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iCONCEPTS

CONCEPTS ON THE VERGE OF TRANSLATION

Robot-Assisted Remote Echocardiographic Examination and Teleconsultation

A Randomized Comparison of Time to Diagnosis With Standard of Care Referral Approach

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ABSTRACT

The strategy using cardiological consultation in addition to the robot-assisted remote echocardiography at a distance was tested in a prospective, randomized open-label trial to evaluate its feasibility and to define its clinical value in a rural area. The present study involved 1 primary healthcare center in the north of Sweden, 135 miles from the hospital where the echocardiograms and the cardiology teleconsultation were performed long distance in real time. Nineteen patients were randomized to remote consultation and imaging, and 19 to the standard of care consultation. The total process time was significantly reduced in the former arm (median 114 days vs. 26.5 days; $p < 0.001$). The time from randomization until attaining a specialist consultation was also significantly reduced ($p < 0.001$). The patients' satisfaction was reassuring; they considered that the remote consultation strategy offered an increased rapidity of diagnosis and the likelihood of receiving faster management compared with the standard of care at the primary healthcare center. (J Am Coll Cardiol Img 2014;7:799–803) © 2014 by the American College of Cardiology Foundation.

The demographic profile in most Western countries is changing, with an increasing number of elderly people and increased requirement for advanced diagnostic and management facilities. Primary healthcare centers (PHCs) and smaller hospitals usually lack such facilities and do not always provide the specialized services. In addition, the expensive transport costs from sparsely populated areas at long distances remain prohibitive for transfer of the sick to the advanced care centers. The wide availability of the information technology and wireless transmission has allowed development of electronic health (eHealth) solutions to overcome these shortcomings not only in developed nations but also in low- and middle-income countries. The

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use of numerous diagnostic modalities at a distance (e.g., ultrasound, long-distance video-assisted consultations, management support systems [remotely guided intensive care units]) is being evaluated for superior healthcare delivery.

To determine the feasibility of providing cardiology consultation with robot-assisted remote

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ABBREVIATIONS AND ACRONYMS

CRF = case report form

GP = general practitioner

HF = heart failure

PHC = primary healthcare center

echocardiography at a distance (CARDIA concept) in a rural county of northern Sweden, a pilot project was developed during 2010 to 2013 (**Fig. 1**). The goal was to establish a safe and efficient eHealth solution for communication and examination to improve the quality of life in heart failure (HF) enrollees. This initiative enabled: 1) long-distance, real-time, robot-assisted echocardiography; and 2) cardiology teleconsultation for a rural PHC as reported earlier (1). In this study, the sonographer estimated that in most cases, the image quality was satisfactory to be used for clinical purposes. As a logical translational next step, a prospective randomized study was undertaken to define the clinical value of remote consultation and echocardiographic examination, and to establish the feasibility of providing an early definitive diagnosis and treatment.

The primary aim of the present study was to test whether the time to diagnosis could be shortened by at least 1 month with the inclusion of the remote echocardiography and cardiology teleconsultation at the PHC compared with the standard of care consultation approach wherein the patient needed to visit the secondary/tertiary care hospital. A secondary aim was to compare the patient experience and satisfaction for receiving remote consultation with remote echocardiographic examination versus the standard of care referral for cardiology consultation. This prospective, randomized study was undertaken in patients suspected of HF at the Storuman PHC in the rural north area of Sweden. Storuman is 135 miles from the Skellefteå county hospital. The remote echocardiographic examination was conducted from Skellefteå, and cardiology teleconsultation was offered on the same day (**Fig. 1**, Online Video 1).

The remote consultation arm included the following steps. First, the patient was examined by 1 of 3 general practitioners (GPs) at the Storuman PHC, and the case report form (CRF), including medical history, clinical findings, list of medications, and an electrocardiogram (ECG), was electronically transmitted to the consultant cardiologist in Skellefteå. Second, a spot for the remote-controlled robotic arm echocardiogram at the Skellefteå county hospital was reserved once every 2 weeks when a trained sonographer performed the echocardiogram on the patient situated at the Storuman PHC. Third, after the remote echocardiographic examination, teleconsultation by the cardiologist (and sonographer) in the Skellefteå county hospital was performed with the patient in the presence of the GP at the Storuman PHC. During this bidirectional communication, the cardiologist could elicit additional information from the GP and the sonographer, and the patient could ask questions. The primary diagnosis and differential diagnosis were discussed, and further investigations as well as the management strategy were outlined.

The remote consultation arm was compared with the traditional standard of care referral approach at the secondary/tertiary care hospital for the cardiology consultation. After the first visit to the PHC, patients were referred to the nearest specialty hospital in the city of Lycksele (65 miles away).

We established the measurable time points for each approach (**Table 1**) that included initial patient visit at the PHC, referral after randomization, securing the appointment, ultrasound examination, cardiology consultation, and when the consultation and plan of care were accomplished. In addition, all patients completed a questionnaire comprising 15 pre-specified qualitative questions with a variable number of alternatives and added narrative as appropriate. The study design and the use of comparative strategies were approved by the ethics committee and the institutional review board of the Umeå University (Dnr 09-036M), and verbal and written consent were obtained from each patient before enrollment.

Those patients with symptoms or signs suggestive of HF were enrolled who, in the opinion of the GP, needed a cardiology consultation with an echocardiographic evaluation. Refusal to participate in the study was the only exclusion criterion. After informed consent was provided, a CRF was completed for each patient. The total time to diagnosis was measured in all cases from the initial patient encounter at the PHC to the final consultation when the CRF was signed off by the GP after teleconsultation or after the in-person consultation and echocardiographic examination.

Continuous data are expressed as mean ± SD and categorical variables as proportions. Non-normally distributed data are calculated as medians, with quartiles and minimum and maximum times given. Normally distributed values were analyzed with the Student *t* test, and the chi-square test with the Fisher exact test was used for categorical data. Differences in the process times between the 2 groups at various landmark events were tested using a nonparametric method (Mann-Whitney *U* test); p values <0.05 were considered statistically significant. A power calculation was performed as described below. The usual wait time for a routine cardiology consultation at Lycksele hospital from the Storuman PHC was estimated to be 3 months, and we hypothesized that the long-distance remote echocardiographic and teleconsultation strategy had the potential to reduce