

Developing and Using a Televideo Application in a Nursing Facility

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Although video-based teleconferencing is becoming more widespread in the medical profession, especially for scheduled consultations, applications for rapid assessment of acute medical problems are rare. After regular business hours in the nursing home, physicians are often not immediately available at the bedside to evaluate patients with acute medical problems. Spontaneous videoconferencing between residents (patients) and off-site, on-call physicians offers additional opportunities for physicians to gather additional information directly from residents. We have designed, assembled, tested, and implemented a portable, wireless conferencing system that uses public Internet channels for secure, live videoconferencing. The system includes a rolling cart with videoconferencing hardware and software, a remotely controllable digital camera, lamps, wireless network, and battery. A semi-automated paging system informs physicians of residents' study status and indications for conferencing. Data transmission occurs wirelessly in the nursing home and then through network cables to physicians' homes. This provides sufficient bandwidth to support quality motion images. IPsec secures communications. Despite human and technical challenges, this system is affordable and functional. We conducted a clinical trial of the system. Although most calls for medical problems did not lead to videoconferencing, physicians and nursing-home residents were satisfied with videoconferencing when it did occur, and physicians reported that making medical decisions was easier with videoconferencing. Videoconferencing was most often conducted to assess residents with changes in mental status, abnormal laboratory values, or falls. Physicians often lacked immediate access to videoconferencing equipment when medical problems with residents occurred. This application could benefit from improved access and portability of equipment.

BACKGROUND

The use of videoconferencing in medical applications is becoming much more commonplace and affordable, as well as reimbursable. The use of videoconferencing in evaluating acute medical problems has seen limited application and success, especially in extended-care nursing facilities, where physicians are seldom available at the bedside at all hours. Through a clinical trial of videoconferencing in an urban nursing facility, we sought to test the effect of a new videoconferencing system on medical decision-making, the use of laboratory and diagnostic testing, referrals to the emergency department, and satisfaction of residents and clinicians. We hypothesized that with the video system, resource utilization would decrease, physicians' confidence in medical decision-making would increase, and patients' and physicians' satisfaction with care would increase.

METHODS

We researched options for conducting and recording videoconferencing. The H.323 protocol suite, which uses the H.261 video codec, was selected as the data transport standard for live videoconferencing, based on our findings of greater industry support and tolerance to the varying bandwidths of the Internet. H.261 requires 64 kbps and scales upwards in multiples of 64 kbps. The VCON Escort 25 and accompanying software, using H.323, were chosen for ease of use, affordability, and availability. The MPEG-1 standard for media encoding (frame size of 352 240 pixels and a frame rate of 30/second) was selected for simultaneous recording and storage of video files—to be made available for later playback by clinicians—due to its high quality of images and motion. A dedicated video capture card facilitated these MPEG recordings.

We built a portable, rolling cart (see Figure) using a composite of off-the-shelf equipment. The \$6,085 cart included a PC with the videoconferencing hardware and software, remotely controllable Canon camera, Cisco wireless networking with Wired Equivalent Privacy (WEP) protocol, uninterruptible power supply, halogen lamps, and PC speakerphone. For security, we used open-source, FreeBSD UNIX routing with tunneled IPsec and strong 256-bit encryption.



Figure. The cart

Among the alternative methods of Internet access were cable-modem, Digital Subscriber Line (DSL), and satellite. Bandwidth achievable over satellite was too low, and latency was significant. DSL with sufficient speed beyond 1 Mbps was not available in most local areas.

We found the cable-modem service provided by Comcast/@Home to be a very good alternative to T1. We measured streaming bandwidth of consistently beyond 2 Mbps to one of our test sites, far above the 1.5 Mbps achievable through T1 lines. Although data traveling to the physicians' homes travel through more than a dozen routers in multiple states, we measured peak throughput beyond 6 Mbps when even our Institute's and hospital's Internet connection was saturated. At 6 of the 7 physicians' homes, we used Comcast or AOL Time Warner cable-modem service; at the seventh physician's home, only T1 was available (except for telephone modem dial-up), and this was used for comparison. Physicians' home workstations included the VCON Escort 25 along with an inexpensive Intel Web Cam. Business-class cable-modem service permitted Virtual Private Networking.

To accommodate the need to track patients' study status and alert the physician to that status and the need to conduct video conferencing, we modified the paging system so that our established Gopher (computer-based provider order-entry system) would generate pager messages, instead of a person-based telephone answering service. When an acute medical problem occurred, the nurse or research assistant in the nursing facility would view an electronic form, identify the patient, and record in the computer the reason for the call and the physician to whom it was directed. The computer would then send the message to the paging service as an electronic-mail message, which was transmitted in turn to the physician's pager. The Gopher inserted into the pager message the patient's study status and whether videoconferencing was indicated.

Following videoconferencing, the recording is uploaded to a streaming video server (Bitcasting MPEG server coupled with a Real-Networks server). A link to each video session is stored in the Regenstrief Medical Records System (RMRS) via HL7 messages. The physicians at home could conduct videoconferencing and simultaneously search the medical record, review previously produced videos, and enter new orders using our established computerized order-entry system.

We enrolled residents of the nursing facility, including residents of any age, admitted to the facility from July 2001 to June 2003. The nursing home is located on the medical campus of Indiana University-Purdue University Indianapolis, and all physicians who provide care for the residents are university faculty. We initially excluded residents with end-stage renal disease, expected stays of 72 hours or less, or inability to speak intelligible English. After administration of the Short Portable Mental Status Questionnaire, we also excluded residents without English-speaking proxies if the screening suggested dementia. Using computer-generated random numbers, consenting participants were then randomized to control or intervention groups, for separate analyses comparing resource utilization between groups. Spontaneous nighttime videoconferencing was initially available to residents randomized to the intervention group. After the first 12 months, the study was broadened, and videoconferencing was made available to all participating residents.

During nighttime study hours, an in-house research assistant processed all calls for acute medical problems, by logging the calls using the institution's computer-based provider order-entry system. The system retrieved the study status of the patient and forwarded a message about the problem to the physician's pager, including whether a video was authorized ("Yes" for conditions likely amenable to videoconferencing a priori; "Discretionary" when usefulness of videoconferencing was more questionable; and "No" for non-participating residents). Interactive videoconferencing could be conducted if the physician were available at the home workstation. Through the workstations, physicians also had access to elements of the electronic medical record, such as laboratory values (for participants in control and intervention groups) and previously recorded videos (only for participants in the intervention group). When physicians were not available for videoconferencing, a non-interactive, scripted batch video could be recorded for later review. Physicians were asked to rate on log paper the usefulness of each episode of videoconferencing. Participating residents were also asked their opinions about videoconferencing. Physicians were also asked later about the impact of videoconferencing on medical decision-making and residents' healthcare. Approximately 28-35 study hours occurred each week on weeknights, plus 0-14 hours per week on weekends. A group of 7 study physicians sharing a nighttime and weekend call schedule participated.

RESULTS

We measured latency of transmission by running a digital clock on the screen of one PC, using a camera to transmit the clock's image to a second PC and using the second PC's camera to transmit the image back to the first PC. By displaying both the digital clock and its looped-back image on the same PC, we observed accurate latencies ranging on average from 0.53 seconds to 1.24 seconds during 10 test runs. With cable-modem systems for Internet access, we experienced unpredictable speeds that varied from about 70 kbps to 4 Mbps. End-to-end Internet connections with up to 17 Internet hops were often observed. In early video tests, videos could distinguish features such as small skin lesions and changes in respiratory patterns.

We successfully enrolled approximately 80% of residents in the nursing facility. At baseline, about 30% of participants surveyed indicated that they could not see a doctor as often as they liked. Nevertheless, relatively well patients who anticipated a short length of stay sometimes preferred not to participate in the study simply due to perceived inconvenience.

We experienced periodic outages and mysterious slowness and network degradation. In particular, the system suffered several episodes of packet losses that required detailed tracing and discussion with technical staff at the offices of the Internet Service Providers (ISP). We noted periods of poor performance related to large-scale denials of service, as well as distinct episodes when difficulties at our institution's ISP cut bandwidth dramatically. At times, the ISP was unable to dedicate time to solve the problems. Video and synchrony over cable-linked Internet without quality of service (QoS) was quite good, even with data sustaining 10-20 Internet hops and no real QoS implementation. Users tolerated loss of video packets quite well, but tolerance to audio dropout was not as good, since the meaning of a sentence can easily be lost when one or two words are dropped. To address this, we provided a cellular telephone that could be selected with a switchbox, as an alternative to IP telephony.

Several human challenges were identified. Physicians were often not available at their home workstations to conduct videoconferencing. At times, nurses and physicians would report that they were too busy to take extra time to use the equipment for conferencing, or patients felt either too ill or too well to participate in episodic conversations or the study as a whole. Video sessions were also occasionally cancelled when ill patients refused to participate in an episode, despite providing earlier consent to the study. Videoconferencing was deemed unnecessary in approximately 65% to 70% of encounters.

In the first 12 months, we enrolled 187 participants with a mean age of 64 years. Women comprised 63% and African-Americans 53%. We studied 394 calls. Physicians conducted 47 video sessions. Videoconferencing was most often conducted to assess residents with changes in mental status, abnormal laboratory values, or falls. Physicians rated 27 of the videoconferencing sessions. Physicians reported that recording (i.e., archiving) failed in several cases. Other commonly reported technical problems included absence or dropout of audio, degradation of image quality, hanging or "freezing" during conferencing, and failure to connect. Despite these difficulties, physicians were quite satisfied with the videos overall. When asked, "To what extent has our new telemedicine program changed your workload (1 = workload is greater, 7 = workload is lighter)?", the mean rating was 4, indicating no change. When asked, "To what extent has the telemedicine program changed patient care (1 = care is worse, 7 = care is better)?", the mean rating was 5.5, indicating better care. In about half of the videoconferencing episodes, participating residents could not comment on the sessions (e.g., due to dementia or sensory impairment), but when asked to rate communication with the doctor, no residents reported that communication was poor or that the communications made healthcare worse than usual (data not shown). No adverse events were reported. We are in the process of analyzing resource utilization.

CONCLUSIONS

We constructed a system to augment nursing-home care through rapid deployment of a portable, affordable, secure, video conferencing system using public Internet channels. Bandwidth and

performance are adequate for effective videoconferencing, but due to QoS issues, using public Internet channels for critical video conferencing without any alternative means of medical evaluation is not generally recommended. Audio communications may benefit the most from QoS.

Physicians indicated that unscheduled, nighttime videoconferencing in a nursing facility with chronically ill, disabled residents eases medical decision-making and improves healthcare. Nevertheless, many or most calls from nurses to physicians in this setting do not prompt the need for videoconferencing. Videoconferencing is most useful for less common but more severe conditions. Improved access and portability of equipment could facilitate development of new applications in this environment.