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Integrated heart failure telemonitoring system for homecare

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Abstract

The integrated telemonitoring system (ITS) for homecare has been designed to improve quality of care as measured by increased nursing productivity, improved patients' clinical and behavioral outcomes and reduction of cost. The system incorporates managerial, organizational, operational and clinical tasks optimized for delivery of quality care through telemonitoring.

A secure, multi-modal computer network that integrates homecare nurses, patients and those who care into one seamless environment has been developed. The network brings together a new generation of small, hand-held, wireless terminals used by nurses and patients with a HIPPA-compliant electronic patient record system at the caregiver's site. Wireless terminals use Gobi multi-standard networking technology for connectivity to any available wireless network. The unique features of ITS include a) picture recognition technology capable of extracting numeric data from in-home physiological signal monitor displays that include blood pressure, weight, oxygen saturation, transmission of lung sounds, and capturing echocardiography and electrocardiography data from mobile units; b) in-home caregiver-assisted interactive examinations of signs and symptoms that include visual impressions of ankle swelling, jugular vein distension measurement, and weight gain; c) video-conference capability, facilitating face-to-face two-way communication of nursing personnel with the patients.

The ITS network has been designed to improve patients' clinical and behavioral outcomes, increase nursing productivity, and reduce the cost of homecare. Patients' co-operation and compliance has been achieved through use of easy-to-use videoconferencing terminals. (Cardiol J 2010; 17, 2: 200–204)

Key words: homecare, heart failure, telemonitoring, wireless networks, video-conferencing

Introduction

An estimated 5 million Americans suffer from heart failure (HF), accounting for approximately 1 million hospitalizations annually at an estimated cost of $23 billion to the U.S. healthcare system [1]. In 2000, heart failure was the most commonly-listed diagnosis in the 533,000 admissions of people over 65, and it is the commonest hospital discharge diagnosis in patients over 65 [2]. The U.S. prevalence of HF approaches 10 per 1,000 among people aged 65 = plus, and it is expected to rise as population trends mean an increase in the proportion of people over 65 [2]. It is estimated that among survivors of heart attacks, about 22% of males and 46% of females will be disabled with HF within six

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years [3]. There is no cure for HF and patients must live with this chronic condition with high morbidity that necessitates frequent outpatient visits, hospital admissions, and the expenditure of significant healthcare resources [4]. The 1-year readmission rate approaches 50% for patients with systolic and diastolic heart failure [5]. In order to reduce the high cost of HF inpatient treatment, and improve overall outcomes, healthcare providers are actively searching for specific disease management programs that incorporate better disease treatment and management plans, and greater use of advanced drugs and device technologies.

Home careis the preferred option for HF patients [6] and multiple HF telemonitoring studies have demonstrated the clinical benefits to patients and to those who provide their healthcare. Nurses in the homecare setting use various ways to improve the care provided to HF patients. The evolution of remote monitoring technologies is expected to help them perform more effectively. A growing body of evidence shows the important role of home health nurses in a multidisciplinary approach to management of heart failure [7]. Home health nurses must have an eclectic mix of skills, including advanced clinical assessment skills, excellent communication skills, and an ability to work independently in often challenging scenarios and environments. In a randomized controlled trial, readmissions of patients with heart failure were reduced by 56% after implementation of a nurse-directed multidisciplinary intervention [8]. Similar results were reported by Stewart et al. [9] who reported a significant decrease in hospitalizations after a home-based intervention delivered by nurses. Interventions for patients with heart failure are based on strategies that facilitate adherence along with improved vigilance and self-monitoring of signs and symptoms among patients [10]. However, home visits are costly in terms of money, time, and effort, especially in the current healthcare environment with nursing shortages and where cost-containment is paramount.

While self-management, medication compliance, and behavior modification play a major role in maintaining the physiological stability of patients, patient adherence to self-care recommendations is usually not optimal. Conviction and confidence are central factors in facilitating self-care. Motivational interviewing, which aims to strengthen conviction and confidence, has been shown to improve self-care [11]. In addition, the patients' readiness to change has also proved effective [11]. The virtual presence capabilities of the suggested Integrated Telemonitoring System (ITS) will allow caregivers in homecare settings to directly influence these aspects of care.

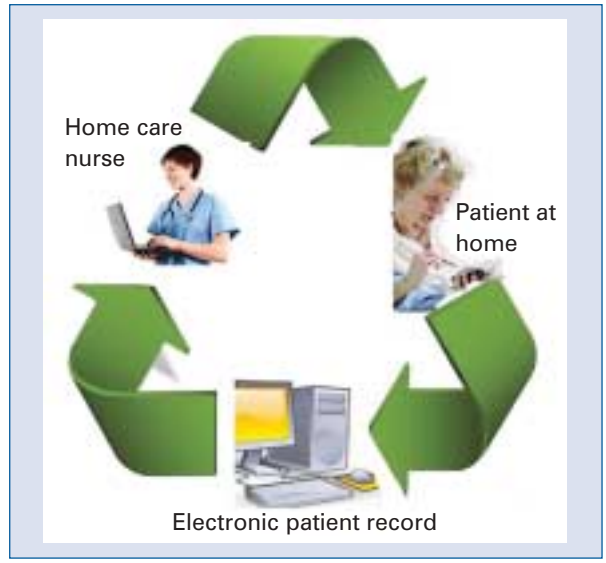

Figure 1. A block diagram of the Integrated Telemonitoring System (ITS) for monitoring heart failure patients.

Methods

The ultimate goal of this project was to design a seamlessly integrated computer network that ties together homecare nurses, patients, the care providers and the health facilities' electronic medical record systems (Fig. 1).

The main objectives included: improved patient outcomes, reduced healthcare costs and improved health-related quality of life for HF patients [12–14]. Unique features of ITS include a) picture recognition technology capable of extracting numeric data from in-home physiological signal monitor displays that include blood pressure, weight, oxygen saturation, transmission of lung sounds, and capturing echocardiography and electrocardiography data from mobile units; b) in-home caregiver-assisted interactive examinations of signs and symptoms that include visual impressions of ankle swelling, jugular vein distension measurement, and weight gain; c) video-conference capability, facilitating face-to-face two-way communication of nursing personnel with patients. Tele-Heart makes use of technologically advanced wireless terminals. These are optimized for both patient and nursing use. Both Nursing Mobile Terminal (MNT) and Patient Communication Terminal (PCT) are equipped with Gobi virtual communications technology [15] capable of connecting to any available wireless network in the

Figure 2. Mobile Nursing Terminal (MNT) (shown in the rightmost panel) combines the features of the notebook computer, video phone, barcode scanner and cell phone. The interactions and data entries are accomplished by voice commands and the touch-screen.

range. Gobi uses MDM1000 chip that can operate on 850 MHz or 1.8-, 1.9- or 2.1 GHz. In the U.S., MNT and PCT can access AT&T's HSDPA or Verizon's EV-DO network, as well as any of 350 networks from Austria to Yemen worldwide. Both terminals are capable of real-time teleconferencing, voice, video, image and data communication over the wireless networks and have the capability to communicate with other medical devices using a low-power Bluetooth protocol.

Key features of the ITS include

1. Home health nurse designed workflow software focused on enhancing nursing productivity and quality of care [16], featuring:
   - — hand-held, lightweight, MNT that can fit into a uniform pocket virtually connected to any available wireless network;
   - — hand-held, lightweight, PCT capable of interactive video communication, imaging of signs and symptoms and physiological data capture.
2. Real-time alarm triggering, alerting cardiologists to changes in patients' status.
3. Secure Electronic Patient Record access via a dedicated HIPPA-compliant gateway.

Nursing terminal

MNT is a hybrid device combining the features of a hand-held computer, video phone, barcode scanner, and a cell phone, as shown in Figure 2.

MNT has been optimized for ease of use and features a side handle and a palm grip. MNT facilitates the communication with the patient, improves the adherence, helps patients to develop effective self-care, and reduces data while helping nurses to deliver faster, more effective and safer care. With an integrated RFID reader, 2.0 megapixel auto-focus camera with dual LED lights, a barcode reader, contactless smart card reader and fingerprint readers, the new MNT is a secure and intuitive platform for barcode medication administration, signs/symptoms capture and electronic medical records capture and review. MNT programmability makes the device adaptable to most workflow requirements [17]. Small size, long battery life and virtual connectivity mean MNT has the potential to become a tool nurses need at the point of care.

Technical specifications of the mobile nursing terminal:

- — linux operating system;
- — intel atom processor (1.86 GHz) Z540 with 533 MHz FSB, 512 KB L2 cache;
- — 1 GB standard RAM configuration;
- — 20 GB solid state storage;
- — 7 inch XGA sunlight viewable 500 NIT Dual Touch LCD screen (1024 × 768 resolution);
- — anti-reflective screen treatment;
- — integrated 2.0 megapixel auto-focus camera with dual LED lights;
- — RFID reader;
- — intel WiFi link 5100 802.11a/b/g/n networking;
- — bluetooth v2.0 + EDR;
- — optional integrated WWAN/gobi-enabled mobile broadband (EV-DO and HSPA);
- — global position system (GPS) receiver;
- — 2D barcode reader (also reads 1D barcodes).

Major features of the software application running on the mobile nursing terminal are listed in Table 1.

MNT facilitates communication with the patient, improves adherence, helps patients to develop effective self-care, and reduces data while helping nurses to deliver faster, more effective and safer care [17]. New MNT is a secure and intuitive platform for barcode medication administration, signs/symptoms capture and electronic medical records capture and review. PCT acts as a home information hub with a direct link to the nurses and physicians. A special adapter allows PCT to transmit mobile echo data directly from the patient's home to the cardiology office or hospital in real time. Increased nursing productivity is achieved by the inclusion of the OASIS [18] reporting application for Medicare and Medicaid applications.

Table 1. Summary of the mobile nursing terminal software features.

Consultation support (voice and touch)	Complete status reporting: If an in-depth examination is needed
SOAP (subjective, objective, assessment, prescription)	Medical history
Prescription viewing	Risk factors
Summary of problems	Vital signs
Summary of treatments	CVP
Weight, CV pressure trendograms	EDEMA
Video conference	Weight
	Lung sounds
	Abdomen

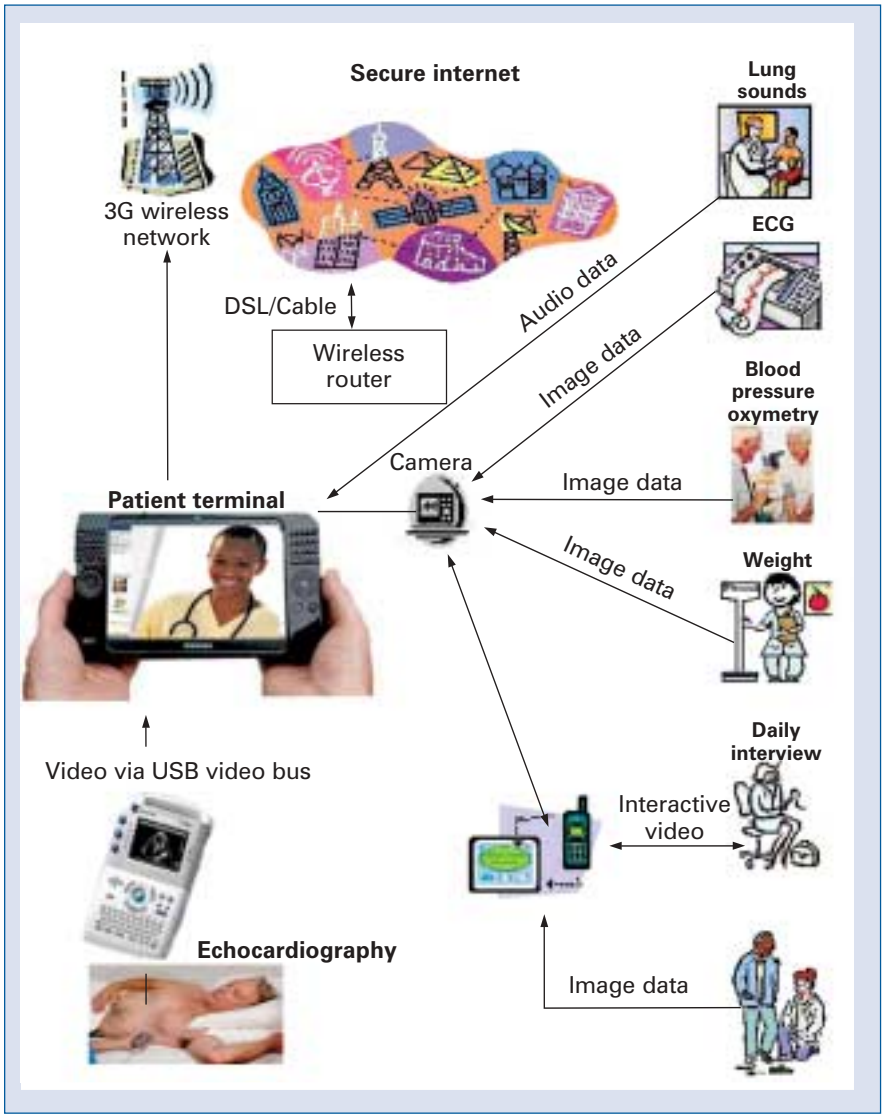

Figure 3. The overview of the VPCS system. The physical patient data (images) is captured from the Patient Communication Terminals and the Mobile Nursing Terminals running Monitel software application.

Patient communication terminal

The PCT has been optimized for ease of use, virtual communication capabilities and long battery life. The technical parameters of the PCT closely follow those of the MNT. The software application running on PCT concentrates on video-conferencing capability and image enabled data capture. The capabilities of a PCT device at a patient's home are summarized in Figure 3.

System operation

A homecare nurse initiates a periodic video call with the patient, preferably in the morning prior to taking medications, and conducts a scripted interview. Under direction from the homecare nurse, the patient reports the medication adherence status, image data of the pulse, body weight and blood pressure. In addition, symptom-related data (e.g. jugular vein distension, ankle edema and lung sounds) are collected using the PCT camera and microphone. All self-examination data is entered into the patient's electronic medical record via a secure Internet connection. When drastic changes in values of blood pressure, weight and pulse are encountered, an automatic alarm to the nurse specialist or a physician in charge is generated. At the end of the patient interview, the nurse completes the intervention by entering the narrative, status report, billing and other required information using voice data entry. The entire video-conference and data collection from the patient requires 10 to 15 minutes of nursing time. The outcome of such an interview is an electronic record, comprising image data of the physiological signs and symptoms, nursing narrative and the administrative data [19].

Conclusions

The ITS network has been designed to improve patients' clinical and behavioral outcomes, increase nursing productivity, and reduce the cost of homecare. Patients' co-operation and compliance has been achieved through use of an easy-to-use video-conferencing terminal. ITS supplements at-home nursing visits with ongoing telemedicine monitoring services [16]. The seamless electronic integration of ITS with cardiology practices caring for heart failure patients and their electronic medical records ensures time accurate handling of alarms and timely medical interventions.

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