A Review Analysis on Ophthalmology Caused by Hypertensionusing Structural Features of Eye

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***Abstract*-The Hypertension is considered as one of the most common diseases that lead to an ophthalmological illness that is Hypertensive Retinopathy. It affects the arterial structure which damages eye vision; later at severity it causes complete vision loss. A diligent study has been carried out to get in depth and detailed knowledge about some of the previous clinical and machine learning methodologies. We have analyzed the functional and structural features along with clinical findings using fundus images. A review analysis deduced that Hypertensive Retinopathy has different severity estimations. The highest level is the swelling in Optic Disk and the initial level has arterial narrowing. A review also infers about the techniques to diagnose at early stage require precise data about its arterial features. Furthermore, by utilizing hybrid set of features in training and classification of arteries and veins in fundus images, the turnout results can yield to accurate and early exposure of grading level in Hypertensive Retinopathy.**

***Keywords:* -Hypertensive Retinopathy; machine learning methodologies; fundus images; Retina**

I. INTRODUCTION

INhuman anatomy the process, when heart pumps blood it narrow down to arteries.Blood pressure is measured by the amount of blood which is pumped by heart and the amount of the resistance to blood flow in arteries. Individuals who are suffering from high blood pressure are known as hypertensive patients and disease itself is called as hypertension. Kiethet.al. introduced malignant hypertension for the first time in in literature in 1928 when patients with presence of retinitis, marked hyper tension and adequate renal function [1]. Hypertension is certainly considered as the "Silent Killer" or "Global Heath Crises" of early 21st century. According to WHO survey analysis in 2008 out of every three adults aged over 25 have high blood pressure [8]. It is the fourth largest mortality risk factor around the world [2].

Hypertensive Retinopathy is an ophthalmic disorderprovoked due to increase in the blood pressure. The signs of disease emerge late while, its obvious chronic change in eye results in optic nerve damage which further leads to the blindness.

Hypertensive Retinopathy is considered to be second among most trivial retinal vascular diseases. This disease primarily damages the blood canal known as arteries of eye so the normal artery is supposed to supply the blood in the body. This retinal arterial disease affects the vascular structure in eye;those tiny arterial vessels get obstruction in their working due to high blood pressure. Thus that disturbance in the natural process of blood flow in eye initiatesophthalmological diseases that promotes to blindness. Hypertensive Retinopathy is likely to be an asymptomatic disease; the victim has no idea about the damages and its effects on the eye.

In Hypertensive Retinopathy there is change in retinal vascular pattern which is divided into two groups, one is vascular deviation and the second is extra-vascular deviation. First group includes effects such as Generalized/Focal Arteriolar Narrowing, Reflex Widening (Copper Wiring), Cross Abnormalities and Tortuosity. Second Group incorporates Retinal Hemorrhage, Hard Exudates and Cotton Wool Spots. Later in 1939 Kieth et al classified patients with hypertensive retinopathy into 4 main groups they proposed the first ever grading technique for hypertensive retinopathy she and Dodson PM et al proposed different grading technique on the basis of increasing clinical severity [3] [4]. However, several evaluations of hypertensive retinopathy since 1996 has been made which questioned the usefulness of the Keith et al classification andrelevance to current clinical practice. Grade 1 signs are not clearly distinguishingfrom grade 2 signs and the grading scheme is not properly correlated with the signs of hypertension [5].

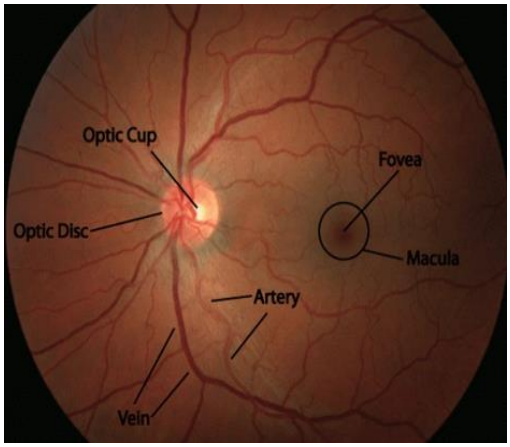

Fig. 1. Normal Retinal Fundus Image [9]

Hypertension cause serious damage to eyes of the patients which is known as retinopathy. Hypertensive retinopathy is a condition which is due to the spectrum of retinal vascular signs in hypertensive patients [6]. The retinopathy was observed in 1859 by Marcus Gunn in series of patients which have hypertension and renal disorders [7].

The image taken by the fundus camera is fundus image mostly ophthalmologists treat and diagnose the patients using these fundus images. Fundus is known to be the inner surface of eye which exists opposite to the lens. Anatomy of eye inside the fundus includes Retina, Vascular Pattern, OD (Optics Disk), Posterior pole, Macula and Fovea. Fundus image of retina can easily identify and located the smallest pixel based changes at micro level.

II. HYPERTENSIVE RETINOPATHY DETECTION: A CLINICAL PERSPECTIVE

In [18] main purpose of their study was to assess the inter-observer and intra-observer grading reliability of the grading system which were proposed by Keith, Wahner, and Baker (KWB). They have used 100 digital retinal image in which normal were 50 and hypertensive were 50 human fundii which were randomly graded by an optometrist (LED) and ophthalmologist by using two different techniques. They have used grade 1 KWB and grade 2 simplified classifications. Digital images were assessed on Fast Stone Image Viewer for windows. The inter-observer level agreement was analyzed for grade 1 and grade 2. The observer of both clinical observers wascompared with gold standard research grader and later with grading coordinator at the Centre for Eye Research Australia (CERA). Then intra-observer level of agreement for both Hypertensive grading system was compared with second grading system by same observers. They selected 25 subgroup image set per grading system. The Cohen's Kappa coefficient was calculated and the degree of agreement was expressed in kappa form. Both clinicians proved that both KWB and simplified classification was found to be equally as effectual as KWB system. The study findings reflect that the simplified classification of hypertensive retinopathy is reliable and repeatable. It also have an plus point over KWB system in correlating retinal microvascular signs to incident cardiovascular risk which supports its adoption in clinical practice.

Yi-Hao Chen, et al. in [19] reviews the clinical and fundus findings in patients with MHT. They have used charts and fundus photographs of patient having MHT from year 1995 to 2000 were retrospectively reviewed. All the patients had complained of blurred vision. Colour photographs of patient's fundus were observed to indicate hypertensive retinopathy grade III and IV by domain expert in this case an experienced ophthalmologist. There were 14 number of sample in this study in which 10 were female and 4 were male sample. All the data of the sample were recorded with unique identifier number in this scenario they have used case 1 for patient 1 of group I. Sample were further divided into 2 groups which bifurcate those who have history of hypertension from who don't have any history of hypertension. The ages of the sample ranges from 12-47 years in group I and from 22-56 year in group II. Systolic and diastolic blood pressure of reach sample was recorded from both groups and mean value were recorded. MHT was diagnosed by an expert ophthalmologist in 4 patients and other 2 patients were referred to gynaecology and nephrology departments. They study revealed that funduscopy has decisive significance in diagnosis and monitoring of MHT. To rectify and control this disorder it is recommended that a detailed fundus examination and blood pressure monitoring is necessary.

In research work [20] A. H. Shah et al. main objective was to detect retinal signs in hypertensive patients. This study was conducted in controlled environment specifically in hospital. The study duration was of one year. In this study 494 patients were subjected which have primary hypertension. In this study 317 were males and 178 were females. 193 patients were above 60 years of age. Initially the hypertension patients were identified by measuring there BP which was recorded by physician of sphygmomanometer. Then these all patients were referred to the ophthalmologist for detection of retinopathy by using funduscopy. They showed that with early detection of this disorder the eyes and other systemic complication of patients can be prevented for further loss.

T. Y. Wong, P. Mitchell In [21] they have discussed the different signs of hypertensive retinopathy which are very common and correlated with high blood pressure. Studies have proven that retinal haemorrhages, micoraneurysms and cotton wool spots predict stoke and death from stroke independently of elevated blood pressure. They have suggested that patients which have such signs should be closely monitored for cerebrovascular risk and intensive measure should be taken to reduce its occurrence risk.

A. Chopra et al. in [20] Hypertensive Retinopathy discuss the ophthalmic detection of organs damaged by the disease. The target organs are predictive through its signals of systemic-hypertension on basis of visual changes, some classifications. The 4 grading Stages of Hypertensive Retinopathy are also suggested by the A. Chopra et al. The paper also discussed cardiovascular risk in individuals having hypertension. The research review analysismeasures the altering perspectives in classification or categorizationand prognostic implication of fundal lesions.

III. CLINICAL CASE STUDIES FOR HYPERTENSIVE RETINOPATHY DETECTION

A Grosso et al. [15] conducted study suggest that arterial narrowing can be assessed through diameter readings using funduscopy. On the basis of this funduscopy retinopathy signs are common in adults' age > 40 even without history of diabetes and high blood pressure. Previous studies provide evidence that even mild blood pressure (BP) can have an

inimical effect on vascular network. High blood pressure in childhood had been deliberate risk for hypertension in recent adulthood. The retinal checkupsare recommended to detect retinal vascular changes in young patients. A previous study claimed thatubiquity of 41% in arteriolar narrowing and8% AV nicking, as shown by funduscopy, in a legion of 97 children & juvenile with essential hypertension.

In [16] J. A. de FigueiredoNeto et al. on ophthalmoscopy, researchers set their own grading scheme of Hypertensive Retinopathy. They evaluated 99 patients whose dataset was available the deduced 51% have grade I abnormalities, 43% in grade II and with 1% in grade III. The study concluded that the Hypertensive Retinopathy has no direct relation with the targeted damage organs.

M. Bhargava and T. Y. Wong in their article [17] have classified there work in detail the Hypertensive Retinopathy growth and long term consequences and its clinical affects damaging the organs. The researchers' observed that in long term the disease can cause pacification in arterial structure, which will advance towards copper wiring, silver wiring, Nicking and Cotton Wool Spotsfinally leads to complete vision loss. Data from last decade was gathered and from previous studies of Hypertensive Retinopathy, its symptoms along with frequently existence in 3-14% of non-diabetic adult's age> 40 years was found. Within the distinct retinal signs, in Hypertensive Retinopathy patients arteriolar narrowing and AVN occur in 7-12%, and utmost familiar lesions or hemorrhages or micro-aneurysms (3-17%), with cotton wool spots (CWS) being comparativelyrare (0.3%). The last decade cumulativeoccurrence of these Hypertensive Retinopathy signs is 16%. According to the research some indications points to genetic domination on diseases. A twin study of vascular caliber of retina stated that the heritabilities of retinal arteriolar and venular calibers were 70% and 83%, respectively.

IV. HYPERTENSIVE RETINOPATHY DETECTION USING MACHINE LEARNING TECHNIQUES USING FUNDUS IMAGES

A critical research carried by C. Muramatsu et al. in 2010[10] indicate that health status of body as in Hypertension creates retinal vasculatures abnormalities. Automatic driven breadth ratio of A/V (arteries over veins) from fundus image would help the medical specialist to diagnose the grade level of hypertensive retinopathy as the severity of diseases may causes blindness. This research produced classification of arteries and veins and calculating the A/V ratio. DRIVE dataset is used after vascular segmentation major artery & vein lower & upper temporal regions selection and creating gold standard. Later on by applying black top-hat algo along with ring filter to detect blood vessels from quarter disc of OD. Lastly feature extraction by linear discriminant analysis and classification give 75% accuracy which are further used for A/V ratio calculations.

In [11] G. C. Manikis et al. presented a skeleton using fundus image for measuring and detecting of retinal vessels. In the research methodology proposed vessel segmentation measuring vessel diameter and region of intersection. Additionally, the methodology provides recovery from any misclassification in segmentation. Integrating all stages produce clinical application to support the medical specialist. Performance of system is test using DRIVE & STARE databases with accuracy rate of almost 94% in addition with low computational cost.

The Paper [12] Support System for the Automated Detection of Hypertensive Retinopathy using Fundus Images written by K. Noronha, K.T. Navya,K. P.Nayak. Detailed analysis of images from fundus camera was performed to identify the early stage Hypertensive Retinopathy. The research team developed a technique to segment the vascular pattern then tortuosity measurement along with diameter calculation and finally the calculation of AVR (Arteriovenous Ratio) all these features are gathered using retinal fundus image. The main idea is ophthalmologist assist in the diagnosis of the grade of Hypertensive Retinopathy. The system tested showing 92% accuracy using DRIVE dataset.

Shilpa Joshi, Dr P.T. Karule in [13] deduced that the network of retinal vascular structure is the pivotal location from where the assessment of retinopathy. They indicate that the vessel network the focal region must be segmented properly for the correct analysis of severity of disease in their research green channel of fundus image is extracted with morphological operations the enhancement of vessels is done. Through disc structuring the proposed system follow the elimination of the background and thresholding. The technique proposed was applied on DRIVE dataset was highly effective and clarifies the blood vessels network for the diagnosis.

In [14] K. Narasimhanet. al. claims that Hypertensive Retinopathy certainly damages the retina which results in blindness. Hypertensive Retinopathy at its severe level can cause diseases such as cardiovascular, renal & heart failure, vision loss and death. Therefore, timely diseases diagnosis and treatment is essential. AVR (Arteriovenous Ratio) is consideredat early diagnosis of diseases so the research proposed an algorithm that segments the vessels after the pre-process is done on fundus image. Pixel based classification is done to classify the blood vessel belong to class this classification use grey level & moment based features extraction.Arteriovenous Ratio is calculated by measuring the width of vessel the variation in AVR (Arteriovenous Ratio) help to identify stage of Hypertensive Retinopathy. VICAVR dataset is used almost 91% was the accuracy rate of the proposed solution.

C. Agurtoet. al. in [27] presented a new method that automatically classifies subjects with hypertensive retinopathy (HR). Initially normalization and enhancement then using automatic location of OD helps to determine ROI later by

vascular width and tortuosity segmentation is completed. Color features extracted helps to classify arteries or veins AVR calculation utilizing six widest (major) blood vessels for each category. Lastly using red intensity mean and amplitude-modulation frequency-modulation (AM-FM) gives features for classification into HR and non-HR using linear regression. The methodology by Carla Agurtoet. al. was tested on 74 images captured by TOPCON and CANON retinal cameras produced with sensitivity and specificity of 90% and 67%, respectively.

Daniel Ortíz et.al.in paper [28] projected a novel technique for calculating the vessels caliber, measures the AVR and deduce the existence of Hypertensive Retinopathy. The author created a local dataset of 50 images of 720x576 using Visucam-Lite camera. Image enhancement by gradients, morphological operations then for segmentation Gabor wavelet and Hessian Matrix are used. Image binarization using Niblack and for ROI and OD detection local threshold method is applied. By image red channel mean value classification is carried out. The features such as slope of vessel and pixel count till boundaries, along with vessels caliber by Parr-Hubbard formulas and measurement of AVR are used in HADIREH system producing accuracy rate of 92%.

V. RESULTS AND COMPARISON

Clinical finding and reviews analysis on Hypertensive Retinopathyin Table 1unveil that the arterial vascular structure is initial principal point where diseases cripple. This early defect in eye vascular network due to Hypertensive Retinopathy will be detected earlier to identify the structural and clinical changes are then compared to its functional changes. In addition, with, comparability between selected features for Hypertensive Retinopathy detection indicates that a more veracity in Hypertensive Retinopathy detection can be accomplished if structural features along with functional features are used in coincidence.Between these all factors and clinical changes that appear in Hypertensive Retinopathy that are arterial narrowing, reflex widening, crossing abnormalities, tortuosity and CWS were noticed. The AVR ratio is one of the most promising features to identify the severity Hypertensive Retinopathy.

The latest research review depicts that arterial structure gives information about Ophthalmological diseases. For Hypertensive Retinopathy AVR ratio is considered as the outcast feature Table 2 explains different types of the AVR (Arteriovenous Ratio) calculation techniques and there success rates. Average arteriolar diameter in ratio with average venous diameter is clearly said to be AVR.

Table 1.Clinical finding and reviews analysis on Hypertensive Retinopathy

Researchers	Methodology	Features	Datasets	Success Rate
C. Muramatsu et. al.	Using Black top-hat transformation vessel segmentation. A/V ratio calculation. Classification on bases of color and width using LDA.	Centerline pixel in 3 channels & AVR Ratio	DRIVE	75.0 % (30/40 pairs correctly identified)
G. C. Manikis et. al.	Iterative thresholding for vessel segmentation. Then after enhancement of skeleton width calculation. Laplacian scale for OD radius.	AVR Ratio	DRIVE & STARE	Accuracy of 94%
K. Noronha et. al.	2D-Match filter for segmentation along with sobel filter. Radon Transformation for feature detection. OD detection using red component histogram then Circular Hough Transform for suitable radius calculation. AVR Classification for vessels caliber the Parr-Hubbar formulas is applied.	Color and width of vessels AVR Ratio	DRIVE	85% (25/30 correctly identified)
S. Joshi and Dr P.T. Karule,	Global Transformation for segmentation after pre-processing along with top-hat algorithm. SVM Classifier is used.	Vessel Width & AVR Ratio.	DRIVE	94% (72/76 correctly identified)
K. Narasimhan et. al.	Pixel based classification is done to classify the blood vessel & moment based features extraction.	Vessel Width & AVR Ratio.	VICAVR	Almost 91% was the accuracy rate.
C. Agurto et. al.	Using vascular width and tortuosity for segmentation Color features helps to classify arteries or veins. AVR calculation utilizing six widest (major) blood vessels for each category. Red intensity mean and amplitude-modulation frequency-modulation (AM-FM) will classify into HR and non-HR using linear regression.	Color & AVR	Local Dataset 45 out of 74 normal images & 29 show signs of HR (TOPCON TRC 50EX & CANON CR-1 Mark II)	Classification accuracy of 87%.
Daniel Ortíz et.al.	Enhancement using gradients, morphological operations then for segmentation Gabor wavelet& Hessian Matrix then binarization using Niblack. ROI and OD detection local threshold method is applied. Classification using red channel mean value. Features extraction slope of vessel and pixel count till boundaries, vessels caliber by Parr-Hubbard formulas and measurement of AVR are used in HADIREH system	Vessel Slope, Pixel Count till boundaries, vessels caliber & AVR	Local Dataset 50 images of 720x576 using Visucam-Lite camera	Above 92%

Table 2. Different types of the AVR (Arteriovenous Ratio) calculation techniques

Research	Methodology	Year
R. ChrBstek, M. Wolf, K. Donath, H. Niemann	The calculation for vessel segments without abnormalities such as bifurcation, narrowing and crossing and with diameter value greater than 3 pixels (FOV 45') and greater than 6 pixels (FOV 22,5") respectively. To distinguish between arteries and veins minimum diameter must be calculated elsewise even for an ophthalmologist is difficult to differentiate.	2002
M. Saeza, S. González-Vázquezc, M. González-Penedoc,M. Antònia Barceló, M. Pena-Seijod, G. Coll de Tuerob,A. Pose-Reinod	Vessel contour points belong to the right and left edges are determined later least square method is used then calculate perpendicular intersection of edges. The regions perpendicular to the vessel detected are called profiles. Lastly, middle point algorithm to collect the group of all points in the profile. After Features selection (luminosity and colour) and vessel labeling after un supervised clustering creating group's K-mean algorithm is used.	2012
J. C. Wigdahl, P. Guimaraes, E. Poletti, A. Ruggeri	The application combines algorithms for vessel segmentation, OD detection, and Artery/Vein classification. Clinical parameters like vessel widths, tortuosity metrics, OD radius, and fractal dimension are calculated. Artery/Vein classification is performed along with vessel crossover points are detected for narrowing and angle in/out.	2015
A. Meshi, J. Shahar, Y. Arbel, S. Berliner, A. Loewenstein, D. Goldenberg	For Uncontrolled hypertensive patients arteriolar narrower mean diameters in comparison to other measurement, statistical importance in the superior arterioles is $P = 0.009$ while of healthy controls mean AVR were smaller ($P < 0.04$), since mean venular diameters were greater $P < 0.01$ at all points of measurement in hypertension.	2015

VI. CONCLUSION

Hypertension is a "Silent Killer" or "Global Heath Crises" which causes Hypertensive Retinopathy the ophthalmological diseases which gradually takes the patient to permanent vision loss. Research concludes that the premature accurate detection of the Hypertensive Retinopathy will helps to control its progression. Ophthalmoscopy (funduscopy) helps the medical specialist to see inside the fundus of eye, the very same fundus image is used by the research's to analysis the disease in detail. In depth study is done to collect data which indicates structural & functional features that are affected due to this disease its early stage symptoms that that alter the normal retinal network.

The research indicates that among all the retinal parts the arterial vessels are the ones which change at initial level later the OD swelling is the highest severity level. Furthermore, the analysis helped to determine some of the efficient methodologies used to extract the arterial network. Comparison of infected arterial network with healthy one assisted to deduce and quantify damage level in the patient by calculating its AVR ratio. The DRIVE dataset is mostly used for testing of the different methodologies.

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