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專題報導

Telemedicine in Cardiovascular Disease

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Abstract

Cardiovascular disease is a leading cause of death in the United States. Of all that, the coronary heart disease is the leading cause of deaths, followed by stroke, and high blood pressure. Heart failure is the common presentation of the cardiovascular disease and response for billions of medical cost. As the innovations of information technology and mobile wireless device, telemedicine has been utilized in various clinical disease to reduce medical cost and improve outcome, especially in cardiovascular disease. Physiologic parameters, such as blood pressure and sugar, heart rate, body weight, peripheral oxygen saturation, and electrocardiogram,are obtained at home and transmitted daily to care-providers. So that, early detection of the warning data before disease worsen, the physicians can adjust the medication and strategies. Several randomized trials and meta-analysis studies have demonstrated the clinical benefits of the telemedicine via invasive implanted device, either risk reduction of mortality or heart failure admission rate.However, there are still arguments and more studies are needed to identify the optimal care model in cardiovascular telemedicine. (J Intern Med Taiwan 2017; 28: 133-139)

Key Words: Telemedicine, Telemonitoring, Remote monitoring

Introduction

Cardiovascular disease is a leading cause of death in the United States, which may account for near 801000 deaths annually, estimated to be 1 of every 3 deaths.[1] Direct and indirect costs of cardiovascular diseases are estimated to more than $316 billion, which includes both health expenditures and lost productivity. Among them, coronary heart disease is the leading cause (45.1 percent) of deaths attributable to cardiovascular disease in the United States, followed by stroke (16.5 percent), high blood Pressure (9.1 percent), and the others.

Furthermore, heart failure is a common and complex clinical presentation of most heart diseases, such as coronary artery disease, valvular heart dis-

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orders, arrhythmias, cardiomyopathy and hypertensive heart disease. Heart failure is responsible for a high hospitalization rate of 24.7/1000 in 1999 to 17.8/1000 person-years in 2011 for those elderly population in the United States and more than $30 billion medical cost.[1,2] Owing to the multiple comorbidities and chronicity of the above mentioned highly prevalent cardiovacular disorders, programs to improve care quality and reduce mortality, hospitalization rate, re-admission rate and total medical cost are crucial and demanding.

Telemedicine was initially designed for remote diagnosis with instructing the procedure of cardiac defibrillation via telephone but subsequently evolved into a more general clinical care model of early detection and management of several chronic diseases. As the innovations of mobile technology continues to improve, the wearable wireless device with automated real-time data transmission appeared, and the clinical applications are extended to various clinical diseases. More and more studies were conducted and currently ongoing to sort out the appropriate models for specific subgroup of the cardiovascular diseases.

Telemedicine in Critical Care or Cardiovacular Emergency

Acute ischemic stroke

Some meta-analysis and randomized studies had reported thrombolytic therapy for acute ischemic stroke could be performed safely and effectively via real-time audio and video communication with high speed transmission of images and clinical information in community hospitals where neurological experts was not available. In that work, the 3 and 6 months follow up showed non-significant difference in mortality or functional independence between telemedicine-guided and experts on-site thrombolysis.[3,4] Therefore, American Heart Association (AHA) and American Stroke Association support the telemedicine strategies for acute stroke whenever on-site stroke expertise physicians are not available.[5]

ST-segment elevation myocardial infarction (STEMI)

The use of pre-hospital 12-leads ECGs was suggested for early diagnosis of STEMI by emergency medical service paramedics utilizing telemedical equipments, with coupled, real-time communication with a PCI-capable center.[6] The strategies of ECG transmission wirelessly to the primary PCI center interpreted by on-call cardiologists has been shown to shorten the primary intervention or thrombolysis reperfusion time with excellent outcomes, and further supported in current latest AHA STEMI guideline.[7]

Telemedicine in Heart Failure

Telemonitoring is a particular medicare model for patients to obtain physiologic parameters at home using equipments with remote data transfer or monitor, such as blood pressure and sugar, heart rate, body weight, peripheral oxygen saturation, and electrocardiogram. These data can be transmitted daily via wireless access (Wi-Fi or Bluetooth) or telephone to specific organization or institute (usually hospital-based remote care center or health promotion private company). To date, five main types of non-invasive telemonitoring were identified in one systematic review: (1) video-consultation, with or without transmission of vital signs, (2) mobile telemonitoring, (3) automated device-based telemonitoring, (4) interactive voice response, and (5) Web-based telemonitoring.[8] So that the care-providers (nurses or trained specialists) can remotely screened the data and close monitor the patient's clinical condition without office visits. They can alert the patients to take some action if abnormal parameters were noticed during screen and inform duty physicians to adjust the medication and to modify management strategies of treatment before clinical conditions worsen. (Figure 1) In some countries, the care-provider may directly make a clinical decision to change medications for patients.

So far, this modality has been shown to successfully reduce heart failure mortality, admission and re-admission rate via recommendation of guideline based medication, and to further guide or monitor device therapies in order to manage the precipitating causes of heart failure and relevant comorbidities, based on a multidisciplinary team care model.[9] Numerous systemic reviews and meta-analysis reported that telemonitoring can substantiallly reduce all-cause mortality, heart failure

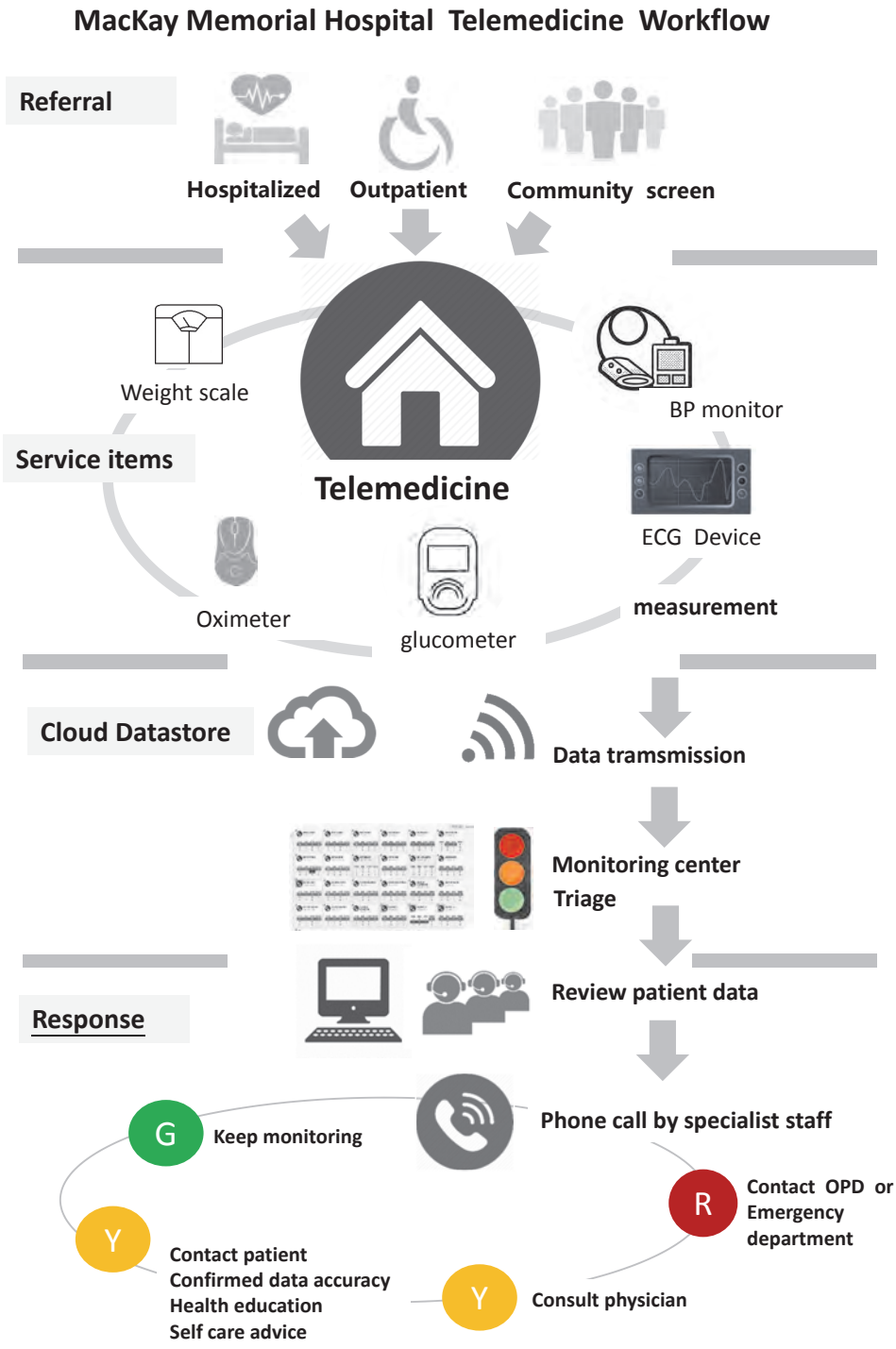

Figure 1. Workflow of the telemedicine in MacKay Memorial Hospital.
G: Green color means stable condition; Y: Yellow color means alert condition; R: Red color means warning condition.

admission rate, and to further improve quality of life and lower cost.[8,10-12] Notwithstanding, some studies showed that remote care delivery only improved quality of life[13] or reduction of 30-days readmission rate without benefit on mortality and hospitalization rate.[14,15]

The largest randomized controlled trial enrolling 1653 heart failure patients in the United States by telephone-based interactive voice-response telemonitoing that collect daily symptoms and body weight was compared to usual care.[16] The primary endpoint was readmission for any reason or all-cause mortality at 6 months with secondary endpoints included hospitalization for heart failure. At the end of the study, there were no significant differences between the two groups with respect to the primary or secondary end points. Similar results were observed in another 2 large randomized controlled trials: the BEAT-HF trial, enrolled 1437 patients with HF in the United States, and the TIM-HF trial, enrolled 710 patients in Germany. Both trials showed no difference in mortality or the composite secondary endpoints of cardiovascular death and heart failure hospitalization.[17,18]

Telemedicine in Arrhythmias

Wearable, non-invasive device: continuous ECG

Arrhythmia is responsible for the main cause of syncope, stroke and sudden cardiac death. It is a potentially life threatening condition which may result in serious morbidity, but usually under-detection. Wearable wireless utilizing continuous ECG monitor is clinical validated and allowed up to 24 hours continuous remote transmission of the respiratory rate, body temperature. ECG rhythm, heart rate and variability. It may increase the diagnosis rate of arrhythmia and impact the strategies of treatment. One meta-analysis of 25 RCT trials for wearable devices showed wearable devices were associated with decreased mortality [RR (95%CI) =0.76 (0.63, 0.92)] and the risk of hospitalizations [0.81 (0.72, 0.91].[19]. The study found clinical benefits among younger patients (<70 years) and reduced hospitalizations at 3 months with improved mortality and hospitalizations at 1 year follow up. However, the benefits was not observed among older patients or in study design that enrolled ambulatory patients as contrary to patients recently hospitalized for heart failure.

Implantable Device

The prospective, randomised, single-blinded, CHAMPION study, enrolled 550 NYHA class III heart failure patients, showed clinical benefits with implanted wireless CardioMems system to monitor pulmonary artery pressure.[20] The pulmonary artery pressure may increase markedly prior to overt symptoms of heart failure. The patients were treated base on the changes of pulmonary artery pressure information. The admission rate for heart failure was 33% decreasein the treatment group compared with the control group (hazard ratio [HR] 0.67 [95% CI 0.55–0.80]; p<0·0001). The sustained benefit could be observed at 18-month (average) follow-up, as well as in the control group during the subsequent open access periods.[21] Pulmonary artery pressure information has became clinically available and useful in guiding therapy after that landmark study. Nevertheless, the safety endpoints of device-related or system-related complications were 1.4 percent.

Previously, the intrathoracic impedance and heart rate variability parameters were found to have a role in early detection the symptoms of heart failure. The former parameter was related to lung water and the later one was associated with post-myocardial infarction mortality, heart failure and various clinical conditions. Remote monitor with intrathoracic impedance transmission from Implanted device ICD, or CRT/+D were reported in some studies that demonstrated decreasing of unscheduled visits and better adherence. But there were no significant benefits in all–cause mortality and heart failure

admission rate.[22,23] However, the device associated precipitating factors of heart failure exacerbation include atrial or ventricular tachyarrhythmia, inappropriate defibrillation shocks, low percentage of biventricular pacing, abnormal device function and inappropriate setting or placement, lung fluid accumulation, and low heart rate variability.

Recently, the IN-TIME study, randomized controlled trial, enrolled 664 patients underwent ICD or CRT-D with chronic heart failure, NYHA class II–III, ejection fraction of no more than 35%. reported significant reduction of primary endpoint in composite death and heart failure admission at 1 year, 63 (18.9%) of 333 patients in the telemonitoring group versus 90 (27.2%) of 331 in the control group (p=0.013) (odds ratio 0.63, 95% CI 0.43–0.90).[24] Possible mechanisms response for this findings were early detection of the onset or progression of ventricular and atrial tachyarrhythmias, early recognition of suboptimal device function and encouraged patients to take more responsibility for healthy life style, including adherence to medicine. Similar positive result was observed in another retrospective cohort study, which included 269,471 patients implanted with pacemakers, implantable cardioverter-defibrillators, or cardiac resynchronization therapy with pacing capability (CRT-P)/defibrillation capability (CRT-D) via wireless remote monitoring.[25]

The prospective randomized CONNECT TRIAL, enrolled 1,997 patients with implantable cardioverter-defibrillators and cardiac resynchronization therapy devices showed significantly reduced the response time to clinical events and the length of CV hospital stay during 15 months follow up.[26]

Telemedicine in Chronic Diseases (DM, HTN, Sleep Apnea)

Telemedicine was reported to be more effective in control blood sugar and achieved the HbA1c target in one meta-analysis which enrolled 55 randomize controlled trials.[27] The impact of telemedicine in diabetes management and dysglycemic onctrol was more prominent in the first 6 months but decrease overtime.

As compared to usual care, substantial BP reduction was observed in non-diabetic patients in the telemedicine group of the RCT trial.[28] The main cause of BP reduction was associated with more prescribed medications in the telemedicine group.

Obstructive sleep apnea is a known risk factor associated to cardiovascular disease and tendency to higher blood pressure. One multi-center randomized controlled trial that compared standard continuous positive airway pressure (CPAP) care and CPAP care with a telemedicine support on blood pressure reduction in high cardiovascular risk OSA patients. The study didn't found any significant difference on primary outcome of blood pressure reduction or secondary outcome of cardiovascular risk reduction between the 2 groups.[29]

Challenges of Telemedicine

Despite the widely spread of Telemedicine technologies and medicare models, there remains some challenges in the clinical implementation or use of telemedicine as routine clinical practice: (1) Technical demand on data transmission assurance, diagnostic accuracy and feeedback for subjects at risk in a timely fashion, either in day-time or 24 hours continuos monitor; (2) Financial issue, either from healthcare system or self-pay in any individual affordable for the business model of remote care; (3), Legal issue, the care system or team members are supposed to take actions to patient's disease and transmitted biological or physiological information, and how to clarify the responsibility between physician, institute and patients remained to be clarified further.

Conclusion

Telemedicine is designed to reduce unnecessary hospital visits by implementing health promo-

tion activities in primary health care, to continuously monitor disease condition, to extend disease management after discharge, and thus to improve the clinical treatment efficacy and clinical outcomes. Several randomized trials and meta-analysis studies have demonstrated the risk reduction on mortality and decreased re-admission rate via more aggresive implanted devices. There are still a few arguments and debates on the generalizibility of such emerging innovations and more studies are needed to provide the most optimal way in the aspect of cardiovascular disorders.

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遠距醫療在心臟血管疾病的應用

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摘 要

一直以來，心臟血管疾病在美國佔據死亡原因首位，其中冠狀動脈疾病包含心肌梗塞是最多數，其次是腦中風，緊接是高血壓性心臟病。然而，心臟衰竭在所有死亡人數中,佔據超過三分之一的比例。大部分心臟血管疾病經常表現出心臟衰竭症狀，包括冠狀動脈疾病、心律不整、瓣膜性心臟病、心肌病變、及高血壓。這些病患經常因為心臟衰竭症狀而住院，每年花費大量醫療人力及資源。改善照顧品質，降低住院率及死亡率，進而減少醫療花費就成為一個重要的議題。隨著資訊科技及無線傳輸醫療儀器的廣泛應用，遠距醫療在眾多醫學次專科領域因應而起。尤其是在心臟血管疾病應用，包括急性心肌梗塞、腦中風、心律不整、心臟衰竭、高血壓及糖尿病。許多文獻已證實遠距醫療的好處，然而仍然有部分爭議需要更多大型臨床試驗數據來釐清疑惑及驗證效益。