Smartphone Telemedical Emergency Department Consults for Screening of Nonacute Dizziness

Manan U. Shah, MD; Seth Lotterman, MD; Daniel Roberts, MD, PhD; Marc Eisen, MD, PhD

Objectives/Hypothesis: Each year, the United States spends over $4 billion on emergency department visits for evaluation of dizziness. Benign paroxysmal positional vertigo (BPPV) is a common cause of dizziness that can easily be diagnosed by observing characteristic eye movements during the Dix-Hallpike test (DHT). The DHT is easily performed; however, interpretation requires more advanced training. This may be part of the reason it is not commonly performed in emergency departments, and instead, patients undergo costly imaging tests. We evaluated whether smartphone-based video recordings of DHT could be assessed telemedically for screening of nonacute dizziness.

Study Design: Feasibility study.

Methods: Dizzy patients underwent objective vestibular testing, but also had videos of their eye movements recorded via a smartphone during the DHT. The videos were remotely reviewed by two neuro-otologists for BPPV screening and were compared to objective and in-person exam findings.

Results: Overall, 30 dizzy patients were evaluated with seven cases of BPPV. The sensitivity for diagnosing BPPV via a smartphone-recording of eye movements of the DHT was 92.86%, with a specificity of 100% and a negative predictive value of 97.87%.

Conclusions: Our initial proof-of-concept study shows that remote screening of BPPV is possible with high specificity. Because the DHT is easily taught, having a remote otolaryngologist interpret the resulting eye movements may increase usage of the test and may lead to cost savings.

Key Words: Benign paroxysmal positional vertigo, dizziness, telemedicine, teleotology, iPhone, smartphone, cost-saving.

Level of Evidence: 4

INTRODUCTION

Each year in the United States, approximately 2 to 3 million people visit the emergency department with a complaint of dizziness or vertigo. In 2013, the estimated US national costs for patients with a chief complaint of dizziness exceeded $4 billion per year. Dizziness or vertigo can be due to a variety of causes ranging from life threatening, such as stroke or cardiac issues, to benign, such as inner ear pathology. One of the most common causes of nonacute dizziness, however, is benign paroxysmal positional vertigo (BPPV), an inner ear pathology. The gold-standard method of diagnosing BPPV is a bedside positional test, called the Dix-Hallpike test (DHT), which results in patients exhibiting characteristic eye movements with specific head and body position changes.

Although the DHT is straightforward to perform, interpretation of the resulting eye movements typically requires more training. Accurate interpretation can require an otolaryngologist or a neurologist, which many emergency departments do not always have readily available. Consequently, recent surveys show the DHT is not frequently performed in emergency departments, and patients are often subjected to costly imaging tests to ensure their dizziness is not due to a life-threatening cause. This leads to significant healthcare expenditures, and the estimated costs of arriving at a diagnosis of BPPV are $2,000 per patient, and BPPV-associated healthcare costs alone have been estimated to approach $2 billion per year. The cost of BPPV diagnosis could be significantly less if it was diagnosed simply by the gold-standard bedside test as part of a physical exam. Furthermore, with the rise of high-deductible insurance plans, these costly tests can place a significant burden on patients for an easily diagnosable disease.

Telemedical otolaryngology consults have been shown to improve access when otolaryngologists are unavailable, and can be cost saving. Prior studies on tele-otolaryngology, however, required costly equipment, which limited their adoption. Today, however, smartphones are ubiquitous, and many are equipped with high-definition video cameras as well as Health Insurance Portability and Accountability Act (HIPAA)–compliant messaging systems.
We aimed to evaluate whether telemedically transmitted smartphone recorded videos of eye movements during DHT could allow a remote otolaryngologist to accurately screen nonacutely dizzy patients in the emergency department for BPPV. In the future, remote consultations using only smartphones could help to avoid unnecessary imaging and create significant cost savings.

MATERIALS AND METHODS

Population and Setting
This study was approved by the Hartford Hospital Institutional Review Board (HHC-2016-0165). It was conducted from September 2016 to November 2016 at an academic tertiary-care neuro-otology practice. All adult patient’s aged 18 years and older presenting to the practice’s vestibular clinic with a chief complaint of dizziness or vertigo were eligible for enrollment. Patients were excluded only if they were unable to undergo a DHT for anatomical reasons, such as cervical spinal fusion or recent neck injury. Written consent was obtained from all patients.

Equipment
To protect patient privacy, all smartphone videos were recorded using the video feature of an application called TigerText (TigerText, Santa Monica, CA), a smartphone-based HIPAA-compliant encrypted data-sharing platform. The TigerText application stores all HIPAA content within the application’s cloud server instead of on the smartphone, and automatically erases all data after 30 days. The software was loaded onto an Apple iPhone 5 (Apple Inc., Cupertino, CA), which was utilized for video recording. The iPhone 5 was provided by the researchers, had all data erased from it before and after the study, and was kept locked in the clinic when not in use for the study. To further protect patient identities, patient videos were only linked to a diagnosis using randomly assigned codes. No other patient identifier information was recorded, and videos were erased within 30 days of recording.

Methods and Measurements
All dizzy patients initially underwent objective gold-standard vestibular testing including an audiogram, videonystagmography (VNG), DHT testing, video-head impulse testing, and balance-plate testing performed by a trained vestibular physical therapist, as well as an in-person evaluation by a neuro-otologist. Subsequently, to simulate an emergency department telemedical consultation, a resident physician performed a DHT on the patient in a standard stretcher and used a smartphone to record the patient’s eye movements during the test. To simulate telemedical transmission, the video, without any sound or other associated history, was later remotely reviewed by two board-certified neuro-otologists for BPPV screening. Remote diagnosis of the DHT was compared to the initial gold-standard diagnosis by in-person and objective vestibular testing (Fig. 1). Once the neuro-otologists had initially seen the patients in person, measures were taken to prevent bias. The video recordings focused only on the patients’ eyes to avoid recognition of other facial features (Fig. 2) (see Supporting Video in the online version of this article), and were reviewed with a 3-week delay from their date of recording. Finally, a second neuro-otologist, who had never seen the patients, also reviewed the videos and provided BPPV screening.

RESULTS
Thirty patients with a chief complaint of vertigo were enrolled. Seven patients were noted to have BPPV on objective testing. Five of the BPPV patients had posterior canal BPPV, whereas two had horizontal canal BPPV. Four patients were noted on objective testing to have unilateral vestibular dysfunction. No patients had acute vertigo. The sensitivity of remote diagnosis for correctly identifying BPPV was 85.71% (95% confidence interval [CI]: 57.19%-98.22%), and the specificity was 100% (95% CI: 92.29%-100%). The disease prevalence was 23.33%, the positive predictive value of a remote diagnosis of BPPV was 100%, the negative predictive value was 95.83% (95% CI: 86.44%-98.81%). When BPPV was diagnosed, the correct semicircular canal of the BPPV was identified by remote diagnosis 91.6% (11/12); the incorrectly diagnosed semicircular canal was due to an inability to determine the laterality of the affected canal in a patient with horizontal canal BPPV.
DISCUSSION

In the United States, vertigo or dizziness is one of the top 10 most common reasons for an emergency department visit in patients over 65 years, and it accounts for an estimated US national cost of over $4 billion per year. Because of the variety of potential causes for dizziness, diagnosing its cause can be difficult in an emergency department setting. A recent survey by Eagles et al. of 1,150 worldwide emergency physicians found that creating a tool to assist with differentiating serious from benign dizziness was among their top priorities. BPPV is one of the most common causes of vertigo and dizziness.

The gold-standard method of diagnosis for BPPV is the DHT, which is an easily performed bedside positional test. The American Academy of Otolaryngology guideline recommends that the DHT should be performed as the screening method for any dizzy patient with symptoms concerning for BPPV prior to performing costly imaging studies such as computed tomography or magnetic resonance imaging. Still, authors have found that 70% of patients with BPPV will undergo unnecessary testing prior to referral to the correct specialist. Likewise, a recent review of 3,522 visits for dizziness in US emergency departments found that the DHT was only performed in 4% of visits. Even when the diagnosis was thought to be BPPV, the DHT was performed in only 21.8% of visits. Although a number of reasons could account for this infrequent use of the DHT, authors suggest this lack of utilization is due to the increased training required to comfortably interpret the DHT or a lack of availability of specialists for consultation.

Here we attempted to evaluate whether smartphone telemedical consults to an otolaryngologist for assistance with interpretation of the DHT are feasible and reliable. We found that in our sample, a neuro-otologist could diagnose BPPV with a high sensitivity and specificity using a smartphone-recorded video of the patient’s eye movements during a DHT. The quality of video was high enough that, for the majority of cases, the neuro-otologist was able to correctly identify the specific semicircular canal affected by the BPPV.

Diagnosis of dizziness using video of oculomotor exams lends itself particularly to telemedical diagnosis, as the diagnosis can be made simply by viewing the movements of the patient’s eye in response to positional movements. In many outpatient settings, eye movements are already recorded for diagnosis using VNG goggles. Using VNG for remote screening has previously been proposed by Newman-Toker et al., who have suggested using recorded oculomotor exams in the emergency department for the diagnosis of stroke and acute dizziness using video head impulse testing goggles. Furthermore, synchronous otolaryngology telemedical visits have previously been shown to be effective as well as cost-effective, including in the field of neuro-otology. Still, most prior studies on tele-otolaryngology describe using specialized and costly equipment, which limits the practicality of widespread adoption in today’s cost-conscious environment. Because smart phones with high-definition video cameras are now ubiquitous, as well as HIPAA-compliant messaging services, we believe telemedical consults are now feasible without any equipment-related barrier to adoption.

There are a number of limitations to this study. Because this was an initial feasibility study, our sample size was limited to 30 patients, and of these patients only seven patients had BPPV. Still, BPPV is often diagnosed via oculography; thus, we believe 30 patients prove feasibility. In similar studies, Newman-Toker et al. utilized a sample size of 12 patients, Yulzari et al. utilized 48 patients to assess teleotolaryngology consults, and Seim et al. utilized 21 patients to evaluate synchronous visits. Additionally, the nature of the nystagmus elicited by BPPV is that the response fatigues with repetition. To ensure patient’s received the gold standard of care, we initially tested them using the gold standard of VNG testing with a DHT prior to reperforming and recording it with a smartphone. Thus, it is possible the second DHT, recorded with a smartphone, elicited less nystagmus. This could account for the slightly lower sensitivity than 100%. Because one of the neuro-otologists had initially examined the patient, there was a concern for bias. To decrease this, the resident who recorded the videos focused only the patient’s eyes, and the neuro-otologist reviewed these videos 3 weeks later without any sound, and the videos were also reviewed by a second neuro-otologist who had never met the patients. In a busy academic clinic it is unlikely that the original neuro-otologist could recall a patient’s diagnosis 3 weeks later solely based on their orbit and iris anatomy. Furthermore, because there was perfect agreement between the specificity for both neuro-otologists, including one who had never seen the patient, it suggests bias was minimized. Finally, the second DHT and smartphone recording were performed by an otolaryngology resident, thus it is likely the recorder had experience performing the DHT and that the recorder knew the importance of adequately recording a video of the patient’s pupils during the test. Emergency physicians are taught how to perform the DHT as part of the evaluation of the dizzy patient and should be able to incorporate video recording with minimal training. Additionally, during a live telemedical consultation, the remote physician could easily direct the test performer on how to perform the test. Finally, one could argue it would be easier to simply further train emergency physicians to interpret the DHT. Yet, although most emergency physicians do receive training, studies suggests that it is ultimately not frequently utilized.

Based on these results, we propose an easily implementable protocol to screen for BPPV, which could save significant costs by avoiding unnecessary imaging studies (Fig. 3). Our data found a high specificity for telemedical BPPV consults, suggesting it is unlikely that a reviewer would mistakenly diagnose a patient with BPPV when it was not. This suggests that telemedical BPPV consults could function as an effective screening test. We envision a protocol in which in addition to a standard history and physical exam, all nonacute dizzy patients presenting to the emergency department quickly undergo a DHT, when able to, and the provider could record the eye movements via a smartphone with a HIPAA-compliant application.
This has the twofold benefit of allowing a replay for analysis, and also, if there was any uncertainty of the results, these videos could easily be transmitted telemedically to an on-call otolaryngologist or neurologist, who could attempt interpretation. If the diagnosis is clearly BPPV, it could avoid the need for further workup and have significant cost savings. If there is still uncertainty, a standard workup could continue. This is similar to the model proposed by Newman-Toker et al. of using video head impulse testing as a screening method for stroke in dizzy patients; however, it is for nonacutely dizzy patients and requires only a smartphone. Although there are still uncertainties in how to seek reimbursement for this type of telemedical consultation, ultimately, for health systems that are attempting to reign in expenditures, particularly with on-staff physicians, this could create meaningful cost savings in avoiding imaging studies. In addition to providing subspecialty expertise in areas without access, utilization of this type of telemedical technology could be helpful for improving diagnostic accuracy in training programs, as well as for providers seeking additional training.

With adoption of any new technology, there are potential risks. The most obvious risk of utilizing any telemedical consultation is a data breach leading to a loss of patient privacy. In our study, to limit this, we utilized a HIPAA-compliant application, and also focused videos only on a patients eye to anonymize the data. Furthermore, because many causes of dizziness can be potentially life threatening, such as stroke or cardiac issues, we caution that this protocol be used only as a screening method or an adjunct to a full history and physical exam in nonacutely dizzy patients. An example of a how a lack of a full history or physical exam could lead to an adverse outcome in this case, could be a case where an elderly patient with vertigo happens to have both BPPV as well as a new-onset cardiac issue. A thorough history would differentiate these two, whereas using a DHT alone could lead a provider astray.

Finally, because smartphone-recorded oculography videos appear to be reliable, we believe in the future a smartphone-based VNG could easily be designed to further allow for telemedical consults for both acute and nonacute vertigo. Smartphones have already been utilized in otolaryngology to create telemedical otoscopes, such as the CelliScope iPhone Otoscope. With a simple combination of Frenzel goggles and a case-like element to attach a smartphone, the high-definition camera present in many phones could be utilized for oculography, and an application could provide interpretation. This could have a twofold benefit of decreasing costs of existing VNG devices and potentially increasing adoption of protocols like those cited by Newman-Toker et al., while also enabling easier telemedical transmission for potential remote consults.

CONCLUSION

Smartphone-recorded telemedical screening consults for BPPV are both feasible and specific in our dataset. As we strive for cost reduction in healthcare, because of the costs associated with evaluating dizzy patients in the emergency department, further studies on telemedical consults for evaluating dizziness and vertigo are warranted. Ultimately, otolaryngologists should strive to find practical, safe, and reliable methods to incorporate telemedicine into their practice to decrease costs and increase access to care.

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BIBLIOGRAPHY


Shah et al.: Proof of Concept and Protocol Proposal

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