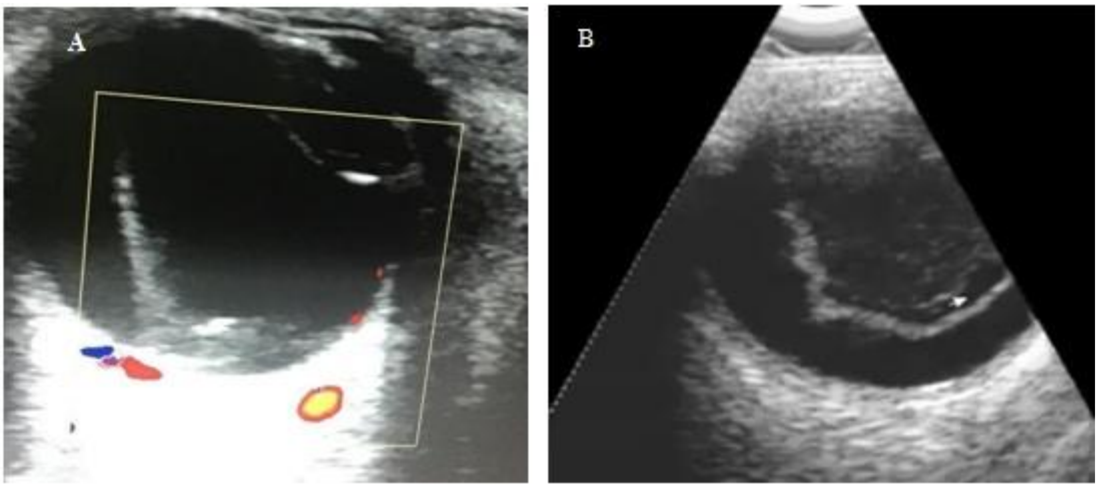

Figure 2

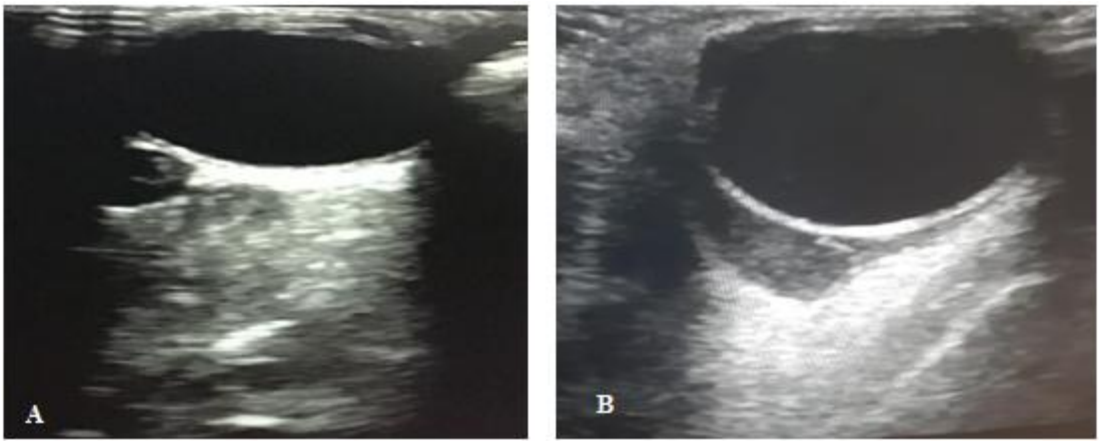

Figure 3

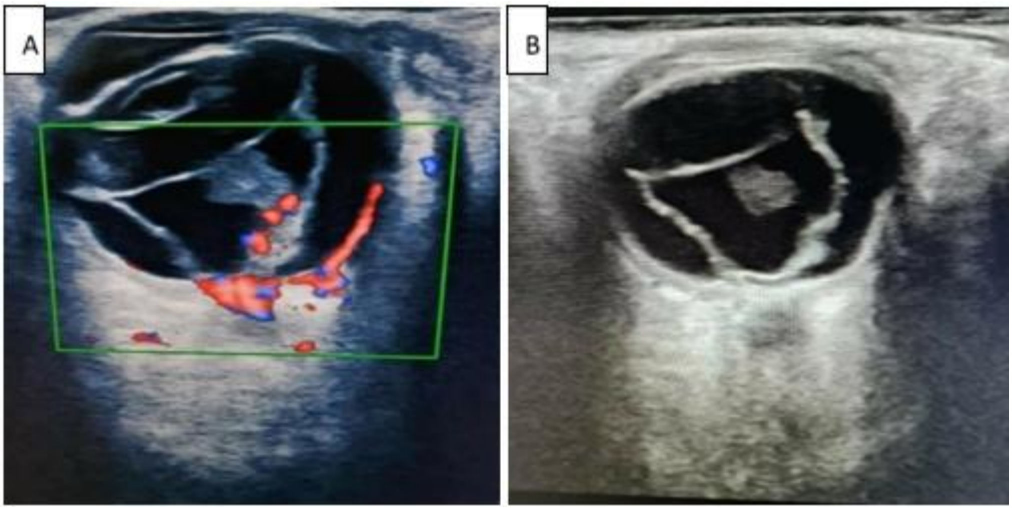

Figure 4

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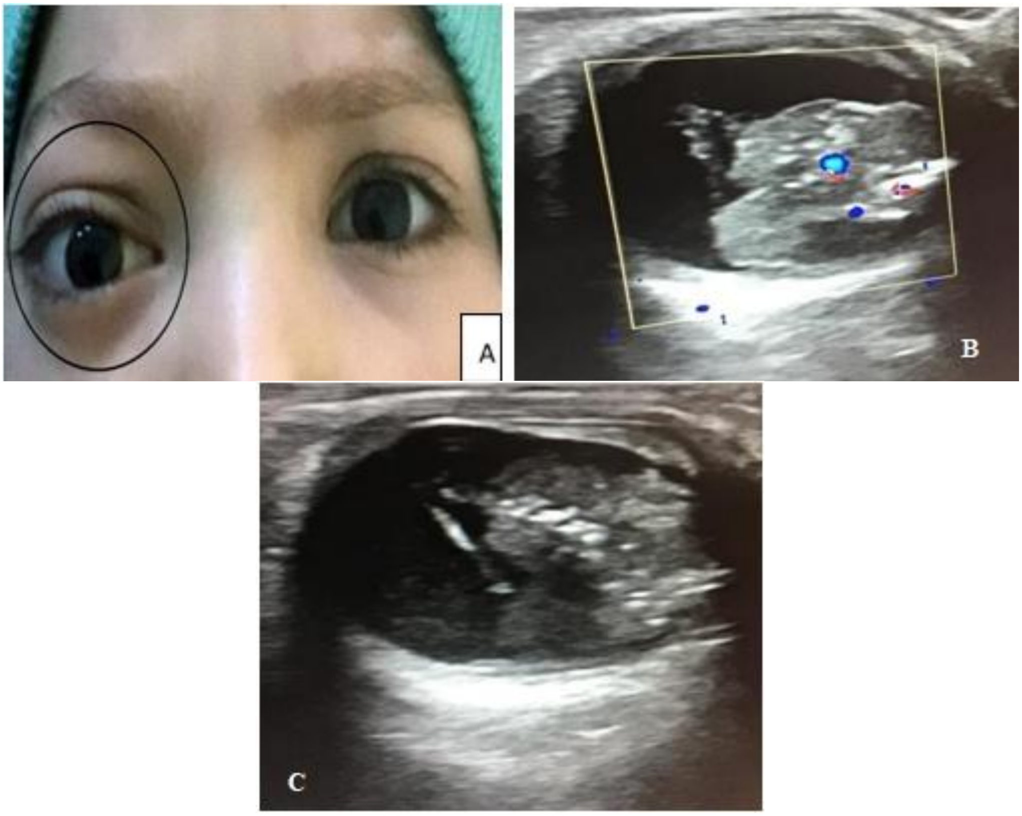

Figure 5

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