Artificial Intelligence for ROP Screening and to Assess Quality of Care: Progress and Challenges

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The goal of retinopathy of prematurity (ROP) screening is to detect the constellation of clinical signs that suggest a high risk of progression to retinal detachment so that urgent treatment can be given. At each screening episode, there are 3 considerations: whether urgent treatment is needed, whether follow-up screening is needed, and whether there is no risk of sight-threatening ROP so that the screening can stop. The decisions are based on a detailed examination of the retina focused on the severity (ie, stage), location (ie,zone), and degree of dilation and tortuosity of retinal blood vessels (ie,plus disease). If ROP is not present, the peripheral retina needs to be assessed to determine the degree of maturity of the retinal vessels; if they are mature or ROP detected earlier is definitely regressing, the screening can stop.

Telemedicine with artificial intelligence (AI) image analysis could transform ROP screening, especially in settings with an insufficient supply of ophthalmologists, which can happen either because of absolute workforce shortages or when ophthalmologists choose not to offer ROP screening because of the time burden or fear of litigation. Telemedicine with AI image analysis is particularly appealing for low-resource settings in which greater exposure to risk factors, such as hyperoxia, can lead to a high frequency of treatment-requiring ROP in infants born at a gestational age (GA) of ,32 weeks, and severe disease can also develop in more mature infants.1 In these settings, wider screening criteria are required, which increases the screening workload.2

In this issue of Pediatrics, Campbell et al3 describe a multicenter screening program in India, the Retinopathy of Prematurity Eradication Save Our Sight program, which was done in collaboration with a United States–based international group, Imaging and Informatics in Retinopathy of Prematurity (iROP). This report describes not only the diagnostic-test accuracy of the deep learning (DL) system developed by this group (iROP DL) but, also, whether the findings can be used as an indicator to assess the quality of neonatal care.

iROP DL, which quantifies plus disease, performed well, with 100% sensitivity and a high specificity compared to image grading by 3 ROP experts as the gold standard. Because missing ROP that requires treatment can have serious vision consequences, a high sensitivity is essential. The low positive predictive value is not surprising because of the low prevalence of treatment-requiring ROP.

The study findings related to quality of care are particularly interesting. There were highly significant associations between the mean iROP DL score and lower birth weight and whether the unit had adequate equipment to mix and monitor oxygen. A striking finding was that only 3 of the 14 study units had enough of this equipment, which is in a frequent and regrettable occurrence in a large number of units in many low- and middle-income countries.

There are some important limitations of this study. iROP cannot be used to assess stage or zone, only plus disease. Whether DL and AI image analysis can achieve equally high diagnostic-test accuracy for these other prognostic signs, compared to clinical examination by indirect ophthalmoscopy or image analysis by an ROP expert, remains to be seen. In India and other low-resource settings, data on GA can be unreliable because of low attendance at antenatal care, high rates of intrauterine-growth restriction, and lack of routine prenatal ultrasound. Because GA is an important risk factor for ROP, in this study, more accurate data may have attenuated the association between iROP DL scores and quality of care.

The study findings might not be generalizable to other regions. For example, the degree of retinal pigmentation, which can be greater for children born in Africa, could impact the interpretation of images.

Several other groups are also working on AI for ROP screening,[4–7] and once systems can provide reliable information on all of the signs needed to make a management decision at each screening episode, together with the availability of lower-cost imaging devices, the door is open for a dramatic change in how ROP screening is delivered and by whom.[8]

In 2019, the World Health Organization and United Nations Children's Fund recommended ROP screening and treatment as standard of care in their "Survive and Thrive" policy.[9] The authors correctly indicate that integrated systems will be essential before the benefits of elemedicine and AI image analysis can be fully realized. Studies of the feasibility, acceptability, and cost effectiveness of this approach would also be required for decision-makers and policy change within countries, with allocation of resources for implementation.

ABBREVIATIONS

AI: artificial intelligence

DL: deep learning

GA: gestational age

iROP: Imaging and Informatics in Retinopathy of Prematurity

ROP: retinopathy of prematurity

REFERENCES

1. Shah PK, Narendran V, Kalpana N. Aggressive posterior retinopathy of prematurity in large preterm babies in South India. Arch Dis Child Fetal Neonatal Ed. 2012;97(5):F371–F375

2. Gilbert C, Fielder A, Gordillo L, et al; International NO-ROP Group. Characteristics of infants with severe retinopathy of prematurity in countries with low, moderate, and high levels of development: implications for screening programs. Pediatrics. 2005; 115(5). Available at: www.pediatrics. org/cgi/content/full/115/5/e518

3. Campbell JP, Singh P, Redd TK, et al. Applications of artificial intelligence for retinopathy of prematurity screening. Pediatrics. 2021;147(3):e2020016618

4. Vijayalakshmi C, Sakthivel P, Vinekar A. Automated detection and classification of telemedical retinopathy of prematurity images. Telemed J E Health. 2020;26(3):354–358

5. Nisha KL, G S, Sathidevi PS, Mohanachandran P, Vinekar A. A computer-aided diagnosis system for plus disease in retinopathy of prematurity with structure adaptive segmentation and vessel based features. Comput Med Imaging Graph. 2019;74:72–94

6. Mao J, Luo Y, Liu L, et al. Automated diagnosis and quantitative analysis of plus disease in retinopathy of prematurity based on deep convolutional neural networks. Acta Ophthalmol. 2020;98(3):e339–e345

7. Rajashekar D, Srinivasa G, Vinekar A. Comprehensive retinal image analysis for aggressive posterior retinopathy of prematurity. PLoS One. 2016;11(10): e0163923

8. Gilbert C, Wormald R, Fielder A, et al.Potential for a paradigm change in the detection of retinopathy of prematurity requiring treatment. Arch Dis Child Fetal Neonatal Ed. 2016;101(1): F6–F9

9. World Health Organization. Survive and Thrive: Transforming Care for Every Small and Sick Newborn. Geneva, Switzerland: World Health Organization; 2019