Telecardiology: supporting the decision-making process in general practice

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Summary

To assess the initial phase of a telecardiology diagnostic service for general practitioners (GPs), we provided 93 GPs in 26 health centres with direct telephone access to a cardiologist, and equipped them with hand-held, automatic standard 12-lead electrocardiogram (ECG) transmitters for on-line cardiac consultations and ECG interpretation in their daily practice. Clinical details, reason for consultation and the ECG signal were transmitted from the GPs' practices or the patients' homes. A consultation followed and a full report, including ECG print-out, was then sent to the GP. During an 18-month study period, 2563 consultations were carried out. The system allowed the identification of 479 patients (19%) with urgent cardiac problems and the remaining 2084 (81%) in whom admission or outpatient investigation was unnecessary. Following the study, we distributed a questionnaire asking the GPs to rate the quality, define the use and consider the benefit of the service to their daily practice. We conclude that a telecardiology diagnosis and ECG interpretation service is simple, reliable and efficacious in routine primary care. It offers instant access to cardiac assessment and supports the decision-making process of GPs. A preliminary cost comparison with a conventional referral indicated that a teleconsultation was substantially cheaper. We expect that the future incorporation of tele-echocardiography would expand the scope of telecardiology even further and allow comprehensive cardiology consultations.

Introduction

The continuing improvements in computer power, image resolution, data compression methods, audio and video communication and performance allow off-the-shelf workstations to be used for the convenient and efficient manipulation of medical data, images, graphics, movies and voice annotation. The integration of multimodal clinical data for on-line processing and consultation follows naturally. These technological advances are now being harnessed to the benefit of medicine, health and social care, enabling the outreach of specialists' medical expertise to the primary-care environment. Using interactive technology, a specialist can conduct and control an examination carried out by the general practitioner (GP) via a two-way sound and picture connection. Numerous studies have shown that the diagnostic quality of such a system can be equal to that of a traditional hospital examination[1–3]. In the field of cardiology, the incorporation of data, such as electrocardiograms, echocardiograms, heart sounds and murmurs, vocal messages and images, opens new possibilities for interactive computing and remote consultation[4].

Electrocardiography and echocardiography have emerged in the past decade as widely used, non-invasive, cardiovascular diagnostic tools which provide high-resolution realtime images of cardiac structure, function and intracardiac blood flow from portable equipment. They have become established as the standards for non-invasive cardiac assessment. Likewise, transtelephonic electrocardiography has been long established as a cost-effective tool for diagnosis, monitoring and rehabilitation of patients with paroxysmal arrhythmias[5–7] and transient ischaemic changes. Transtelephonic exercise monitoring has also proved to be an effective alternative for hospital-based rehabilitation programmes[8]. However, recent developments in transmission capability in echocardiography, such as the miniaturization of equipment components and improved image compression, offer further extension of

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remote cardiac diagnostics[9]. An inexperienced doctor could perform investigations in a local hospital or primary-care environment and transfer ultrasound signals (M-mode, two-dimensional echo and Doppler data) to a referral hospital, where a cardiologist could serve as a consultant. The diagnostic precision is sufficient for the method to be applied clinically[10]. Clinical assessment can incorporate cardiac transtelephonic auscultation through audio/video and data communication links using an electronic stethoscope[11].

The present study was part of the development of a comprehensive telecardiology consultation service. Its aims were to assess telesupport for routine decision making of GPs in their daily practice based upon their requirements for specialist consultation in making management decisions, not merely electrocardiographic measurements. It also aimed to prioritize outpatient clinics' workloads, filter patients and identify the minority in need of instant attention.

Methods

Ninety-three GPs, working in 26 health centres serving a population of about 200,000 in north London, participated in this trial. GPs were offered telecardiac consultation from their practices or from patients' homes. Using any terrestrial or cellular telephone lines, they could obtain direct access to a cardiac monitoring centre (CMC) staffed by cardiology registrars and cardiac technicians. The registrars had easy access to a consultant cardiologist for discussion of any difficult or doubtful cases. GPs were supplied with an automatic standard 12-lead electrocardiogram (ECG) transmitter with direct voice access to the CMC for cardiac consultation and ECG interpretation. The CMC, based at the Cardiology Department in Edgware General Hospital, operated a 24-hour service, providing continuous coverage, which included collecting and analysing data, consulting and reporting. When required, the GP or nurse could telephone, identify the patient by name and date of birth, and provide clinical details, the patient's history and the reason for consultation. The caller could then transmit a standard 12-lead ECG signal. A brief consultation, discussing diagnosis and patient management, followed and a full report, including ECG print-out, was mailed or faxed to the GP. Timely appointments were made on-line for further outpatient assessments, if required. Instant admission for patients with acute myocardial infarction was arranged when indicated, which involved prewarning the hospital's medical teams.

System description

We used acoustic ECG transmitters which were miniaturized, hand-held, battery-operated devices (9 V), weighing approximately 350 g. A patient cable was purpose-designed as a harness to be hung around the patient's neck, allowing the height to be adjusted as required. The harness (Fig 1), with clear markings, variable length and appropriate directions of precordial leads, made the placement of standard leads easy. Disposable electrodes were used. GPs or their nurses recorded an ECG in the device's memory, where it was stored for transmission. The ECG acoustic transmitters could only store one recording at a time. The CMC receiving station was computer based, using a 386 file-server with database software which allowed the on-screen display of the ECG. However, following a replacement of transmitters, receiver and software (Aerotel HeartView), an on-screen measurement program running on a 486DX server and a user-friendly database program were used, while the station also had a fax modem incorporated allowing for instant, direct reporting (Fig 2). Alternative manual ECG recording devices could be used when necessary from the registrars' homes following call diversions. These were portable ECG recorders with an acoustic coupler to allow recording from the telephone line.

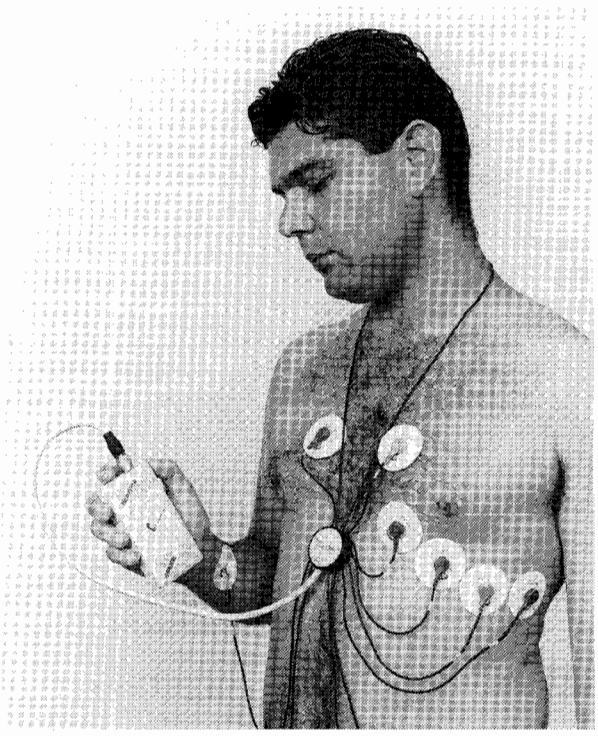

Fig 1 ECG transmitter with harness and leads.

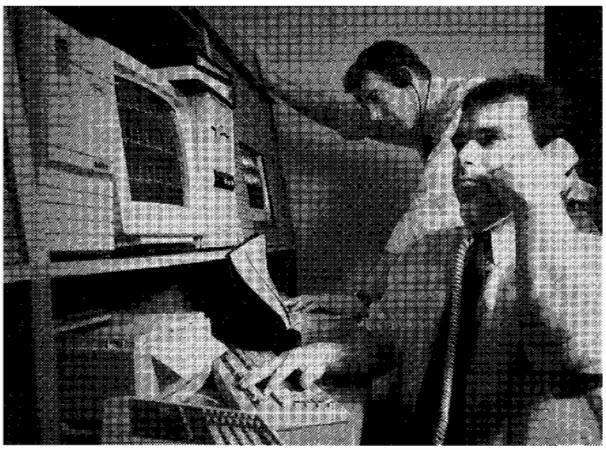

Fig 2 A Cardiac Monitoring Centre.

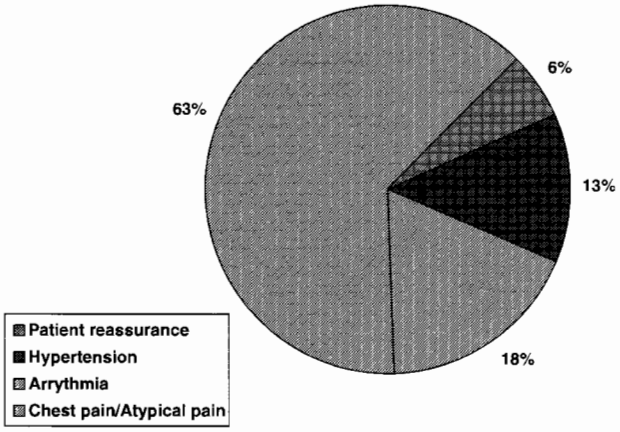

Fig 3 Reason for consultation ($n=2563$).

Evaluation

Following a study period of 18 months, we distributed a questionnaire to all participating GPs asking them to define the use and grade the quality of the service, as well as to consider and grade any benefits the service offered their daily practice (Appendix 1).

During the study every call was monitored and all data pertaining to clinical assessment, diagnosis, referral intention, course of suggested patient management and ECG registration were documented. Study parameters included: service efficiency, accessibility, change of referral patterns, filtering and priority grading of clinical referrals, response time to acute situations and cost–benefit implications. An intention-to-treat analysis was performed. The analysis group included all consultations carried out throughout the study. A secondary analysis was carried out correlating patient symptoms as recorded at the time of transtelephonic consultation with associated ECG disorders.

Following teleconsultation, we prioritized referrals to outpatient clinics, which were reorganized to meet specific demand for assessments. We divided outpatient clinics into arrhythmia (palpitation), ischaemia (chest pain), risk factor stratification/secondary prevention clinics, and clinics for the investigation of cardiac failure and murmurs. Appointments were filtered based broadly on teleconsultation results and appointments were made on-line following teleconsultation.

Results

We carried out 2563 consultations over the 18 months. We analysed the reasons for consultation as indicated by the GP upon calling the CMC. These were classified as chest pain which may or may not have been of cardiac origin; arrhythmia; hypertension; patient reassurance or unspecified reason (Fig 3).

We also reviewed the management decisions of these 2563 consultations, and classified them as: normal ECG with/without minor non-specific changes; mild disorders requiring no further investigation; those requiring referral for further investigation; and patients for whom urgent or immediate hospitalization was indicated. The management distribution analysis (Fig 4) demonstrated that, following the transtelephonic consultation, 81% of patients could be managed by the GP without any further need for referral.

Of the 1615 consultations carried out where the GP indicated the reason for consultation as chest pain or atypical pain, 359 patients presented symptoms suggestive of acute ischaemia. Among those patients, significant ST depression was present in 147, significant ST elevation suggestive of ischaemia was present in 107, while 30 patients were diagnosed as definite acute myocardial infarction on ECG grounds (Fig 5).

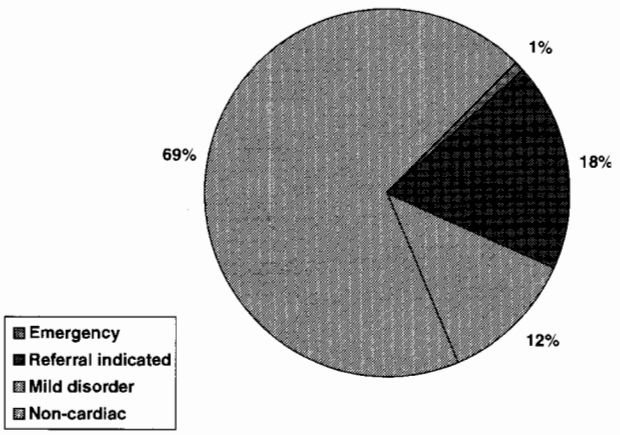

Fig 4 Patient management following consultation ($n=2563$).

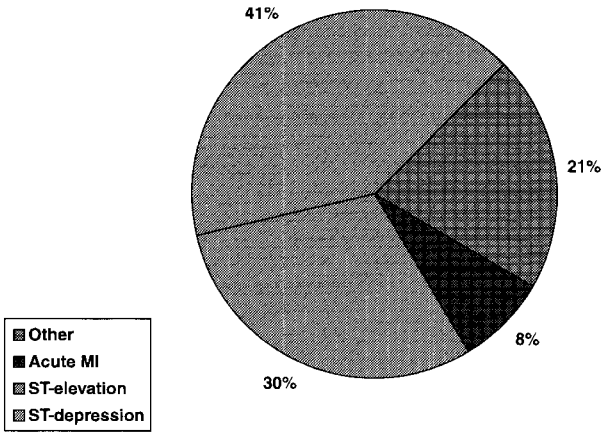

Fig 5 Distribution of diagnoses following chest pain ($n=359$).

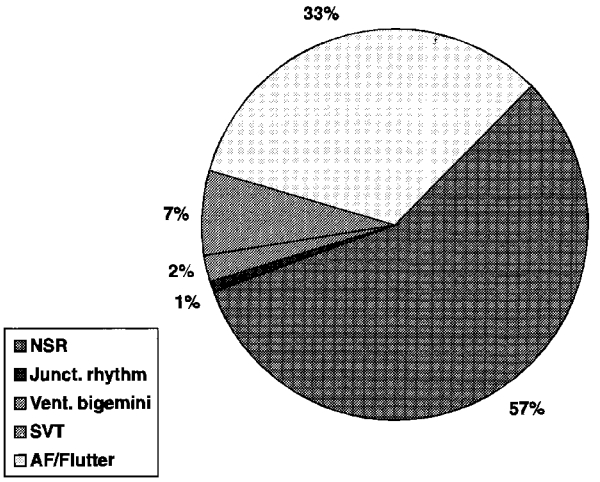

Fig 6 Distribution of diagnoses following suspected arrhythmia ($n=282$).

Of the 461 consultations where the GP indicated past or present arrhythmia, 282 had symptoms suggestive of arrhythmia. Of these, 92 had atrial fibrillation or flutter, 21 had supraventricular tachycardia and 5 patients had ventricular bigemini, while 2 presented accelerated junctional rhythm. There were 162 patients in normal sinus rhythm (Fig 6).

The system allowed the identification of 479 (19%) patients with urgent cardiac problems, who were offered immediate hospital admission or early outpatient assessment as appropriate. In the remaining 2084 (81%) patients, the need for admission or outpatient investigation was excluded.

An analysis of the completed questionnaires provided by the participating GPs revealed that the most common applications for the service were general management of cardiac patients, ECG interpretation and obtaining a cardiologist's opinion, and differentiating cardiac/non-cardiac situations. The maximum benefits were gained by the alteration of management, that is, the opportunity to manage patients in the practice instead of referring them to an accident and emergency department or requiring an outpatient assessment (Table 1).

Although the quality of data available following the study did not allow for a comparative quantitative referral analysis, the data indicated a change in referral trend reducing the number of non-urgent and unnecessary referrals, while a substantial increase in assessments resulting in diagnosis of severe pathology was noted.

A simple comparative cost analysis of teleconsultation compared with referral indicated that substantial savings in hospital resources could be achieved. Hospital consultation time was reduced to the essential communication, which averaged about 3 minutes, or 10% of

Table 1 Rating of consultation service by GPs

Quality	Rating*	Application	Rating†	Benefits	Rating‡
Efficiency	6	Control of arrhythmia	3	Alteration of management practice instead of A&E	6
Accessibility	6	Hypertension	2		
Response time	5	Reassurance of patients	2	Enhance doctor–patient relationship/ improved care	5
ECG analysis	6	Supporting decision making	3		
Cardiac consultation	5	Assessment of acute situations	2	Boon to the practice	4
Appropriate response to acute situations	6	Diagnosis of emergencies	2	Saving of patient's time	6
		General management of cardiac patients	4	Saving of referrals	5
		ECG interpretation+cardiologist's opinion	4	Speeding of referrals	5
		Differentiating cardiac/non-cardiac situations	4	Saving of GP's time	4
		General health screening	2		

A&E–referral to an accident and emergency department.
* 1=very dissatisfied to 6=very satisfied.
† 0=not used to 4=used very often.
‡ 1=strongly disagree to 6=strongly agree.

the ordinary outpatient consultation slot of half an hour. Further savings were obtained by registrars performing the routine teleconsultations instead of a consultant.

Discussion

We have described a routine telecardiac consultation service limited to clinical data and tele-electrocardiography assessment. When incorporated into a comprehensive, non-invasive telecardiac consultation service including tele-echocardiography, this approach can be expected to change significantly both the priorities and the mode of assessment of cardiac patients in primary and secondary health care.

Compared with primary-care consultations, referral of patients to a secondary-care facility for consultation is always more alarming and time consuming for the patient, interfering with his or her normal routine while also deferring decision making and imposing an additional heavy cost on the supplier of health-care services.

Cardiovascular disease remains the leading cause of morbidity and mortality in developed countries, while health services in these countries are experiencing a number of conflicting influences. Developments of technology and imaging techniques have greatly increased diagnostic powers. These developments have been well publicized, creating widespread awareness of them among both the general public and patients. Additionally, government initiatives such as the *Health of the Nation* policy[12] in the UK have increased public expectations, not only for high-technology health care but also for rapid, unimpeded access. On the other hand, hospital diagnostic facilities have expanded slowly while the debate regarding the future funding and provision of health services continues. With the rapid expansion of medical knowledge in all disciplines, it is unrealistic to expect that the individual primary-care physician can keep abreast of all developments and diagnostic procedures alone. However, through the effective use of technology and existing highly trained medical personnel, GPs' diagnostic services and patient-management capacity can be enhanced, such that they can satisfactorily assess and treat patients at the primary level, accurately identifying those who require referral for consultant opinion and intervention. Telemedicine facilitates realtime discussions between physicians in primary and secondary care. It is this ability to overcome the problems of access that makes the technique so potentially useful.

Currently many GP practices in the UK are devoid of ECG equipment, seldom make use of equipment, have inexperienced interpreters, or demand expert knowledge and advice. ECG recording by GPs in isolation has failed to improve the specificity and sensitivity of the referral process. As an alternative, the local hospital may offer a direct-access ECG service. This requires that the patient visits the hospital at least once, perhaps after a wait of days or weeks, and must return to the GP some days after the recording has been made, following reporting by a hospital doctor and mailing of the report back to the GP. In the light of the report, the GP then decides whether to refer the patient to an outpatient clinic. A referral involves a letter which must pass through the hospital's outpatient registration system until a decision is made regarding the hospital's perception of the urgency of the matter. Discussion between the GP and the hospital consultant is relatively rare. It is not uncommon that when the patient is eventually seen, it is decided that it is a relatively minor matter which should be dealt with by the GP.

Our experience has shown that patient evaluation time is cut considerably when there is discussion of the case with a hospital physician who is able to see the ECG. Simple problems can be dealt with over the telephone and agreement reached regarding a management strategy which, in many cases, obviates the need for patient referral. At the same time the patient has had ready access to specialist expertise without having to leave the primary-care setting. In our study the GPs' responses to the questionnaire indicated that this consultation service had obvious advantages over the well established transtelephonic ECG 'stand alone' technique. The direct-access service increased GPs' confidence following verbal consultation and offered an opportunity to alter and improve the management of cardiac patients in their practice instead of unnecessary referrals to accident and emergency departments. GPs also indicated that the service enhanced the doctor–patient relationship.

The telecardiology service can accurately identify patients with urgent problems requiring rapid assessment at the hospital or even emergency admission. The system is portable, so that it can be used in patients' homes, facilitating the emergency evaluation of chest pain. In a number of cases, we have been able to diagnose acute myocardial infarction, arrange immediate transfer to hospital and begin thrombolytic therapy within a few minutes of arrival.

The backbone of the service was provided by cardiology registrars, who were all experienced in cardiology and had ready access to consultant support in doubtful or complicated cases. Where appropriate, the consultant was able to speak directly to both patient

and GP. Both GPs and patients expressed their complete satisfaction and confidence in the quality of consultations throughout the trial.

Although no accurate financial analysis has been carried out, simple computations can be used to estimate the cost-effectiveness of this project. The approximate cost of employing a consultant for an hour in the National Health Service is £25, whereas a registrar costs £12.50 per hour (£1 is 1.20 ECU or $1.57). A typical initial outpatient consultation would take 30 minutes. By comparison, a telecardiac consultation would involve the hospital physician for only about five minutes. This reduces the physician costs by some 80%. In addition, a patient's referral to the hospital involves clerical and secretarial costs relating to the appointment bookings, schedules, file management and reception duties, followed by a letter of consultation for the GP. This cost is of the order of £20. Support of 26 primary-care centres involved an initial investment in hardware and software of about £20,000. This included computer equipment, telecommunications and ECG monitoring equipment for 93 GPs, which averaged £770 per practice, or £86 per GP. Management costs were minimized as the service was run by the cardiology firm with registrars on duty sharing the on-line consultations. However, a staff nurse or a cardiac technician was required to service the CMC for data acquisition, ECG measurements and reporting. The further operating costs of the service, excluding salaries, have been estimated at about £2 per consultation for telephones, printing and postage.

Extension of the service by the incorporation of remote echocardiography is possible by use of the ISDN. Although currently expensive, ISDN 30 allows the transfer of realtime images at an acceptable frame rate. Using this technology, the hospital physician can participate in an investigation carried out in the practice, probably by a technician, by giving directions and comments. Immediate recommendations would be available to the GP with regard to patient management. In developed countries, this is likely to find greatest application in the assessment and management of patients with known or suspected cardiac failure, the one area of cardiology where the prevalence of a condition is increasing. There is now good evidence of the value of treatment with angiotensin-converting enzyme (ACE) inhibitors in improving both prognosis and quality of life. Figures suggest that these drugs are underused in the community and that some GPs are reluctant to initiate this treatment without hospital support.

We conclude that a telecardiology diagnosis and ECG interpretation service is simple, reliable and efficacious in routine primary care. It offers instant access to cardiac assessment and supports GPs' decision making. It results in early detection of heart disease, on-line assessment of suspected acute events, adequate filtering and priority grading of referrals for patients requiring further investigation while reducing the load of unnecessary referrals for primary diagnosis.

The telecardiology study reported here was based on transtelephonic communication and transmission of clinical and ECG data. It was part of a study of comprehensive telecardiac assessment services for primary health care incorporating a tele-echocardiography service and may pave the way for the development of similar services for primary health care in other disciplines.

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Appendix 1. Routine transtelephonic ECG monitoring and cardiac assessment service in primary health care

Questionnaire

Quality control

Please assess the service and rate it on a scale of 1 to 6 according to the following criteria (circle your choice): 6 = very satisfied, 5 = fairly satisfied, 4 = a little satisfied, 3 = a little dissatisfied, 2 = fairly dissatisfied, 1 = very dissatisfied.

(1) Efficiency 6 5 4 3 2 1
(2) Accessibility 6 5 4 3 2 1
(3) Response time 6 5 4 3 2 1
(4) ECG analysis 6 5 4 3 2 1
(5) Cardiac consultation 6 5 4 3 2 1
(6) Appropriate response to acute situations 6 5 4 3 2 1

Application

These aim to define the utilization of the service in your practice. Please circle your choice according to the following keys: 4=used very often, 3=used fairly often, 2=used sometimes, 1=almost never used, 0=not used.

(1) ECG interpretation+cardiologist's opinion 4 3 2 1 0
(2) Differentiating cardiac/non-cardiac situations 4 3 2 1 0
(3) Control of arrhythmia 4 3 2 1 0
(4) Hypertension 4 3 2 1 0
(5) Assessment of acute situations 4 3 2 1 0
(6) Diagnosis of emergencies 4 3 2 1 0
(7) General management of cardiac patients 4 3 2 1 0
(8) Reassurance of patients 4 3 2 1 0
(9) Supporting decision making 4 3 2 1 0
(10) General health screening 4 3 2 1 0

Effect on the general practice

The following statements have been suggested by some general practitioners. Please circle the reply which best represents your assessment or experience based on the following scale: 6 = strongly agree, 5 = moderately agree, 4 = slightly agree, 3 = slightly disagree, 2 = moderately disagree, 1 = strongly disagree.

(1) Alteration of management–some patients can be managed in practice instead of referral to A&E 6 5 4 3 2 1
(2) Saving of referrals 6 5 4 3 2 1
(3) Speeding up of referrals 6 5 4 3 2 1
(4) Saving of GP's time 6 5 4 3 2 1
(5) Saving of patient's time 6 5 4 3 2 1
(6) Improved care+enhancement of doctor/patient relationship 6 5 4 3 2 1
(7) Boon to practice 6 5 4 3 2 1

Comments, criticism and suggestions:

Thank you for your contribution.