Telemedicine for Pediatric Retinal Diseases

2015 Ophthalmic Photographers’ Society Mid-Year Program

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Telemedicine

- Synchronous
  - Examination and diagnosis in real-time
  - Traditional medical specialties

- Store-and-forward
  - Data capture and storage
  - Suitable for image-oriented specialties (ophthalmology, radiology, cardiology, dermatology)
  - Diagnostic decisions are based on review of patient images captured by non-physician care providers

Telemedicine in Pediatric Retinal Practice

- Retinopathy of Prematurity - ROP

Why ROP?

- Decreasing availability of subspecialty-trained ophthalmologists willing to assume care for premature infants.
  - A 2006 survey conducted by the AAO showed that only 54% of pediatric ophthalmology and retina specialists are willing to screen for ROP
  - 1 in 5 planned to stop screening
  - 11% of all ophthalmologists perform ROP exams and 6% treat ROP.

- Lack of adequate ophthalmic care in locations far from major medical centers, retinal specialists, or pediatric ophthalmologists.

Why ROP?

- Increasing rate of ROP and vision loss in developing countries where neonatal care and survival of premature infants are rapidly improving.
  - Studies of children in schools for the blind show that ROP is an important cause of blindness in China, Southeast Asia, Latin America and Eastern Europe

Why ROP?

- The current gold standard of this screening is binocular indirect ophthalmoscopy (BIO) with scleral depression.

- Infant is often uncooperative.

- Documentation requires transcription from the physician’s memory to a drawing.

- Numerous studies show a wide range of disagreement of diagnosis among “experts”.

Why ROP?

Gilbert et al., JAMA 1997
Gilbert et al., Pediatrics 2005

Mukherjee et al., Ophthalmology. 2006

Kemper et al., J AAPOS 2008

National Eye Institute, NIH Ref# ROP02

Gilbert et al., Ophthalmology, 2006
Why ROP?

- ROP is a good model for telemedicine applications:
  - Diagnosis based on retinal appearance.
  - Universally accepted, evidence-based, diagnostic classification standard.
  - Continues to be a leading cause of childhood blindness throughout the world because of inadequacies in screening.
  - BIO is time-intensive and physiologically stressful to infants.
  - Clinical expertise is often limited to larger academic centers, and is therefore unavailable at the point of care.

ROP Telemedicine

- What role should a telemedicine program have in ROP care?
  - Examination vs. screening
  - Complements bedside exam
    - Identify high-risk infants for BIO

Telemedicine Technology for Pediatric Retina

- Hardware
  - Cameras

- Software
  - Image storage and analysis

Image Capture—Fundus Cameras

- RetCam — Clarity
  - Wide angle (130°), contact
- NM-200D — NIDEK
  - Narrow angle (30°), non-contact
- Kowa handheld fundus camera — Kowa
  - Narrow angle (30°), non-contact

PHOTO-ROP Standard Image Set
Image Capture- Challenges

• Excessive pressure eliminating plus disease

• Small palpebral fissure or small pupil limiting adequate illumination of the retina

• Dark fundus pigmentation with poor image contrast

• Vitreous or corneal haze due to extreme prematurity

• Cataract, vitreous hemorrhage, motion artifacts

Image Capture

• PHOTO-ROP Study:
  – 300 image sets (3836 images) were acquired for remote reading at the reading center.
  – 92% (293/300) of the image sets were interpretable.

• Ells et al. found that wide-angle images were captured successfully in 96% of examinations, and that 94% of retinal image sets could be graded remotely to identify plus disease, zone, or stage of ROP

Image Capture– Software

• Bundled with camera
  – RetCam – internal image analysis software

• Investigator designed

• Commercial
  – FocusROP

Image Analysis

• Trained nurses, during or immediately after fundus imaging

• Ophthalmologists, at a remote image-review station

• Automated
  – Plus disease
    • ROPool
    • RISA – Retinal Image Multiscale Analysis
    • Vessel Map
    • CAIAR – Computer Assisted Image Analysis of Retina

Automated Image Analysis- Challenges

• Definition of a reference standard

• Algorithms for quantifying vascular features

• Selection of retinal vessels for analysis

• Combination of parameters into overall diagnosis

• Development of cutoff points for “abnormality”

• Clinical studies

Automated Image Analysis- Challenges

• Definition of a reference standard
  – There is significant inconsistency in plus disease diagnosis among experts
    • 12% in CRYO-ROP
    • 27% in Gelman et al. (JAPOS, 2007).

• Selection of retinal vessels for analysis
  – ICROP definition of plus: Arteriolar tortuosity and venular dilation greater than or equal to that of a standard published image.
Cost of Telemedicine Program

- Price of fundus camera
- Wages for additional staff
- Computer systems
- Costs to securely post and maintain the images
- Reimbursement to those interpreting the images.

Cost analysis

- Jackson et al. compared telemedicine exams to BIO for ROP management.
- Cost-utility analysis
  - Quantifies costs against value gained by medical interventions
  - The value resulting from an intervention is expressed in quality-adjusted life years (QALYs)
- The lifetime costs in infants <1500 g.
  - $3193/QALY for telemedicine
  - $5617/QALY for ophthalmoscopy
- Interventions that cost $50,000 or less/QALY are considered highly cost effective.
  - CABG - $6880/QALY
  - Liver transplant - $327,500/QALY
- Screening for ROP by ophthalmoscopy in this study was a highly effective intervention and screening for ROP by telemedicine was even more effective.

Jackson et al., Arch Ophth, 2008

Cost savings

- Telemedicine may offer other benefits for ophthalmologists including time savings.
- Richter et al. found that telemedicine examinations required significantly less physician time than standard indirect ophthalmoscopy
  - 1.02-1.75 minutes per telemedicine exam
  - 4.17-6.63 minutes per ophthalmoscopic exam

Richter et al., AJO 2009

Additional benefits of fundus photography

- Include documentation of the ROP exam for medico-legal issues
- Reduce number of NICU transfers for second opinions
- Retinal findings can be viewed by the neonatal team and patient’s family, promoting greater understanding of the patient’s condition.
- Procedure is less painful to the infant compared with BIO.
- Valuable in the training of ophthalmologists

Medicolegal Considerations

- Utilize evidence based standards to classify, diagram, and record exam findings
- Foster a team approach among those involved – NICU, Pediatricians, Ophthalmologists
- Collaborate with providers and staff to create written policies governing key decisions:
  - Transfer, discharge, follow up, and treatment
  - Implement a standard reading process
  - Set realistic time frame for image reading and reporting
  - Automatically refer for BIO for unreadable images
  - Carefully train staff who operate the fundus camera
  - Periodic assessments, site visits
- Institute a formalized ROP tracking system
- Designate criteria for credentialing and privileging ophthalmologists for telemedicine
- Draft documentation guidelines for the informed consent process
- Establish telehealth equipment and maintenance standards

Annalino Hj, J Health Care Risk Manag, 2011

SUNDROP

- Stanford University Network for Diagnosis of Retinopathy of Prematurity
- Involves four NICUs
- Nurses are trained to capture serial wide-angle retinal images.
- Has been providing remote care for at-risk infants at Stanford University since 2005.
- 36 month report: 230 infants imaged (1059 examinations, 10,921 images)
- 10 infants with referral-warranted ROP
- 9 diagnosed with treatment warranted ROP by BIO
- No missed cases

Jackson et al., Arch Ophth, 2008
What is the role of telemedicine?

- Bedside ophthalmoscopy and digital fundus imaging are neither identical nor exactly interchangeable.
- But they are complementary.
- The role of telemedicine in pediatric retina will continue to evolve with improving technology and additional clinical studies.