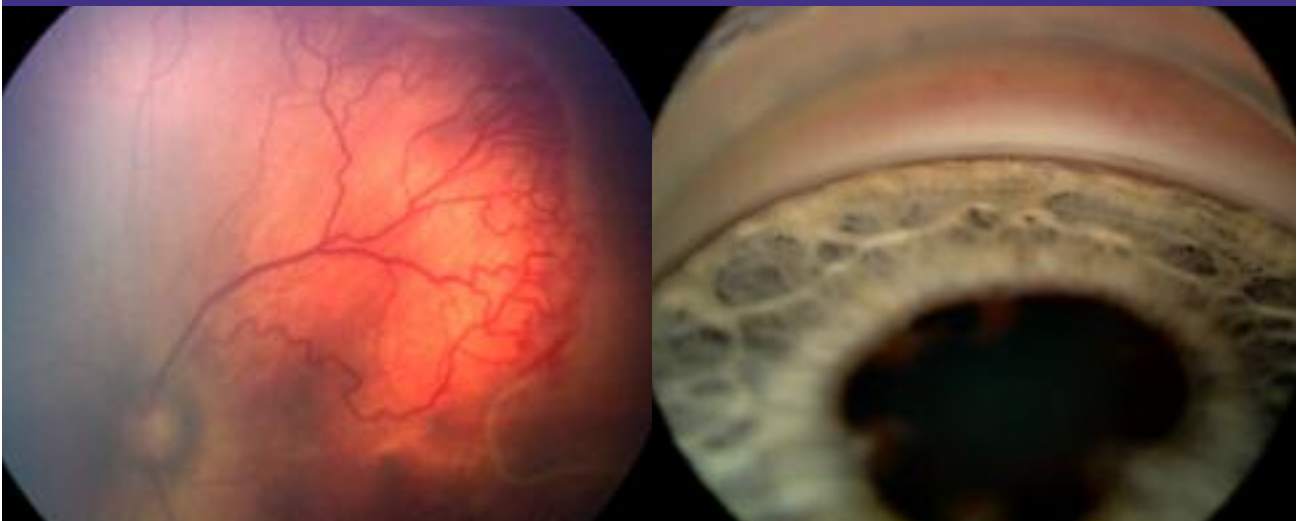


A SUPPLEMENT TO

Retinal
PHYSICIAN.

October 2008

International Experience With Photographic Imaging for Pediatric and Adult Eye Disease



**HIGHLIGHTS FROM A SYMPOSIUM HELD PRIOR TO THE
WORLD OPHTHALMOLOGY CONGRESS**

HONG KONG, ROC ■ JUNE 27, 2008

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Retinal Photography for Management of ROP

Let me begin by making a bold statement: In addressing retinopathy of prematurity, it is possible through the practice of good screening, early laser intervention and vitrectomy for 4A disease to achieve a rate of blind eyes from ocular causes of 1%. This is based on the Early Treatment of ROP (ETROP) study, which found a 91% success rate for early intervention,¹ and other research that has shown a success rate of 90% for vitrectomy in the population of patients who fail early intervention.² Combining these two findings gives a success rate of 99%.

Do we have any clinical support for this statement? In fact, we do. At William Beaumont Hospital, we conducted a 10-year study with 3000 eyes, and of those, only one was blind. The common factor uniting the infants in this cohort is that they all had good screening. Without good screening as a foundation, it is impossible to provide good care for ROP. The hallmark of effective ROP management is early laser therapy, and you cannot do early laser unless you have made an early and accurate diagnosis. The same is true for early vitrectomy. Good screening, then, is the single most important step in the continuum of care. And it is critical to stay with the disease right from the start, because should one get behind in ROP care, it is very difficult to catch up. The answer to this problem is, again good screening.

Now, what is the best way to obtain a good screening exam? You might say that an experienced examiner in the NICU is a good way to do that. They look at the eye directly and then draw their impressions on a piece of paper. However, this is a very inexact way of evaluating disease. It is also a very old way of performing exams, one

that has remained unchanged for nearly 30 years. Yet this approach remains the norm in ROP. The same is certainly not true for adult pathology such as diabetic retinopathy or macular degeneration. In those diseases, digital screening has been the standard of care for nearly a decade. It's time that we brought evaluation of the pediatric eye into the modern age as well.

There are numerous advantages to photographic screening. First, this method provides better documentation. Second, it allows you to precisely compare the status of the eye from one exam to the next and track vascular changes over time. Photographic screening also, for the first time, enables a telemedicine approach to ROP. Several clinical studies, including the recently published international PhotoROP study³ and another that evaluated telemedicine screening in developing countries,⁴ have demonstrated that remote photographic screening can effectively identify infants who require a direct bedside examination or who have treatment-warranted disease.

For the purposes of clinical care, we can say that ROP is basically a posterior pole disease. Staging of the disease requires identification of peripheral changes but treatment is most often posterior pole driven. Zone 1 disease, posterior zone II disease and certainly plus disease, these are still posterior pole findings. Therefore, a very good image of the posterior pole is, in itself, generally adequate to determine how to proceed with clinical management. As an example, the image below provides very clear evidence of severe plus disease (**Figure 1**). There are dilated and tortuous blood vessels in the entire posterior pole. It is easy to make the diagnosis with this image.

Advantages of Photographic Documentation

- Better patient care, particularly in the hands of the novice examiner
- Better documentation than drawings
- Serial photographs to track disease over time
- Telemedicine screening possible
- Images can be shared for consultation
- Tool to educate parents



Figure 1. RetCam photo showing plus disease in the posterior pole.

Overall, then, digital imaging provides better documentation, and better documentation produces better care. You can study and review images after the time of examination. You can compare images from different points in time, and conduct side-by-side analysis to confirm disease progression or regression. You can share images for consultation with colleagues, either in person or by email. And in the near future, Web sites will be available to assist with reading and interpretation. These are just some of the distinct advantages of using digital imaging for ROP.

Photographic documentation is particularly useful in the hands of the novice examiner or, as many of our Asian colleagues face, in situations where many infants are located in areas distant from an expert in ROP. In these cases, novice examiners can acquire the photographs, then tap a more experienced clinician to read the images. In other words, there is the option for expert assessment where none existed before.

In conclusion, ROP screening is a decision-tree that requires clear and timely visual information about retinal anatomy: We have to make a determination based on the status of the eye today to determine how to assign care in

the next few days or weeks. We need to determine if or when a next exam is needed, and what type of exam it should be — either a photographic exam or a bedside binocular indirect exam. We must determine if the patient should be referred for immediate treatment. And we need to perform frequent assessment, no matter where the infant is, so that we do not fall behind in managing the disease. This is what is needed for good clinical care. And this is where photographic imaging can provide a highly effective solution. **RP**

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BY RAJVARDHAN AZAD, MD, FRCS, FAMS



State of ROP Management: The Indian Experience

In India there are 26 million childbirths per year. The number of low birth weight infants is 7.8 million. Approximately 1.7 million are born weighing less than 2500g and, of these, just over 20% are under 1500g. This means that there are at least 350,000 children born each year who are at risk for ROP.

I want to emphasize two points. One is the critical point of detection. We often diagnose too late in the course of the disease, when it is already quite advanced. This leads to unfavorable outcomes after laser, such as disk drag and macular drag. The second important point is that once a diagnosis of ROP has been made, early treatment is the key to preventing significant vision loss.

Looking at the point of detection, there are three critical stages: 32-34 weeks, when the first examination should be performed; 35-37 weeks, which is the peak period for diagnosis of ROP; and 40-44 weeks, when you determine that the infant is no longer at risk. Of these periods, the second one is most critical. In a country such as India, where there exists a large number of at-risk infants and few ROP experts, it may not be possible to perform serial

Results of Screening	Period I 1993-94	Period II 1999-2000
Patients (N)	66	76
Patients with ROP	13 (19.7%)	24 (31.5%)
Grades of ROP <i>Stage I & II</i>	7 (10.6%)	19 (25%)
<i>Stage III threshold ROP treated cases</i>	6 (9.0%)	5 (6.57%)

Figure 1. Rate of ROP diagnosis and treatment before and after adopting a more aggressive screening approach

screening in every child. So it is that peak period where we should place the greatest focus.

This table shows the benefit of a good screening program (**Figure 1**). In the mid-1990s, we began focusing more aggressively on ROP screening, both in terms of

screening more infants and improving the skill of our screeners. Looking at our rate of detection both before and after this period in time, we see that we have diagnosed more than 50% more cases in the second period. We have also treated a greater number of patients earlier and reduced the number of infants with more advanced disease.

We've been using the RetCam for more than 5 years and since beginning our digital screening program, I have stopped using indirect ophthalmoscopy. The RetCam is very easy to use, it provides excellent images, and I can easily retrieve earlier pictures to compare side by side with more recent exams. We performed a study of the RetCam 120 versus indirect ophthalmoscopy. We looked at 320 eyes in 162 children. RetCam examination had a sensitivity of 96.3% and a specificity of 97.7%. We missed disease in 10 eyes, but these were inconsequential because it was zone III disease. So, this study confirmed our clinical impression that RetCam allows us to detect all clinically meaningful cases of ROP.

In India, we see a relatively high number of older gestational age infants who develop ROP. A typical presentation might be an infant born at 33 weeks and weighing 1625g. These infants do not fall within the typical criteria for ROP, but they are very sick, with multiple organ system complications, and requiring oxygen for long periods.

Another typical situation we see is where a child is referred after an initial laser surgery with a poor outcome. Here digital imaging is very useful because we can carefully study the condition of the retina and determine what has gone wrong. In the case shown, the referring surgeon clearly performed inadequate cryotherapy (**Figure 2**). I performed the operation again to complete the necessary ablation and the child did quite well.

ROP has now been included in the Government of India's priority list of addressing childhood blindness. As part of this emphasis, we have begun an ROP awareness program, which we are undertaking in conjunction with the Indian Ministry of Health and the World Health Organization. To date, we have conducted seven workshops

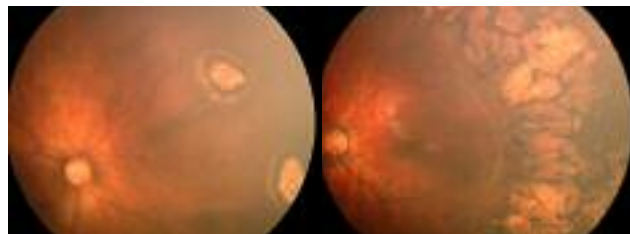


Figure 2. Assessment of infant with poor outcome following initial laser surgery. Photographic imaging documented inadequacy of the first procedure (left), and patient was retreated, with good results.

around the country, where we have trained 160 neonatologists and ophthalmologists. As a result of this effort, we have opened 18 new screening centers around the country. We plan to conduct at least eight more workshops in the next 2 years.

Looking ahead, what are some of the emerging areas of interest in ROP? One obvious question to be answered is what I call the X factor. By this I mean the factor or combination of factors that cause some infants to develop ROP while others do not. Other issues include the use of new therapies, in particular anti-VEGF drugs, and the long-term effects of ROP, such as refractive error. Hot topics that are particularly relevant for India are the role of breast feeding, which seems to confer a protective effect and which is now the focus of a major public education campaign in the country. And of course, telemedicine screening and screening by nonretinologists or even non-physicians is a huge issue that is important for us in India because of the limited number of ROP experts.

In summary, ROP is a very relevant disease in India as well as other Asian countries, but it need not be a blinding disease. We are very proud of the work we are doing in India. We have made ROP a priority, and have seen significant improvements. We have challenges in terms of the number and the profile of infants at risk, as well as in trying to ensure timely diagnosis. But if we combine better training with digital imaging, we can make even more progress. **RP**

BY DARIUS MOSHFEGHI, MD

Experience with a Telemedicine Screening Program for ROP: The Sundrop Network



For many years, the gold standard in ROP evaluation has been indirect ophthalmoscopy. But, as Dr. Trese pointed out, this technique is antiquated by today's medical practices. In addition, I would ask: How solid is this gold standard? The fact is, no studies have ever been done to demonstrate the overall effectiveness of this approach, nor have studies been

performed to determine the inter- or intra-clinician variability in creating or interpreting the hand-drawn images that are inherent to this method of evaluation.

The obvious limitation of binocular indirect examination is that we are left with a subjective interpretation of the condition of the retina. This form of documentation has



Figure 1. Composite of RetCam images showing progression from stage 1 (left) to stage 2 (center) and stage 3 ROP over time.

distinct disadvantages, which include lack of reproducibility, lack of precision, lack of longitudinal viewing and lack of a hard copy for future consultation or referral.

In contrast, digital imaging with the RetCam (Clarity Medical Systems, Pleasanton, Calif.) provides an objective representation of the relevant anatomy and allows us to precisely track the status of the retina over time. This is exemplified in this series of composite images (**Figure 1**), which show an unmistakable change from stage 1 to stage 2 to stage 3 ROP. A major strength of this approach is that if you cannot recall the exact condition of the eye previously, you can refer to the earlier photos and confirm unequivocally whether there has been progression of disease. It is impossible to do this based on the hand-drawn diagrams that are the norm today.

Digital screening also is efficacious, as I will show next, and I believe it is cost efficient. In addition, permanent photographic documentation is valuable for medico-legal purposes and as a tool to educate parents about the condition of their infant. Finally, and for some clinical settings most significant, digital screening enables for the first time, a remote screening model. These are all critical factors for standardizing screening and providing optimal care.

I am going to share with you data from our telemedicine program, called SUNDROP for Stanford University Network for Diagnosis of Retinopathy of Prematurity. This is an 18-month retrospective, longitudinal study involving four local neonatal intensive care units connected in a hub-and-spoke model to the central reading center. Images were read by a single observer, namely, myself. NICU nurses were instructed in the use of the camera and quickly became proficient at obtaining a standardized set of images. The objective of the study was to determine the efficacy, the rate of complications and the sensitivity and specificity of a telemedicine screening program. The primary outcome was

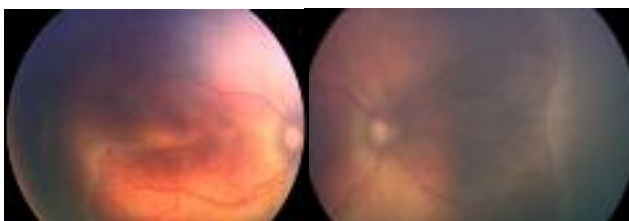


Figure 2: Referral-warranted ROP diagnosed by telemedicine screening.

identification of treatment-warranted retinopathy of prematurity, which we defined as was any Early Treatment of ROP (ETROP) type I disease, for example, threshold, or stage 4 or stage 5 disease. In total, we evaluated 97 patients, 194 eyes, 452 unique examinations and more than 4969 images. We identified

seven patients with treatment-warranted ROP. Six were confirmed to have treatment-warranted ROP upon bedside exam by binocular indirect. This translates into a sensitivity of 100%. The specificity was 98.9%. The positive predictive value was 85.7% and the negative predictive value was 100%. This last number is very important because it means that we did not miss any case of treatment-warranted disease. We can say that because had we missed significant disease, an infant would have progressed to retinal detachment, and we saw no retinal detachments in this study.

This is an example where I made a determination of referral-warranted disease (**Figure 2**). You can clearly see involvement of zone I. This also demonstrates the ability of NICU personnel to capture nasal and temporal images.

In terms of safety, we saw no adverse events. There are no ocular findings that could be related to the camera. There were no infections, and no episodes of apnea or bradycardia other than we would normally anticipate in a similar patient base.

We can conclude from these findings that telemedicine is a very good tool for screening for treatment-warranted ROP. It provides adequate visualization of all of zone II. I believe that it is also very good in identifying plus disease. A few reports have suggested that applying too much pressure with the camera can conceal this finding. However, while pressure might reduce vascular dilatation, tortuosity should remain fairly unchanged.

The limitation of a telemedicine approach is that it cannot clear an infant. The three termination criteria involve zone III or mature retinal vascularization, and the camera does not reliably capture that when a non-trained photographer uses the equipment. Telemedicine also is not yet recommended for screening post-treatment because of the lack of three dimensionality.

In summary, we have shown that digital imaging is an effective tool for ROP screening — one that overcomes the limitations of binocular indirect ophthalmoscopy. Digital imaging provides longitudinal views. It provides objective documentation of the retina. It provides permanent photographs that can be used for consultation with colleagues and parent education. And it can identify all cases of ROP that require treatment, even when nonexperts capture images. With broader use of this technology, I believe we can make real progress toward the goal Dr. Trese cited of 1% or fewer blind eyes. **RP**



Diagnosis and Treatment of Pediatric Retinal Disease in Hong Kong

I would like to share with you our experience of retinopathy of prematurity (ROP) screening in Hong Kong. These data come from a retrospective study of all infants born in public hospitals from 2002 and 2003. We sought to answer three questions: Are we meeting established guidelines in terms of which infants to screen? Are we screening appropriately in terms of timing? And what are the screening outcomes?

We reviewed 466 cases. Half of these infants had a birth weight of 1000-1500g, one-quarter were less than 1000 g, and one-quarter were more than 1500g. We looked at how our screening compared to the British guidelines and to the American guidelines from 2001.

The British guidelines recommend screening infants with a birth weight less than 1500g or gestational age of 32 weeks or younger. The 2001 American guidelines recommend screening infants with a birth weight less than 1500g or gestational age of 28 weeks or younger. I should note that the American guidelines were updated in 2006 and now recommend screening infants with a birth weight less than 1500g or gestational age less than 30 weeks.

We found that our screening practices in Hong Kong exceeded both of the Western guidelines. Eight percent of screened infants were outside of the British criteria, and 25% were outside of the American criteria from 2001. So we were actually screening more liberally.

Moving on to timing of examinations, the British recommendations call for a first exam 6-7 weeks after birth, whereas the American guidelines advise performing the first exam at 4-6 weeks postnatal age or 31-33 weeks postconceptional age, whichever is later.

Again, we found that we did well in this measure. In approximately 90% of cases, we met or exceeded the recommendations. In fact, a significant number of infants were screened earlier than stipulated in the guidelines.

In terms of outcomes, about 30% of infants developed ROP of varying severity. Twenty-nine cases, which represents 20% of those infants who developed ROP and 6% of all infants screened, required laser treatment. Gestational age of the infants who required treatment ranged from 23-31 weeks, and all but one had a birth weight under 1 kg.

Our data are consistent with other analyses showing a clear link between lower birth weight or younger gestational age and development of ROP. Approximately 75% of infants with a birth weight less than 1000g developed ROP. In infants with a birth weight greater than 1500g, the incidence of ROP was 2.5%, and none required treatment. The findings were very similar with regard to gestational age. Almost 90% of infants born before 26 weeks developed ROP. By 28-30 weeks, fewer than 4% developed ROP and none required treatment.

Of the infants who underwent laser treatment, 74% reached threshold disease. In four eyes treated with prethreshold disease, they nonetheless progressed and, despite vitreoretinal surgery, went on to complete blindness.

This audit shows that our outcomes are quite similar to other countries. Furthermore, these data are now 5 years old. If we were to perform a similar analysis now, I believe we would see additional improvement.

We also have experience using the RetCam for retinoblastoma. It is a rare disease, but the prognosis for survival is good, especially with early detection. This disease can have a long period of recurrence, which makes photographic documentation particularly valuable.

We show here images from a 6-month old patient: First we have the initial presentation; then the eye following chemotherapy and local destructive therapy, showing tumor regression; and 1 year after presentation, showing recurrence at the edge of the tumor, for which the patient was retreated (**Figure 1**).

This patient went on to develop recurrence again at 3 years and 5 years. He ultimately was treated with radiation and is now doing well. In the management of this patient, we benefited greatly from the availability of serial photographic images. This echoes what the other speakers said, which is that good documentation is required to ensure good clinical care. RP

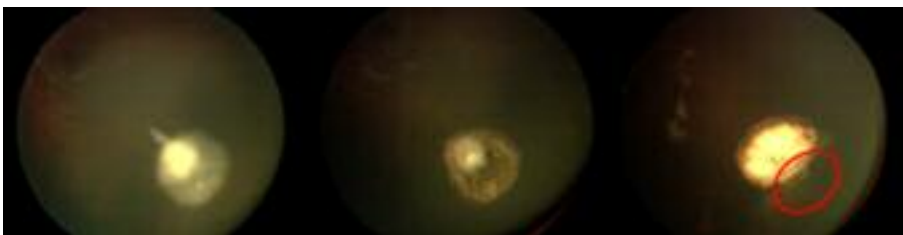


Figure 1. Retinoblastoma in a 6-month old infant at initial diagnosis (left), following laser surgery (center), and at 1-year showing recurrence (circle). Photographic documentation provides an excellent tool to track neoplastic changes over an extended period of time.



ROP in Western Australia

Our problem in Western Australia is not the number of patients but rather the vastness of our state. We have just over 2 million people in an area of 1 million square miles. Almost 90% of the population resides in and around Perth. The population in the rest of the state is so sparse that it makes no sense to have advanced level nurseries in distant towns. Therefore, most threatened premature labors are transferred to Perth, which is enabled by a superb medical air transport system. Consequently, more than 90% of premature infants are delivered at the major obstetrics hospital, resulting in extremely high infant survival: greater than 90% survival in infants over 28 weeks gestational age (GA), and 70-90% survival in infants 25-28 weeks. We have approximately 30,000 live births per year. With a rate of prematurity of 1.2%, that translates into approximately 350 preemies annually. This is a rather small number but given the very low mortality, most of these infants, even the very young ones, will survive and be at risk for ROP.

Essentially all preemies in Western Australia are managed at one of the two level 3 NICUs in Perth. We have two screeners and a dedicated nurse who tracks every infant and ensures that we adhere to the screening schedule for each one. We screen according to Australia's National Health and Medical Research Council (NHMRC) guidelines, which includes infants up to 32 weeks GA and birth weight of 1500g. We also screen older and heavier infants who have been very sick or who are identified by the neonatologist to be at increased risk for ROP.

Before adopting digital imaging, I had the same problem discussed by others, namely, the diagrams I drew were absolutely terrible. Now we document every case with the RetCam. Digital imaging is especially useful for us because, given the small num-

ber of premature infants, we can follow all children up to 5 years of age, and digital imaging gives us excellent longitudinal documentation. Within the next few years, we hope to have a large enough series to demonstrate the utility of following these patients for an extended duration rather than discharging them to follow-up after treatment.

We previously managed patients based on the CryoROP guidelines, but our current treatment criteria are based on the ETROP guidelines, as this approach appears to be associated with better visual and structural outcomes. ETROP guidelines divide patients into two groups. Type 1 is the high risk group, those infants who need to be treated promptly. This includes zone I any stage with plus disease; zone I, stage 3 without plus disease; and zone II, stage 2 or 3 with plus disease. Type 2 patients are those at lower risk who need only to be observed: Infants with zone I, stage 1 or 2 without plus disease; and zone II stage 3 without plus disease.

The graph shows the number of laser surgeries performed throughout Australia since 2001 (**Figure 1**). Once we moved from the CryoROP to ETROP guidelines, the number of procedures increased significantly. Then in 2006, we launched the BOOST II trial. This is a pan-Australian trial, still in enrollment, that controls for the level of supplemental oxygen. Our American colleagues generally hold that oxygen does not play a role in the development in ROP and we do not yet have definitive data to indicate that it does. However, since implementing the tighter O₂ controls in BOOST II, the number of cases requiring laser has dropped almost to the level observed when we were using the CryoROP criteria. So, we have to say that the jury is still out on oxygen. We will no doubt learn more when we have the results from BOOST II in 2010.

In addition to regimented screening in the NICU, we are vigilant about screening post-discharge. We even go so far as to track down each infant if they fail to appear for a scheduled screening. This vigilance both in and out of hospital has produced dramatic results. In the last 10 years, we have not had a single patient who needs to attend blind school.

Looking ahead, we are eager to see the findings from the BOOST II trial and new data from ETROP, which hopefully will increase our understanding of the causes, prevention and treatment of ROP. We also look forward to the availability of new therapies, most notably VEGF, and to iterations in RetCam technology, in particular a smaller, more portable device that will more readily allow us to capture follow-up exams in the infants' home region rather than requiring them to be in Perth. RP



Figure 1. Laser surgeries performed in years using the CRYO-ROP and ETROP screening criteria, respectively, and since initiating the BOOST II trial to study the effects of supplemental oxygen.



The Rop Challenge In Rural India: Preliminary Report of A Telemedicine Screening Model

The ROP situation in India is defined by the numbers. With more than 27 million live births each year, and about 2% of these premature, the number of infants who require screening is very large and growing. This contrasts with the near drought of experts to manage this disease countrywide. It is indeed a grim reality that we have perhaps 20 ophthalmologists in the entire country who are involved in ROP screening and comprehensive treatment.

In India and other middle-income countries, as in the West, ROP is the single most important and preventable cause of infant blindness. In the past decade, improvements in neonatal care, increased survival rate and better awareness of ROP have resulted in a surge of ROP. It is not surprising that India is said to be suffering from the 'third epidemic' of the ROP wave.

In addition to very low birth weight infants, we are now seeing an increasing number of heavier infants developing ROP, a finding not unique to India but seen in other countries in the region. These 'heavy babies' are extremely sick children and have been oxygenated for weeks, often unmonitored. These at-risk heavy infants would be missed if we adhered to Western screening guidelines.¹

We have launched an initiative to create a comprehensive framework to address ROP in India, not just in infancy but with visual rehabilitation through early childhood. The backbone of the initiative is a "Triple T" strategy. First is the Tele-ROP program, which is the focus of this presentation. Second is the Training of peripheral (outreach) ophthalmologists to perform screening and laser treatment. This is done by means of in-situ training sessions followed by a structured ROP fellowship. The third component of the initiative is Teaching the pediatrician (or neonatologist) and the obstetrician about their role in ROP management. We believe it is important to reach the latter because these physicians share a long rapport with the mothers and can prompt them to seek an eye exam once a premature delivery is inevitable.

The Tele-ROP program we have underway validates whether a trained technician can accurately screen for and identify referral-warranted disease. The pre-pilot study has three rural, one semi-urban and one urban center (as a control). In the protocol, the technician acquires the images, and using a simple logic sheet and grading chart makes a 'decision' whether the infant requires follow up, immediate

referral, or no follow up. Simultaneously, the infants are also evaluated by an ROP specialist using the gold standard of indirect ophthalmoscopy as the control measure. The autonomy of the treating ophthalmologist is supreme. In the final study with 10 centres, the images will also be simultaneously graded by a group of Indian and international experts in near "real-time" settings to validate these grades.

We now have data from the first 90 infants. Screening criteria are a birthweight of less than 2 kgs or gestational age less than 34 weeks, consistent with the guidelines described earlier. The mean birth weight varied from 1153-1795g and mean gestational age from 30-34 weeks. As would be expected, the infants managed in the rural hospitals are older and heavier, while the smallest or most premature infants are treated in the urban or semi-urban centers. We see a variably high rate of ROP, from 7.7% to 46%, with the rate increasing as we move from the rural to semi-urban to urban centers where the sicker infants are.

The graph shows how the technicians performed compared to assessment by binocular indirect by an ROP expert (Figure 1). When we look at the more severe forms requiring immediate examination by an ophthalmologist, for example, AP-ROP, zone 1 disease and zone II posterior disease, the technicians assessment correlates 100% with the gold standard. In other words, the technicians correctly identified every case where the infant needed treatment.

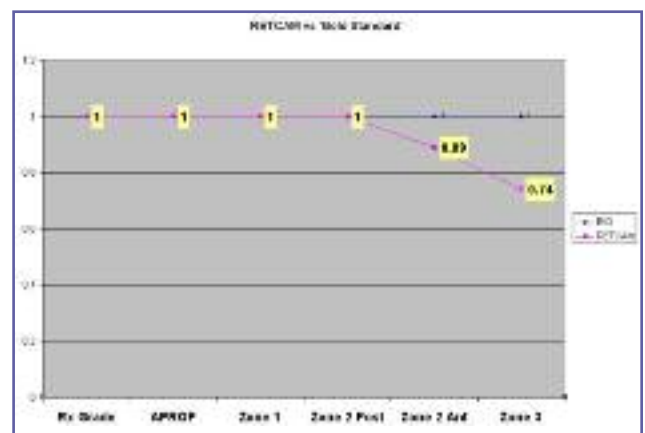


Figure 1. Correlation of ROP screening performed by trained technicians using digital imaging compared to binocular indirect examination by an ophthalmologist. Screening by digital imaging successfully identified all cases of referral-warranted ROP.

In zone II anterior, the number is still very good, 89%. Even in zone III, where we would expect a lower correlation with the BIO, the technicians correctly detected disease in 75% of these cases. This is due to the fact that they are able to image the temporal ora in a good percentage of infants, and we have the images to prove it. So in just a short period of time and with good training, the technicians have become adept “screeners.”

Here is a case of referral-warranted disease that was detected by the technician (**Figure 2**). A 27-week infant, weighing just over 1000g, was correctly diagnosed with referral-warranted disease. The image of the right eye is not processed, but the left eye, after processing, shows flat neovascularization in zone I, suggesting AP-ROP. The technician was able to turn around a seemingly poor quality image and, after processing, to arrive at the right clinical decision. The processing was done by the technician, who used the built-in RetCam software.

We are committed to moving ahead with our triple strategy, including expanding the Tele-ROP program to include internet-based analysis, training peripheral ophthalmologists, neonatologists and gynecologists, and strengthen-

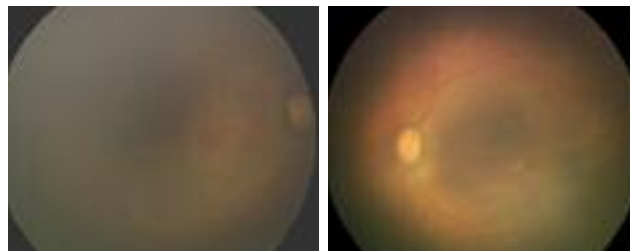


Figure 2. Diagnosis of referral-warranted disease by a trained technician. Image of the right eye (left) is unprocessed. After processing, image of left eye shows flat neovascularization in zone I, suggestive of AP-ROP.

ing our surgical and rehabilitation skills at the tertiary care level. This calls for teamwork. Only with efforts such as these can we hope to effectively address the growing ROP burden and provide excellent care to all of our special patients. **RP**

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Use of the EyeCam in Anterior Segment Imaging: An Alternative to Gonioscopy

BY IKE AHMED, MD, FRCS



An essential part of the diagnosis and management of glaucoma is assessment of the angle by gonioscopy. However, this assessment too often goes unperformed, a finding supported by recent studies from the United States. In fact, it is somewhat alarming to discover how often gonioscopy seems to be omitted from glaucoma examinations.^{1,2} The reasons for this omission may include a lack of appreciation of its importance, the technical difficulty of gonioscopy, the potential for artifact, and lack of standardized documentation.

Some of these challenges may be addressed with the use of the EyeCam. This digital imaging system is already validated for use in pediatric retinal disease (known in that application as the RetCam), where it has been shown to produce high quality, high resolution photographs of the back of the eye. With minor modifications in imaging technique, it is possible to apply this technology to the anterior segment as well.

We have begun evaluating the EyeCam for anterior

segment imaging, particularly as an alternative to gonioscopy. Using a noncontact technique in which coupling gel is applied between the cornea and the lens of the camera, the EyeCam is placed in the appropriate quadrant, where it provides direct visualization of the angle (**Figure 1**).

We've undertaken a study to compare “EyeCam goniography” to the existing gold standard of clinical gonioscopy. The latter was performed by a tertiary care glaucoma specialist to ensure accuracy of diagnosis, while the EyeCam exam was performed by a technician or fellow. This element of the protocol was based on experience with the RetCam in screening for retinopathy of prematurity. It has been shown in that setting that staff without expertise in ophthalmological manipulation, for example, NICU nurses, can readily learn to use the camera and obtain diagnostic quality images.

In our protocol, we looked at angles ranging from zero to grade 4 (Shaffer classification) and sought to determine



Figure 1. Eyecam gonioscopy of an open angle showing the major angle structures.

if there was a correlation between the measurements obtained with the EyeCam and those obtained by clinical gonioscopy. The next phase was to assess the sensitivity and specificity of EyeCam imaging to detect narrow or occludable angles. For this we used an arbitrary assessment of a grade 2 angle by clinical gonioscopy. Preliminary findings from the study are very encouraging. We found excellent correlation between photographic gonioscopy and clinical gonioscopy.

Looking ahead to clinical use, the EyeCam may offer a number of advantages compared to current methods. First, the EyeCam provides direct, real-time view of the angle with excellent color resolution and excellent optical quality; in essence, we can obtain color gonioscopy photographs of the angle. Other imaging technologies, although certainly useful to assess the angle, don't give the direct anatomical picture that we are accustomed to seeing with the gold standard of gonioscopy. Another advantage of the EyeCam is the absence of compression artifact, which can be a complicating factor with current gonioscopic techniques.

Once the technology is more fully validated, EyeCam gonioscopy has the potential to replace gonioscopy as the

gold standard for documentation of the angle, much as optic disc photography has become the gold standard in documentation of the nerve. We can all agree that writing a cup-to-disc ratio or drawing a cup on a disc is not the most ideal method of documenting the nerve. The same is true of documenting the angle, which until now was left to paper notes and clinical diagrams. The ability to clinically document the angle in a photograph and follow it over the time is important, as is the ability to document treatment effect. In this way, broad-based use of the EyeCam could help increase our understanding of the pathology of the disease and our therapeutic approaches to angle closure.

Finally, from a public health perspective, EyeCam could play an important role in large-scale glaucoma screening given that images can be captured by non-specialists or even non-physicians. This is a very relevant issue for discussion here in Asia because so many people in this part of the world don't necessarily have access to, or they are reluctant to see, doctors. The public health benefits could also extend to the Western world, where the demands for glaucoma screening will increase in the face of an aging population.

In summary, our experience with the EyeCam is quite promising. In initial studies we've demonstrated a high degree of correlation between EyeCam gonioscopy and clinical gonioscopy, and high sensitivity and specificity for the camera in detecting occludable angles. If these findings are confirmed in subsequent research, EyeCam technology could have widespread application in anterior segment imaging, especially as an alternative to clinical gonioscopy for glaucoma screening and management. **RP**

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