

Telemedicine and Electronic Health Records in the Diagnosis and Treatment of Retinopathy of Prematurity

BY MICHAEL F. CHIANG, MD

Retinopathy of prematurity (ROP) is a vasoproliferative disease that has traditionally been diagnosed by serial dilated ophthalmoscopy. Despite advances in treatment based on the findings of the CRYO-ROP and ETROP trials,^{1,2} ROP remains a significant cause of childhood blindness throughout the world.³

Retinopathy of prematurity is a challenging disease for ophthalmologists to manage for a number of reasons. Retina specialists and pediatric ophthalmologists see most of their patients in the clinic. Babies with ROP, by contrast, are hospitalized in neonatal intensive care units (NICUs), so the ophthalmologist must travel to see them, and this introduces the need for significant travel time and coordination. This mode of care for ROP also involves coordination with the neonatologist to ensure that the babies are dilated when the ophthalmologist arrives, that other tests are not scheduled during the scheduled exam time, and so on. The examinations themselves require significant time, and they are difficult to do: These tiny babies are very sick, and it is a challenge to examine them in detail for long periods of time.

On top of these issues, there is tremendous medicolegal liability in providing ROP care, with the highest monetary awards in all of ophthalmology, according to the Ophthalmic Mutual Insurance Company (OMIC). After all, when babies with severe disease become blind, the result is a lifetime of blindness.

Telemedicine is a technology that can address many of these problems. In telemedical diagnosis of ROP, photographs and data are obtained for subsequent interpretation by a remote expert.⁴ Studies by our center and others in recent years have shown that telemedicine can improve the results of ROP screening. For example, we performed a prospective study assessing the accuracy, reliability, and image quality in ROP diagnosis via

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telemedicine. In this study, in a consecutive series of 67 infants, a trained neonatal nurse acquired wide-angle retinal images using a standard protocol. These images were uploaded to a web-based telemedicine system and then interpreted by 3 retina specialists who provided diagnoses and rated the quality of the images. The remotely made diagnoses were compared with the results of indirect ophthalmoscopy by an experienced pediatric ophthalmologist. Particularly at later premenstrual ages (PMAs; 35 to 37 weeks), the accuracy and reliability of the telemedical diagnoses were high, and image quality was rated adequate or possibly adequate for diagnosis in 93% to 100% of eyes.⁴

This and other studies have demonstrated that telemedicine is a promising strategy to address limitations of the existing paradigm of ROP care: clinical examination by a pediatric ophthalmologist with indirect ophthalmoscopy. Telemedicine addresses challenges of the current care model, including quality and accessibility, and it is more cost-effective than ophthalmoscopy.^{4,5} The challenges of setting up telemedicine networks and integrating them into clinical care scenarios—such as attaining interpretations in a timely manner and ensuring adequate privacy and security of data sent over the Internet—have been addressed to a great enough degree that telemedicine programs are now in place in multiple centers.^{6,7}

INTERSECTION OF TELEMEDICINE AND ELECTRONIC HEALTH RECORDS

Use of electronic health record (EHR) systems has increased in the United States over the past decade, and particularly since the adoption of the Health Information Technology for Economic and Clinical Health (HITECH) Act in 2009. According to data from the Centers for Disease Control and Prevention, by 2010 almost half of office-based physicians surveyed reported using all or partial EHR systems in their practices.⁶ Electronic health records have the potential to improve the quality and accessibility of ophthalmic data, and they have been described by the Institute of Medicine as essential technology for medical care.⁸

A survey by the American Academy of Ophthalmology in 2008 found that adoption of EHR in ophthalmic practices was low but comparable to that seen in other specialties; however, satisfaction with the systems was high among those who had already adopted the technology.⁸ A follow-up survey published in 2013 showed that EHR adoption rates are continuing to rise.⁹ One study by our group found significant qualitative and quantitative differences between EHR and paper records, with more hand-drawn sketches in paper notes and more textual descriptions and interpretations in EHR.⁹

Importantly, EHRs create opportunities to incorporate images directly into the medical record. This is an area where the advents of EHR and telemedicine for ROP nicely dovetail. Traditionally, in ROP diagnosis by serial ophthalmoscopy, the ophthalmologist sketches what he or she sees in the infant's retina at each visit. These drawings are often subjective and imprecise, and do not capture all the detail and richness of the actual retinal findings. Based only on serial drawings from multiple examinations, it is often very difficult to determine whether the retinal disease has progressed. Although identification of disease progression is critical in ROP, ophthalmologists often need to rely on their memories because hand-drawn sketches of retinal findings are so imprecise.

In ROP diagnosis via telemedicine, by contrast, photographs are used to try to represent the retina, and a good photographic image may depict retinal findings far more objectively and precisely than a hand-drawn sketch or a text-based description. With serial images taken from multiple eye exams for telemedicine diagnosis of ROP, identification of disease progression might be done more effectively.¹³ From this perspective, the ability to upload retinal photographs into the EHR may be an advantage of telemedicine over traditional ophthalmoscopy for ROP management.

Among the principal advantages of EHR are that it makes data available anytime and anywhere, and that it makes a larger and more thorough dataset available

to users. Where telemedicine for ROP aligns nicely with EHR is that EHR provides the infrastructure to be able to store data and transmit it from place to place. Images can be uploaded and become part of the patient's EHR, and the EHR can then provide the infrastructure to allow remote interpretation of the images.

LOOKING TO THE FUTURE

The question that remains to be answered definitively is whether telemedicine diagnosis of ROP is "ready for prime time"—whether it is good enough to replace serial onsite ophthalmoscopic examinations, and whether image-based telemedicine diagnoses are inherently less accurate than ophthalmoscopic examinations.

We addressed some of these questions through a study to evaluate intraphysician agreement of telemedicine vs ophthalmoscopy.¹⁴ A series of 206 eye exams was performed by pediatric ophthalmologists on infants who then had retinal images captured by a trained neonatal nurse using a widefield fundus camera. The images were uploaded to a telemedicine system, and 4 to 12 months later telemedical interpretations of the images were done by the same ophthalmologists. In 86% of cases, there was intraphysician agreement between the ophthalmoscopic and telemedical interpretations. The intraphysician agreement between in-person examination and telemedical interpretation for ROP was therefore very high.

However, in many of the 14% of cases in which there were discrepancies between telemedicine and ophthalmoscopic diagnoses, it turned out that the telemedicine diagnosis may have been more "correct." For example, in some of these discrepancies, the ophthalmoscopic exam found no disease, whereas the telemedicine interpretation said there was disease. Some of the retinal photographs in these cases showed that clear evidence of ROP disease was missed by the in-person ophthalmoscopic exam.

In principle, there are some potential diagnostic advantages of telemedicine. With a retinal photograph, the physician can carefully scrutinize the location and extent of disease. In comparison, ophthalmoscopic exams are often limited by movement of infants, or by systemic complications such as apneas and bradycardias in fragile premature infants.

At the end of the day, then, is telemedicine good enough to replace ophthalmoscopy? Published studies have shown that of all the doctors performing ROP examinations in the United States, approximately half are general ophthalmologists who have not received fellowship training in pediatric ophthalmology or vitreoretinal surgery. In Oregon, I have cared for infants who received outpatient ROP follow-up examinations from optom-

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etrists because of supply-and-demand challenges in rural areas. There is a rationale that having an expert reviewer perform a remote telemedicine interpretation may be more valuable than having someone who is less experienced do a “real” eye exam.

Even if the “right” person does a remote interpretation on that rural infant, however, what if treatable disease is found? Who will do the treatment? Can the infant be transferred to a center for treatment in a timely manner? These and other logistical issues must be worked out in order for telemedicine to work in the real world.

Both telemedicine and EHR are relatively new technologies, still being adopted and adapted for use in ophthalmology in general and in ROP care in particular. It will be exciting and enlightening to participate in the further integration of these technologies to potentially improve the care of these tiny, very sick patients. ■

Michael F. Chiang, MD, is the Knowles Professor in the Departments of Ophthalmology and of Medical Informatics and Clinical Epidemiology and is Vice-Chair (Research) in the Department of Ophthalmology at the Casey Eye Institute at Oregon Health & Science University in Portland, OR. Dr. Chiang is an unpaid member of the Scientific Advisory Board for Clarity Medical Systems. He may be reached at chiangm@ohsu.edu.



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