Telemedicine and Hypertension
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Abstract

- **Objective:** To review telemedicine approaches for management of hypertension.
- **Methods:** Review of studies that illustrate the use of telemedicine in hypertension and discussion of an ongoing clinical trial, the Take Control of Your Blood Pressure study, an example of a telemedicine intervention to improve blood pressure control.
- **Results:** Hypertension places a significant burden on patients and health care systems; less than one third of patients on medication for hypertension have adequate blood pressure control. The adequate management of hypertension requires a potential complex interaction between patients, their social support, providers, and the health care system. Applications of medical informatics may facilitate the management of hypertension.
- **Conclusion:** Although the number of controlled trials examining telecommunication-based interventions of hypertension remains small, there are examples where informatics applications may have a demonstrated clinical value.

Heart disease and stroke remain the first and third leading causes of death, respectively, in the United States and impose an enormous financial burden, with total costs estimated at more than $290 billion in 2004 [1]. Hypertension is an important modifiable risk factor for stroke and a major risk factor for coronary heart disease, congestive heart failure, and renal disease [2,3]. Abundant evidence shows that effective blood pressure (BP) control lowers risk of cardiovascular disease [4,5]. Therefore, an important element to help reduce the burden of hypertension-related disease is to increase the proportion of patients with adequately controlled BP. Of the approximately 50 million Americans with hypertension, less than one third have their BP under control [6].

The increasing prevalence of chronic disease combined with tightening health care budgets have contributed to growing interest in patient self-management programs. Self-management programs emphasize the patient’s role in managing their illness, providing them with the knowledge, skills, and confidence needed to live an active and meaningful life. An accumulating body of literature demonstrates that successful self-management reduces hospital admissions, length of stay, and outpatient visits, as well as reduces health care costs [7–13].

Hypertensive patients are good candidates for self-management. As with other chronic diseases, effective hypertension management involves complex pharmacotherapy regimens, physical activity, dietary and weight management, as well as other disease-specific interventions. The point of access for these interventions need not be limited to clinics. Telemedicine has been defined as “the use of electronic information and communication technologies to provide and support health care when distance separates the participants” [14]. Telemedicine offers potential advantages in the care of patients with hypertension, including greater patient convenience through the avoidance of office visits and timelier follow-up with more frequent medication adjustments to optimize BP control [15]. In addition, telemedicine technology has been proposed as a means of increasing worker productivity, reducing resource use, and enhancing cost-effectiveness of chronic illness care [16–18]. Below we review existing research conducted using telemedicine for the management of hypertension and describe an ongoing multisite telemedicine intervention for BP control.

**Review of Hypertension-Related Telemedicine Studies**

**Studies to Improve BP Control**
The use of telecommunication systems in medicine has been increasing; however, few trials have assessed the efficacy of such technology for improving BP control in patients with essential hypertension. In a randomized controlled trial (RCT), Friedman et al [19] enrolled 267 patients with BP of 160/90 mm Hg or greater and followed them for 6 months. They evaluated an automated telephone patient monitoring and counseling intervention that required patients in the telephone group to weekly report home-based self-measured blood pressures, their knowledge of and adherence to antihypertensive medication regimens, and medication side effects. Mean antihypertensive medication adherence improved 18%...
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for telephone system users and 12% for controls, and mean diastolic BP decreased 5.2 mm Hg in users compared with 0.8 mm Hg for controls (both, \( P < 0.05 \)). A limitation of the study was the potential for self-report bias because patients often erroneously report self-measured blood pressures [20–22]. Cost-effectiveness ratios were calculated for the telephone system users. The cost per 1 mm Hg improvement in diastolic BP was approximately $5 across all participants and less than $1 for the least adherent patients (ie, those who took less than 50% of their medications at baseline). Bondmass et al also reported a significant decrease in BP in 33 therapy-resistant hypertensive African Americans using a telephone monitoring system over 3 months, although their trial lacked controls [23]. As in the previous study, patients self reported their BP measurements, raising the concern of self-report bias [20–22].

In an RCT of 121 adults with essential hypertension, Rogers et al [24] evaluated a home monitoring service consisting of automatic transmission of 24-hour ambulatory BP data over telephone lines, with BP information converted into report forms and automatic weekly transmission of BP report forms to physicians and patients. Using this simple feedback mechanism, mean systolic BP decreased by 4.9 mm Hg for intervention patients and 0.1 mm Hg for patients receiving usual care. Better BP control in the telemedicine group was not necessarily due to more frequent changes in type or dose of medications because patients who had no medication change also showed decreases in their BP. The authors suggest that better patient adherence partially explains these improvements.

Port et al [25] reported that among 50 patients with treated mild-to-moderate hypertension who were asked to measure their BP twice a day and enter this BP measurement into an interactive data collection device, only 32% showed a decrease in systolic BP. The remaining sample showed no change or increase in BP over a 12-month period. There was no control group in this study. The interactive device forwarded the collected data using an automated modem connection with a telephone link to a server. Doctors could gain access to the patient’s data by means of a secure internet connection. In addition, every morning patients were asked to confirm their BP measurements, raising the concern of self-report bias.

Other Studies

The internet has enabled a variety of “remote doctoring” models to be developed [27]. In terms of disease management, patients send clinical measurements from their home computers or medical devices to a centralized site. Below, we review a few of these studies. One significant barrier that needs to be surmounted before any of these interventions are accepted once efficacy is determined will be having physicians embrace these forms of technology, because there is limited reimbursement for these services [28].

Studies have documented the accuracy and benefits of using telemedicine and home BP monitors. A pilot study involved a system that measured a patient’s BP at home and transmitted the data automatically to a hospital database. The accuracy of BP readings using the system was compared with a standard digital sphygmomanometer. The measurement effort for the systolic readings of 4 subjects was 1.7% to 2.7% and for the diastolic readings it was 2.7% to 3.2% [29]. In another study of 411 hypertensive patients who performed telemedical home BP measurements (4 times daily for 5 days) using a memory-equipped BP device with an interface for connecting it to a modern and automatic transmission of BP
data over an analog telephone line [30], there was a strong correlation between home BP and ambulatory BP (systolic \( r = 0.847 \), diastolic \( r = 0.812 \)). The telemedicine home BP measurements were substantially better than clinical BP measurements. In a third study, an RCT was conducted to assess the efficacy of a telemedicine service for the diagnosis of hypertension [31]. A total of 74 patients from outpatient clinics were randomized to receive a telemedicine service consisting of using an automatic home BP monitor connected to an ordinary telephone line for the transmission of BP data to a central computer. BP was measured by the patient 3 times in the morning and 3 times in the evening, and a weekly report was sent to patients’ physicians. Patients randomized to usual care were followed for 6 weeks, and physicians were instructed to care for them in accordance with the guidelines of the Sixth Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC-6) [32]. Sensitivity, specificity, and predictive values were calculated using mean 24-hour ambulatory BP measures as the gold standard. The telemedicine arm had a sensitivity of 63.6% and a specificity of 80% in detecting hypertension as compared with a sensitivity of 26.3% and specificity of 94.4% for the usual care group. There was no statistical difference in specificity between the 2 groups. Thus, the ability to detect individuals who truly have hypertension was superior in the telemedicine group [31].

A Patient-Tailored Telemedicine Intervention for Hypertension

The telephone is commonly used in ambulatory care practice [33–35]. Depending on the specialty of the physician, practice setting, and other physician and patient characteristics, between 10% and 57% of patient-physician contacts occur over the telephone [33,34]. Take Control of Your Blood Pressure (TCYB) is an example of an ongoing patient-tailored telephone intervention designed to improve BP control. This RCT is occurring in 3 primary care clinics in the United States southeast region and will recruit over 600 hypertensive patients. Patients are randomized to receive either a nurse-administered tailored behavioral intervention via telephone; a combination of nurse intervention and BP monitors; home BP monitors alone; or usual care.

Nurse-delivered telemedicine interventions have been found to improve patient outcome for multiple disease states [36] and have several beneficial features. First, telephone reminders are effective in changing behavior [37]. Second, telephone interventions are relatively easy to implement. Third, patients generally appreciate being reminded by a health care provider and such reminder systems may improve the patient-provider relationship [37]. Fourth, telephone-based interventions can be disseminated at relatively low cost [38,39]. Fifth, they can address multiple facets of care and can include a comprehensive approach to improving health outcomes; in the case of BP control, no factor has been shown to consistently improve control. Finally, they can be tailored to patients’ needs, fostering behavioral changes conducive to health [40–42].

In TCYB, patients in the intervention group receive feedback from the nurse based on data obtained from the baseline evaluative assessment and during subsequent bimonthly contacts for 24 months. Information is presented in an easily understood format over the phone; the average phone call takes 10 minutes. The nurse uses a database to help guide unique patient components of the intervention during the telephone calls. By keeping the intervention telephone-based, the nurse is able to follow a much larger panel of patients than would be possible using an in-person intervention [36]. We chose to use a nurse-based intervention as opposed to an automated telephonic monitoring intervention because of the complexity of the tailored intervention. Given the number of modules and potential tailoring patterns, programming the intervention to make it automated would be difficult. Once the efficacy and cost-effectiveness of the intervention can be shown, we will automate as much of the intervention as possible.

Patient Factors Targeted

Patient factors targeted for tailoring in the intervention include perceived risk of hypertension, memory, literacy, social support, relationship with their health care provider, side effects of therapy, and health behaviors. For patients identified as lacking adequate understanding of the risks associated with hypertension, nurses explain at set intervals the importance of maintaining BP control. Because the risks of hypertension are greater if patients are African American or have diabetes [43], a recent diagnosis of hypertension, or immediate relatives with hypertension [44], specific information is provided to patients with these particular characteristics. Information about the benefits of treatment is presented using relative risk reduction models [45]. Patients who are identified as having self-reported memory deficits are provided various mnemonic strategies such as cueing (eg, pairing taking medication with an established behavior such as brushing teeth) or monitoring (eg, using a calendar to track medication taking). In addition, these individuals have their medical regimen explained to significant others.

Patients identified as having low levels of literacy have their hypertension regimen explained verbally to them and to a significant other by the nurse at any call when their regimen is altered. In addition, patients are provided with medication containers to assist with remembering to take their medications and a 1-page visual summary (eg, a picture of a person exercising) of the telephone discussion. Individuals who identify themselves as being socially isolated or lacking
adequate social support receive information about hospital and community resources available, including a toll-free number to assist them in obtaining medications and getting to their doctor appointments.

Individuals who report communication problems with providers are queried about whether they have enough time to discuss problems with their providers, whether they are “feeling heard” by their provider, and whether they understand information that was explained to them. The nurse can make suggestions such as recommending patients make a list of their issues and concerns prior to their visit and present it to the provider during the visit. The nurse may also role-play with patients to empower them to improve communication with their provider.

On each phone call, the nurse queries the patient about any specific side effect identified as being related to antihypertensive medication use. If a patient is having a side effect, the nurse educates the patient about the specific side effect, reminds patients to make a list of potential side effects they are experiencing, and encourages them to discuss them with their primary care provider. The nurse contacts the provider if a patient reports any potentially life-threatening side effects.

All patients receive information on caffeine use and salt intake. Individuals identified as being obese (body mass index ≥ 30), reporting high levels of stress, current smokers, or heavy drinkers (>14 alcoholic drinks per week) receive information regarding weight and stress reduction, smoking cessation, and alcohol use, respectively. The nurse queries patients on their stage of initiating a particular health behavior (ie, not thinking of changing, thinking of changing, preparing to act, and acting/cessation of the behavior). The nurse discusses the benefits of exercise and offers a National Heart, Lung, and Blood Institute handout describing the Dietary Approaches to Stop Hypertension (DASH) diet to those individuals interested in the material. The DASH diet has been found to lower blood pressure [46] and the handout provides information on sodium and caffeine intake. In addition, the nurse is able to refer individuals to a smoking or alcohol cessation clinic if patients use tobacco products or excessive amounts of alcohol.

**Blood Pressure Monitoring in TCYB**

For patients randomized to the patient self-monitoring intervention, a trained research technician instructs patients in the use of an electronic BP measurement device. As mentioned, accurate home BP measurement is feasible and improves BP control [44,47], thereby reducing the risk of cardiovascular events [48]. It may allow for more timely alterations in medical regimen and thus more rapid achievement of target blood pressure levels [49]. It also can reduce the need for frequent office visits [50] and subsequently reduce the total cost of hypertension care compared with usual care [47].

The monitors being used in TCYB store recorded BP and time of measurement in memory. A large percentage of the older adults who will be enrolled in the study are not likely to have access to the internet. As far as transmitting blood pressures over the telephone, we require patients to come into the clinic every 6 months to demonstrate their accurate use of BP monitors and to ensure that their monitors are configured properly. This is particularly important given that the duration of the intervention will be 24 months. Thus, it was decided that since patients would have to bring in their devices, we would obtain BP readings at that time. Patients will take their BP every other day at the same time. They will record their BP and send in a log every 2 months. The requirement of recording their BP is expected to result in patients being more motivated and proactive in improving their BP control. To verify patients are correctly recording their BP, we will also examine the recorded BP stored in the devices.

The primary outcome of the study is BP control at baseline and at subsequent 6-month intervals. At each measurement, 2 measures are obtained using a random-zero sphygmomanometer [51], which minimizes observer bias [52]. A secondary set of analyses will be to estimate the cost per additional patient maintaining BP control in the 3 patient intervention arms of the study relative to the control group. The incremental cost-effectiveness ratio will be calculated as the difference in the average cost per patient between study arms divided by the difference in the proportion of patients maintaining control of their BP.

**Conclusion**

In order for the treatment of hypertension using telemedicine interventions to continue to grow and be accepted, high-quality evidence of its effectiveness must be demonstrated. Studies reviewed included methodologies that varied considerably and frequently were not fully delineated, making it difficult to draw firm conclusions. If telemedicine is to become a viable health service option, it must be shown that the costs of treatment are at least equal to if not lower than those of alternative approaches that produce similar outcomes. In a health care marketplace increasingly focused on both the cost and quality of care, research to establish the effectiveness and cost-effectiveness of telemedicine interventions will be important to payers and policy makers. The public sector, particularly the U.S. Department of Veterans Affairs and state correctional systems, are likely to lead the way in testing and examining the use of telemedicine to treat hypertension and other chronic diseases.

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