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Original research article

EFFICACY OF HYPERBARIC OXYGEN THERAPY MONITORED BY FLUORESCEIN ANGIOGRAPHY IN PATIENTS WITH RETINAL ARTERY OCCLUSION

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Abstract: *Retinal artery occlusion (RAO) is a critical ophthalmic condition, often likened to a stroke of the eye, due to its sudden onset and the severe, potentially permanent loss of vision it can cause.* ***Objectives:*** *The study's main objective is to find the efficacy of hyperbaric oxygen therapy monitored by fluorescein angiography in patients with retinal artery occlusion.* ***Methods:*** *This prospective observational study was conducted at Shalamar Hospital, Lahore, from August 2023 to February 2024. Data were collected from 85 patients. Patients were recruited from the ophthalmology department. Patients aged > 18 years who presented with acute RAO, defined by sudden visual loss and confirmed by clinical examination and initial FA. Both CRAO and BRAO cases were included, provided that the onset of symptoms occurred within 24 hours before presentation were included in the study.* ***Results:*** *The study involved 85 patients aged 45 to 78 years and a mean age of 55.67 years. The gender distribution was predominantly male (61%), with 52 males and 33 females (39%). Among the patients, 59% had Central Retinal Artery Occlusion (CRAO), while 41% had Branch Retinal Artery Occlusion (BRAO). The average time to initiate Hyperbaric Oxygen Therapy (HBOT) was 10 hours, ranging from 4 to 22 hours. At baseline, the mean Best Corrected Visual Acuity (BCVA) was 20/200, with no patients achieving a BCVA of 20/60 or better. After the initial HBOT, the mean BCVA improved to 20/160, with 10% of patients reaching 20/60 or better. At the 24-hour follow-up, BCVA further enhanced to 20/120, with 25% of patients achieving 20/60 or better.* ***Conclusion:*** *It is concluded that hyperbaric oxygen therapy (HBOT) can significantly improve retinal perfusion and visual acuity in patients with retinal artery occlusion, particularly when initiated within 10 hours of symptom onset.*

Keywords: Fluorescein Angiography, Hyperbaric Oxygenation, Retinal Artery Occlusion, Retinal Perfusion, Visual Acuity.

Introduction

Retinal artery occlusion (RAO) is a critical ophthalmic condition, often likened to a stroke of the eye due to its sudden onset and the severe, potentially permanent loss of vision it can cause. It is mainly divided into central retinal artery occlusion (CRAO) and branch retinal artery occlusion (BRAO)based on the site of the obstruction as being in the central artery or a branch from it. CRAO is commonly more severe, and the attendant visual acuity is generally significantly worse (1). RAO has multiple causes and culprits, including atherosclerosis, embolism, and vasculitis among them. Due to the sudden cessation of the blood flow, there is ischemia and hypoxia, which cause speedy and irreversible loss of retinal ganglion cells and other neural elements of the retina. Although the disease can be quite disabling, therapeutic interventions continue to be limited, and the outcomes are typically unfavorable; most patients suffer from substantial and permanent vision loss (2).

Several interventions have been proposed to be used in managing RAO; among these is hyperbaric oxygen therapy (HBOT) due to its beneficial impacts in counteracting the effects of retinal ischemia. HBOT refers to using 100% oxygen under more significant pressures than atmospheric pressure, and the procedure is usually carried out in a hyperbaric oxygen chamber (3). This treatment modality increases, to a large extent, the partial pressure of oxygen in the blood and tissues and enhances DO2 in the hypoxic areas of the body, including retinal ischemia. The basis for using HBOT in RAO can be explained with reference to the possibility of enhancing the oxygen supply to the retinal neurons with the outcome of recovering vision (4). Early application of HBOT is critical since retinal damage cannot be reversed is very short and may take only a few hours from the onset of the symptoms. FA is a very useful, informative technique in ophthalmological practice, which allows assessing the retinal and choroidal circulation (5). It is carried out by administering sodium fluorescein through an intra-venous route as this is a dye that, when administered, circulates in the systems and outlines the retinal vessels under blue light. The resulting angiograms offer distinctly enhanced visualization of blood flow in the RAs and RVs, which facilitates the detection of blockages, leaks, and non-perfusion regions (6). In the context of the RAO, FA can check the degree of ischemia of the retina and track the impact of therapeutic measures, such as HBOT. By using this method, clinicians understand if the HBOT is truly

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improving perfusion within the specific regions of the retina (7).

The employment of FA to supervise HBOT in RAO patients significantly improves managing the illness. In managing RAO, conventional interventions, including ocular massage, anterior chamber paracentesis, and intra-arterial fibrinolysis, have been of slight effectiveness and come with many problems. In contrast, there is HBOT, a non-invasive treatment that hazards the root cause, hypoxia, and not just the work of trying to loosen or melt the occlusion (8). Since HBOT increases the amount of oxygen delivered to the ischemic retina, it may halt the process of further damage and actually stimulate tissue repair and visual gain. Nevertheless, the effectiveness of HBOT in treating RAO is still inconclusive and remains an object of discussion among doctors (9). The studies and case reports have shown that there is improvement in some cases; in other cases, no progress or minimal improvement has been established. Variability has been attributed to methodology, including the timing of treatment, degree of occlusion, and the patient's characteristics. Moreover, the duration of HBOT and the pressure level providing effective treatment in RAO patients have not been discussed yet, so the topic needs further research with the purpose of clarifying those indicators (10).

Objectives

The study's main objective is to find the efficacy of hyperbaric oxygen therapy monitored by fluorescein angiography in patients with retinal artery occlusion.

Methodology

This prospective observational study was conducted at Shalamar Hospital, Lahore, from August 2023 to February 2024. Data were collected from 85 patients. Patients were recruited from the ophthalmology department. Patients aged > 18 years who presented with acute RAO, defined by sudden visual loss and confirmed by clinical examination and initial FA. Both CRAO and BRAO cases were included, provided that the onset of symptoms occurred within 24 hours before presentation were included in the study. Patients declined in the study if they have prior retinal diseases like DR/AMD, prior ocular surgeries, patients with CHF, history of angina or myocardial infarction within the past three months, severe pulmonary disorders likely to decrease' tolerance to HBOT, or any known hypersensitivity allergic to fluorescein dye. All patients were subjected to complete ophthalmological examination, Snellen's visual acuity, slit lamp biomicroscopy, applanation tonometry, and initial FA to map out the severity of retinal ischemia and occlusion. Kovach et al. used images of FA of DM patients with normal macular perfusion as controls to compare the effects of HBOT on retinal perfusion. Patients were given HBOT as an early treatment in the process after the first evaluation. The therapy was done in a hyperbaric chamber with the intervention of a certified hyperbaric doctor. The treatment regimen utilized pure oxygen at 2. 0 to 2 flow rates. The pressures used ranged from 5 ATA absolute for 60 to 90 minutes per session. The exact number of sessions depended on the patient's reaction; the majority had not less than three sessions within the first 24 hours. FA was done several times throughout the study to record alterations in retinal blood flow as well as the efficacy of HBOT. Consequently, FA was done again at the end of the initial HBOT session, after 24 hours of treatment, and at other follow-up appointments. The Snellen test performed visual acuity before the Xlnp introduction and at each follow-up visit done by the same examiner. Data Analysis

Data were analyzed using SPSS v29. The primary analysis compared the FA findings and visual acuity before and after HBOT.

Results

The study involved 85 patients aged 45 to 78 years and a mean age of 55.67 years. The gender distribution was predominantly male (61%), with 52 males and 33 females (39%). Among the patients, 59% had Central Retinal Artery Occlusion (CRAO), while 41% had Branch Retinal Artery Occlusion (BRAO). The average time to initiate Hyperbaric Oxygen Therapy (HBOT) was 10 hours, ranging from 4 to 22 hours. (Table 1)

Table 1: Patient Demographics and Clinical Characteristics

Characteristic	Value
Number of Patients	85
Age Range (years)	45 - 78
Mean Age (years)	55.67±4.81
Gender	Male:52(61%) Female: 33 (39%)
Type of RAO	CRAO:50(59%) BRAO: 35 (41%)
Mean Time to HBOT Initiation	10 hours
Range of Time to HBOT Initiation	4 - 22 hours

The mean arterial filling time at baseline was 22 seconds, with 80% of non-perfusion areas in CRAO and 60% in BRAO. After the initial HBOT, the mean arterial filling time reduced to 18 seconds, with 47% partial and 24% complete reperfusion, while non-perfusion areas decreased to 65% in CRAO and 40% in BRAO. At the 24-hour follow-up, the mean filling time further reduced to 15 seconds, with 35% partial and 38% complete reperfusion in CRAO and 54% partial reperfusion in BRAO, with non-perfusion areas dropping to 40% in CRAO and 20% in BRAO. After one week, the mean filling time was 12 seconds, with 30% partial and 55% complete reperfusion, and non-perfusion areas reduced to 15%. (Table 2)

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Table 2: Fluorescein Angiography Outcomes

Time Point	Mean Arterial Filling Time (seconds)	Partial Reperfusion (%)	Complete Reperfusion (%)	Non-perfusion Areas (%)
Baseline	22±4.5	-	-	80(CRAO) 60(BRAO)
After Initial HBOT	18±3.8	47	24	65(CRAO) 40(BRAO)
24-Hour Follow-up	15±3.2	35	38 (CRAO) 54 (BRAO)	40(CRAO) 20(BRAO)
One-Week Follow-up	12±2.9	30	55	15

At baseline, the mean Best Corrected Visual Acuity (BCVA) was 20/200, with no patients achieving a BCVA of 20/60 or better. After the initial HBOT, the mean BCVA improved to 20/160, with 10% of patients reaching 20/60 or better. At the 24-hour follow-up, BCVA further enhanced to 20/120, with 25% of patients achieving 20/60 or better. One week after HBOT, the mean BCVA was 20/80, with 45% of patients reaching 20/60 or better, and by the one-month follow-up, BCVA improved to 20/60, with 50% of patients achieving this level of visual acuity. (Table 3)

Table 3: Visual Acuity Outcomes (BCVA) Over Time

Time Point	Mean BCVA (Snellen)	Percentage of Patients with BCVA 20/60 or Better (%)
Baseline	20/200	0%
After Initial HBOT	20/160	10%
24-Hour Follow-up	20/120	25%
One-Week Follow-up	20/80	45%
One-Month Follow-up	20/60	50%

For patients with Central Retinal Artery Occlusion (CRAO), the mean arterial filling time at baseline was 23 seconds, which improved to 16 seconds after HBOT. In this group, 40% of patients achieved complete reperfusion, while 45% had partial reperfusion. For those with Branch Retinal Artery Occlusion (BRAO), the baseline mean arterial filling time was 21 seconds, decreasing to 14 seconds post-HBOT. Among BRAO patients, 54% experienced complete reperfusion, and 38% had partial reperfusion. (Table 4)

Table 4: Improvement in Retinal Perfusion by RAO Type

RAO Type	Mean Arterial Filling Time at Baseline (seconds)	Mean Arterial Filling Time After HBOT (seconds)	Percentage of Patients with Complete Reperfusion (%)	Percentage of Patients with Partial Reperfusion (%)
CRAO	23±4.2	16±3.4	40%	45%
BRAO	21±4.8	14±3.0	54%	38%

Discussion

The results of this study provide valuable insights into the efficacy of hyperbaric oxygen therapy (HBOT) in treating retinal artery occlusion (RAO). This condition often leads to significant visual impairment if not promptly managed. Since FA allowed evaluating alterations in retinal perfusion, we herein report the effects of HBOT on CRAO and BRAO in 85 cases (11). Thus, the present study shows that HBOT can enhance retinal circulation and visual vision in RAO adult patients, especially if treatment starts at a certain period. Most of the patients had better arterial fill times and a decrease in non-perfusion areas after HBOT, and this was found to be much better in the patients who received HBOT within 10 hours of the onset of the symptoms (12). They formally advance propose the belief that early start clinical intervention is of utmost importance for obtaining the most measure of reparation from HBOT, conforming to the prognostication that retinal tissues are susceptible to the inadequacy of oxygen supply and, therefore, timely provision of supplemental oxygen supply is critical in avoiding irreversible ischemic damage (13).

The study also depicted some variability in the results of CRAO and BRAO patients. There was a similar improvement in the group with BRAO and the control group after HBOT; however, there was a greater improvement in the rate of complete reperfusion among patients with BRAO. This difference may be due to a more focal lesion in BRAO, with a smaller area of the retina being involved. Therefore, there is less damage to the retina, and the body can better deliver oxygen and recover the retinal cells (2). Moreover, CRAO tends to involve a greater area of the retina in ischemia, which may prevent complete visual rehabilitation even when optimal therapy is provided. This is also evidenced by the findings, which showed the relationship between the time of starting HBOT and the improvement of the visual acuity early treatment, which is therefore crucial (3). Patients who underwent HBOT within 10 hours of the onset of the symptoms recorded significantly better BCVA than those treated later. Of course, this aligns with a principle in stroke management called ‘time is vision,’ implying that early intervention should be done to salvage retinal function (4).

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Regarding the quantitative changes, however, it must be noted that a certain proportion of patients demonstrated either mild or no positive changes in reperfusion metrics and vision. These cases may, therefore, indicate the inability of HBOT to undo ischemic damage once it is established, especially in case of severe occlusion or in patients who presented late to the hospital (5). Such variability also emphasizes the importance of additional studies to define the factors that could predict the treatment outcomes for patients with RAO and determine the optimal conditions of HBOT for all the subtypes of this pathology. The safety of HBOT was considered good, with the failure observed in major side effects of the therapy. While minor short-term injuries considered were ear barotrauma and transient claustrophobia, none were severe and did not require further management. These data indicate that HBOT is a fairly safe intervention for RAO if exclusion criteria are observed during the patient assessment (6).

As a control and monitoring tool, FA is a solid value added in this study, as it enabled quantification of retinal perfusion and direct visualization of the HBOT therapy effects. However, these are not without their limitations. In this research, the study was made at a single center with a piloting sample size, which may not be the population's representative sample. Hence, its generalizations may only be generalizable to the sample from which they were derived (7, 8). Further, as the study was observational in nature, there was no provision of a control group and, therefore, no definite way of proving that all the improvements witnessed could be exclusively linked to the administration of HBOT. The results of the current trials would have to be confirmed in further randomized control trials with larger patient samples and longer LTD, as well as to incorporate HBOT into the treatment repertoire for RAO.

Conclusion

It is concluded that hyperbaric oxygen therapy (HBOT) can significantly improve retinal perfusion and visual acuity in patients with retinal artery occlusion, particularly when initiated within 10 hours of symptom onset. The study suggests that early intervention with HBOT may offer a valuable treatment option for preserving vision, especially in branch retinal artery occlusion (BRAO) cases.

Declarations

Data Availability statement
All data generated or analyzed during the study are included in the manuscript.

Ethics approval and consent to participate.
It is approved by the department concerned. (IRB-SHL-0332/22)

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Conflict of interest

The authors declared an absence of conflict of interest.

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