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Original Article

Outcomes of Laser Hyaloidotomy in Premacular Hemorrhage: Identifying Predictors of Treatment Success and Need for Vitrectomy

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Abstract

Objectives: This study aimed to evaluate the outcomes of laser hyaloidotomy (LH) in treating premacular hemorrhage (PMH) and identify factors influencing treatment success.

Methods: In this retrospective cohort study, patients with PMH of any etiology treated with LH were included. Patient demographics and PMH characteristics were documented. Treatment efficacy was assessed based on successful hyaloid puncture, blood drainage into the vitreous cavity, and the need for pars plana vitrectomy (PPV).

Results: A total of 56 eyes from 51 patients (36 males, 15 females; mean age: 46.32±15.07 years) underwent LH for PMH (all cases had subhyaloid hemorrhage). The median symptom duration was two days (range: 0–30 days). The mean time interval between advising and performing LH was 4.92±12.82 days. Pretreatment visual acuity ranged from counting fingers to 6/36. LH was successful in 14 eyes (25%), while 42 eyes (75%) failed, primarily due to non-drainage of PMH (32 eyes, 76%) or persistent vitreous hemorrhage (10 eyes, 24%). PMH secondary to proliferative diseases universally requires PPV. PMH located within the retinal arcades or closer to the presumed fovea was more likely to necessitate PPV ($p=0.001$).

Conclusion: LH demonstrated limited efficacy, particularly in PMH associated with proliferative diseases or in those confined within the inferior retinal arcade. These cases frequently required early PPV. Incorporating vitrectomy into the initial treatment strategy may optimize outcomes for specific PMH subgroups.

Keywords: Hyaloidotomy, laser, outcomes, premacular hemorrhage, vitrectomy

Introduction

Premacular hemorrhage (PMH) causes profound vision loss and is defined as blood accumulation beneath the posterior hyaloid (subhyaloid) space or beneath the internal limiting membrane (ILM) (sub-ILM) space in the macular region, including the fovea (1,2). It can be caused by several factors, including proliferative retinal vascular diseases such as proliferative diabetic retinopathy and retinal vein occlusions, as well as non-proliferative retinal or choroidal vascular diseases such as rupture of retinal artery macroaneurysm and polypoidal choroidal vasculopathy, arteriovenous communication of the retina, and blood dyscrasias (3-5). Non-vascular disorders that cause premacular bleed include trauma, laser in situ keratomileusis, Valsalva, Terson's syndrome, and Purtscher's retinopathy (6-10). The distinction between subhyaloid hemorrhage (SHH) and sub-ILM hemorrhage is crucial in clinical practice, as these entities differ in both clinical presentation

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and optical coherence tomography characteristics. Recognizing these differences is essential, as the underlying etiologies and management strategies vary significantly between the two conditions (11).

Various treatment modalities for PMH have been described, with the primary goal of clearing the hemorrhage from the foveal region and improving visual acuity. Observation, laser hyaloidotomy (LH), pneumatic displacement of hemorrhage by intravitreal injection of gas and tissue plasminogen activator, and pars plana vitrectomy (PPV) are some of the procedures currently available (12-14). When planning treatment for a PMH, several factors are usually taken into consideration. These include the patient's presenting visual acuity, the level of the PMH (sub-hyaloid or sub-ILM), obscuration of the fovea, the cause of the hemorrhage (proliferative or non-proliferative), the extent of the hemorrhage (> or <3DD), the height of the hemorrhage, and finally, the patient's single-eyed status (3-5). Though spontaneous resolution of the PMH is possible in most cases, it can take several weeks or months depending on the dimensions and total volume of blood present, which can be incapacitating to the patient when it occurs bilaterally or in single-eyed patients. Furthermore, prolonged contact with hemoglobin and iron may result in poor visual outcomes due to pigmentary macular changes or the formation of epiretinal membranes, as well as toxic damage to the retina (13). As a result, observation as a form of treatment is usually reserved for cases with a small amount of blood (<3DD) or pure sub-ILM bleed (15). Active non-surgical interventions such as LH or pneumatic displacement with gas injection are planned to rapidly clear or displace preretinal blood from the foveal region, prevent secondary retinal damage due to the presence of long-standing blood, improve visual acuity, and eliminate the need for PPV. There are numerous papers in the literature (anecdotal case reports and case series) that discuss the utility and outcomes of neodymium-doped yttrium aluminum garnet LH for various etiologies (3-5,14). These studies, however, do not give readers specific guidelines on when to consider LH or other treatment options for the initial management of PMH.

In this study, we will review our series of PMH cases treated with LH and identify the key factors that may influence the outcome of this treatment modality.

Methods

Patients above 18 years, with recently diagnosed (<1-month duration) PMH and without significant vitreous hemorrhage of any etiology, attending the retina clinic of a tertiary eye care hospital in South India between June 2017 and May 2024 were included in this retrospective cohort study. The study was conducted as per the Declaration of Helsinki, and all the necessary details related to the study were supplied to the Institutional Review Board and Ethics committee of Narayana Nethralaya (EC Ref. No: C/2019/03/04). Age, gender, etiology, interval between symptoms and presentation to retina clinic, and interval between presentation and active intervention, pre- and post-treatment visual acuity, need and reason for surgical intervention, and total follow-up duration were all recorded. Optical coherence tomography imaging was performed in all cases to determine the predominant location of the PMH (subhyaloid or sub-ILM), and fundus fluorescence angiography was used as needed. Only eyes that showed blood confined to the subhyaloid space–with typical convex dome-shaped elevation, and absence of ILM draping or cleavage lines suggestive of sub-ILM localization–were included in the LH group. The dimensions of the hemorrhage were measured on the color fundus photographs obtained on the Optos® Daytona machine (UK) using the device's in-built calipers. The horizontal and vertical dimensions of the hemorrhage, as well as the vertical distance from the presumed foveal center to the inferior-most boundary of the hemorrhage were noted.

The treating retina specialist presented the patient with three management options for PMH: observation, LH, and primary PPV. Observation was preferred for: (A) eyes with hemorrhages <3-disc diameters not involving the fovea; (B) elderly or monocular patients with guarded visual prognosis or unfit for laser, and (C) patient refusal of laser intervention. Primary PPV was considered for: (A) patients with large dense hemorrhage (>6-disc diameters) obscuring the fovea and located in eyes with known proliferative retinopathy or associated traction and (B) patient preference for quicker visual recovery. The potential risks, expected outcomes, and subsequent steps were thoroughly discussed with the patient. Informed consent was obtained from all patients undergoing LH and PPV.

For LH, a Q-switched Nd: YAG laser (Ellex Super Q, Ellex, USA) was utilized, emitting a single laser burst through a well-dilated pupil via a slit-lamp delivery system. A Goldmann three-mirror contact lens (Volk) was employed to precisely focus the laser energy on the posterior hyaloid membrane. The perforation was strategically created near the inferior and most dependent edge of the PMH while avoiding retinal blood vessels and the fovea. Initial laser energy was set at 2 mJ and was incrementally increased by 1 mJ, up to a maximum of 10 mJ, as needed. The number of laser spots applied varied from one to five, depending on the response, to ensure effective perforation of the hyaloid and facilitate blood drainage into the vitreous cavity.

The LH procedure was initially performed by a senior vitreoretinal fellow (≥18 months of experience) and, in cases of unsuccessful attempts, was subsequently re-attempted by the attending faculty. Treatment success after LH was defined as successful drainage of blood from the premacular space into the vitreous, with no subsequent requirement for PPV. The procedure was deemed unsuccessful if a posterior hyaloid puncture could not be created despite multiple attempts or if blood failed to drain into the vitreous cavity following a successful puncture.

PPV was performed as a primary intervention in select cases of PMH or as a secondary procedure following LH failure. Secondary PPV was considered after a minimum of 4 weeks of follow-up post-LH, if there was: (A) Persistent non-clearing vitreous hemorrhage; (B) recurrent hemorrhage, and (C) failure of blood drainage into the vitreous.

The time interval between LH and subsequent PPV, when required, was also documented.

Statistical Analysis

All data were analyzed using GraphPad Prism version 9.4.1 (681) for Windows, GraphPad Software, San Diego, California, USA, www.graphpad.com. The Kolmogorov-Smirnov normality test showed the data sets to be of the non-parametric variety, and hence only non-parametric statistical tests were used in this study. Quantitative variables between the 2 groups were analyzed using the Mann–Whitney U test, and Chi-square test was used to compare the categorical data between the 2 groups. $P<0.05$ were considered statistically significant.

Results

For this study, 84 eyes of 78 patients presenting with PMH were included. Six patients had bilateral PMH. There were 56 (72%) males and 22 (28%) females in the study. The average age of the patients was 43.68±14.08 years. Mean duration of symptoms was 13.06±6.05 days. Causes of PMH at presentation are included in Table 1.

In 24 (29%) eyes, the PMH was observed at presentation. 54 (64%) eyes underwent LH, and 6 (7%) eyes underwent PPV at the initial presentation. Eighteen of the 24 (75%) eyes that were observed initially showed resolution of the PMH over a period ranging from 2 to 5 months. In the remaining 6 (25%) eyes, LH was attempted in 2 (33%) eyes, whereas PPV was performed in 4 (67%) eyes for non-resolving PMH after a median period of 3.25 weeks. In total, 56 eyes underwent LH in the study. Analysis of these 56 eyes was performed further in this study.

Table 1. Causes of premacular hemorrhage at presentation

Causes	No. of eyes (n=84)
Proliferative diabetic retinopathy (n, %)	22 (26)
Valsalva retinopathy (n, %)	18 (21)
Trauma (n, %)	14 (17)
Branch retinal vein occlusion (n, %)	11 (13)
Ruptured retinal artery macroaneurysm (n, %)	8 (10)
Polypoidal choroidal vasculopathy (n, %)	5 (6)
Blood dyscrasias (n, %)	5 (6)
Terson's syndrome (n, %)	1 (1)

LH Group

This study included 56 eyes from 51 patients, with five patients presenting bilateral PMH. The etiologies of bilateral PMH included proliferative diabetic retinopathy (n=3), trauma (n=1), and Valsalva retinopathy (n=1). The cohort comprised 36 males (71%) and 15 females (29%), with a mean age of 46.32±15.07 years. The median duration of symptoms was 2 days (range: 0–30 days). The mean interval between recommending and performing LH was 4.92±12.82 days (range: 0–58 days). Pre-treatment visual acuity ranged from counting fingers close to the face to 6/36. The mean vertical distance between the presumed fovea and the inferior boundary of the PMH was 5.211±2.63 mm. The mean maximum vertical and horizontal diameters of the PMH were 10.64±5.171 mm and 11.83±6.504 mm, respectively. All eyes in this cohort exhibited hemorrhage predominantly in the subhyaloid space on optical coherence tomography, with no cases of sub-ILM hemorrhage observed.

Outcomes of LH

There was no drainage of blood from the premacular space in 32 of the 56 (57%) eyes that had LH. Ten (42%) of the 24 eyes where blood was successfully drained from the premacular space into the vitreous required PPV later for non-resolving vitreous hemorrhage. To summarize, 14 (25%) eyes had treatment success after LH, while 42 (75%) eyes had treatment failure. Following a successful LH, the visual acuity ranged from 6/6 – 6/18. Table 2 provides information and analysis of the factors based on whether or not blood was successfully drained from the premacular space into the vitreous cavity after LH. PMH >7 days duration encountered more frequent treatment failures ($p=0.001$). The treatment success did not differ significantly when LH was performed in a young patient (≤40 years) compared to an older patient (>40 years). When all the proliferative and non-proliferative causes of PMH were combined, and the treatment outcomes were compared between the two groups, proliferative causes of premacular bleeding failed to drain into the vitreous cavity after LH (100% vs. 39%; $p\leq0.001$).

There was a requirement for performing PPV in 42 (75%) of the 56 eyes that underwent LH. Ten (24%) eyes required PPV for non-clearing vitreous hemorrhage, while the remaining 32 (76%) eyes required PPV for failure to drain PMH into the vitreous space and, in some cases, for the development of additional tractional retinal detachment. PPV was required in all cases of PMH caused by proliferative diseases. Table 3

Table 2. Univariate analysis of factors associated with success or failure of drainage of blood into the vitreous cavity from the premacular subhyaloid space after laser hyaloidotomy

	Drainage success (n=24) (%)	Drainage failure (n=32) (%)	p
Duration of symptoms			
≤7 days	16 (67)	7 (22)	0.001
>7 days	8 (33)	25 (78)	
Age			
≤40 years (n=30)	11 (37)	19 (63)	0.565
>40 years (n=21)	10 (33)	11 (67)	
Valsalva retinopathy (n=16)	11 (69)	5 (31)	0.018
Proliferative diabetic retinopathy (n=10)	0 (0)	10 (100)	0.003
Trauma (n=11)	8 (63)	3 (27)	0.041
Branch retinal vein occlusion (n=7)	0 (0)	7 (100)	0.016
Retinal artery macroaneurysm (n=6)	3 (50)	3 (50)	>0.999
Blood dyscrasias (n=3)	2 (67)	1 (33)	0.571
Polypoidal choroidal vasculopathy (n=2)	0 (0)	2 (100)	0.501
Terson's syndrome (n=1)	0 (0)	1 (100)	>0.999
Non-proliferative causes (n=39)	24 (61)	15 (39)	<0.001
Proliferative causes (n=17)	0 (0)	17 (100)	

Table 3. Comparison of premacular dimensions between eyes that required PPV and eyes that did not require PPV after laser hyaloidotomy

	Eyes where PPV not needed (n=14)	Eyes where PPV needed (n=42)	p
Vertical distance of the hemorrhage from the presumed fovea to the inferior-most boundary of the PMH (mm)	9.465±4.632	4.165±1.287	0.001
Maximum vertical dimension of detached subhyaloid space (mm)	10.64±5.171	9.256±6.125	0.567
Maximum horizontal dimension of detached subhyaloid space (mm)	12.07±7.125	11.45±6.981	0.725

mm: Millimetre; PPV: Pars plana vitrectomy; PMH: Premacular hemorrhage.

compares the pre-treatment dimensions of the premacular SHH between those who required PPV and those who did not after LH. Figure 1 demonstrates the case examples of patients treated with LH for PMH and reasons for its failure, while Figure 2 demonstrates the case examples of patients successfully treated with LH, observation, and primary PPV for PMH.

Complications after LH

Tractional retinal detachment occurred in 7 of 10 (70%) eyes with proliferative diabetic retinopathy and 5 of 7 (71%) eyes with branch retinal vein occlusion due to contraction of the posterior hyaloid membrane and subsequent traction on the fibrovascular membrane. PPV was used to treat these cases. In cases where the PMH was successfully drained, no other complications such as increased intraocular pressure, epiretinal membrane formation, retinal and choroidal hemorrhage, macular hole, or retinal break formation were observed.

PPV Outcomes in Eyes Treated with LH

Out of a total of 84 eyes included in the study, 52 (62%) eyes underwent PPV at some point during the course of treatment. These included 42 (81%) eyes after failed LH, 6 (14%) eyes at the initial presentation itself, and 4 (5%) eyes after an initial period of observation. Thirty of the 42 (71%) eyes that required PPV after LH underwent surgery after a period ranging from 2–4 months. The visual acuity of these patients by the last follow-up visits improved to ≥ 6/18 in 87% (n=26) eyes.

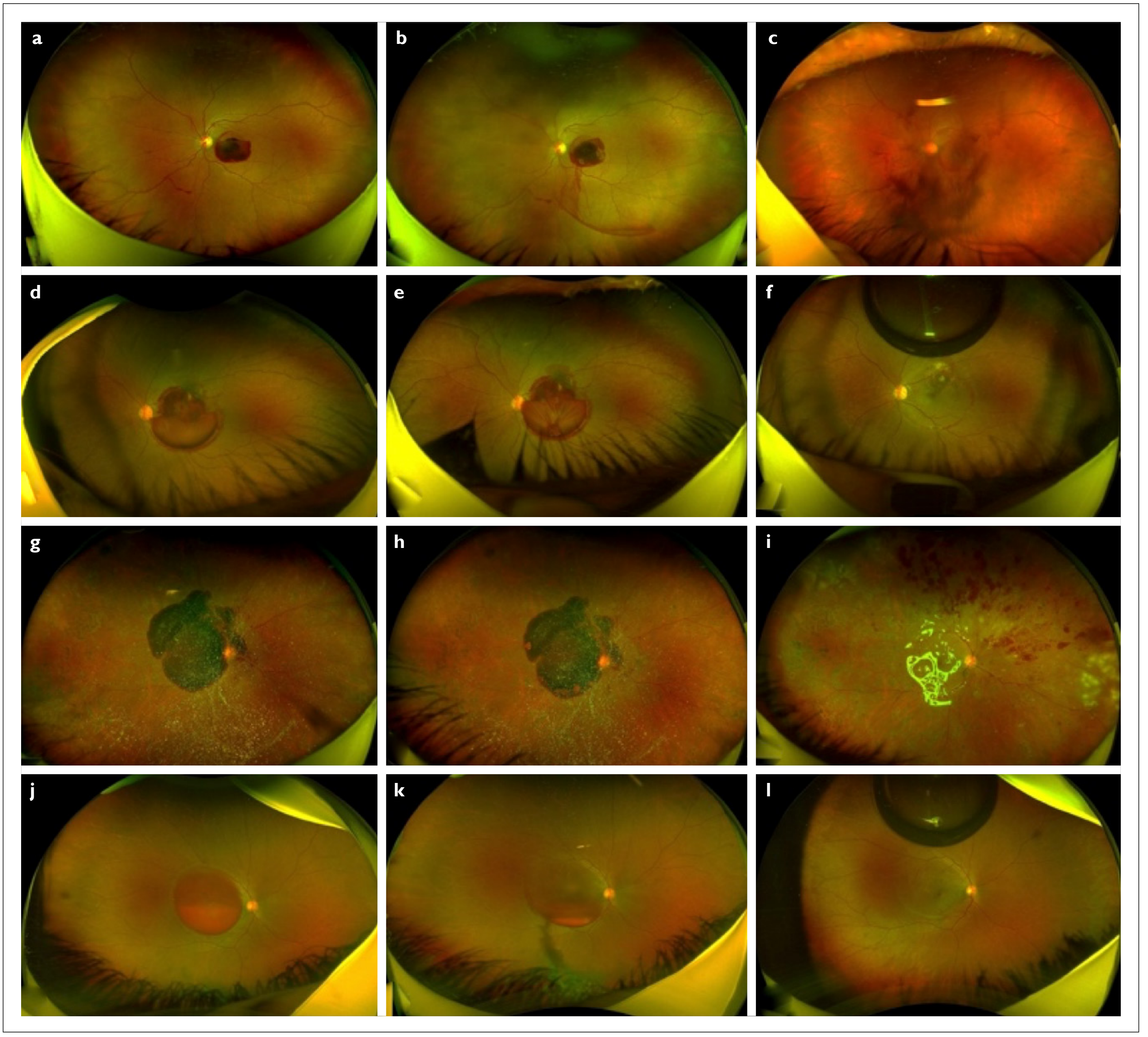

Figure 1. Reasons for treatment failure after laser hyaloidotomy (LH) for premacular subhyaloid hemorrhage (SHH) depicted with the help of case illustrations: Row 1: **(a-c)** Premacular SHH limited to the posterior pole within the retinal arcades demonstrated successful drainage of the premacular blood into the vitreous cavity following LH requiring pars plana vitrectomy (PPV) for non-clearing vitreous hemorrhage. Row 2: **(d-f)** After LH, premacular SHH caused by a non-proliferative superotemporal retinal artery macroaneurysm failed to drain blood into the vitreous cavity. The failure in this case illustration was due to the inability of the laser to successfully puncture the posterior hyaloid membrane. Row 3: (g-i) Treatment for a dense premacular bleed by LH brought on by proliferative diabetic retinopathy was unsuccessful because it was not possible to puncture the retrohyaloid membrane. Later, PPV was performed on the patient to treat the premacular hemorrhage. Row 4: **(j-l)** Following LH, premacular blood from Valsalva retinopathy with SHH restricted to the retinal arcades revealed insufficient drainage of the SHH. The patient underwent PPV at the end and displayed improved visual acuity.

Discussion

This study examined the outcomes of LH in eyes with PMH from various causes and identified factors that can help a clinician predict success or failure after LH. The study revealed five significant observations: (a) Better LH outcomes can be achieved if symptoms last for <1 week; (b) patient's age has no bearing on the success of LH; (c) higher chances of treatment failure in eyes with PMH secondary to proliferative diseases; (d) localized PMH confined within the retinal

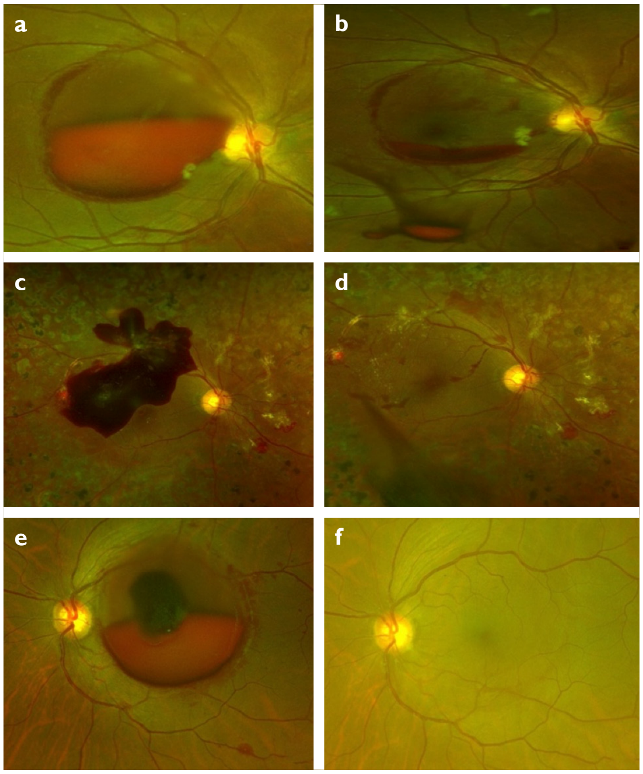

Figure 2. Case illustrations depicting successful management of premacular bleed following laser hyaloidotomy (LH), observation, and primary pars plana vitrectomy (PPV): Row 1: **(a, b)** Successful management of dense premacular bleed secondary to Valsalva retinopathy treated with yag-LH. Row 2: **(c, d)** Complete resolution of premacular bleed, sparing the foveal center in a patient with proliferative diabetic retinopathy with no active management. Row 3: **(e, f)** Successful management of dense premacular bleed secondary to Valsalva retinopathy treated with primary PPV. Patient achieved early visual rehabilitation following surgery.

arcades required more PPV after LH; and (e) improved visual outcomes after PPV. According to the findings, non-invasive LH has a limited role in the management of PMH in the current era when compared to a safer microincision PPV.

Blood located in the subhyaloid space typically lacks clotting factors (13). The presence of blood in this space produces a characteristic boat-shaped configuration due to the red blood cell sedimentation in the most dependent inferior portion of the detached posterior hyaloid (16). Conversely, a PMH with blood located in the sub-ILM space remains confined, limiting displacement and increasing the risk of direct retinal damage by the laser itself. Therefore, these cases are less amenable to laser treatment. The most common reasons for the failure of PMH following LH include the sub-ILM heme and clogging of the puncture site by sedimented red blood cells (3-5,17).

On the other hand, vitreous hemorrhage differs from SHH in several aspects, including rapid clot formation, slower clot lysis, red blood cell hemolysis, prolonged persistence of erythrocytes, and the absence of a polymorphonuclear response (18,19). The vitreous collagen matrix promotes rapid clotting and impedes hemorrhage resolution by preventing passive diffusion, delaying the inflammatory cellular response. Consequently, hemolytic blood remains in the vitreous cavity for an extended duration, leading to compromised visual quality. Moreover, prolonged intraocular heme retention increases the risk of complications such as proliferative vitreoretinopathy, ghost cell glaucoma, and hemolytic glaucoma (18). Thus, despite successful drainage of blood from the premacular space into the vitreous cavity, the eye remains at an elevated risk of complications and persistent visual impairment. Consequently, in cases of PMH, active surgical intervention through PPV may facilitate faster visual recovery and reduce the risk of complications associated with long-standing, non-resolving vitreous hemorrhage (20).

An important finding in this study was the absence of disparity in LH outcomes between young and elderly eyes. The outcomes are expected to differ significantly due to the substantial variation in the clinical, histological, and ultrastructural composition of the posterior hyaloid membrane, which is dependent on the age of the patient (21).

One significant finding in the current study was the inability of laser perforation of the posterior hyaloid membrane in eyes with proliferative retinopathy, such as diabetic retinopathy and retinal vein occlusion. Puncture of the posterior hyaloid membrane, on the other hand, was successful in eyes without proliferative diseases, such as trauma, Valsalva retinopathy, and other non-proliferative causes. The difference in the composition of the posterior hyaloid membrane between these two groups of diseases could explain this. Hyalocytes are sentinel macrophages that live in the posterior vitreous cortex, just ahead of the ILM. Hyalocytes contribute to increased cellular proliferation after abnormal posterior vitreous detachment and vitreoschisis, which are common in proliferative retinopathies, resulting in macular pucker and fibrous/fibrovascular proliferations (22). In addition, in proliferative retinopathies, new vessels style on the posterior (retinal) surface of the posterior hyaloid membrane, causing changes in the posterior hyaloid membrane itself (23,24). Furthermore, after LH in proliferative diseases, the posterior hyaloid membrane may contract, causing increased traction on the neovascular tissue and retina, leading to further bleeding, tractional retinal detachment, retinal break formation, and combined retinal detachment (25). As a result, it is prudent not to consider LH as a treatment option in PMH caused by proliferative retinopathies due to increased chances of drainage failure and increased risks of post-laser complications.

In our study, we assessed the vertical extent of the SHH–measured from the presumed foveal center to its inferior margin–as a surrogate for hemorrhage size and its potential for spontaneous or facilitated clearance. Our findings suggest that LH was more effective when the SHH extended beyond the inferior retinal arcade, allowing the drained blood to disperse into the larger inferior vitreous cavity. Conversely, when the hemorrhage was confined to the macular region, particularly within the inferior retinal arcade, the likelihood of requiring PPV remained high, even in cases where LH technically succeeded in creating drainage. This may be attributed to limited vitreous liquefaction and impaired clearance dynamics over the posterior pole, which results in stagnation of the drained hemorrhage in the visual axis. The persistent vitreous opacity continues to compromise central vision, both in terms of acuity and subjective visual quality.

Therefore, in cases where SHH is localized within the macula and does not extend beyond the arcades, LH may offer limited clinical benefit. In such scenarios, primary observation (for small, non-visually significant hemorrhages) or early PPV (for visually disabling hemorrhages) may be more appropriate strategies. This tailored approach may help reduce treatment delays, avoid redundant interventions, and improve both anatomical and functional outcomes.

In the current study, PPV was used as the primary treatment option for PMH in 7% of the eyes, whereas LH was used in 64% of the eyes. Furthermore, 75% of the eyes where LH was attempted required PPV to resolve the PMH or non-resolving vitreous hemorrhage. All proliferative causes of PMH for which LH was initially attempted were later treated with PPV. Furthermore, 87% of cases improved in visual acuity (>6/18) following PPV in the study. These findings highlight PPV's high anatomical and functional success rate in PMH management and suggest that it be considered much earlier in the treatment algorithm, despite being more invasive than LH. These findings are supported by Ghali et al.'s (26).

publication, which concluded that PPV was a beneficial surgical treatment for PMH of various pathologies, ensuring rapid visual recovery with no serious side effects.

The study has the advantage of evaluating the results of a large number of patients treated with LH for PMH from a single center. Furthermore, the study identified factors that may influence treatment outcomes following LH. However, the study is a retrospective one and does not include a head-to-head comparison between observation, LH, and PPV for PMH management in a prospective, randomized clinical trial design.

Conclusion

This study provides a comprehensive analysis of key PMH attributes that may be an important factor to consider when managing PMH. Based on our findings, LH should be avoided in eyes with PMH due to proliferative causes. PPV should be included much earlier in the PMH treatment algorithm.

Disclosures

Ethics Committee Approval: This study was approved by the Narayana Nethralaya Ethics Committee (Date: 27.03.2019 Number: C/2019/03/04) and conducted in accordance with the tenets of the Declaration of Helsinki.

Informed Consent: Informed consent was obtained from all patients.

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