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Review on Role of Tele Cardiology in Tele Medical Services

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***Abstract* - E-health, one of the essential and emerging fields in the modern world paving way of hope for thousands of patients to live their peaceful lives. Recently telemedicine has become a requisite for tackling problems of paralyzed patients and patients who are recovering from chronic and other disorders. One of the notable points in the medical field is the treatment for "cardiac diseases" which can also be achieved by Tele medicine. With the help of the internet, technology and the modern equipment, the way of accessing the system is becoming simpler day by day and the ultimate goal is that to reach out many rural areas where high standard medical facilities is still considered as a dream. Store and forward, Remote monitoring and the Real-time interactive service acts as the pillars of Tele health. These methods have the potential to reach out every nook and corner. Limited prerequisite knowledge of the equipment is enough for the general practitioner or even for the patient itself to collect the data. As it is mainly based on internet, the data acquired can be transferred, processed and preserved for future use. Currently it is applicable only in highly specialized hospitals which will be soon taken into establishment in every hospital resulting in the accessibility for every person.**

Keywords – Tele Medicine, Technology, Tele Cardiology, ECG, Methods of Tele medical services.

I. INTRODUCTION:

Tele medicine is one of the most emerging health care sector services. It is mainly the care given by the health care provider to the patient in the remote area via technology and innovative equipment [6, 12, 14, 18]. It can reduce the pressure on the medical personnel, who are of low in number, and who are extending their passion to the patients in remote areas. It seems to be found that it is mainly promising in the cardiovascular disease, because early, tailored interventions are extremely cost-effective in terms of life-saving and functional recovery. It also helps the doctors to be interactive with their patients whenever they need [7, 11]. It involves the use of computer, audio, video-conferencing methods through which the communication would become much better.

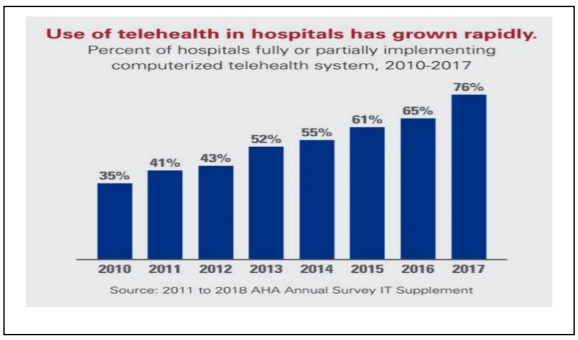

Fig.1: Statistics of Tele medical services
(Source- https://www.aha.org)

For the past decade, innovative approaches have evolved and in the current COVID-19 climate, it has become one of the indispensable measures for the patients to have access to the care they need. All these decisions and the processes must be under the control of HIPAA (Health Insurance Portability and Accountability Act of 1996) and MCI ("Medical Council of India Act of 1956) [15]. However these types of medical services are getting boomed in India after foreign countries, but its value can be much seen in the foreign countries. In India, the various plans are getting implemented to execute these medical care in a faster way, similar to the other countries, and everything should be according to the terms of section 27 of MCI act, with this act, any person whose name is enrolled in the Medical register can practice and provide their service as a medical practitioner in any state of India based on their qualification [6, 8]. By this act, the practice of Telemedicine by the medical practitioner is permissible within the states. In addition to all these, Appointments on medical practitioners in hospital may reduce in number and waiting hours might get reduced.

A. TECHNOLOGY:

In a telemedicine network there exists three basic components: the Electronic Personal Record (EPR), digital devices and telecommunications. The main motive of the network is to collect and analyse the specific consolidated patient data from multiple medical centres or hospitals to organize them within network to make the appropriate medical decisions [10, 13].

An EPR can be an open source or free software; the most popular solution for internet applications is the three

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layer client-server application (mainly used for its speed and performance) i.e. It can be used by different medical centres mutually implementing Tele health applications [13]. The telemedicine platform manages all medical information and integrates (assembles) it with the EPR, which consolidates all the healthcare data in a characterized way. The various characteristics of the platform might be:

1) Usability.
2) Web architecture;
3) Easy access to details (i.e., application or webpage).
4) Interconnected access to information through network/server.
5) Dynamic customization of health data (easy customization).
6) Coincidence and interactive with multiple data.
7) Communication support, as the main standard communications systems, to external server to server and/or platforms of technology providers.
8) Health data and various Biological signals acquisition bases.
9) Fit to Standards.
10) Computable logics, inferencing, discovery, and data federation between informatics.
11) Terminology and coding standardization, e.g. ICD (ICD-9-CM), LOINC, SNOMED, UHID, AIFA;
12) Syntactic standardization, e.g. HL7, (CDA, Clinical Document Architecture), DICOM.

The internet connection will have the direct effect on the speed of transmission and the quality of the live conference (both audio and video).

II. TYPES OF TELEMEDICINE:

In this service, there are three types namely,

1) Store and forward:

In this type of telemedicine, the data from the patient is transferred to a doctor, later the report is evaluated and response is sent back to the patient which does not involves the live interaction of doctor and patient. The data can be stored by a patient itself or a medical practitioner from a small clinic to specialized doctors. By this, a doctor can receive the reports from various patients and analyse and send the response back to the patient which is similar to that of the process taken in the hospital where the processed data such as reports, images and bio signals of a particular patient by a doctor is consulted[16].

Unlike the medical service performed in Fig.2, this method is applicable when the patients are in the remote area who couldn't frequently visit the doctors due to various crisis like distance, financial issues etc. The store and forward method gets a lot of advantages such as the time saving, financial crisis, lessens the burden of the patients of travelling through long distances and also a sophisticated interaction of the doctor and the patient. Mainly this method is used in the fields of dermatology, ophthalmology and radiology. Although it consists of a lot of advantages it also includes various disadvantages which include the misdiagnosis to the patients which is one of the complicated things when the reports of the patients are mingled during the processing.

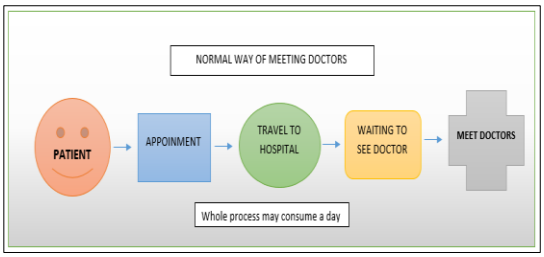

Fig. 2: Normal way of meeting doctors.

2) Remote monitoring:

It is the regular monitoring of the patient/s for a prolonged time by the practitioner/nurses. The medical parameters such as the oxygen level, haemoglobin level, glucose level, blood count, weight, height are collected in a single database and are analysed by the healthcare provider team. It is different from the store and forward method in that it works as a periodical process whereas store and forward method is an occasional one. These tele medical networks perform as in Fig.3. This method is applicable for the chronic diseases and diabetes mellitus. Various health monitoring equipment were used to monitor the patients which is also practiced in some clinics. It has some disadvantages that the data collected by the patients itself in home may be inaccurate, but it rarely occurs. Lot of elderly people can be benefitted by this method and it is practiced mostly in the multispecialty hospitals as a separate branch.

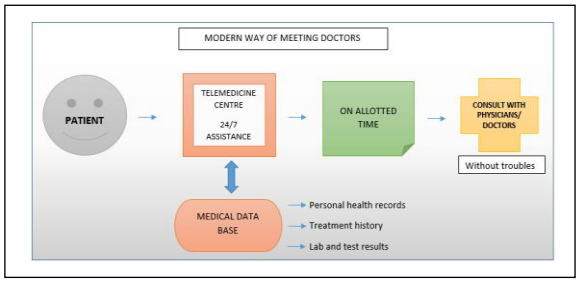

Fig. 3: Modern way of meeting doctors.

3) Real-time interactive service:

It is the type of telemedicine service which involves the live interaction and enquiring the health of the patient by the doctor which does not involve any time lag. In other words, it is a face to face video visit of the doctor with the patients [20]. Real time interactive service is applicable for the conditions of emergency and also in the times of cognitive disorders. It leads a way to give counselling to the patients who are mentally affected. This is similar to the visit to the doctor in a physical manner but it is a video interacting service. The video communication service used regularly would not be applicable for this service but high technological specified equipment were used which would work properly without any connectivity problems and also secure the details of the patients with ease. This is one of the effective types of the telemedicine fields than the store and forward and remote monitoring methods. This method also provides the doctor to examine and treat the patients with the consultation of the highly specialized doctors so that the complications of the misdiagnosis can be reduced to the minimum limit.

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Other than these types, there exist some basic components of telemedicine such as: Tele consultation, Tele monitoring, Tele mentoring

A. TECHNICAL REQUIREMENTS:

To achieve a well versed Tele medical service, there are certain basic requirements which require:

1. Internet connection:

For providing a good care for the patient, both patient and doctor sides must possess a stable broadband connection with strong and stable bandwidths of internet. A lag in any one of the side may cause an unstable service and it is not appreciable because it deals with the life of a person. A basic business broadband connection should be sufficient at about 50-100 Mbps (Megabits/sec) [5].

2. Knowledge to access technical devices:

These services include the computer (with certain software packages), audio and video devices. And the user of the device must have the knowledge and experience to handle and operate these devices

3. Training:

The medical practitioner must have been trained enough to provide the service. Improper practice method can cause complexity to the patient and there are certain codes which are essential to be aware while enabling these services HCPCS (Human common procedure coding system) codes such as G2010 and G2012 [7]. Medicare's 2019 Final Rule approved HCPCS code G2010 for reimbursement, which allows providers to be paid for remote evaluation of images or recorded video submitted to the provider (also known as "store and forward") to establish whether or not a direct visit is required. This allows providers to get paid for services they typically perform and which promote quality patient care that they otherwise wouldn't have been paid for in the past. Brief communication technology-based service, e.g. virtual check-in, by a physician or other qualified health care professional who can report evaluation and management services, provided to an established patient, not originating from a related evaluation and management (e/m) service provided within the previous 7 days nor leading to an e/m service or procedure within the next 24 hours or soonest available appointment; 5-10 minutes of medical discussion.

III. TELECARDIOLOGY

Tele Cardiology enables the specialists to interpret the electrocardiographic recordings via telephone transmission. It has the potential to change the way cardiac care is being delivered in the primary care setting. This review discusses the current status of cardiac care in the community, and highlights how Tele cardiology can help support general practitioners in the diagnosis and management of acute and chronic cardiac disease, as well as provide the potential for screening opportunities in particular patients at risk. Also reviewed is the success of recent trials of a Tele cardiology service in the north west of England. Thanks to developments in technology and ever decreasing costs, Tele cardiology has the potential to save time, money and lives. Tele cardiology, it would seem, is set to revolutionize cardiac care in the community, making savings and bridging the gap between primary and secondary care.

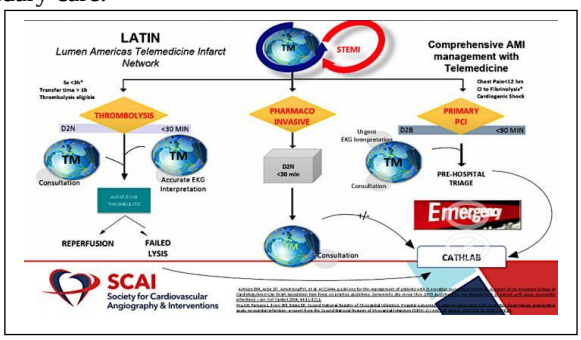

Fig.4: Tele medicine based networks
(Source https://www.dicardiology.com)

The cardiovascular diseases are one of the major causes of the deaths worldwide which takes up around 17.9 millions of lives every year. In USA, the analysis shows that one person dies every 37 seconds due to cardiovascular disease. In India, both the heart disease and the stroke contribute about 28.1% of the total deaths by the 2016 survey. Four out of five deaths of cardiovascular deaths are caused by heart attacks and strokes [19]. More than one third of deaths occur prematurely in people who are below 70 years of age in the world and in India it is 50% of the deaths. Cardiovascular diseases are a group of disorders of the heart and blood vessels and include coronary heart disease, cerebrovascular disease, rheumatic heart disease and other conditions. Hence this type of diseases make complexity in number of deaths which also increases the death rate in the rural areas when compared to the urban areas as the treatment is non-accessible. But it can be overcome by method of Tele cardiology which is one of the effective fields in telemedicine.

Tele cardiology makes a diagnosis to be made, and allows the required personnel to be prepared for the patient even before admission, cutting down on the time to surgery and preventing further muscle damage. Tele cardiology is a modern medical practice in which the power of telecommunications plays an important role which achieves remote diagnosis and treatment of heart disease [20]. This includes coronary heart disease, chronic and acute, as well as arrhythmias, congestive cardiac failure and sudden cardiac arrest. Tele cardiology is one of the oldest applications in telemedicine and it is in act since the last 10-20 years which provides the patients a specialized care. The telemedicine network can be seen in Fig.4. Tele cardiology allows the remote specialist interpretation of electrocardiographic recordings through telephone transmission. Doctors and other healthcare providers use electrocardiographic data, which is transmitted remotely in real time for interpretation by a specialist. Over 2 lakh patients worldwide are being managed via remote implantable electronic cardiovascular device monitoring to facilitate the patient's immediate physiological response .Advancing technology is making it easier and less expensive to set up wireless or satellite networks for this purpose, increasing their effectiveness and ease. The wireless communication of Tele Cardiology service can be seen in Fig.5 [15]. Individuals at risk of

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Cardio vascular diseases may demonstrate raised blood pressure, glucose, and lipids as well as overweight and obesity. These can all be easily measured in primary care facilities. Continuous home monitoring of cardiac patients like weight, blood pressure and heart rate, using Tele cardiology, can improve outcomes in heart failure patients.

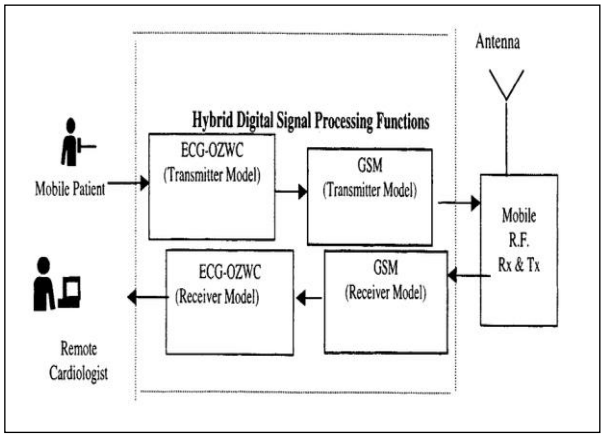

Fig.5: Tele Cardiology working model
(Source- https://www.researchgate.net)

A. WORKING:

The practice of Tele cardiology service mainly depends upon the availability of the specialized device, which does not only involves in recording the 12-lead ECG setting, the ECG images should be transmitted in the form of a sound signal over the communication network(telephone line). In the converse, it is again converted back into an image on screen. The working can be seen in Fig.6. After that the physicians interpret the details, a report is generated, meanwhile the written summary of the report can be emailed or faxed to the patient hub. All these ECG data will be stored for future references of ECGs. Single-lead ECG machines are available in the form of a watch-like device to enable quick monitoring when the patient needs it, while still at home. This allows for a better interpretation and diagnosis of the disease condition. This device can store the images recorded, and transmit them once the patient reaches the GP's office. The advantage is that the patient need not wait to reach the doctor's office, but can record the ECG as and when symptoms are present.

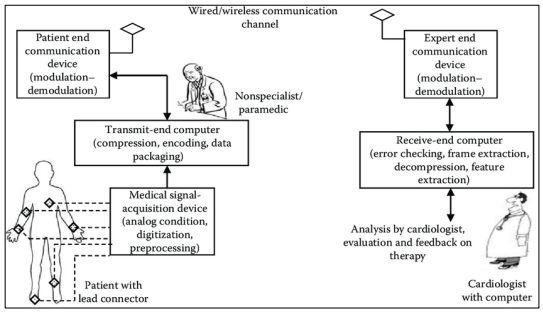

Fig.6: Wireless Communication of Tele Cardiology
(Source-https://www.researchgate.net)

B. REQUIREMENTS:

Standard telephone lines (PSTN) or the patient's mobile phone are enough for the transmission of a one-lead electrocardiography (ECG) [13]. Digital lines (ISDN) may be required to transmit signals from more complex devices (e.g. multi-lead ECG or video). Digital subscriber lines (e.g. ADSL) for high-speed Internet connections can be used for every type of video, signal and images in cardiology.

IV. ECG

The role of ECG in Tele cardiology causes a great positive impact in the telemedicine field as it is one of the useful devices which is related to the heart diseases. Electrocardiography (ECG) is a useful diagnostic tool in the diagnosis and management of ischemic heart disease and cardiac arrhythmia, and its availability in the primary care setting is now common. Tele cardiology has been in use in one form or another for just over a century, and has multiple applications. We believe that recent advances in Tele cardiology provide an accurate, convenient and cost-effective solution for ECG testing in the primary care setting.

A. ECG IN PRIMARY CARE:

There are several reasons for having reliable ECG testing at the primary care level. Although the majority of patients with acute coronary syndrome present to secondary care, some may present to their GP. Under these circumstances, ECG testing is mandatory and reliable interpretation of the result may inform not just the diagnosis, but also the need for urgent referral. From the perspective of diagnosing and managing cardiac disease, opportunistic screening programs may detect ECG changes such as atrial fibrillation or left ventricular hypertrophy in high-risk individuals with conditions such as hypertension and dyslipidemia. It may also aid the early detection of silent myocardial ischemia in specific patient groups at high risk of coronary artery disease, e.g. diabetics or patients with chronic kidney disease [2]. There is vast potential, and the idea that ECGs should be put to widespread use in the assessment and monitoring of heart failure and chest pain of recent onset is now reflected in guidelines published by the National Institute for Health and Clinical Excellence (NICE).

Pre-hospital, In-hospital and Post-hospital are the categories applied in the Tele cardiology.

1) Pre-Hospital

As in Pre-hospital period, Tele cardiology is used to give assistance for the treatment of an acute coronary syndrome or heart attack by constituting emergency medical services. Studies on it have shown the feasibility of obtaining a 12-lead ECG during the pre-hospital period. Diagnostic quality ECGs can be successfully transmitted for approximately 85 percent of patients with chest pain who are eligible for 12-lead ECGs. Pre-hospital 12-lead ECG transfer improves pre-hospital diagnostic accuracy for patients with a final hospital diagnosis of Acute Myocardial infarction, angina or non- ischemic chest pain [19].

The guidelines of the American Heart Association for cardiopulmonary resuscitation and emergency

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cardiovascular care recommend the use of out-of-hospital 12-lead ECG diagnosis in urban and suburban paramedic systems.

The major purpose of pre-hospital 12-lead ECG diagnosis is to receive an emergency physician before the arrival of the patient the early detection of acute myocardial infarction with ST-segment elevation and the communicating that information. Transmission of pre-hospital 12-lead ECG directly to the attending cardiologist's mobile telephone lessened door-to-device time by >1 hour when patients with ST-elevation myocardial infarction were directly transported to invasive centres, bypassing local hospitals. The telephone display shows adequate resolution for ECG interpretation.

2) In-Hospital

In-hospital Tele cardiology is used as link between small hospitals in rural regions and main hospitals centres. Telemedicine here has the potential to improvise the access to echocardiography diagnoses in the ICU - Intensive Care Unit, emergency room and infant nursery [10]. Several studies have reported close to 100 percent diagnostic agreement when live telemedicine interpretations were compared with videotape interpretations and the mean time from the echo-images recording to reporting was significantly shorter than the traditional method. Live transmission of foetus or neonatal echocardiograms by paediatricians led to the prompt change in management of patients including transport to the main clinic whenever it is necessary [13]. Recently, videoconferencing for the transmission of echocardiography data has been also proven useful for the assessment of children with suspected cardiac diseases.

3) Post-Hospital

I. **Tele consulting Between GPs and Specialists**

General practitioners (GPs) deal with increasing numbers of patients with cardiac disease, who have often been discharged early from the hospital and whom the GP must manage by themselves. Telemedicine has primarily been applied in the arrhythmias diagnosis, otherwise used directly by GPs as an alternative to walk in or ambulatory visits for patients with chronic conditions or systemic hypertension. The advantages include early diagnosis and tailored therapeutic interventions, home management of conditions, availability of specialist tele consultation out of the hospital, and improvement in the appropriateness of hospital admissions and referrals to the emergency department.

II. **Home Tele nursing for Chronic Cardiac Diseases**

Home Tele nursing is a unified approach that involves the patient, the family, the GP and specialized cardiac centres [12]. There is some evidence implies multi-disciplinary management and home-based intervention can result in reduced readmission rates and length of hospital stay in for chronic cardiac patients. Tele monitoring allows the follow up of patients for long time periods. In truth, Tele monitoring and Tele assistance with the aid of nurses, specialists and GPs can afford to a disease management program.

III. **Diagnosis for Arrhythmias, Monitoring of Pacemakers and Implantations of Cardioverter Defibrillators (ICDs)**

Palpitation is a common symptom that sometimes results from a substantial cardiac arrhythmia. Usually a 24-hour Halter monitor is used, but this instrument give low yield in patients whose symptoms occur rarely or infrequently. Trans telephonic event recorder is an another instrument used for studying the palpitations

Trans telephonic pacemaker monitoring which gives accurate and reliable result data and to reveal the significant quantity of unpredictable abnormalities in heart, such as failure in sensing and capturing tachyarrhythmia's which eventually necessitate the pacemaker mode change [2]. The rate of ICD implementation get increasing due to the recent trails on prevention of sudden cardiac death, in particular the arrival of biventricular ICD for patients with heart dysfunction. Remote ICD interrogation allows frequent, convenient, safe and comprehensive monitoring. Device- and patient-related problems were reliably detected and reduced the iteration of outpatient visits. Patients are highly satisfied with the convenience and trouble-free use of the system.

V. BENEFITS

The essential advantage of the Tele cardiology is the support given by it to the primary care practitioners during the correct diagnosis in terms of right time and accuracy. It provides a better environment among average practitioner in improving the clinical training, by increasing the clinician's level of knowledge at primary level i.e. operating a simple device to the collection of data from the patient and much more. Thus it covers each and every practitioner who is equipped to offer a better care of the patients which is one of the most sensitive and important aspect of a hospital environment and also in cases of distant medical needs. Tele cardiology devices are small, compatible and portable, which makes them more efficient to move for the patient's side to make a quicker and more accurate diagnosis and has the proven ability in high standards of treatment to improve the quality of health care, increase cost-effectiveness and save lives in an optimistic way. The events of acute coronary diagnosis are made faster and more convenient and also increasing access to specialist care, ensuring greater efficiency of patient triage and management, and lower the burden on secondary referral hospitals thus making it as simple as possible.

There are mainly four attributes telemedicine:

1) Increased access
2) Increased accuracy
3) Cost- effectiveness
4) Comprehensive, population-based care and delivery of guidelines-based acute myocardial infarction (AMI) management [2]

VI. CONVENIENCE, MOBILITY AND EASE OF USE

Tele cardiology devices are small, mobile like things which are usually operated by a single button and also used in mobile phone. They are keen in ensuring portability, compatibility so that they can be moved easily

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from room to room and also can be taken out into the community when there is a need for travelling. They can be helpful in supporting the service of those GPs on-call and also would be indispensable to those practicing in remote areas which are the notable point. The mind-set of the patient would feel more convenient and in a comfortable way that they can undergo ECG testing in their home itself or within the environment of local GP's instead of travelling to a hospital and subjected with the same orthodox way of ECG testing. This device allows healthcare providers improve patient compliances and provide benefits by the best convenient approach in investigating and managing heart disease.

VII. LIMITATIONS OF EVIDENCE AND FUTURE DIRECTIONS

Tele cardiology needs to be subjected and processed to the kind of Cochrane-standard meta-analyses which is the results of the many individual studies that are combined to produce an overall statistic that are normally employed to assess the effectiveness of any medical intervention apart from the positive results and reviews. To materialize these studies it may take some time and also it may take some time to more widely accept the technology.

VIII. CONCLUSION

Despite the diversity of models and the lack of systematic research, successful Tele cardiology programs exist. One barrier to more widespread implementation is that there are many different software, hardware and telecommunications options, but none are designed specifically for cardiology. Thus each component may function well in isolation, but integrating the components is more difficult. Reimbursement for Tele cardiology consultation is also limited and may discourage many physicians from participating.

Tele cardiology, by bringing expert ECG interpretation to primary care, has the potential to save time, money and lives. Both physicians and patients benefit in terms of ease of access, speed of diagnosis, efficiency of management and the freeing up of resources. There remains a need for further large randomized controlled trials and cost-efficacy data to evaluate these findings on a wider scale. In conclusion, Tele cardiology has the potential to revolutionize the way various heart conditions are managed in the primary care setting. Tele cardiology is here to stay and may represent a step change for the use of further clinical tools that harness information technology to augment patient care.

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