Telenephrology: current perspectives and future directions

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There is increasing interest in telemedicine among physicians and patients; however, the evidence regarding the quality of care delivered by telemedicine, and telenephrology in particular, compared with in-person care is limited. In this review, different electronic modalities used to deliver nephrology care are reviewed and critiqued, with a focused analysis from the Australian and United States perspectives. Both countries are geographically expansive with significant rural populations where access to nephrology care is limited. However, their health care systems are organized differently. The Australian health care system is a mostly nonprofit, single-payer system, whereas the United States system is more fractured with a greater proportion of patients covered by for-profit private insurance or no insurance coverage. Videoconferencing is widely used in Australia to manage kidney disease including chronic kidney disease, dialysis, pediatric nephrology, and post-kidney transplantation care. In contrast, the United States telenephrology experience is limited, with most reports originating from the Veterans Health Administration, a single-payer system providing care for nearly 9 million veterans, ~3 million of whom reside in rural communities. Preliminary reports from the Veterans Health Administration suggest that that delivery of nephrology care via videoconferencing results in clinical outcomes that are at least equivalent to in-person care and improved patient adherence to scheduled appointments. Nevertheless, large, adequately controlled studies are needed to identify patient populations that are most likely to benefit from telenephrology and to determine the optimal systems for the delivery of telenephrology care.

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Telemedicine, as defined by the World Health Organization, is "the delivery of health care services, where distance is a critical factor, by all health care professionals using information and communication technologies for the exchange of valid information for diagnosis, treatment and prevention of disease and injuries, research and evaluation, and for the continuing education of health care providers, all in the interests of advancing the health of individuals and their communities."[1] More specifically, telenephrology uses these technologies to care for patients with kidney disease. The broad definition encompasses Web-based applications, videoconferencing, and remote monitoring devices that collect physiological data such as blood pressure (BP). The varying modalities of telehealth communication are designed to reduce spatial, geographic, and temporal distance between patients and physicians with the stated goal of improving access to care and health outcomes.

The technologies used in the performance of telemedicine/telenephrology can depend on several factors including the local technologic resources, equipment costs, local laws and regulations, and goals of the program. That being said, no studies have rigorously evaluated the role of these technologies to achieve the aims of improved access and health outcomes. In this review, we evaluate the effect of these technologies on renal health. First, we review how Web-based and remote monitoring systems have been implemented to improve access to and quality of renal care. We then evaluate the role that videoconferencing plays in the delivery of nephrology care in Australia and the United States, 2 countries with divergent health care systems, where nephrologists struggle to deliver care to geographically disparate populations. Finally, we review the barriers that prevent greater adoption of telenephrology into practice and potential solutions.

Web-based telemedicine programs

Web-based programs provide a means to educate and communicate with patients with chronic kidney disease (CKD) outside of the traditional institutional setting. In the United States, Hispanic patients with CKD are less likely to receive kidney transplants than non-Hispanic whites. This discrepancy has been attributed, in part, to lower levels of health care literacy regarding transplant options. To address this inequity, Gordon *et al.*[2] developed a Spanish language

Website to educate Hispanic patients with CKD about kidney transplant options, focusing on the relevant risks, benefits, and alternatives necessary for patients to make informed decisions. Pretest and posttest surveys were administered to evaluate the impact of the intervention on transplant-related knowledge. Ninety-six percent of eligible subjects participated. The Website increased same-day knowledge by 17.1%, and knowledge scores remained 11.7% above the pretest level after 3 weeks. Moreover, 95% of participants stated that they would recommend the website to others, implying that culturally sensitive Web sites engage and educate patients.[2]

Web-based nephrology consultation has also been piloted and evaluated. Primary care providers (PCPs) referred patients to a hospital-based nephrology practice in the Netherlands via a Web-based consult, which abstracted clinical and laboratory data from the electronic medical record (EMR) and forwarded the consult question and information to the nephrologist.[3] The consultant could respond in 1 of 3 ways: (i) provide answers to simple questions, (ii) ask the PCP to gather more clinical data and then reconsult, or (iii) request the patient to be evaluated in person. For program evaluation, the time devoted to initiating and responding to the consult was collected. The nephrologist devoted $<$10 minutes for each consult, and the average response time per consult was 1.6 days (95% confidence interval 1.2–1.9 days). For each consult requested, PCPs were asked whether they would have referred to nephrology in the absence of the Web-based nephrology consult. Of the 122 consults placed, PCPs identified 43 (35.3%) consults that would have directly been referred to nephrology for an in-person evaluation in the absence of the Web-based system.[3] However, after Web-based consultation, the nephrologist determined only 7 of these 43 (16.3%) consults required referral for in-person specialty evaluation. Importantly, of the remaining 79 (64.7%) Web-based consults for which PCPs did not consider in-person nephrology evaluation necessary, 10 were judged by nephrologists to require in-person evaluation.[3] Thus, electronic consultation can increase access to subspecialists, in this case, the nephrologists, who can identify patients who are most likely to benefit from their assessment.

Other investigations combined remote home monitoring with Web-based systems to improve BP management. In a prospective observational study, 66 kidney transplant recipients were recruited to have their BP monitored at home. Patients were instructed to measure their BP at designated times and frequency.[4] The BPs were transmitted into the Good Health Gateway platform. A clinical pharmacist reviewed the BPs and medications and then suggested an antihypertensive intervention, which was reviewed by a physician. Systolic and diastolic BPs were reduced by 6 mm Hg and 3 mm Hg, respectively, after 30 days, and the effect persisted up to 180 days of follow-up.[4] In a prospective study of patients with CKD ($N = 43$), home BP monitoring with clinical support was compared with usual in-person care.[5] Home monitoring and usual care significantly reduced systolic BP by 13 mm Hg and 8.5 mm Hg ($P < 0.05$ compared with the initial systolic BP), respectively, suggesting that the home BP monitoring intervention was at least as effective as usual in-person care.

In India, remote monitoring via Web and text message communication was implemented in urban and rural peritoneal dialysis (PD) patients.[6] Patients were trained to log on to the Website, enter physiological data, schedule home and clinic visits, and upload photographs of PD fluid and the exit site. Text-messaging permitted swift access to PD experts. Technique failure rates and the risk of peritonitis did not differ between urban and rural patients; however, 5-year patient survival was greater in rural than urban PD patients,[6] which was notable because previous studies reported lower rates of survival of rural PD patients than their urban counterparts.[6–8]

These small studies suggest that Web-enabled telenephrology is acceptable to many patients with CKD and may result in clinical outcomes that are similar to traditional in-person care. However, these studies were of inadequate size, and most were not randomized and lacked appropriate controls, thereby preventing clear conclusions regarding the efficacy of telenephrology. Well-designed and adequately powered prospective studies are therefore needed to determine the optimal modalities/interventions and patient populations most likely to benefit from Web-based telemedicine.

The Australian experience with videoconferencing-based telenephrology

The history of telemedicine in Australia dates back to the 1870s when the telegraph was used due to long distances between health care facilities and rural and remote areas of Australia.[9] However, it was only in the mid-1990s that published literature appeared on the use of telemedicine in health care delivery in Australia.[10] Although there has been a rapid increase in publications on the role of telemedicine in other specialties, there remains a paucity of published data on telenephrology in Australia.

Telenephrology is particularly invaluable in Northern Australia (The Northern Territory, Northern Queensland, and Northern Western Australia) where distances between major health care centers and communities are vast and the rates of CKD are among the highest in the world, particularly among the indigenous population. In the late 1990s to the mid-2000s, teleconferencing was primarily used in the Northern Territory for care coordination between specialty services and the remote and rural clinic staff.[11]

In 1994, a study by Mitchell *et al.*[12] analyzed the clinical application of a telemedicine network that linked renal units at the Queen Elizabeth Hospital to 3 satellite dialysis centers in South Australia. In $2^1/_2$ years of operation, there were $>$6000 instances in which the telemedicine equipment was used to conduct clinical care. Interviews were conducted with 18 medical, nursing, and allied health staff and dialysis patients, which revealed that the full range of staff, including surgeons, nephrologists, nurses, and allied health staff, were able to use the technology successfully. This study was the first