Lecture on Tele-ECG
by
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Why develop Tele-ECG?
Alarming Fact...

According to the World Health Organization (WHO), cardiovascular disease makes 17.5 million deaths which represent around 31% of global death and twice the number from cancers. The American Heart Association (AHA), reports that in 2012, the percentage of women death due to heart disease had reached 56% while it was 30% in 1997.

As per the article in Times Of India, Front page dated 16/08/2012 and titled: “Unhealthy at 65: India has 76% shortfall in government doctors”, there is acute shortage of doctors and others medical practitioners’ in India.

According to the Rural Health Statistics 2011 in 12th Plan draft chapter :-

<table>
<thead>
<tr>
<th></th>
<th>Target</th>
<th>Actual</th>
<th>Shortfall (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doctors</td>
<td>1,09,484</td>
<td>26,329</td>
<td>76</td>
</tr>
<tr>
<td>Specialists</td>
<td>58,352</td>
<td>6,935</td>
<td>88</td>
</tr>
<tr>
<td>Nurses</td>
<td>1,38,623</td>
<td>65,344</td>
<td>53</td>
</tr>
<tr>
<td>Radiographers</td>
<td>14,588</td>
<td>2,221</td>
<td>85</td>
</tr>
<tr>
<td>Lab technicians</td>
<td>80,308</td>
<td>16,208</td>
<td>80</td>
</tr>
</tbody>
</table>

Source: Rural Health Statistics 2011 in 12th Plan draft chapter.
Why Tele-ECG is Required in India?

- 70% of our population resides in RURAL Area
- 75% of the doctors are in URBAN Area
- More than 90% of the population comes under Mobile Network Coverage Area
Tele-ECG : The Concept
What is ECG?
Definition

EEG (ElectroEncephaloGraphy) : Electrical Signals from Brain
EMG (ElectroMyoGraphy) : Electrical Signals from Fiber muscles
ECG (ElectroCardioGraphy) : Electrical Signals from Cardiac muscles

An Electrocardiogram (ECG) is a test that records the electrical activity of the heart and can be used to measure: -

• Rate and regularity of heartbeats
• The size and position of the chambers
• The presence of any damage to the heart
• Effects of drugs or devices used to regulate the heart
• Wide range of cardiac disorders such as the presence of an inactive part (infarction) or an enlargement (cardiac disorders) of the heart muscle.
How are these Electrical Signals generated?
- *Cells* are connected with each other by electrical window called GAP JUNCTION.
- Repolarization in *NORMAL* cells is caused by inflow of K⁺ ions and in *MYOCARDIAL* cells by inflow of Ca²⁺ ions.
Typical action potential signal

- ECG, EEG etc. signals are the resultant of several action potentials produced by a combination of different cells
Action potentials → measured waveforms

- Propagation of action potential through different body tissues produces final waveform recorded by electrodes
Why 12-Channels of ECG?
• The 12 leads allow tracing of electric vector in all three planes of interest
• Not all the leads are independent, but are recorded for redundant information
Normal ECG Signal

- P – atrial depolarization
- QRS complex – ventricular depolarization
- T – ventricular repolarization
Tele-ECG developed at BARC

User Specifications: -

• Should be portable so that it can be carried easily to any place.
• Should be Battery operated.
• Should have Display to view the ECG.
• Should have the capacity of storing the data that can be shown to the expert at convenient time.
• In case of emergency, it should have the facility of sending the ECG data to an expert immediately for consultancy.
• Should be of low cost.
Tele-ECG developed at BARC

Derived Specifications:

✓ Principle of voltage measurement → All inputs needs to be buffered
✓ Small Size & Battery Operated
✓ Diagnosis → Shape of Waveform. Frequency Response: 0.05 Hz to 150 Hz
✓ Common Mode Rejection Ratio > 80dB
✓ 1mV of ECG → Gain (selectable)
✓ Circuit Protection from High Voltage
✓ Interfaces: Bluetooth
✓ Low Power Consumption
✓ Can be interfaced with mobile
Block Diagram
12-Channel Tele-ECG developed at BARC

12-Channel Tele-ECG Instrument  Tele-ECG Instrument in action
Patient: Demo
Date: 2015_08_31 15-37
Comment: ecg normal
CHSSNO: 45325
Date of birth: 5/6/80
Age: 35
Height: 150
Sex: Male
Weight: 75
Medications: Nil
Blood Pressure: 120/80
X=25mm/sec Y=10mm/mV 0 to 40(Hz)
(3X4 Sequential ECG Report)
<table>
<thead>
<tr>
<th>Specifications</th>
<th>Details</th>
</tr>
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<tbody>
<tr>
<td><strong>Principle:</strong></td>
<td>Bio-potential sensing by surface electrodes</td>
</tr>
<tr>
<td><strong>Configuration:</strong></td>
<td>Einthoven 12 Leads Simultaneous/Sequential</td>
</tr>
<tr>
<td><strong>Mode:</strong></td>
<td>Test / Patient</td>
</tr>
<tr>
<td><strong>Defibrillator Protection:</strong></td>
<td>Upto 8KV</td>
</tr>
<tr>
<td><strong>Lead Fail Detection:</strong></td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Gain (User Selectable):</strong></td>
<td>1, 2, 3, 4, 6, 8 &amp; 12</td>
</tr>
<tr>
<td><strong>Frequency (User Selectable):</strong></td>
<td>0/0.5/0.8 Hz to 25/40/150 Hz</td>
</tr>
<tr>
<td><strong>CMRR:</strong></td>
<td>115 dB</td>
</tr>
<tr>
<td><strong>Sampling Rate:</strong></td>
<td>500 samples per second</td>
</tr>
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</table>
| **Connectivity:** | Mobile-Mobile → MMS/Apps  
Mobile-PC → Internet/Bluetooth  
Unit-Mobile/PC → Bluetooth |
| **PCB Size:** | 3.5”(L) x 2.5”(B)x 0.5”(H) inches |
| **PCB Weight:** | 100 gms |
| **ECG Report Format:** | PNG/PDF |
| **Power Consumption:** | Acquisition ≈ 50mA @ 4.2V |
Salient features of Tele-ECG

- Significantly low cost instrument as compared to the commercially available instruments.
- Simultaneous acquisition of all the 12-leads
- Battery operated thereby ideal for use in rural area where there are frequent power-cuts.
- Operates on commonly available rechargeable mobile battery.
- Records ECG of hundreds of patients on single recharge.
- Lead Fail Alarm to indicate if any lead connection is improper.
- ECG is stored in a digital format for future reference.
- Can be used to study Heart Rate Variability (HRV) and perform its statistical analysis for the purpose of disease characterization.
- Can be used for study of Tridosha of Ayurveda: Vata, Pitta & Kapha.
- In city hospital; as the instrument is battery operated and small in size, it can be taken to the bedside of the patients and thus eliminates the need of carrying the patient to the ECG room.
- Several ECGs can be taken and stored. Once all ECG has been taken, all data can be transferred to the PC. Usually the city hospitals have LAN and thus all this data gets stored in the database and is available for future reference. The expert can see the report on his/her PC and give comments that will be available to all the doctors throughout the hospital, thus eliminating the need of taking out hardcopy of report for every patient.
- In case hardcopy is required, printout on A4 size paper can be taken from the printer attached to the Mobile/PC. This printout does not fade away with time as in the case of hardcopy from a thermal printer.
Typical Work flow of Tele-ECG in Rural Area

The patient approaches primary health care centre with intense chest pain

The rural doctor takes the ECG of the patient from 12-Channel Tele-ECG machine

ECG report is generated on the mobile phone. The rural doctor sends this report to the expert through WhatsApp/ MMS

This saves the patient from complications as the treatment is administered within the GOLDEN HOUR

The rural doctor administers the required emergency treatment and sends the patient to the nearest city hospital for further treatment.

The expert reads the report and talks back or sends his recommendations through SMS to the rural doctor
Typical Work flow of Tele-ECG in City Hospital

- A hospital with a Local Area Network (HMS) running through different Wards
- ECG Machines deployed in several wards
- Cardiologist may be only in ICCU or will be of limited availability
Tele-ECG Utility in Wards
Tele-ECG Utility in ICCU

Data Received

Name: Ashoke
Age: 25

Enter Diagnosis: Normal
Recommendation: Normal ECG, No further Action Required
Handheld 12-Channel Tele-ECG Instrument
“Cardiac Care – Just a Click Away”

Some of the prominent Licensees for “Handheld 12-Channel Tele-ECG Instrument” technology

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<thead>
<tr>
<th>SN</th>
<th>Party Details</th>
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<tbody>
<tr>
<td>1</td>
<td>Shri. Suresh</td>
</tr>
<tr>
<td></td>
<td>M/s Star Automations, Puducherry</td>
</tr>
<tr>
<td></td>
<td>Phone: +91978622233</td>
</tr>
<tr>
<td></td>
<td>Email: <a href="mailto:info@starautomations.com">info@starautomations.com</a> / <a href="mailto:admin@starautomations.com">admin@starautomations.com</a></td>
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<tr>
<td>2</td>
<td>Abhinav</td>
</tr>
<tr>
<td></td>
<td>M/s Cardea Labs, Bangalore</td>
</tr>
<tr>
<td></td>
<td>Phone: +91884551260 / +919911053168</td>
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<td></td>
<td>Email: <a href="mailto:abhinavfunda@gmail.com">abhinavfunda@gmail.com</a></td>
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Thank You