Telemedicine in diabetic retinopathy: Access to rural India

Taraprasad Das, Rajeev Reddy Pappuru

Diabetic retinopathy (DR) is a growing concern in India. The first step in management of DR is timely screening. With 10% prevalence in rural India, 11 million people are likely to have DR by the year 2030. With limited resources and skilled manpower, it will not be possible to have routine eye examination to identify and treat these patients on a regular basis. Telemedicine is a possible answer in these situations where patients could be remotely screened and appropriately advised. With the advent of several technological advances such as low cost hand-held nonmydriatic camera, increased capabilities of the smartphones to take external eye and retinal photographs coupled with improving broadband connectivity; teleophthalmology in the management of DR could be a reality in the not too distant future.

Key words: Diabetic retinopathy, India, rural, screening, telemedicine

Telemedicine is exchange of medical data by electronic telecommunication technology that allows patients' medical problems evaluated and monitored by a remotely located physician.[1] Electronic medical record system has not only allowed creating a paperless office and easy to analyze collected data but also has created a platform to seek opinion from a specialist for decision-making and in data sharing. In addition, ophthalmology, in general, being highly image sensitive is particularly suited for telemedicine.

Diabetic retinopathy (DR) is unique for several inherent reasons for telemedicine. The diabetics take a variable length of time to developing manifest retinopathy and all manifest retinopathies are not vision-threatening for treatment. The yearly incidence of developing sight-threatening DR (STDR) in the Liverpool Diabetic Eye Study was 0.3% in the 1st year, rising to 1.8% by the 5th year, and the cumulative incidence of STDR was 3.9%.[2] The current estimated prevalence of STDR globally is 10.2% among diabetics.[3] It has been stated that DR develops in 4–7 years after onset of noninsulin-dependent DM.[4] Development of DR depends on several factors such as type and duration of DM, status of blood pressure, and serum lipid. Hence, it is advised that all diabetic patients receive a comprehensive eye examination including a dilated fundus examination. From a pure ophthalmologist point of view, it is impractical to examine all people with DM with the current limited trained manpower of both ophthalmologist and optometrists. Hence, it is the value of telemedicine in diabetics where the basic physical data and the fundus photograph are collected closer to patients' habitat and opinion on the presence/absence of retinopathy, and the need for treatment is sought from a remotely located expert ophthalmologist.

Diabetic Retinopathy Fits into Screening Criteria

Wilson and Jungner[5] have defined 10 criteria for screening of chronic diseases such as DM and DR. These are listed in Table 1 along with the DR screening alignment.[6]

India has a Large Burden of Diabetic Retinopathy

DR is the leading cause of visual disability in diabetics. The reported prevalence of DR in India ranges from 17.6% to 28.2%.[7-10] With this prevalence, the number of people with DM is likely to increase to 79.4 million and people with DR is likely to increase to 22.4 million by the year 2030.[11] Both DM and DR are relatively less, between 10% and 12%, in rural India compared to urban India[12-14] but not small enough to ignore. Considering that prevalence of DR at a moderate level of 20% in urban India and at a lower level of 10% in rural India and assuming that 70% of Indians live in rural areas, the incidence of DR in rural India could rise to 10.97 million by the year 2030. In addition, there is an acute shortage of skilled manpower to screen DR in rural India. Traditionally, the two popular methods of DR screening are either ophthalmologist led or optometrist led. Both methods are effective and are used both in India and globally. However, with the large emerging burden, it may no longer be the cost effective

Srimati Kanuri Santhamma Centre for Vitreo Retinal Disease, L. V. Prasad Eye Institute, Hyderabad, Telangana, India

Correspondence to: Dr. Taraprasad Das, L. V. Prasad Eye Institue, Road #2, Banjara Hills, Hyderabad - 500 034, Telangana, India. E-mail: tpd@lvpei.org

Table 1: Wilson and Jungner screening criteria and diabetic retinopathy screening alignment

#1	Wilson and Jungner criteria	The condition sought should be an important health problem
	DR screening alignment	DM and DR are important health problems
#2	Wilson and Jungner criteria	There should be an accepted treatment for patients with recognized disease
	DR screening alignment	Laser, intravitreal anti-VEGF, and vitreous surgery are accepted treatment for DR
#3	Wilson and Jungner criteria	Facilities for diagnosis and treatment should be available
	DR screening alignment	Most eye care facilities are capable of confirming and treating DR
#4	Wilson and Jungner criteria	There should be a recognized latent or early symptomatic stage
	DR screening alignment	Reduction of vision is an early recognizable symptom of DR
#5	Wilson and Jungner criteria	There should be a suitable test of examination
	DR screening alignment	FFA and OCT confirm the clinical diagnosis
#6	Wilson and Jungner criteria	The test should be acceptable to the population
	DR screening alignment	Current standard of care in DR is accepted by people
#7	Wilson and Jungner criteria	The natural history of the condition, including development from latent to declared disease, should be adequately understood
	DR screening alignment	There is a particular pattern of progression of DR from nonproliferative to proliferative stage
#8	Wilson and Jungner criteria	There should be an agreed policy on whom to treat as patients
	DR screening alignment	Treatment guidelines for R are based on evidence
#9	Wilson and Jungner criteria	The cost of case-finding (including diagnosis and treatment of patients diagnosed) should be economically balanced in relation to possible expenditure on medical care as whole
	DR screening alignment	The current cost of detecting and treating DR is not inexpensive in absolute terms although it is known to improve the vision-related quality of life
#10	Wilson and Jungner criteria	Case-finding should be a continuing process and not once for all project
	DR screening alignment	Follow-up of confirmed patients and detection of new patients is an established practice in DR

DM: Diabetes mellitus; DR: Diabetic retinopathy, FFA: Fundus fluorescein angiography, OCT: Optical coherence tomography, VEGF: Vascular endothelial growth factor

method of DR screening. This is truer in rural India. Hence, a cost-effective DR screening is required in rural India, and this is possible with the existing and emerging technology of telemedicine.

Categories of Telemedicine

The American Telemedicine Association has described four categories of DR screening from identification of mild NPDR (Category 1) to the one that exceeds the ability of Early Treatment Diabetic Retinopathy Study photographs (Category 4) [Table 2].[15]

DR screening is done by direct and indirect ophthalmoscopy and fundus photography. Fundus photography is more popular than ophthalmoscopy because it is more objective. It is also convenient because it does not need the ophthalmologist to be always present in the screening site; the stored photographs could be examined later, and when in doubt, could be confirmed with another expert. The technological improvements in fundus photography– from analog to digital, from 30° to 45° to 60° field in most digital cameras, and from mydriatic to nonmydriatic retinal cameras – have made the fundus photography as the most accepted form and standard of care in DR telescreening. In past, satellite connection has been used for transmission of the fundus photographs for teleconsultation. With improvement in internet and wire-free connection, the current generation of cameras is capable of transmitting the fundus images at fraction of cost incurred in the past.

Our Experience

We have established such a system of receiving the fundus photographs obtained in a hand-held nonmydriatic fundus

Table 2: American Telemedicine Association diabetic retinopathy telescreening categories

Category	Description
1	The system that identifies patients with none or very mild NPDR
2	The system that identifies patients with or without STDR
3	The system that identifies NPDR, PDR, and macular edema with sufficient accuracy for appropriate decision-making
4	The system that equals or exceed the ability of ETDRS photographs to identify DR lesions

DR: Diabetic retinopathy, ETDRS: Early Treatment Diabetic Retinopathy Study, NPDR: Nonproliferative diabetic retinopathy, PDR: Proliferative diabetic retinopathy, STDR: Sight-threatening diabetic retinopathy

camera placed at centers managing diabetes, and the images are both qualified and quantified for DR in the image reading center, L. V. Prasad Eye Institute Imaging Laboratory and Analysis Center (LILAC). Certified technicians grade the images and the specialist's opinion is sought in difficult ones. This has further reduced the ophthalmologist's time required to screen these patients. In a pilot study, the LILAC received fundus photographs of 229 diabetic subjects over 6 months; images of 32 subjects were ungradable (small pupil, lens opacities, etc.,) and 94 were diagnosed to having treatable DR (unpublished data). With increasing and powerful internet services planned in India, this method could be the most cost-effective method of DR telescreening in rural areas.

A few Indian studies have confirmed the superiority of fundus photography in teleophthalmology of DR care and

good patient satisfaction.[16,17] Some Indian investigators have used the services of the Indian Space Research Organization designed teleophthalmology vehicles to transmit images from outreach locations to the DR reading and grading center at the base eye care facilities. While this facility may not be available to everyone and everywhere, the internet or cloud-based facility will be cost effective that delivers equally reliable information.

The current lacunae in telescreening of DR in India are lack of enough broadband capacity in India. A satellite transmission is preferred over an internet system.[6] As India is progressing in digital technology, we hope that this deficiency will be effectively addressed.

Future Direction

We foresee two important future developments; one, further miniaturization of fundus camera, superior picture quality, and reduced cost of the cameras; two, autodetection of fundus lesions in DR. This will empower and enable the patients for informed decision-making. Smartphones are increasingly used in ophthalmic screening.[18] There are many attempts currently made for autodetection of retinal lesions.[19] While we are on the threshold of witnessing a revolution in DR screening, the knowledge, attitude, and practice (KAP) toward diabetes and retinopathy needs considerable improvement (authors' unpublished data). We are less likely to benefit from these disruptive technological unless the KAP also improves.

Conclusion

Prevalence of DR in rural India (or the world) is not too different than the urban people. However, the rural population is disadvantaged for not having a similar access to skilled personnel, particularly a specialist ophthalmologist similar to their urban counterpart. The modern technology of digital nonmydriatic photography, particularly the smartphones, fast expanding broadband transmission of these fundus pictures, and smarter autodetection of the retinal lesions will make the rural diabetic patients no more remain disadvantaged. The success of these new developments partly rests on similar improvement in the KAP of the rural folk.

Conflicts of interest

There are no conflicts of interest.

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