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Marina Serper

Michael L Volk

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Published in final edited form as:

Clin Gastroenterol Hepatol. 2018 February ; 16(2): 157–161.e8. doi:10.1016/j.cgh.2017.10.004.

Current and Future Applications of Telemedicine to Optimize the Delivery of Care in Chronic Liver Disease

Marina Serper^{*‡} and Michael L. Volk[§]

^{*}Division of Gastroenterology, University of Pennsylvania Perelman School of Medicine, Philadelphia, Pennsylvania

[‡]Department of Medicine, Corporal Michael J Crescenz VA Medical Center, Philadelphia, Pennsylvania

[§]Division of Gastroenterology and Transplantation Institute, Loma Linda University, Loma Linda, California

Telemedicine is defined broadly by the World Health Organization as the delivery of health care services at a distance using electronic means for “the diagnosis of treatment, and prevention of disease and injuries, research and evaluation, education of health care providers”¹ to improve health. Although no single accepted definition exists, *telehealth* often is used as the umbrella term to encompass telemedicine (health care delivery) in addition to other activities such as education, research, health surveillance, and public health promotion.² These various terms often are used interchangeably throughout the literature, leading to confusion.^{1,3} For the purpose of this review, we will use the term *telemedicine* to describe any care delivery model whereby patient care is provided at a distance using information technology such as cellphones, computers, or other electronic devices.

Telemedicine through telephone and video technology has been used since the 1960s in the sectors of the military and space. Over the past several decades, as the use of wireless broadband technology has become more advanced and cell phone and internet use has become nearly ubiquitous, there has been a rapid emergence of technological modalities to facilitate health care delivery at a distance. The various forms of telemedicine currently in use are described in Table 1. Any of these can be provided as synchronous, such as a video teleconference with a clinician, or asynchronous/ store-and-forward, which may encompass review of prerecorded data such as clinical information through an electronic consultation, or of pathology and/or radiology images.

In the United States, the use of telemedicine is increasing. According to a 2017 survey of 184 health care executives conducted by the American Telemedicine Association, 88% believed that they would invest in telehealth in the near future, 98% believed that it offered a competitive advantage, with the caveat that 71% believed that lack of coverage and

Address requests for reprints to: Michael L. Volk, MD, MSc, AGAF, Division of Gastroenterology and Transplantation Institute, Loma Linda University, 25865 Barton Road, Suite 101, Loma Linda, California 92354. mvolk@llu.edu; fax: (909) 558–3724.

Conflicts of interest

The authors disclose no conflicts.

payments were barriers to implementation. Recent studies have shown that telehealth interventions are effective at improving clinical outcomes and decreasing inpatient utilization, with good patient satisfaction in the areas of mental health and chronic disease management. The Veterans Administration (VA) has emerged as an early telehealth adopter in chronic disease settings such as mental health, dermatology, hypertension, heart failure, and, as of 2016, has provided care to nearly 700,000 (12%) Veterans since its inception.⁴⁻⁶ Despite the increased uptake, significant infrastructure and legal barriers to telemedicine remain and the literature regarding its utility in clinical practice continues to emerge.

Compared with other chronic diseases (eg, heart failure, diabetes, mental illness) there is a dearth of literature on the use of telemedicine in liver disease. The first portion of this review synthesizes currently published literature of telemedicine/telehealth interventions to improve health care delivery and health outcomes in chronic liver disease including published peer-reviewed articles, abstracts, and ongoing clinical trials. The second portion discusses a framework for the future development of telemedicine and its integration into clinical practice by citing examples currently used throughout the country as well as ways to overcome implementation barriers.

Use of Telemedicine in Chronic Liver Disease: A Literature Review

We performed a systematic review of telemedicine in chronic liver disease. In consultation with a biomedical librarian, we searched for English-language articles for relevant studies with adult participants from July 1984 to May 2017 in PubMed, OVID Medline, American Association for the Study of Liver Disease, EMBASE, Web of Science, clinicaltrials.gov, Elsevier/Science Direct, and the Cochrane Library (the search strategy is shown in the Supplementary Material). The references of original publications and of review articles additionally were screened for potentially relevant studies. Abstracts that later resulted in no publications and studies in which telemedicine was used to deliver care, but was neither an exposure nor outcome, were excluded. Social media studies were not considered telemedicine if no patient care was involved. Studies of purely medical education interventions or those that evaluated the accuracy of technology to aid in diagnosis also were excluded.

Supplementary Table 1 shows the 20 published articles of telemedicine studies. Among these, there were 9 prospective trials, 3 retrospective studies, 2 case reports, and 6 small case series. One of the studies was randomized prospectively and 10 were uncontrolled.

Telemedicine in Hepatitis C Treatment

Much of the published literature of telemedicine in liver disease (Supplementary References) has described the use of video teleconferencing for the management of hepatitis C virus (HCV), both in the era of interferon-based treatment and with new direct-acting antivirals. Several studies in the United States and throughout the world retrospectively evaluated the use of live telemedicine/videoteleconferencing to deliver HCV therapy to incarcerated patients, those living in rural areas, and in the VA using the spoke-and-hub model. Generally, sustained virologic response rates were similar or higher with telemedicine than among patients receiving in-person visits, whereas discontinuation rates

were generally low and side effects were well managed. Visits generally were led by nurses or specialty-care physicians and were associated with high patient satisfaction. A randomized study comparing a telephone-based self-management intervention of cognitive behavioral therapy vs usual care for 19 Veterans undergoing HCV treatment with interferon-based regimens showed that the telephone-based cognitive behavioral therapy group had lower depression and anxiety symptoms and reported a better quality of life. Several more recent abstracts have described successful use of telemedicine for HCV treatment (Supplementary Table 2 and Supplementary References). One of the most cited examples of telemedicine for HCV has been the Extension for Community Healthcare Outcomes (ECHO), or Project ECHO.⁷ This care model initially was designed to increase access to interferon-based treatment for patients with HCV in rural areas of New Mexico. In contrast to previously cited examples in which subspecialty or physician nurses directly provided clinical care in HCV, ECHO targeted front-line primary care providers to enhance expertise and enable problem-based learning via live video teleconferencing. Primary care providers participating in ECHO presented cases to content experts through video-linked knowledge networks; didactic presentations also were developed for provider education. The program has been expanded to Utah and Arizona and showed success with high rates of HCV treatment initiation and sustained virologic response.⁸ As an early adopter of telemedicine and after the success of Project ECHO in 2011, the VA developed and implemented the Specialty Care Access Network–ECHO to increase access, training, and provide real-time expert consultation for primary care physicians in multiple chronic conditions, including HCV and chronic liver disease.¹ Several recent unpublished abstracts in the VA have reported on the use of telemedicine via videoteleconferencing to increase access to hepatology care in cirrhosis with high patient satisfaction.

Telemedicine to Aid in Procedural/Surgical Management

A few reports have been published in the use of synchronous video and digital technology to aid in periprocedural management in liver disease. A case report highlighted a successful example of gastroenterologist-led teleproctoring using basic video technology to enable a surgeon to perform sclerotherapy for hemostasis in the setting of a variceal bleed.⁹ Another case report described the transmission of smart phone images from surgical trainees to an attending physician to make a real-time decision regarding a possibly questionable liver procurement, which took place 545 km away from the university hospital.¹⁰ A retrospective case series described the feasibility and successful use of high-resolution digital macroscopic photography and electronic transmission between liver transplant centers in the United Kingdom to increase the utilization of split liver transplantation, a setting in which detailed knowledge of vessel anatomy is needed for advanced surgical planning.¹¹ Similarly, an uncontrolled case series from Greece reported on the feasibility and reliability of macroscopic image transmission to aid in the evaluation of liver grafts for transplantation.¹²

Telemedicine to Support Evaluation and Management of Hepatocellular Carcinoma

One recent abstract reported on the use of asynchronous store-and-forward telemedicine for screening and management of hepatocellular carcinoma and evaluated process outcomes of specialty care access for newly diagnosed patients.¹³ A multifaceted approach included live video teleconferencing and centralized radiology review, which was conducted by a

multidisciplinary tumor board at an expert hub site, which provided expert opinion and subsequent care (eg, locoregional therapy, liver transplant evaluation) to spoke sites. As a result of the initiative, the time to specialty evaluation and receipt of hepatocellular carcinoma therapy decreased by 23 and 25 days, respectively.

Remote Monitoring Interventions

The literature for remote monitoring in chronic liver disease or after liver transplant currently is emerging. A prospective pilot study by Thomson et al¹⁴ evaluated the utility of a telephone-based interactive voice response intervention in predicting hospitalizations and death among 79 patients with decompensated cirrhosis. Parameters such as self-reported weakness and more than a 5-pound weight gain in 1 week were associated with increased rates of hospitalization. Ertel et al¹⁵ recently published results of a nonrandomized pilot study of remote monitoring using smart tablets among 20 liver transplant recipients. Patients were followed up for 90 days after the liver transplant surgery whereby daily weights, blood glucose reading, and vital signs were transmitted to the transplant center; violations of preset thresholds were recorded, although it was not clear whether members of the clinical team were asked to act upon the violations. Re-admission rates among patients in the pilot study at 30 and 90 days were 20% and 30%, respectively, compared with 40% and 45% among historical controls. Patients with 100% daily interaction with the smart tablets did not experience any re-admissions. Another abstract described a nurse-led remote monitoring intervention paired with at-home video teleconference visits among 31 patients with alcoholic cirrhosis.¹⁶ The majority of patients were able to stop alcohol intake, improve their nutrition, and increase physical activity. Supplementary Table 3 shows additional ongoing or completed telemedicine interventions in liver disease as obtained from www.clinicaltrials.gov.

Proposed Framework for Advancing Telemedicine in Liver Disease: The Case for More Research and Policy Changes

Telemedicine can serve 2 main goals in liver disease: improve access to specialty care, and improve care between visits. For the first goal, the technology is straightforward and limited research is required; the main barriers are regulatory and reimbursement. As an example, one of the authors (M.L.V.) uses telemedicine to perform liver transplant evaluations in Las Vegas, NV, a state without a liver transplant program. Patients are seen initially by a nurse practitioner who resides in Las Vegas, and those patients needing transplant evaluation are scheduled for a video visit with the attending physician who is physically in California. This works well and patients love it, however, the business model is dependent on the downstream financial incentive of transplantation. In addition, various regulatory requirements must be satisfied such as monthly in-person visits. For the second goal, a number of exciting possibilities exist such as remote monitoring and patient disease management, but more research is needed.

Research

According to the Pew Research Center, 95% of American adults own a cellphone and 77% own a smartphone. These devices passively gather an extraordinary amount of data that

could be harnessed to identify early warning signs of complications (remote monitoring). Another potentially fruitful area of research is patient disease management. This includes using technology (eg, reminder texts) to effect behavior change such as with medication adherence, lifestyle modification, education, or peer mentoring. As an example, co-author (M.S.) is leading a study to promote physical activity among liver transplant recipients by using an online web portal developed by researchers at the University of Pennsylvania (Way to Health), which interfaces with patient cell phones and digital accelerometer devices. Participants receive daily feedback through text messages with their step-counts, and small financial incentives are provided for adequate levels of physical activity. Technology also can facilitate the development of disease management platforms, which could improve both access and in-between visit monitoring, especially in remote areas. One of the authors (M.L.V.) currently is leading the development of a remote disease management program with funding from the American Association for the Study of Liver Diseases.

Despite the tremendous promise, traditional research methods in telemedicine may be challenging given the rapid and increasing uptake of health technology among patients and health systems. As such, the classic paradigm of randomized controlled trials to evaluate the success of an intervention or change in care delivery often is not feasible. We believe there is a need to recalibrate the definition of what constitutes a high-quality telemedicine study. For example, pragmatic trials and those designed within an implementation science framework that evaluate feasibility, scalability, and cost, in parallel with traditional clinical outcomes, may be better suited and should be accepted more widely.¹⁷

Policy

Even when the technology is available and research shows efficacy, the implementation of telemedicine in clinical practice faces regulatory and reimbursement barriers. The first regulatory question is whether a patient–provider relationship is being established (with the exception of limited provider–provider curbside consultation, the answer usually is yes). If so, the practice then is subject to all the usual regulatory concerns. The provider needs to be licensed at the site of origin (where the patient is located) and hold malpractice coverage for that location, and the video and medical record transmission should be compliant with the Health Insurance Portability and Accountability Act. The next challenge is reimbursement. Medicare only pays for video consultation if the patient lives in a designated rural Health Professional Shortage Area (www.cms.gov), and reimbursement by private payers varies. Even this is dependent on ever-changing state laws. Reimbursement for remote patient monitoring is even more limited (the National Telehealth Policy Research Center publishes a useful handbook: <http://www.cchpca.org/sites/default/files/resources/50%20State%20FINAL%20April%202016.pdf>). Absent a bipartisan Congressional effort to remedy this situation, the best hope for removing reimbursement barriers lies with payment reform. The Medicare Access and CHIP Reauthorization Act of 2015 mandates that the Centers for Medicare and Medicaid Services shift from fee-for-service to alternative payment models in the coming years. In these alternative payment models, providers are responsible for the overall quality and total cost of care for a population of patients. In this scenario, there may be a financial incentive for telemedicine, especially remote monitoring, to keep patients out

of the hospital. Until then, under current payment models, reimbursement is limited and the barriers to widespread implementation are high.

Conclusions

Telemedicine has continued to increase in uptake and shows tremendous promise in expanding access to health care, promoting patient disease management, and facilitating in-between health care visit monitoring. Although the future is bright, more research is needed to determine optimal ways to integrate telemedicine—especially remote monitoring—into routine clinical care. We call on our specialty societies to send a clear political advocacy message that policy changes are needed to overcome regulatory and reimbursement challenges.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

The authors would like to thank Lauren Jones and Mackenzie McDougal for their assistance with the literature review.

Abbreviations used in this paper:

ECHO	Extension for Community Healthcare Outcomes
HCV	hepatitis C virus
VA	Veterans Administration

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Table 1.**What Is and Is not Telemedicine**

Types of telemedicine	
Televisits	Usual patient–provider visit, but via videoconference
Telesupervision	Midlevel provider or house officer presents to attending in another location (with or without patient present)
Telemonitoring	Signs or symptoms sent electronically from patient to provider team in another location
Tele-interpretation	Remote interpretation of radiology and other tests
Teleconsultation	Provider in one location presents a case to an expert in another location (with or without patient present; eg, ECHO or remote tumor board)
Not telemedicine	
Remote education	Medical education only, no patient Involved
Remote technology used for research (eg, online questionnaires)	Research, not medicine
Social media	Not traditionally considered as medicine no patient–provider relationship

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