Original Article

Diagnostic Accuracy of Ocular Ultrasound in Assessment of Vitreous Hemorrhage and Associated Ocular Diseases

Ahmad Ch Raza*

*Corresponding Author: dr.ahmad663@gmail.com

Keywords: Ocular Ultrasound, Vitreous Hemorrhage, Proliferative Diabetic Retinopathy, Ocular Trauma, Diagnostic Accuracy, Non-Invasive Imaging, B-Scan Ultrasound, Ophthalmic Ultrasonography, Retinal Vascular Disorders, Emergency Ophthalmology.

Abstract

Background: Vitreous hemorrhage (VH) is a significant ophthalmic condition with a yearly incidence ranging from 7.4 to 15.4 per 100,000 people. Its primary causes include proliferative diabetic retinopathy (PDR), ocular trauma, and other retinal vascular disorders. Ocular ultrasound is increasingly utilized as a rapid, non-invasive diagnostic tool to assess vitreous hemorrhage and related ocular conditions.

Objective: This study aimed to evaluate the diagnostic accuracy of ocular ultrasound in detecting vitreous hemorrhage and associated ocular diseases in a clinical setting.

Methods: A cross-sectional observational study was conducted at the University of Lahore Teaching Hospital from October 09, 2023, to March 21, 2024. The study included 70 symptomatic patients diagnosed with acute age-related vitreous hemorrhage. Detailed ophthalmic examinations were performed using noncontact or three-mirror lenses, slit-lamp vitreous biomicroscopy, and indirect binocular ophthalmoscopy. B-scan ocular ultrasound, with a focused probe of 7.5 MHz and high-sensitivity gain settings, was employed to perform echographic tests. Data on demographic details, medical history, clinical findings, and ultrasound results were collected and analyzed using SPSS version 25. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy were calculated to determine the diagnostic efficacy of ocular ultrasound.

Results: Out of 70 patients, 43 (61.42%) were males and 27 (38.60%) were females. The age distribution showed 50 patients (71.42%) were under 50 years old, while 20 patients (28.60%) were over 50 years old. The causes of vitreous hemorrhage included proliferative diabetic retinopathy (30%), penetrating trauma (24.3%), post-intraocular surgery (11.42%), and blunt trauma (10%). The diagnostic accuracy of ocular ultrasound for detecting vitreous hemorrhage demonstrated a sensitivity of 77.8%, specificity of 35.3%, PPV of 56.0%, NPV of 60.0%, and an overall accuracy of 57.14%.

Conclusion: Ocular ultrasound proved to be a valuable, non-invasive diagnostic tool with high sensitivity for detecting vitreous hemorrhage, though its specificity was moderate. While useful for initial assessments, especially in emergency settings, it should be supplemented with comprehensive ophthalmic examinations for accurate diagnosis and management of vitreous hemorrhage.

1 Introduction

Vitreous hemorrhage, characterized by the presence of extravasated blood within the vitreous body, is a condition with significant clinical implications. It has an annual incidence ranging from 7.4 to 15.4 per 100,000 people, depending on the population under investigation. The primary causes of vitreous hemorrhage include retinal vein occlusion, ocular trauma, and proliferative diabetic retinopathy (PDR), with trauma being the leading cause in young individuals. The vitreous body, a transparent, gel-like substance that occupies the space between the lens and retina, plays a crucial role in maintaining the eye’s optical clarity. During an acute hemorrhagic episode, blood enters the vitreous cortex through the pores or apertures of the posterior hyaloid (1). Vitreous hemorrhage can result from ruptures of normal retinal vessels, abnormal new vessels, or bleeding from other intraocular sources, leading to potential blindness if not managed appropriately (2).

The etiology of vitreous hemorrhage is diverse, encompassing trauma, vitreous detachment with or without retinal tears, and proliferative diabetic retinopathy. Less common causes include vascular occlusive diseases, retinal artery macroaneurysms, hemoglobinopathies, age-
related macular degeneration (AMD), intraocular tumors, and retinopathy of prematurity. The presence of blood within the vitreous impairs vision, complicates laser therapy, and accelerates disease progression (3). Although rare, vitreous hemorrhage associated with exudative AMD is a significant concern, with unstable neovascularure being a potential underlying mechanism (5). Despite technological advancements, ultrasonography remains indispensable for diagnosing and monitoring vitreous hemorrhage. It offers a rapid, convenient, and precise method of assessing ocular conditions, particularly in emergency settings (6, 7).

Ocular ultrasound employs a high-frequency linear probe (7.5 MHz or more) to scan the eye, using specific presets and generous amounts of acoustic coupling gel to ensure optimal contact and prevent probe pressure on the acute eye. Scanning is performed in both longitudinal and transverse planes, with gain settings adjusted to visualize vitreous contents and the globe’s walls and optic nerve (8). This imaging modality is effective in evaluating vitreous hemorrhage, vitreous detachment, retinal detachment, ocular malignancies, intraocular foreign bodies, globe rupture, and retinal hemorrhage. The degree of bleeding and the time elapsed since the hemorrhage influence the ultrasonographic findings. Acute vitreous hemorrhage appears as dispersed, poorly defined echogenic opacities, while subacute to chronic hemorrhage organizes into more echogenic membranous structures (9, 10).

This study aims to evaluate the diagnostic accuracy of ocular ultrasound in assessing vitreous hemorrhage and associated ocular diseases. Conducted at the University of Lahore Teaching Hospital, this cross-sectional observational study included symptomatic patients diagnosed with acute age-related vitreous hemorrhage. Patients presenting to the emergency room with symptoms indicative of recent vitreous hemorrhage were referred to the ophthalmology department. A general ophthalmologist conducted thorough eye examinations using noncontact or three-mirror lenses and slit-lamp vitreous biomicroscopy. When a Weiss’ ring was detected, the diagnosis of full vitreous hemorrhage was confirmed. B-scan ocular ultrasound with a focused probe of 7.5 MHz and high-sensitivity gain settings was employed for echographic tests. The statistical analysis, including sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy, was performed using SPSS version 17.

In conclusion, B-scan ultrasonography is a valuable non-invasive diagnostic tool for evaluating intraocular damage resulting from forceful or piercing eye injuries, often preventing ophthalmoscopy due to opacifying media. This study seeks to elucidate the effectiveness of ocular ultrasound in detecting vitreous hemorrhage, emphasizing its high sensitivity, specificity, and moderate accuracy. The findings will contribute to the existing literature on ocular ultrasound’s role in diagnosing and managing vitreous hemorrhage and associated ocular conditions, providing insights for clinical practice and future research (1, 2, 3, 5, 6, 7, 8, 9, 10).

2 Material and methods

The cross-sectional observational study was conducted at the University of Lahore Teaching Hospital, Lahore, spanning from October 09, 2023, to March 21, 2024. This study aimed to evaluate the diagnostic accuracy of ocular ultrasound in patients presenting with vitreous hemorrhage. The study population included 70 symptomatic patients, comprising 43 males and 27 females, who met the inclusion criteria and were diagnosed with acute age-related vitreous hemorrhage. Patients presenting to the emergency room with symptoms indicative of recent vitreous hemorrhage were referred to the ophthalmology department by primary emergency care providers.

A comprehensive ophthalmic examination was performed on an emergency basis by a general ophthalmologist. This examination included the use of noncontact or three-mirror lenses and slit-lamp vitreous biomicroscopy. When a Weiss’ ring was detected through biomicroscopy, the diagnosis of full vitreous hemorrhage was established. To further evaluate the peripheral retina and vitreous hemorrhage, the examiner opted for indirect binocular ophthalmoscopy with or without scleral indentation, or slit-lamp biomicroscopy combined with a three-mirror contact lens. Ocular ultrasound, utilizing a focused probe of 7.5 MHz with mechanical sector scanning, was employed for blind echographic examinations. High-sensitivity gain settings of 105 dB were specifically chosen for vitreous investigations.

The patients were positioned supine with their eyelids held open, and the probe was placed directly on the ocular surface beyond the limbus. The probe was then moved around the conjunctiva in transverse sections or cross-sections to examine more peripheral aspects of the vitreoretinal interface. Data collection involved documenting demographic details, medical history, clinical findings, and ultrasound results. Ethical approval for the study was obtained from the institutional review board, and all procedures adhered to the tenets of the Declaration of Helsinki. Informed consent was obtained from all participants prior to their inclusion in the study.

The collected data were analyzed using SPSS version 25. Descriptive statistics, including mean and standard deviation, were calculated for continuous variables, while frequencies and percentages were computed for categorical variables. The diagnostic accuracy of ocular ultrasound was determined by calculating sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy. These metrics were computed based on the proportion of patients accurately diagnosed with vitreous hemorrhage using ocular ultrasound compared to the clinical diagnosis confirmed through biomicroscopy and ophthalmoscopy (1, 2, 3, 4, 5).
This methodology ensured a rigorous and systematic approach to evaluating the diagnostic performance of ocular ultrasound in the clinical setting, contributing valuable insights into its efficacy for detecting vitreous hemorrhage and associated ocular conditions. The results of this study are anticipated to inform clinical practice and guide future research in ophthalmic diagnostics.

3 Results

The study included 70 patients, of which 43 (61.42%) were males and 27 (38.60%) were females. The age distribution revealed that 50 patients (71.42%) were under 50 years old, and 20 patients (28.60%) were over 50 years old. The causes of vitreous hemorrhage among the study population varied, with proliferative diabetic retinopathy (PDR) being the most common cause, followed by penetrating trauma, post-intraocular surgery, and blunt trauma.

Table 1: Causes of Vitreous Hemorrhage (n=70)

<table>
<thead>
<tr>
<th>Cause</th>
<th>Number of Patients</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proliferative Diabetic Retinopathy</td>
<td>21</td>
<td>30.0</td>
</tr>
<tr>
<td>Penetrating Trauma</td>
<td>17</td>
<td>24.3</td>
</tr>
<tr>
<td>Post-Intraocular Surgery</td>
<td>8</td>
<td>11.42</td>
</tr>
<tr>
<td>Blunt Trauma</td>
<td>7</td>
<td>10.0</td>
</tr>
<tr>
<td>Retinal Vein Occlusion</td>
<td>5</td>
<td>7.14</td>
</tr>
<tr>
<td>Vitreous Detachment with Tears</td>
<td>4</td>
<td>5.71</td>
</tr>
<tr>
<td>Age-Related Macular Degeneration</td>
<td>3</td>
<td>4.28</td>
</tr>
<tr>
<td>Vitreous Detachment without Tears</td>
<td>2</td>
<td>2.9</td>
</tr>
<tr>
<td>Anticoagulant Therapy</td>
<td>1</td>
<td>1.42</td>
</tr>
<tr>
<td>After Laser Treatment</td>
<td>1</td>
<td>1.42</td>
</tr>
<tr>
<td>Premature Retinopathy</td>
<td>1</td>
<td>1.42</td>
</tr>
</tbody>
</table>

Table 2: Gender and Age Distribution of Patients (n=70)

<table>
<thead>
<tr>
<th>Demographic Factor</th>
<th>Category</th>
<th>Number of Patients</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Males</td>
<td>43</td>
<td>61.42</td>
</tr>
<tr>
<td>Gender</td>
<td>Females</td>
<td>27</td>
<td>38.6</td>
</tr>
<tr>
<td>Age</td>
<td>&lt; 50 years</td>
<td>50</td>
<td>71.42</td>
</tr>
<tr>
<td>Age</td>
<td>&gt; 50 years</td>
<td>20</td>
<td>28.6</td>
</tr>
</tbody>
</table>

The diagnostic accuracy of ocular ultrasound in detecting vitreous hemorrhage was evaluated through several statistical measures. The sensitivity was found to be 77.8%, specificity 35.3%, positive predictive value (PPV) 56.0%, negative predictive value (NPV) 60.0%, and...
overall accuracy was 57.14%. These values indicate the effectiveness of ocular ultrasound in diagnosing vitreous hemorrhage in comparison to the clinical diagnosis confirmed by biomicroscopy and ophthalmoscopy.

**Figure 2: Diagnostic Accuracy of Ocular Ultrasound for Vitreous Hemorrhage**

![Diagnostic Accuracy of Ocular Ultrasound for Vitreous Hemorrhage](image)

**Table 3: Diagnostic Accuracy of Ocular Ultrasound for Vitreous Hemorrhage (n=70)**

<table>
<thead>
<tr>
<th>Diagnostic Parameter</th>
<th>Value</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>28 (True Positive)</td>
<td>77.8</td>
</tr>
<tr>
<td>Specificity</td>
<td>12 (True Negative)</td>
<td>35.3</td>
</tr>
<tr>
<td>Positive Predictive Value (PPV)</td>
<td>28 (True Positive) / 50 (Total Positive)</td>
<td>56.0</td>
</tr>
<tr>
<td>Negative Predictive Value (NPV)</td>
<td>12 (True Negative) / 20 (Total Negative)</td>
<td>60.0</td>
</tr>
<tr>
<td>Overall Accuracy</td>
<td>(28+12) / 70 (Total Cases)</td>
<td>57.14</td>
</tr>
</tbody>
</table>

**Figure 3: Ocular Ultrasound Image Showing Vitreous Hemorrhage**

The results show that ocular ultrasound has a reasonable sensitivity in detecting vitreous hemorrhage but a lower specificity. This indicates that while ocular ultrasound is effective in identifying cases of vitreous hemorrhage, there is a substantial rate of false positives. These findings highlight the utility of ocular ultrasound as a diagnostic tool in emergency settings, especially for initial evaluations, although its limitations should be considered in clinical practice.
The detailed distribution of causes for vitreous hemorrhage provides insight into the predominant etiologies within the study population, with proliferative diabetic retinopathy and trauma being significant contributors. The gender and age distribution tables offer a demographic overview of the patients, illustrating the prevalence across different groups. Overall, the study underscores the diagnostic potential and limitations of ocular ultrasound in the context of vitreous hemorrhage, guiding its application in clinical settings.

4 Discussion

The current study evaluated the diagnostic accuracy of ocular ultrasound in the assessment of vitreous hemorrhage and associated ocular diseases, highlighting its utility and limitations in clinical practice. The findings demonstrated a sensitivity of 77.8%, specificity of 35.3%, positive predictive value (PPV) of 56.0%, negative predictive value (NPV) of 60.0%, and an overall accuracy of 57.14%. These results align with previous studies, which have shown that ocular ultrasound is a valuable tool in diagnosing vitreous hemorrhage, particularly in emergency settings. However, the relatively low specificity observed in this study suggests a considerable rate of false positives, which necessitates cautious interpretation of ultrasound findings (1, 2, 3).

Proliferative diabetic retinopathy (PDR) and trauma were the most common causes of vitreous hemorrhage in the study population. This is consistent with existing literature, where PDR has been identified as a leading cause of vitreous hemorrhage, especially in patients with advanced diabetic eye disease (11). Trauma, both penetrating and blunt, also remains a significant etiology, particularly among younger patients. The findings underscore the importance of considering these etiologies in the differential diagnosis when evaluating patients with vitreous hemorrhage (2, 4).

One of the strengths of this study was its systematic approach to patient selection and thorough diagnostic evaluation using both clinical and ultrasonographic methods. The use of high-sensitivity gain settings in ocular ultrasound ensured detailed visualization of vitreous contents, contributing to the diagnostic process. However, the study also had limitations, including its relatively small sample size and the single-center design, which may limit the generalizability of the findings. Additionally, the study relied on the expertise of a single general ophthalmologist, which may introduce variability in diagnostic accuracy due to differences in operator skill and experience (5, 6).

Previous studies have reported higher diagnostic accuracy for ocular ultrasound, with some demonstrating nearly perfect sensitivity and specificity. For instance, Vrablik and colleagues (2015) conducted a meta-analysis that highlighted the high accuracy of ocular ultrasound in detecting retinal detachment and vitreous hemorrhage in emergency department settings (12). However, the lower specificity observed in this study may reflect challenges in distinguishing between different intraocular pathologies using ultrasound alone, emphasizing the need for complementary diagnostic tools and clinical correlation (7, 8).

The study also identified that small and peripheral retinal tears, which often accompany vitreous hemorrhage, were difficult to detect with ocular ultrasound. This finding is in line with previous research by Blumenkranz and Byrne, which indicated that minute retinal tears are challenging to visualize using ultrasonography due to their subtle echogenic characteristics (14). This limitation suggests that while ocular ultrasound is valuable for initial assessments, it should be supplemented with detailed ophthalmoscopic examination and possibly other imaging modalities for comprehensive evaluation (10).

In terms of practical implications, the study supports the use of ocular ultrasound as a rapid, non-invasive diagnostic tool, particularly useful in emergency settings where immediate assessment of vitreous hemorrhage is crucial. The ability to quickly identify vitreous hemorrhage and its underlying causes can significantly impact patient management and treatment decisions. However, the study also highlighted the need for improved training and standardization in the use of ocular ultrasound to enhance diagnostic accuracy and reduce the rate of false positives (13, 16).

Further research is needed to explore the factors influencing the variability in diagnostic accuracy of ocular ultrasound, including operator experience, equipment quality, and specific ultrasonographic techniques. Future studies with larger, multi-center cohorts could provide more robust data and help refine the protocols for using ocular ultrasound in clinical practice. Additionally, investigating the integration of ocular ultrasound with other diagnostic tools, such as optical coherence tomography (OCT) and fundus photography, could offer a more comprehensive approach to diagnosing vitreous hemorrhage and associated ocular diseases (15, 17).

In conclusion, the study demonstrated that ocular ultrasound is a useful diagnostic tool with high sensitivity for detecting vitreous hemorrhage, albeit with moderate overall accuracy and a lower specificity. The findings underscore the importance of combining ultrasonographic assessments with thorough clinical examinations and considering the limitations of ultrasound in detecting small and peripheral retinal tears. Enhanced training and standardization in the use of ocular ultrasound, along with further research, are recommended to optimize its diagnostic efficacy in clinical settings (18, 19, 20).
5 Conclusion
In conclusion, this study demonstrated that ocular ultrasound is a highly valuable diagnostic tool for detecting vitreous hemorrhage, particularly in emergency settings where rapid assessment is crucial. The findings revealed a high sensitivity of 77.8%, highlighting its efficacy in identifying cases of vitreous hemorrhage. However, the specificity of 35.3% and overall accuracy of 57.14% indicate that while ocular ultrasound is effective for initial screening, it has limitations in distinguishing between different intraocular pathologies, leading to a substantial rate of false positives. The predominant causes of vitreous hemorrhage in the study population were proliferative diabetic retinopathy and trauma, consistent with existing literature. The study underscores the necessity of combining ocular ultrasound with detailed clinical examinations and possibly other imaging modalities to achieve accurate diagnoses. Moreover, the variability in diagnostic accuracy suggests a need for enhanced training and standardization in the use of ocular ultrasound. Future research should focus on larger, multi-center studies to validate these findings and explore the integration of ocular ultrasound with advanced diagnostic tools, aiming to optimize its application in clinical practice. Overall, while ocular ultrasound offers significant benefits as a non-invasive, rapid diagnostic method, its limitations must be acknowledged, and it should be used as part of a comprehensive diagnostic approach for managing vitreous hemorrhage and associated ocular conditions.

References

DOI: https://doi.org/10.61919/jhrr.v4i3.1243; 2024 © Open access: Creative Commons; Double blind peer reviewed.
Disclaimers

**Author Contributions**  All authors contributed significantly to this work. Author A designed the study and conducted the experiments, while Author B analysed the data and wrote the manuscript.

**Conflict of Interest**  The authors declare that there are no conflicts of interest.

**Data Availability**  Data and supplements available on request to the corresponding author.

**Funding**  NA

**Ethical Approval**  Institutional Review Board (IRB) University of Lahore.

**Trial Registration**  NA

**Acknowledgments**  NA

2024 © Open Access. This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution, and reproduction in any medium or format, with appropriate credit to the original author(s) and source, a link to the license, and an indication of any changes made. If the material is not covered by the license, permission from the copyright holder is required. More details are available at "Creative Commons License".