2014 Clinical Care Innovation Challenge

Title: Non-mydriatic Ocular Fundus Photography in the Emergency Department

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Description

Examination of the ocular fundus is a key element of the physical examination. Despite remarkable advances in various diagnostic medical technologies (e.g., neuroimaging), visualization of the ocular fundus often provides the only diagnostic clues in the identification of potentially serious diseases. Examination of the fundus is necessary for the diagnosis of various disorders causing acute visual loss that require urgent management (e.g., retinal detachment), the detection of warning signs of impending visual loss and potentially catastrophic neurologic complications (e.g., papilledema, central retinal artery occlusion), and the determination of severity for certain medical conditions (e.g., hypertensive crisis). Our innovation is an interdisciplinary project between neuro-ophthalmology and emergency medicine to improve care in the emergency department by supplanting direct ophthalmoscopy with non-mydriatic fundus photography. Non-mydriatic fundus photography allows wide-field photographs of the ocular fundus (optic nerve and retina) to be taken without pharmacologic pupillary dilation. Patients with headache, focal neurological deficits, visual complaints, and severely elevated blood pressure are evaluated with this technique. In 704 patients evaluated, 79 (11%) had an ocular fundus finding, such as papilledema, relevant to their ED management. In the first phase of our project, emergency physicians, who examined only 14% of patients by direct ophthalmoscopy, missed all of these findings. During the second phase, emergency physicians using non-mydriatic photographs reviewed 68% of cases and identified 46% of the relevant abnormalities during their routine clinical care without additional ophthalmology training. Emergency physicians also reported that photographs were helpful in 35% of cases, even when they were normal. Ongoing initiatives involve a web-based training module on interpreting fundus photographs and expansion to additional centers supported by...
telemedicine. Our hope is that our collaboration will begin to restore the importance of ocular fundus examination in patient care and lead to improved diagnosis of sight-threatening, and, in some cases, life-threatening disease.

**Goals & Objectives**

1. Promote systematic examination of the ocular fundus in appropriate patients
2. Improve the diagnosis of relevant ocular fundus findings by providing an easier method of examination, by training of frontline providers, and by offering expert collaboration
3. Improve education about the importance and use of the ocular fundus examination in patient care

**Relevance of Innovation Program/Intervention**

Please explain how this innovation integrates at least two of the three academic medicine areas: clinical care, education and/or research?

Non-mydriatic ocular fundus photography in the emergency department is an innovation that integrates all three areas of academic medicine: clinical care, education, and research. From a clinical care perspective, the project has created a unique opportunity for a multi-disciplinary care program among the Departments of Ophthalmology, Emergency Medicine, and Neurology. This collaboration has resulted in timelier and more accurate care for patients presenting primarily with non-ophthalmologic complaints to the emergency department (e.g., headache, focal neurological deficits, and systemic hypertension). From a research standpoint, the project has provided insights into the epidemiology of ocular fundus abnormalities among patients presenting to the emergency department, and has created new avenues for exploration, including a recently funded R01 grant to evaluate the value of ocular fundus findings in the risk stratification of patients presenting to the emergency department with transient ischemic attack and minor strokes. We hope that ocular fundus photography will provide a platform for the rapid diagnosis of vision-threatening neuro-ophthalmic diseases, such as central retinal artery occlusion and anterior ischemic optic neuropathy. Such a platform will be necessary for clinical trials of therapies for these conditions that will likely require urgent administration in a fashion analogous to tissue plasminogen activator (tPA) for acute ischemic stroke. From an educational perspective, we integrated ocular fundus photography into the medical school curriculum and demonstrated its advantages over direct ophthalmoscopy in a study of 119 medical students. For learning relevant features of the ocular fundus, 77% of students preferred photographs to ophthalmoscopy on simulators or humans. The students’ accuracy was better when interpreting fundus photographs than when performing ophthalmoscopy on simulators, and their performance improved after specific teaching about assessing fundus photographs before testing (p = 0.02). Examination of the ocular fundus was found to be easier and less frustrating when using photographs than when using ophthalmoscopy on simulators or humans. Seventy percent said they would prefer to have fundus photographs instead of using the ophthalmoscope during upcoming clinical rotations. In a one-year follow-up study of the same students, 107 (90%) of which participated, the students’ self-reported median frequency of fundus examination over the preceding year was <10% (interquartile range: 0%-20%). Of 107 students, 85 (79%) felt uncomfortable with ophthalmoscopy, 47 (44%) stated they would not perform ophthalmoscopy during general physical examinations, and 81 (76%) stated they would prefer using photographs vs. ophthalmoscopy for fundus examination. Students continued to be more accurate using photographs than ophthalmoscopy and still preferred photographs for examining the ocular fundus. Most students felt uncomfortable with ophthalmoscopy. Of concern, 20% of students cited discouragement by their clinical preceptor as their primary reason for not performing ophthalmoscopy, which suggests that graduate medical education may be needed to create a long-term change in the use and performance of the ocular fundus examination. Similarly, we are currently evaluating a web-based training module we developed for emergency department physicians.
to learn the key aspects of evaluating ocular fundus photographs in hopes of improving their real-time clinical evaluation of the photographs.

**Methodology**

Please describe any resources, guidelines and/or requirements that were needed to accomplish this innovation, include any specific skills or processes that were used and/or needed. *(limit 500 words)*

The resources required for this project included:

1. The non-mydriatic fundus camera itself (we used a Kowa alpha-D series camera but other equivalent cameras are also commercially available)
2. An appropriate location for the camera preferably with (a) the ability to dim or extinguish the lights, and (b) network port access to upload photographs into the electronic medical record and to transmit images for clinical review
3. People to obtain ocular fundus photography on patients (we have used nurse practitioners, medical students, physicians, and research staff)
4. The availability of expert reviewers to review photographs within a reasonable time frame to ensure there are no missed findings with relevance to patient safety (we provided review within 24 hours, but usually at near real-time)
5. Information technology resources to develop processes and software for the automatic flagging of eligible patients, labeling of photographs with necessary patient identifiers, and uploading of photographs into the medical record.

We developed standard operating manuals and procedures and provided training to all involved staff. Staff training consists of written materials, hands-on in-person training, and observation by a member of the team until the staff member feels comfortable obtaining photographs on his or her own. Although our procedures had various iterations for research purposes, our main clinical program has been carried out as follows. Adult patients who present to our emergency department with a predetermined set of triage chief complaints at high risk for ocular fundus findings (i.e. headache, acute focal neurologic deficit, acute visual changes, or a triage diastolic blood pressure ≥120 mmHg) are eligible. The electronic medical record flags potentially eligible patients automatically when the triage nurse enters the patient’s chief complaint and vital signs. To be included, the patients also have to be medically stable and able to sit up. Photographs of the posterior pole of the ocular fundus (optic disc, macula, and major retinal vessels) are obtained from both eyes of patients by staff using a commercially available, FDA-cleared, non-mydriatic ocular fundus camera. Photographs are immediately placed in the patient’s electronic medical record. Emergency physicians are notified that a patient had photographs by both an icon on the electronic medical record’s census screen and by a report form given to them by the photographer. Within 24 hours, a neuro-ophthalmologist reviews the photographs for findings of clinical relevance and contacts the appropriate member of the patient care team to arrange follow-up for any findings not identified during the patient’s routine care. In any cases with diagnostic uncertainty, the patient is contacted to have an in-office examination.

**Explain how you collaborated with internal and external entities on this project including how you engaged patients, providers and/or key partners throughout the innovation process.**

During the development of the project, the Neuro-Ophthalmology Unit presented the idea to key stakeholders in the Department of Emergency Medicine, including the Department Chair, Clinical Director of the Emergency Department, and Director of Emergency Neurosciences Research. Their enthusiastic support of the concept was very important for engaging the rest of the clinical faculty in the project. Integration into the electronic medical record required the input and support of the Information Technology group within our healthcare system as well as the development of custom software by members of our research team with a background
in Information Technology. This collaboration was required in order to provide the computing resources and systems needed for the identification of eligible patients at triage, the timely clinical review of ocular fundus photographs, the labeling of the photographs with patient information, the uploading of the photographs to the electronic medical record, the cataloguing and archiving of the fundus photographs, and the creation of the web-based educational module. The emergency department nurse practitioners were identified as the photographers for the first phase of the project. We identified a leader among the nurse practitioners who became the project champion and who engaged her colleagues and fostered excitement about being part of this innovative project in clinical care and research. The nurse practitioner champion was also offered opportunities to collaborate in the research project that permitted her recognition as an author on the key papers. This provided her with close contact with the lead members of the project team throughout its course and helped promote her career.

Funding

How was this project funded/sponsored? Explain the successes and limitations the amount of funding had on the project.

The project was funded by a combination of pilot institutional, foundation (Knights Templar Eye Foundation, Research to Prevent Blindness, and American Academy of Neurology Foundation), and federal funds (UL1-RR025008, KL2-RR025009, and K23-EY019341). The institutional and foundation funding allowed us to initiate the project and to develop it into a study competitive for federal funding. The federal funding has allowed our innovative project to grow, but because these funds are restricted to research and are of a time-limited nature, we will be transitioning to support from the Department of Emergency Medicine to sustain what has become an important part of their clinical care model.

Have you received any additional recognition/awards for this work, or published this work in the literature?


Monitoring & Evaluation

Describe the impact and measures of success of your program/intervention. The innovation should
demonstrate a positive impact on results/outcomes (e.g. 20% improvement over baseline in cost, quality, data tools, clinical outcomes, patient satisfaction, provider satisfaction, etc. For multi-year programs/initiatives, include examples of how improvements have been achieved in the program over time.

The primary impact of our project was determined by (1) the improved frequency of ocular fundus examination in appropriate patients and (2) the improved identification of ocular fundus findings relevant to emergency department care. Based on the initial research phase, emergency physicians only examined 14% of patients with headache, focal neurologic complaints, visual complaints, or severe elevations in diastolic blood pressure using the direct ophthalmoscope. In the second research phase, ocular fundus photographs were provided to the emergency department physicians who used them to view the ocular fundus in 68% of cases. Expert over-reading of cases provided an evaluation of all patients except those with photographs that provided no diagnostic information due to poor technical quality (only about 3% of patients). Using the direct ophthalmoscope, the emergency physicians identified none of the findings of relevance to emergency department care (defined as optic disc edema, isolated intraocular hemorrhage, grade III/IV hypertensive retinopathy, retinal vascular occlusion, or optic disc pallor). However, when they had access to the ocular fundus photographs they identified 16 of the 35 relevant findings (46%) during their review of the fundus photographs without additional ophthalmology training. The physicians also reported that the fundus findings were helpful to their care in over 50% of the cases where they reviewed the photographs emphasizing how the absence of findings was also considered to be very important by the emergency department physicians. Another measure of success was patient and staff satisfaction. For each photography session, the nurse practitioner rated the ease and speed of fundus photography and patients rated the ease, speed, and comfort of non-mydriatic photography on a 10-point Likert scale (10 best). Mean scores for each scale were 8.7 or better, suggesting that ocular fundus photography was well-liked by staff and patients alike. In our medical student education program we assessed our impact through testing. The pre-test and post-tests (simulator and photograph) each had 48 items. Students answered an average of 28.8 questions correctly on the pre-test (60%). They answered an average of 8.2 additional questions correctly on the simulator post-test (77% correct of 48) and 11.9 additional questions on the photograph post-test (85% correct of 48), both significantly better than the pretest (p<0.001). Performance on the post-test was significantly better using fundus photographs compared to simulators (p<0.001). At one-year follow-up, two series of questions used the same images for both the simulator and photographs, and students continued to perform better using photographs (mean: 16.6 vs 14.3 of 24 correct; P = .0008).

Describe up to four results of your program explaining the significance of this innovation including, but not limited to improved quality, culture change, costs, patient satisfaction. What were the lessons learned anticipated or unanticipated)?

1. A nearly five-fold improvement in the frequency of examination of the ocular fundus by emergency department physicians in cases where it is indicated.
2. A dramatic increase in the identification of ocular fundus abnormalities by emergency department physicians without additional education (from 0% to 46%), and the identification of the rest by expert review These two results led to improvements in patient safety and accurate diagnosis as well as decreased medico-legal liability for the emergency physicians.
3. A culture change of closer collaboration between emergency medicine and ophthalmology and an increased awareness by emergency physicians of the importance of the ocular fundus examination in the care of their patients.
4. Inroads into new medical education programs for ocular fundus examination This increase in awareness has led to closer collaborations on patient care, research, and education that have begun to transform this area of medicine. The most important lesson learned, albeit expected, was the amount of coordination and hard work on the part of the project champions to overcome barriers to the
project’s success. We are commonly asked about which camera we put in the emergency department. Our reply is always that there is much more to success than just putting a camera in the emergency department. Without the right people, energy, and infrastructure, it will sit unused.

Identify the limitations you experienced in implementing your project and strategies used to mitigate these challenges. Describe any “out of the box” thinking or creative approaches to meeting project goals.

Because the project was initially conceived as research, written informed consent was required. This was an important limitation because, as initially designed, the emergency department staff members involved in the study were responsible for obtaining informed consent. Even with the short, modified consent approved by the IRB, the informed consent process required enough time above and beyond their normal duties that it proved onerous. An additional limitation was the lack of a mechanism to automatically identify patients who were eligible at triage instead requiring active vigilance by the emergency department staff to identify patients. Given the demanding clinical patient flow in the emergency department, the lack of an automated identification process lead to relatively poor and inconsistent inclusion of patients during the initial part of the project. Both of these problems were addressed during this second phase of the project when research specific staff obtained informed consent and an automatic identification system was added at triage to the electronic medical record. The implementation of these solutions led to the identification of 99% (387 of 392) of the eligible patients. The primary quality limitation of non-mydriatic photography is pupil size. The best way to dilate the pupil without medication is by dimming the lights. However, it is generally quite difficult to dim or extinguish the lights in the emergency department. In order to provide a darkened environment, we used a custom hood that was placed over the camera and the patient’s head and shoulders to provide a dark environment that resulted in improved photographic quality.

Potential for Replication

Provide examples on how this proposal can be scaled/replicated within and/or across other medical institutions.

Our project can be replicated within different settings of our institution as well as be scaled and replicated across other medical institutions. Indeed, in one of our publications listed above (Toffoli et al.) we were able to demonstrate that non-mydriatic ocular fundus photography was able to be performed on almost all 3-year-olds and some cooperative 2-year-olds, exceeding the age range of ocular fundus examination provided by direct ophthalmoscopy (i.e., “very cooperative 3 to 4 year olds” according to the American Academy of Pediatrics). Other settings of relevance would include neurology clinics and general medical clinics. In the latter case, non-mydriatic fundus cameras are becoming increasingly prevalent for use in diabetic retinopathy screening and their use could be expanded to systematically examine patients with other indications for ocular fundus examination. With the advent of high quality handheld ocular fundus cameras we have recently begun a project in one of our neurologic intensive care units that may identify patients at higher risk of increased lengths of stay and in-hospital mortality based on fundus abnormalities. Finally, we would anticipate that our project can be relatively easily scaled to other emergency department settings due to the relatively low cost of a non-mydriatic fundus camera (similar to that of an ultrasound machine), the ability of local physicians to provide initial review, and the advantages of telemedicine for consultation between local physicians and experts.