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An Audio/Video Reporting Workflow to Supplement Standardized Radiology Reports

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Abstract Radiology studies are inherently visual and the information contained within is best conveyed by visual methodology. Advanced reporting software allows the incorporation of annotated key images into text reports, but such features may be less effective compared with in-person consultations. The use of web technology and screen capture software to create retrievable on-demand audio/visual reports has not yet been investigated. This approach may preempt potential curbside consultations while providing referring clinicians with a more engaged imaging service. In this work, we develop and evaluate a video reporting tool that utilizes modern screen capture software and web technology. We hypothesize that referring clinicians would find that recorded on-demand video reports add value to clinical practice, education, and that such technology would be welcome in future practice. A total of 45 case videos were prepared by radiologists for 14 attending and 15 trainee physicians from emergency and internal medicine specialties. Positive survey feedback from referring clinicians about the video reporting system was statistically significant in all areas measured, including video quality, clinical helpfulness, and willingness to use such technology in the future. Trainees unanimously found educational value in video reporting. These results suggest the potential for video technology to re-establish the radiologist's role as a pivotal member of patient care and integral clinical educator. Future work is needed to streamline these methods in order to minimize work redundancy with traditional text reporting. Additionally, integration with an existing PACS and dictation system will be essential to ensuring ease of use and widespread adoption.

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Introduction

The standard report for radiologic studies is a narrative, typically containing a brief history, description of study findings, and a conclusion. Since the near ubiquitous adoption of Picture Archiving and Communications Systems (PACS), this format has served as the primary means for communicating findings to referring clinicians and documenting results in an electronic medical record (EMR). Both radiologists and primary clinicians benefit from the efficiencies of text reporting. For most cases, electronic access to a text report often provides sufficient communication without the need for an in-person discussion or phone call. For radiologists, advanced voice recognition software enables rapid dictation. Standardized reporting makes this process even more efficient, giving radiologists faster turnaround in high volume practices.

The drawbacks of text-only reports include the potential commoditization of radiologist's work, lengthy reports that may distract or inadequately convey findings, and decreased visibility of radiologists. Inconsistent or imprecise verbiage in reports may confuse and frustrate referring providers, leading to decreased reliance on the radiologist's input. Until now, these shortcomings have been tolerated in order to generate fast turnaround times. However, with recent declines in reimbursements and the transition towards value-added care and precision medicine, radiologists need better methods of communication with referring clinicians. This may be a difficult realization because it antagonizes the constant urgency for expedited reporting and high volumes. However, improving communication falls within the goals of the Affordable Care

Act, which rewards a team approach to patient care, particularly for inpatient medicine services [1]. This forces radiologists to reconsider how best to convey information to the primary medical team. Traditional text reports may inadequately express nuances of a case. Findings that deserve emphasis may become buried in reporting details. Medical legal requirements obligate radiologist to cover all pertinent negatives and incidental findings, leaving less time and energy for putting unexpected findings into context, answering the most important clinical questions, or producing reports that demonstrate problem solving in a broad clinical context.

In-person interactions between referring clinicians and radiologists in the setting of "radiology rounds" ensure accurate communication of study results and proper patient care [2]. This format has the added effect of including radiologists in a multidisciplinary team where they may interpret studies within a clinical context. Radiology rounds have become less frequent as clinical volumes rise, and efforts have been made to rediscover this form of communication in a modern setting [3]. For complex patients, face-to-face interaction between radiologists and clinicians may still be routine, especially at large academic centers with interdisciplinary case conferences like tumor boards. Curbside consultations also still occur, though these have become less convenient for all parties with high clinical volumes.

To ameliorate limitations in traditional text-only reports, feature-rich reporting methods have been explored, including the automatic generation of reports from annotated images [4]. Clinicians may use report images as footnotes to the text summary. Still, the anatomy and pathology of complicated radiology studies may be difficult to convey by a prosaic method even if key images are included. Live video conferencing is a modern technology available to radiologists for connecting remotely with clinicians, but this is not yet widely used probably due to the inherent time commitment required.

Providing clinicians with a supplemental audio/video report to accompany the usual text report may obviate the need for real-time communications while providing succinct and informative reporting efficiently. A supplemental AV file may even preempt an in-person consultation if it convincingly answers a clinical question or simplifies a complicated case. Because videos could be created and viewed at the convenience of the radiologist and ordering provider, respectively, they minimize disruption to workflow while radiologists retain their essential role in a multidisciplinary team.

The audio and screen capture of radiology interpretations is not a new idea and has been documented in prior patent filings [5]. However, because video reporting has not been commercially integrated into a PACS, it has not undergone formal evaluation. Modern web technology and screen capture software allow the development of an environment where AV files can be easily created and shared with clinicians using cloud technology. In this project, an audio/video radiology reporting tool is created using screen capture software and a cloud-based website that stores and serves videos. The tool is evaluated by referring attending and trainees with the hypothesis that video reporting adds value to clinical management and education in the emergency and internal medicine setting.

Materials and Methods

A waiver from the Institutional Review Board was obtained. A website for uploading and serving videos was created using the Python-based Flask web development environment [6], an open source webserver (NGINX, San Francisco, CA), and cloud-based storage services (Amazon Web Services, Seattle, WA) (Fig. 1). Two example videos were posted on the website for testing purposes.

AV files comprising the video reports were created using SnagIt screen capture software (TechSmith, Okemos, MI) and iSite PACS (Philips, Amsterdam, Netherlands). Image annotations were hidden using a built-in PACS hot-key feature in order to prevent the release of patient protected information. A standard radiology workstation dictaphone was used for audio recording. Videos were saved on local workstations temporarily in MP4 format.

Video files were uploaded to the public website, www.rayvid.com, using the drag and drop feature of a modern web browser. For security purposes, videos were uploaded with options to automatically delete content from the cloud server after 24 h and/or allow referring clinicians delete privileges after viewing. No Digital Imaging and Communications in Medicine (DICOM) data or patient-protected information was released or stored on the remote cloud storage. Upon uploading a video, the website returned a confidential video hyperlink that was retrieved by the radiologist (Fig. 2).

Videos were created from select cases at the discretion of two fourth year radiology residents. Case selection criteria were based on the need to communicate subtle, interesting, or potentially confusing findings. In some cases, a video report was generated if the referring clinician called with a specific question or placed priority on a certain study. Both normal and abnormal interpretations were included in the study. Normal anatomy was highlighted for cases with high clinical suspicion but no pathology. This was intended to reassure referring clinicians that abnormalities had been ruled out, while providing educational value. The creation of videos occurred simultaneous to the dictation of preliminary reports. Movies were limited to 2 min in duration expressing only pertinent positives or negatives of a case. Details and incidental findings could be found in the text report. In all cases, the content within the movie remained consistent with findings in the text report. Thus, videos served a supplemental role in the reporting process, similar to telephone communication of results.

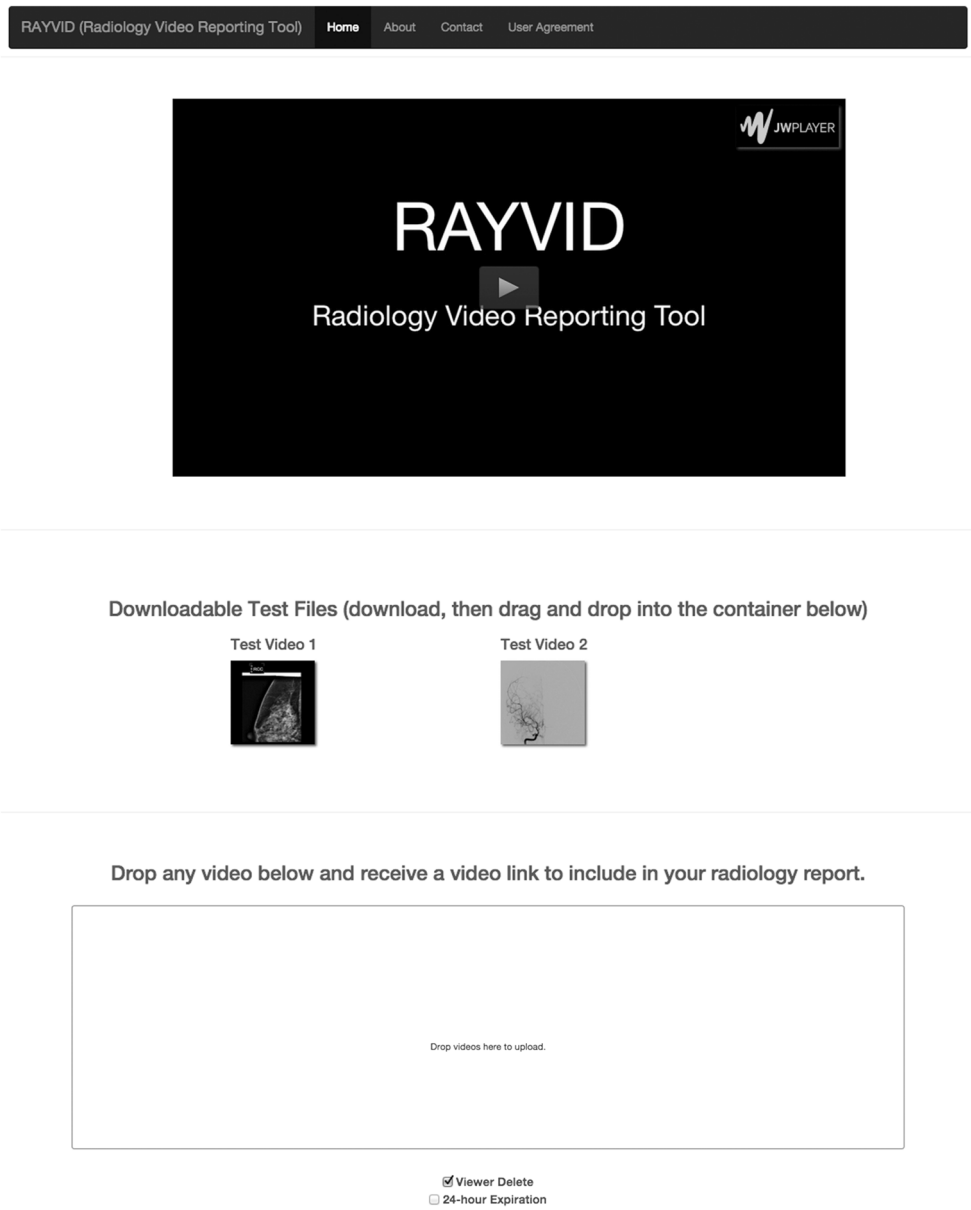

Fig. 1 Website. The custom website is divided into three sections (from *top* to *bottom*): video player, downloadable test movies, and a drop container for MP4 videos. An introductory movie is by default loaded into the player at the website homepage. Test movies can be downloaded and dragged into the movie drop container, and user-created MP4 videos may be uploaded in the same manner

Referring clinicians received video links via secure email at the same time preliminary reports were available on PACS. Clinicians were encouraged but not obligated to follow the hyperlink to view the video report as a part of their clinical workflow. Text and video reports were available to clinicians simultaneously, during clinical practice, and without specific instructions on which to consume first. After viewing the videos, the provider could opt to delete its content by clicking a website button. Alternatively, videos could automatically be expunged from cloud storage within 24 h as determined by the radiologist.

Shortly after viewing the videos and reading the preliminary reports, participating clinicians were given a several question survey via secure email. Separate surveys were composed for attendings and trainees. Questions were asked on a Likert-type scale. For example, attendings were asked to rate the quality and helpfulness of the video summaries, as well as the likelihood they would use such a supplemental reporting system again. All three questions were asked on a five-point scale, where five represented the most positive response, such as "excellent quality," "very helpful," and "would definitely use again." An additional "yes/no" question was included, asking attendings whether the videos changed their clinical practice. Trainees were asked to compare the experience of watching the videos with in-person consultations, in addition to survey questions inquiring about video quality, educational value, and whether they would consider sharing videos with their patients. Trainees were also surveyed

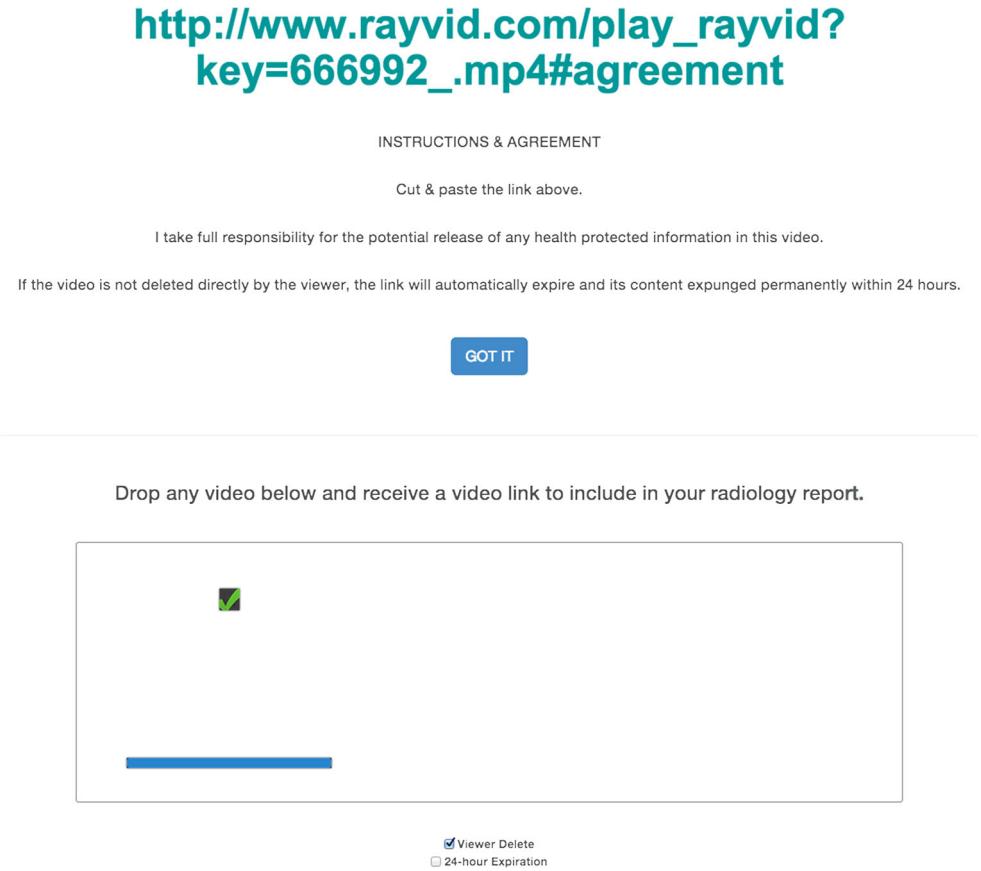

Fig. 2 Video hyperlinks. Before uploading videos, the user can decide whether to grant clinicians delete privileges and/or apply an automatic 24-h expiration of the content. After completion of the upload, the web application returns a confidential hyperlink to the video content

using Likert-type questions, ranging from three- to five-point scales. There was no explicit question regarding the comparison of video reports with standard text reports. Clinicians were only asked to evaluate the video reporting system as a supplement to text reports. Participants were not reimbursed for their time.

Survey results were compiled and analyzed using R software version 3.0.3. Statistical significance of responses was assessed by converting answers to the appropriate numeric scale for Likert data, followed by analysis using the Wilcoxon signed rank test for nonparametric data. The mode, median, and frequency of each survey response were also calculated.

Results

Once familiar with the screen capture software and patients, video creation by the radiologist took less than 5 min for each case. Screen capture software allowed multiple views and sequences to be included simultaneously in videos, as this reflected a point-of-view perspective from the radiologist's workstation (Fig. 3). Each video was under 2 min in length, ranging in size from 8 to 40 megabytes (MB's), and was uploaded to the cloud server via the public website in less than 10 s. Videos in MP4 format were accepted by the web application and could be replayed on a desktop computer or handheld device such as an iPad or iPhone. Two example videos on the public website were successfully downloaded and dropped into the upload container for testing purposes. Hyperlinks to the example videos subsequently worked as expected. Direct inquiries into the cloud database confirmed that videos could be manually deleted after viewing or were automatically expunged from storage 24 h after uploading. In all cases, the corresponding video links sent to providers and web application worked as expected using a modern web browser on a desktop computer or handheld device.

A total 14 attending level physicians and 15 trainees, including residents and fellows, all from either emergency medicine or internal medicine specialties participated in this study. Forty-five videos were created, each describing imaging from a different patient case. All videos except for one were created and viewed by a single clinician. One video was shared between an attending and trainee. Video reports were created from multiple modalities including ultrasound, plain film, computed tomography, and magnetic resonance imaging studies. Twenty-two case videos were created for the panel of attending physicians, each attending involved in one to three case videos. Twenty-six videos were created for the panel of trainees, each trainee being involved in one to five case videos.

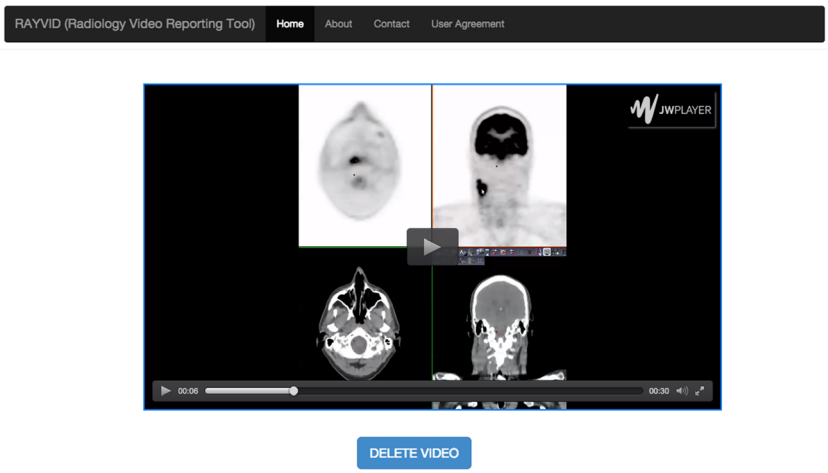

Fig. 3 Viewing movies. The hyperlinks generated by the web application direct the user to the website where movies are preloaded into the player. Screen capture software enables the viewer to see the case through the radiologist's eyes, displaying different modalities as needed in multiple planes, simultaneously. User options include full screen viewing on desktop or handheld devices, video replay, and deletion of the video from the cloud database after viewing

Fourteen attending providers surveyed across 22 cases most commonly gave video quality, helpfulness, and consideration for future the highest scores on a five-point Likert scale, with frequencies of 91 (20/22), 95 (21/22), and 100 % (22/22), respectively (Fig 4). Median value for all three questions was also five. Results from all three questions met statistical significance for being more positive than neutral with p values less than 0.01. Attendings reported a change in management for 3 of 22 cases (14 %) as a result of viewing the video reports.

Fifteen trainees surveyed across 26 cases most commonly gave video quality, educational value, and willingness to share videos with patients the highest possible respective scores of five, three, and five, with frequencies of 88 (23/26), 100 (26/26), and 73 % (19/26) (Fig 5). Trainees most frequently rated video reporting as being similar to in-person consultations (three on a four-point scale), comprising 77 % (20/26) of responses. Median values were equal to the mode for all four questions and met statistical significance for being more positive than neutral with p values less than 0.01.

Discussion

Despite the longstanding availability of tools for producing video reports, there has been little work to establish and

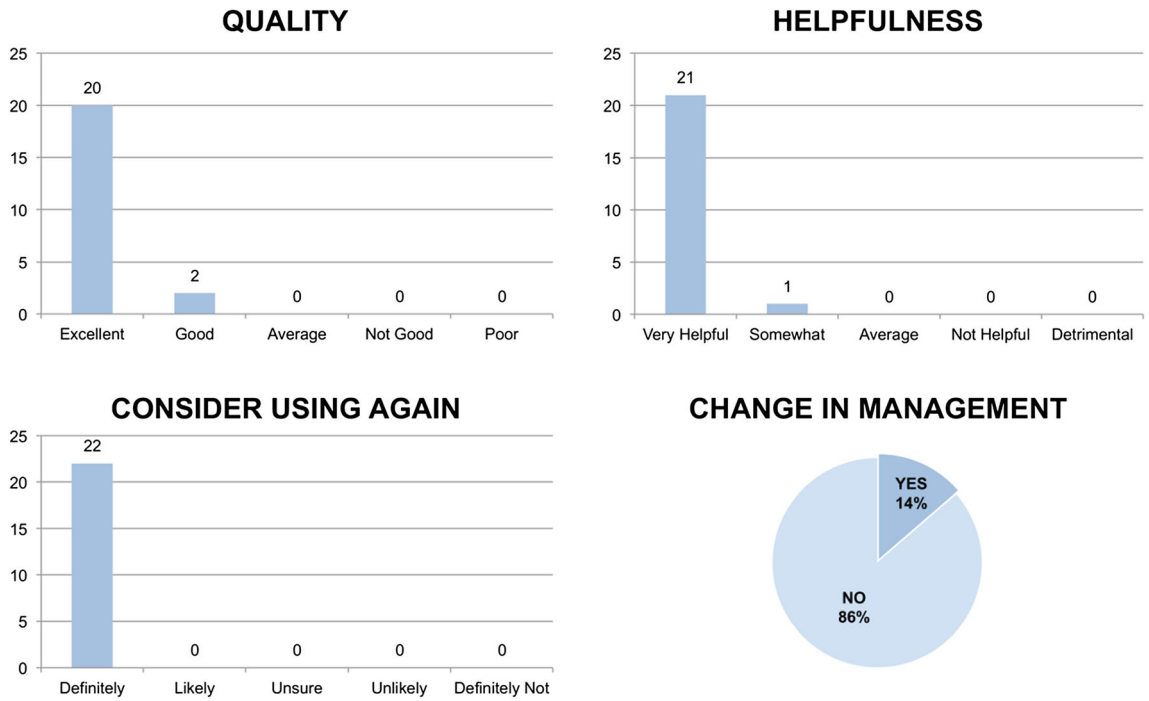

Fig. 4 Attending survey results. The total number of case videos shared with attendings was 22 (y-axes of bar charts), with the distribution of survey results shown on the x-axes. Video reporting resulted in a change in management for a small number of cases (*bottom right* pie chart)

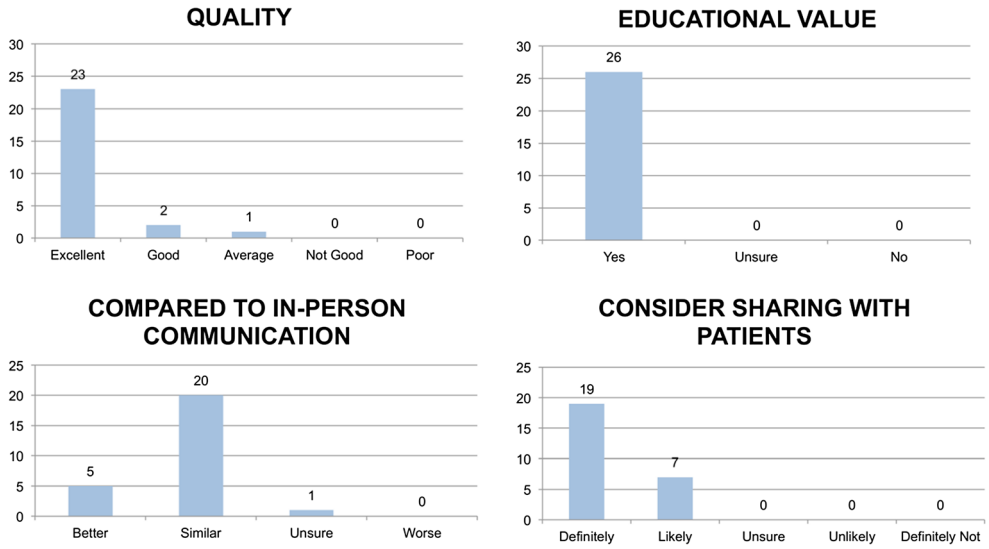

Fig. 5 Trainee survey results. The total number of case videos shared with trainees, including residents and fellows, was 26 (*y*-axes of bar charts). The distribution of survey results is shown on the *x*-axes. Although the technology was not formally evaluated with patients, most trainees shared a strong consideration for sharing videos with their patients

evaluate a radiology workflow that supports this methodology. This may be due to an inherent discomfort towards using popular online video sharing websites for such a purpose. The need for patient confidentiality and professionalism in an easy-to-use web application necessitated the creation of an alternative video hosting website for radiologists. In this work, a dedicated website and workflow were developed to upload and share radiology video reports with referring clinicians using screen capture software and modern web technology (Fig. 6).

This evaluation suggests the feasibility of an enhanced radiology reporting system that includes audio/visual supplements to help distill pertinent findings for referring clinicians. The custom website provides an easy to use and clean interface for sharing anonymized videos of patient images. The web application may be expanded in future releases to enable any short-term video communication between physicians or serve as a platform for teaching videos and case conference presentations. Such technology may also enable referring clinicians an efficient means to share radiologic images with their patients on handheld devices [7].

Protected health information in this project was safeguarded through the use of a PACS feature that hides annotations on clinical images. Additionally, the videos could only be recovered using a confidential link known only by the radiologist and referring clinician. Further security was provided by ensuring that all content was automatically deleted within 24 h of posting if not by the user after viewing. However, a practical implementation must ensure high levels of security by requiring registered users to provide passwords prior to viewing videos. Acceptance of online video reporting may also depend on the continued adoption of cloud storage technology and development of adequate security measures.

Limitations

Efficiency is an ongoing concern for radiologists. While feasible, the described method is not integrated into an existing PACS and involves separate screen capture software as well as a video repository web application. Allowing for these disparate parts, total time for producing and uploading a video was less than 5 min. Two radiology trainees created movies for this small study and future work should focus on including attending radiologists. This would support the future viability of video technology from the radiology perspective. In high volume settings, video reporting would negatively affect productivity and thus may only be a reasonable application for select cases that prove difficult to articulate by prosaic method alone. Efficiency could be improved in future releases by fully

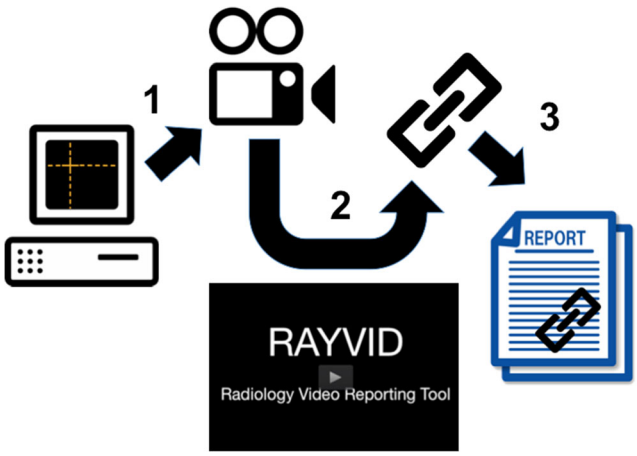

Fig. 6 Workflow. Video report generation is divided into three parts: creation and saving of a screen capture AV file in MP4 format, movie upload to the web application and receipt of a video hyperlink, and possible inclusion of the hyperlink in a text report

integrating this workflow into a PACS. For example, dictaphone buttons might help automatically launch, create, and store videos on the fly, requiring little extra dedicated time by radiologists.

The creation of supplemental video reports creates potential conflicts with text reports. Inconsistencies could arise between the two forms, and it is radiologist's responsibility to keep both consistent. While this may seem burdensome, it is similar to frequent use of phone communication with referring clinicians, which is necessarily consistent with text reports. If movies are made simultaneous to the creation of text reports, discrepancies may be minimized, and phone communication or in-person consultations may be obviated. A final concern may be that video reporting becomes the de facto means of communication with referring clinicians. This work focuses on video reports being a supplemental form of communication only for certain cases. Again, the role of video reports is similar to phone communication, where the text documentation still serves as the primary reference.

Conclusion

A dedicated web application for sharing anonymized videos of radiologic images was developed, enabling an initial evaluation of a supplemental radiology video reporting system. In addition to the usual text report findings, the video reports described above are accessed via hyperlinks that may be included in text reports. Features of the workflow include the potential to provide quick visual summaries, teaching, detailing of pathology, answers to specific clinical questions, and opportunities for referring clinicians to share images directly with patients. This early evaluation suggests that it may improve communication between radiologists and referring providers while potentially changing management in some instances. Furthermore, this technology may pre-empt potentially more disruptive telephone calls or face-to-face interactions. Continued development of standardized cloud security measures along with improved integration of the described workflow may encourage its future acceptance. The long-term transformation of video reporting into a billable activity will likely be determined by its proven effectiveness for improving patient care.

References

1. Barnes KA, Kroening-Roche JC, Comfort BW: The developing vision of primary care. The New England Journal of Medicine 367(10):891–893, 2012
2. Hoff WS, Sicoutris CP, Lee SY, Rotondo MF, Holstein JJ, Gracias VH, Pryor JP, Reilly PM, Doroski KK, Schwab CW: Formalized radiology rounds: the final component of the tertiary survey. The Journal of Trauma 56(2):291–5, 2004
3. Mamlouk MD, Anavim A, Goodwin SC: Radiology residents rounding with the clinical teams: a pilot study to improve the radiologist's visibility as a consultant. Journal of the American College of Radiology 11(3):326–8, 2014
4. Weiss DL, Kim W, Iv BFB, Prevedello LM: Radiology reporting : a closed-loop cycle from order entry to results communication. Journal of the American College of Radiology 11(12):1226–1237, 2014
5. G. Rose, "Audio/video interface as a supplement to radiology reports," U.S. Patent 8434005 B2 2009.
6. A. Ronacher, "Flask: web development, one drop at a time," 2014. [Online]. Available: http://flask.pocoo.org/.
7. Sharpe R, Wei J, Venkataraman S, Knox M, Dialani V, Slanetz P, Prakash S, Mehta T: Redefining radiology reporting practices: patient preferences and perspectives. In: ARRS scientific session—efficacy/administration/informatics, 2014