English

Teleophthalmology and its application for the early detection of Diabetic Retinopathy: a review article

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Abstract

Introduction: *In Peru as well as worldwide the morbidity of both Diabetes Mellitus and Diabetic Retinopathy is of relevance, As well as in many countries, especially those in the developing world, the lack of ophthalmologists and even more so of retinal sub-specialists means that tools such as telemedicine are considered a strategic and viable alternative for the early detection of diabetic retinopathy.* **Method***: The present article describes the review of scientific studies related to the application of tele-ophthalmology in pathologies of Diabetes Mellitus for the early detection of Diabetic Retinopathy.* **Results and discussion:** *In the articles reviewed, the use of intelligent cellular phones or smartphones for the acquisition of images of the fundus of the eye is proposed, which generated a positive expectation considering the proliferation of this type of equipment, as well as the possibility of complementing it with artificial intelligence solutions for the optimization of the screening procedure.*

Keywords: Teleophthalmology; Diabetic Retinopathy; Artificial Intelligence; Early Diagnosis; Telemedicine.

Resumen

Teleoftalmología y su aplicación para la detección temprana de Retinopatía Diabética: un articulo de revisión.

Introdución: *En el Perú así como a nivel mundial la morbilidad tanto de Diabetes Mellitus como de Retinopatía Diabética es de relevancia, así como en muchos países, sobre todo aquellos en vías de desarrollo, la carencia en la oferta de oftalmólogos y más aún de sub especialistas en retina hace que herramientas como la telemedicina se consideren una alternativa estratégica y viable para la detección temprana de Retinopatía Diabética.* ***Método:*** *El presente artículo describe la revisión de estudios científicos relacionados a la aplicación de teleoftalmología en patologías de Diabetes Mellitus para la detección temprana de Retinopatía Diabética.* ***Resultados y Discusión:*** *En los artículos revisados se plantea el uso de celulares inteligentes o smartphones para la adquisición de imágenes de fondo de ojo, lo que generó una expectativa positiva considerando la proliferación de este tipo de equipos, así mismo la posibilidad de complementarlo con soluciones de inteligencia artificial para la optimización del procedimiento de tamizaje o screening.*

Palabras-clave: Teleoftalmología; Retinopatía Diabética; Inteligencia Artificial, Diagnóstico Precoz; Telemedicina.

Resumo

Teleoftalmologia e sua aplicação na detecção precoce de Retinopatia Diabética: um estudo de revisão.

Introdução: *No Peru, bem como em todo o mundo, a morbidade tanto da Diabetes Mellitus quanto da Retinopatia Diabética é relevante, assim como em muitos países, especialmente nos países em desenvolvimento, a falta de suprimento de oftalmologistas e, mais ainda, de subespecialistas da retina significa que ferramentas como a telemedicina são consideradas uma alternativa estratégica e viável para a detecção precoce da Retinopatia Diabética. Método: Este artigo descreve a revisão de estudos científicos relacionados à aplicação da teleoftalmologia nas patologias do Diabetes Mellitus para a detecção precoce da Retinopatia Diabética. Resultados e Discussão: Nos artigos revisados, propõe-se o uso de smartphones ou smartphones para a aquisição de imagens de fundo, o que gerou uma expectativa positiva considerando a proliferação desse tipo de equipamento, bem como a possibilidade de complementá-lo com soluções de inteligência artificial para otimização da triagem ou procedimento de triagem.*

Palavras-chave: *Teleoftalmologia; Retinopatia Diabética; Inteligência Artificial; Diagnóstico Precoce; Telemedicina.*

INTRODUCTION

Diabetes mellitus (DM) is a major global public health problem and there is concern about the increase in the number of patients in the coming decades due to an aging population and changes in lifestyles.[1,2] The term MD, according to the World Health Organization (WHO), encompasses the metabolic alterations of multiple etiologies characterized by chronic hyperglycemia and disorders in the metabolism of carbohydrates, fats and proteins, resulting from defects in the secretion of insulin, its action or both. [1,2]

The World Health Organization estimates that more than 346 million people worldwide have diabetes and that 552 million people will be affected by 2030.[3]

Diabetic Retinopathy (DR) is the second leading cause of blindness worldwide and the first in people of reproductive age in developing countries. It is also the leading cause of blindness among people of working age in industrialized countries, with the risk of blindness being 25 times higher than in the general population.

DR is the most common microvascular complication of diabetes and the leading cause of vision loss in working-age adults aged 20 to 74 in the United States, accounting for 12% of new cases annually. In the United States they do not receive the recommended annual screening for DR, and vulnerable populations with less access to specialized medical care have an estimated detection rate of between 10% and 20% per year. [3]

In Peru, the latest figures on the prevalence of DM have been reported by Seclén and Col. in 1997, who found 7.6% for Lima; 6.7% for Piura; 4.4% for Tarapoto and 1.3% in Huaraz. [2]

We determined the prevalence and risk factors of diabetic retinopathy in patients with type 2 diabetes (DM2), at Hospital Nacional Dos de Mayo (HNDM), between 1991-1994, through a prospective clinical study. 427 patients were divided into 2 groups, randomly according to age and sex: I) No diabetic retinopathy (No RD, n = 180) and II) diabetic retinopathy, (RD, n = 247). Results: Prevalence was, No RD: 42.38% and RD: 57.62%, prevalence for RDNP (non-proliferative) and RDP (proliferative), were: 47.29% and 10.33%, respectively. Time of MD (10 years) was the only significant risk factor associated with the appearance of DR, blindness was found in 12.19% of DR.[1]

The prevalence of DR is similar to that found in global and national studies. Time of diabetic disease was the risk factor statistically associated with the occurrence of DR. A high risk of blindness was found in this population, given the high prevalence of DR.[1]

METHOD

The present article describes the review of scientific studies related to the application of tele-ophthalmology in pathologies of Diabetes Mellitus for the early detection of Diabetic Retinopathy.

RESULTS AND DISCUSSION

The high prevalence of DR in Peru implies the implementation of a strategy of early detection through screening procedures. Screening for DR is an important aspect of MD management worldwide. According to the International Council of Ophthalmology (ICO), even if an adequate number of ophthalmologists were available, using ophthalmologists or retinal subspecialists to screen all people with MD is an inefficient use of resources. In Peru, as in the regions of Latin America, there is a deficit of ophthalmologists, those who are working in large urban areas, the deficit is even greater if they are retinal subspecialists.

This scenario of lack of specialists in less urban and rural areas, where diabetes is also important and where it is necessary to detect cases of DR as early as possible, the implementation of telemedicine strategies, specifically tele-ophthalmology, becomes relevant, A strategy of this type has not yet been implemented in Peru, if there are initiatives at the level of approaches such as those of the National Institute of Ophthalmology (INO), however they have not yet been implemented, in this article we have reviewed some studies related to teleophthalmology focused on the early detection of DR, which will proceed to describe.

In the article "A Smartphone-Based Tool for Rapid, Portable, and Automated Wide-Field Retinal Imaging "[3] the use of the smartphone to obtain wide-field retinal images in a fast, portable and automated way is proposed. According to the article, images or photographs of the retina can be used to help with the diagnosis and monitoring of retinal diseases. However, access to traditional retinal cameras is limited by their high cost and the need for qualified operators. Conventional imaging approaches require the cooperation of the patient in a stabilized, upright head position, which can be difficult among ill, wheelchair-bound, and immobile patients, as well as for children.

Portable ophthalmoscopes with digital image capture offer an alternative, but their acquisition and operation in first-level health care facilities would be a limitation. Smartphone-based retinal imaging approaches have been described to take advantage of the high-resolution camera and wireless data transfer capability to capture diagnostic images in real time (synchronous) or remotely (asynchronous), with low costs. This research demonstrates the growing potential of smartphone imaging to expand the accessibility of eye care and photo detection of vision-threatening diseases.

There is great interest in the validation and integration of smartphone-based retinal photography into community disease screening programs, such as glaucoma and diabetic retinopathy (DR).

Ophthalmologists recognize that DR telehealth through retinal photography in the primary care setting, with remote consultation by an ophthalmologist, is a mechanism to improve access and therefore improve outcomes in a cost-effective manner[3].

The "gold standard" for the DR photography detection technique is the seven-field, 30 field, mydriatic tabletop retinal photography, in which 14 images per eye from seven standard fields comprising the posterior 90° of the retina are evaluated to determine the risk of vision loss and retinopathy. It is important to note that images made by non-expert operators can affect image quality and is an important consideration for detection efforts.

The article[3] proposes the development of the Ocular CellScope, an imaging device integrated into a smartphone and portable capable of capturing high quality images of the retina over a wide field. From extensive field tests with that device, several challenges facing the performance and use of that device and smartphone-based retinal photography in general are identified.

First, examining large regions of the retina with a handheld device requires extensive operator experience to obtain complete images of the peripheral retina. Second, sustained levels of bright white light illumination for high resolution retinal imaging can be uncomfortable for patients, resulting in poor image location caused by changes in vision and decreased image quality from motion artifacts. Third, smartphone imaging approaches generally require two-handed operation and are asymmetrical, with different orientation for the right and left eye, increasing operator instability and movement. Fourth, the lack of optimized data management for image acquisition, viewing and storage slows down the workflow and increases examination time.

This study3 used a retinal imaging system, using CellScope Retina, which addresses the above issues and incorporates automation to improve image quality and reliability. The proposed system uses the 100° field, which was chosen to ensure that a larger portion of the retina is shown with Retina CellScope than the Early Treatment Diabetic Retinopathy Study (ETDRS) detection technique, which evaluates the posterior 90° using seven individual 30° field images.

In addition, CellScope's images have a resolution of 52.3 pixels per retinal grade, exceeding the minimum resolution requirement of 30 pixels per grade described by the National Health Service for DR. The article reports that Retina CellScope is the first demonstration of a smartphone-based automated system capable of imaging, bonding and reviewing a wide-field retinal mount on a fully portable platform without the need for an external computer3.

The article "Automated diabetic retinopathy detection in smartphone-based fundus photography using artificial intelligence "[4], addresses automated DR detection through fundus procedures using smartphones and artificial intelligence. This study raises the need for regular retinal screening for all people with diabetes, a need that is not met in most countries, especially in developing countries.

As stated in the previous scientific article, the use of retinal photographs for classification and interpretation by ophthalmologist-retinal specialists is widely accepted for the detection of DR. However, the availability of retinal specialists is a major constraint in most countries; even when available, there may be significant waiting times for DR qualification or advice due to their high demand. This leads to the consideration of artificial intelligence and its "continuous and automatic learning" for DR detection, which occurs by providing and processing thousands of retinal images of varying degrees of DR for your learning system.

This study uses an artificial intelligence software called "EyeArt" which according to the article was able to qualify images for early DR detection with a sensitivity of 99.1% and specificity of 80.4%. The results reported in this article are at the level of rating comparison made by ophthalmologists using retinal images using specialized cameras with a mydriatic background.

The use of AI to analyze retinal images is attractive, since it fits with the current trend in Teleophthalmology and Telemedicine in general. Automated DR classification software has potential benefits in efficiency, reproducibility and early detection of DR.

Other recent studies have shown that Artificial Intelligence (AI) could be used to qualify retinal images taken with conventional fundus cameras and determine which DR patients need referral to the ophthalmologist. The study in question[4] adds the use of artificial intelligence (AI) to fundus images made on smart phones.

Artificial intelligence as a set of technologies that serve to emulate unique characteristics of the human intellect implements the simulation of human intelligence processes by machines, especially computer systems. These processes include learning (the acquisition of information and rules for the use of information), reasoning (using the rules to reach approximate or definitive conclusions) and self-correction.

In-depth learning has been mainly applied to the analysis of medical images. In-depth learning systems have demonstrated diagnostic performance in the detection of various medical conditions, including tuberculosis by chest radiography, lymph node metastases secondary to breast cancer from tissue sections. Thus, it has been identified that deep learning has allowed the detection of diabetic retinopathy.

A benefit in ophthalmology could be the detection, as for DR, Retinopathy of prematurity, for which there are well established guidelines. The use of deep learning coupled with Telemedicine can be a long-term solution to evaluate and monitor patients for eye care. However, programs face problems related to implementation, availability of human assessors, and long-term financial sustainability.

Finally, the study "Implementation of a diabetic retinopathy referral network, Peru"[5] describes how 11,849 patients were examined over a 4-year period, increasing the number of diabetic retinopathy screenings by 138.1% over the previous year. To this end, a referral network was implemented that provided effective and timely treatment

for patients with diabetic retinopathy, articulating factors such as education, detection and care; after integrating 12 health facilities of the three levels of care: 9 health centers, 2 hospitals and the Regional Institute of Ophthalmology of Trujillo, located in the region of La Libertad, where the study was developed.

According to the article[5], the effectiveness of this reference model could be greater if tele-health is used for the different phases; through tele-management, it can be coordinated with all first-level facilities in the 12 provinces that comprise the study region and only with the centers closest to the institute - as the network did; with tele-medicine, for example, cases could be handled in all first-level facilities, avoiding unnecessary referrals to the hospital (second level of care); and finally, with tele-training, staff can be oriented and the process guide socialized. In this sense, it would help this strategy to increase its coverage if an efficient system of care for users with diabetic retinopathy is generated in the country.

CONCLUSION

According to the morbidity of Diabetes Mellitus (DM) worldwide and in Peru and its other possible effects such as Diabetic Retinopathy (DR) as the second cause of blindness worldwide, early detection strategies of DR are of high relevance not only in terms of the eye health of affected people but also the effect on the economy of the health system. Telemedicine in Peru is a tool that has been implemented and promoted for a few years now, especially in the form of synchronous consultations with specialist health professionals, as well as asynchronous telediagnosis experiences specifically in teleradiology, telemamography, there is not much documentation of experiences in tele-ophthalmology, There may be experiences at the academic level in the private sector, but one of the limitations identified for implementation with State health facilities is that they do not have specialized equipment such as digital retinography cameras or similar, which is why the approach of using smart phones is attractive.

According to the articles reviewed, the results obtained with images obtained from smart phones, such as cameras with good resolution, are promising for the purposes of early detection, or screening with the objective of identifying as early as possible cases that deserve to be fully evaluated by an ophthalmologist who finally performs the diagnosis of DR. Possibly one of the challenges in their implementation, beyond the use of technology, is having a defined protocol for capturing images that will allow this screening to be done as effectively as possible. This in turn leads to the need to train the people who would carry out this procedure mainly in first-level health facilities.

A next step would be the implementation of artificial intelligence solutions that automatically, and with the help of the database of acquired images and the reference database, would make it possible to carry out DR screening with greater sensitivity and specificity.

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