Technical Considerations for Prehospital 12 Lead Transmission
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National Institutes of Health
Resuscitation Outcomes Consortium

Joint Investigator
National Heart, Lung, and Blood Institute
IMMEDIATE Trial

Chief of Medical Operations
Dallas Area BioTel System

Co-Chief in the Section on
EMS, Disaster Medicine, and Homeland Security
Southwestern Medical Center
Objectives

- Definitions and Purposes of Real-time ECG Transmission
- Methods of transmission
- Equipment required for transmission
- Challenges confronting ECG transmission and reception
- Models of excellence
- Examples of difficulty in transmission
- Case presentation
- Summary
- Questions
The BioTel Numbers

- 1300+ Fire Medics with Central On-line Medical Command
- 15 Cities
- ~ 220,000 Responses
- ~ 100,000 transports
- ~ 120,000 non-transports
- ~ 1,700+ Cardiac arrests
- ~ 5,000 suspected ACS patients
The Future of EMS Appears Dimly Charted

“Sailing ships are safe in harbors, but that’s not what sailing ships are for…”
The emerging of a subspecialty: EMS Medicine
The Critical Point

♦ EMS is Medicine
The Evolving Scope of EMS

- They used to call us for a ride
- Now they’re calling us for an exam, to get checked out, to receive some services, and they’ll decide if they want further evaluation and care or not
- How do we deal with this evolution?
Medics are becoming “Out of Hospital Intensivists” and EMS Medicine may become a subspecialty.
Protocol Makes STEMI Patient Transfer Safer

BY FRAN LOWRY
Elsevier Global Medical News

New Orleans — Implementation of an organized transfer protocol has yielded evidence that moving high-risk ST-elevation myocardial infarction patients—even those who are in cardiogenic shock—from community hospitals for percutaneous coronary intervention can be done safely.

No deaths occurred during transfer of 746 STEMI patients for PCI using the Level 1 Heart Attack program, a standardized transfer protocol

IOM’s Four-States Seeks Emergency Care Crisis

Single-agency idea gets

WASHINGTON — Although the federal government should play a key role in repairing the nation’s emergency health care system, much of the job of reform may fall on the emergency care community itself, according to health experts, lawmakers, and federal officials who met at the Institute of Medicine’s final workshop on the future of emergency care.

Following previous regional workshops in Salt Lake City, Chicago, and New Orleans, the IOM conducted its fourth stop on a nationwide tour to disseminate the findings from this summer’s three landmark reports on the state of emergency care (ACEP News July 2006).

As we went around the country, we heard that this IOM report may be the most
Real-time ECG field transmission is the electronic sending of an electrical recording of a cardiac event to a hospital-based facility at the time of acquisition of the recording.
Earlier activation of ER & cath lab

**Purposes**

- Assist in strip interpretation
- Real-time quality control
Field Transmission Methods

FAX and Receiving Station

Email attachment

Ischemia management over Internet Protocol (I.P.)
Many monitors have only the capability for an “RJ-11” interface (phone line connection) which allows the sending of the 12 lead as a FAX connection.
This requires the ability to get a “dial tone” in earlier monitors.
Send 12 Lead ECG Fax by Digital Cell Phone
also works with regular FAX machines

- Works with analog fax machines
- Provides LaserJet quality faxes
- Works over digital cellular
- FDA 510k Clearance

For more information call
800-854-8865

Email sales@orange-box.com

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TelEnable™ Technology
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EMS-Enable™

Orange Box Portable Unit

- Easy to use
- Works on-site and in moving ambulances
- Compatible with Zoll, Welch Allyn, Medtronics, and most other 12-lead fax enabled monitors
- Faxes transmitted FREE of transmission and artifact error
- Battery powered rechargeable NiMH
- Rugged Pelican case
- Data encrypted during transmission to ensure patient privacy
- Dimensions: 8.5”w x 6.5”d x 3.75”h
- 1-year Factory Warranty
- FDA 510K Cleared
- Available with optional embedded digital phone

FDM Fixed Installation

- Easy to use
- Works in moving ambulances
- Compatible with Zoll, Welch Allyn, Medtronics, and most other 12-lead fax enabled monitors
- Faxes transmitted FREE of transmission and artifact error
- Data encrypted during transmission to ensure patient privacy
- Rugged extruded aluminum enclosure
- Runs on standard 12v DC power
- Dimensions: 5”w x 5”d x 2”h
- 1-year Factory Warranty
- FDA 510K Cleared
- Available with optional embedded digital phone
The “Tellular” Device
Intelligent RJ-11 Interface Environment

- Operating temperature range: -10°C to + 50°C
- Storage temperature range: -40°C to + 60°C
- Humidity: 5% to 95% (non-condensing)
Connectivity Options

GPS antenna

Power Supply

External Battery Backup Unit w/Power Supply (optional)

AC Power

Serial / RJ-11 Data

Optional fax connection

Computer (Internet, E-Mail, Fax, Data)

Phone (Voice)
Phonecell® SX5T-535C
Fixed Cellular Terminal

Features
- 1X RTT packet data* (requires Telular custom serial data cable)
- Circuit switched digital computer fax and data via RJ-11 phone cable (V.8, V.22, V.22bis, V.32, V.32 TCM, V.32bis TCM)*
- Group 3 analog fax (V.17, V.21, V.27ter, V.29)*
- Compatible with popular supplementary services including caller ID, call waiting, 3-way calling, and call forwarding*
- Automatic end-of-dialing (no SEND key)
- Supports up to five phones (5 REN)
- Easy set-up using DTMF telephone or PC
- Simple desktop or wall-mount installation
- 8k EVRC and 13k QCELP vocoder support
- Hotline

Connectivity Options

Specifications
Air Interface Standard
- TIA/EIA/IS-2000A

Transmit Power
- 200 mW (23dBm)

Frequency Ranges
- CDMA 800 824-849 MHz
- PCS (CDMA) 1900 1850-1910 MHz
- 869-894 MHz
- 1930-1990 MHz

Dimensions and Weight
- Metric (cm) 18.2 W x 5.1 H x 21.1 L
- U.S. (inches) 7.1 W x 2.0 H x 8.3 L
- 0.57 kg. (1.3 lb)

Environment
- Operating temperature range: -10°C to + 50°C
- Storage temperature range: -40°C to + 60°C
- Humidity: 5% to 95% (non-condensing)

Intelligent RJ-11 Interface
- Ringer equivalence number (REN) 5.0
- Dynamic echo cancellation
- PSTN Emulation

LED Indicators
- Power/Battery status
- Signal status
- Message status
- ON/OFF hook status

Connectors
- Two RJ-11 interface jacks for telephone, Group 3 analog fax, or analog data
- Data port for 1X RTT packet data or circuit-switched digital PC fax/data (optional serial data cable required)
- TNC antenna connector (50 ohms)
- SMA connector for GPS antenna
- AC power input jack

Antenna
- 2 dBi dipole antenna included
- Optional higher gain antennas

AC-to-DC Switching Power Supply (Included)
- Voltage: 110 - 230 VAC
- Frequency: 50/60 Hz

Emergency Battery Backup (Optional)
- 4 AA batteries provide up to 1 hour talk time and up to 3.5 hours of standby (Batteries Not Included)

External Battery Backup (Optional)
- Provides up to 3.5 hours talk time and up to 15 hours standby time

Approvals
- FCC ID: MTFCDMAFWT2004
- Verizon Wireless approved
Reasons why the ED can’t receive the 12 lead ECG

1. **ED Fax machine not turned on**
2. **ED Fax machine not set to receive**
3. **ED fax machine out of paper**
4. **ED fax machine dedicated line disconnected**

Thanks to
Terry Valenzuela, MD
Medical Director
Tucson Fire Department
January 25, 2007
Other monitors have the ability to connect "digitally" and then send the 12 lead to a FAX machine.
Advanced versions of the “FAX” Concept: The Digital “Receiving Station”
The quality of the images sent can be outstanding...
Name: 12-Lead 1
HR 159bpm Abnormal ECG **Unconfirmed**
ID: 101406124512 12/14/2006 12:48:15 PM wide QRS tachycardia
Patient ID: PR 0.000s QRS 0.188s Left bundle branch block
Incident ID: 615292 QT/QTc: 0.350s/0.586s
Age: 65 Sex: F P-QRS-T Aves: 0.0 118
REPORTING FEATURES:

- 12-lead ECG Report—receive patient data directly in the Emergency Department from a LIFEPAK 12 defibrillator/monitor in the field via landline, cellular or satellite phone.

- Trend Summary Report—includes patient information, vital sign values and trending graph.
- Vital Signs Summary Report – includes patient information, event and vital sign logs.
- Snapshot Report – includes patient information and 8 seconds of waveform data captured at the time of transmission.
Ischemia Management over Internet Protocol: 

The future is (just about) now!
Power to see the big picture
Features

- Adjustable ECG size and autogain
- 8.4 inch (diag.), 4-wave color display, largest in its class
- 12-lead data transmission
- Data collection and event summary
- Strip chart printer
- Automated self-tests
- Operational checks
- Individual, adjustable volume of QRS beeper, voice prompts, and alerts
- Lithium ion battery (2 bays) with capacity gauge
- “Ready-for-Use” indicator
- Configuration mode
- Diagnostic mode
- Carrying Case
- Bed rail hook
- AC and DC power modules, optional
- Ambulance mounting bracket, optional

Measures
12.4 x 7.7 x 11.7 inches
12-Lead ECG

Input: 12-Lead cable: leads I, II, III, aVR, aVL, aVF, V1-V6

Display View: All 12-lead ECG waves display simultaneously

Strip Record: All 12-leads print on the strip chart printer in 3x4 format

Transmission: CompactFlash data card; cellular dial-up Internet connection
Philips HeartStart 12-Lead Transfer Station
Product Information

Point-of-care data transmission application
Philips HeartStart 12-Lead Transfer Station

HeartStart 12-Lead Transfer Station software, installed on an Internet-connected server, allows you to forward a 12-lead ECG report taken in the field from your HeartStart MRx monitor/defibrillator to the receiving hospital. This gives the Emergency Department and/or Catheterization Lab a head start in preparing for patient care while the patient is still en route, which is beneficial for many reasons:

- An emergency physician can give more informed treatment advice to the paramedic in the field
- The patient can be routed to the most appropriate hospital
- Precious hospital treatment minutes are saved, reducing myocardium damage
- Diagnosis and treatment may be better because it will be based on a true presenting rhythm before it has been temporarily improved by paramedic-administered drugs
INTERNET

FAX to ER

Email to ER and PDA

Send to Digital Receiving Station
Physio is STILL planning to release their upgraded STEMI gateway “soon”...
Transmission capability is OPTIONAL!!!
ECG Transmission From Ambulance Cuts Time To Direct Clot Removal

Science Daily — When emergency medical technicians (EMTs) wirelessly transmit electrocardiograms (ECG) directly to a cardiologist’s hand-held device, heart attack patients can potentially receive direct clot removal in half the usual time, according to cardiologists at Duke University Medical Center and NorthEast Medical Center, Concord, N.C.

Cutting this "door-to-reperfusion" time is critical, the cardiologists said, because the sooner a patient suffering from a heart attack receives an artery-opening procedure, the more likely heart muscle can be saved, and that the patient will potentially derive a survival benefit.

While the American College of Cardiology (ACC) and the American Heart Association recommend that patients have their arteries opened directly within 90 minutes of arriving at the hospital — the NorthEast Medical Center team was able to cut that time to 50 minutes. The national average "door-to-reperfusion" is about 100 minutes, the researchers said.

The results of the pilot project were presented March 13, 2006, by Duke Clinical Research Institute cardiology fellow George Adams, M.D., during the 55th annual scientific sessions of the ACC in Atlanta. His study is one of five finalists for an ACC Young Investigator Award.

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Heart Disease
Signs, symptoms for men & woman. Learn more at prevention.com.
www.Prevention.com

Improve HDL up to 50%
Raise HDL Cholesterol Guaranteed The Doctor-Recommended HDL Product
www.arizonapharmaceuticals.com

Heart Stent Lawsuits
Drug coated stents linked to blood clots & heart attacks.
www.youhavealawyer.com/stents

Herpes Transmission
How Genital Herpes is Spread & How to Lower Your Risk of Passing it on
www.managherpes.com

Prevent Strokes
Flush out excess Fibin, lowers the frictional resistance to blood flow
www.instituteforvibrantliving.com
And yet ANOTHER way to get connected:

onBoard™ Mobile Gateway 1000
Technical Specifications

Compatibility
- Operates with WiFi certified client devices (Intel Centrino Certified)
- Supports all client operating systems

WAN Wireless Networking
- Plug-in compatibility with current wireless WAN standards including GPRS, EDGE, UMTS, 1X RTT, EV-DO, UMTS TDD (IP Wireless), Flash-OFDM (Flexton)
- Future compatibility with new wireless WAN standards such as UMTS HSDPA, 802.16, EVDV, EVDO Rev A, 802.20
- Integration with other technologies through 802.11, Ethernet, USB
- PPP (RFC 2516)
- Mobile IP Support (Optional)

LAN Wireless Networking
- Ethernet
- IEEE 802.11b/g (AP and client)

Power Management System
- Auto Power-up
- Graceful Power-down

Dimensions
- Width: 10.79 in / 27.4 cm
- Depth: 8.79 in / 22.3 cm
- Length: 2.37 in / 6.0 cm

Weight
- 6.5 lbs / 2.9 Kg

Platform
- Pentium
- 20G storage
- Linux
- OSGI
- GPS based reporting based on NMEA 0183 standard (Optional)

In Motion Technology, Inc.
Queen's Court
Suite 250
625 Agnes Street
New Westminster, BC
Canada V3M 5Y4
Telephone: (604) 523-2371
Fax: (604) 523-3286
So, who is transmitting 12 leads, and who isn’t?
<table>
<thead>
<tr>
<th>Location</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portland</td>
<td>Yes, with 65% success rate</td>
</tr>
<tr>
<td>Milwaukee</td>
<td>Yes, with 65% success rate</td>
</tr>
<tr>
<td>Dallas</td>
<td>Yes, but problems with different agencies</td>
</tr>
<tr>
<td>Raleigh</td>
<td>Yes, but Nextel problems</td>
</tr>
<tr>
<td>Seattle</td>
<td>Yes when possible</td>
</tr>
<tr>
<td>Tucson</td>
<td>Yes for 19 years</td>
</tr>
<tr>
<td>Nashville</td>
<td>Yes</td>
</tr>
<tr>
<td>Houston</td>
<td>Yes</td>
</tr>
<tr>
<td>Atlanta</td>
<td>Yes</td>
</tr>
<tr>
<td>Columbus</td>
<td>Yes</td>
</tr>
<tr>
<td>City</td>
<td>Response</td>
</tr>
<tr>
<td>-----------------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>Philadelphia</td>
<td>Not yet, working on it, about to roll out 12 leads</td>
</tr>
<tr>
<td>Fort Worth</td>
<td>Not yet, working on it</td>
</tr>
<tr>
<td>San Diego</td>
<td>Not yet, working on it</td>
</tr>
<tr>
<td>Cleveland</td>
<td>Not yet, working on it</td>
</tr>
<tr>
<td>El Paso</td>
<td>Not yet, working on it</td>
</tr>
<tr>
<td>New Orleans</td>
<td>Not yet, working on it</td>
</tr>
<tr>
<td>Austin</td>
<td>Not yet, working on it</td>
</tr>
<tr>
<td>Richmond</td>
<td>Not yet, working on it</td>
</tr>
<tr>
<td>New York</td>
<td>Not yet, working on it</td>
</tr>
<tr>
<td>L.A.</td>
<td>Not yet, thinking about it</td>
</tr>
<tr>
<td>City</td>
<td>Response</td>
</tr>
<tr>
<td>--------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Honolulu</td>
<td>No, medics well trained, plus short transport times</td>
</tr>
<tr>
<td>Miami</td>
<td>No, medics well trained, plus short transport times</td>
</tr>
<tr>
<td>Phoenix</td>
<td>No, medics well trained, plus short transport times</td>
</tr>
<tr>
<td>Indianapolis</td>
<td>No, medics well trained, plus short transport times</td>
</tr>
<tr>
<td>Chicago</td>
<td>No, medics well trained, plus short transport times</td>
</tr>
<tr>
<td>Boston</td>
<td>No, medics well trained, plus short transport times</td>
</tr>
<tr>
<td>San Francisco</td>
<td>No, and don't have 12 leads</td>
</tr>
<tr>
<td>Charlotte</td>
<td>No</td>
</tr>
</tbody>
</table>
Email Addresses of the “Yes” Responders from the Eagles Consortium

Ray Fowler, Dallas: snerd@earthlink.net
Terry Valenzuela, Tucson: terry@aemrc.arizona.edu
David Persse, Houston: david.persse@cityofhouston.net
Brent Myers, Raleigh: brent.myers@co.wake.nc.us
Eric Ossman, Atlanta: eossman@emory.edu
Ron Pirallo, Milwaukee: pirrallo@mcw.edu
Corey Slovis, Nashville: slovis.corey@vanderbilt.edu
Dave Keseg, Columbus: dkeseg@iwaynet.net
Jonathan Larsen, Seattle: jonathan.larsen@seattle.gov
Don’t make the mistakes that we’ve made…

…*make some of your own!!*
## The Future of Field Critical Care

**Name:** HERMANDEZ  
**ID:** 101506021250  
**Patient ID:** PR 0.116s  
**Incident ID:** 615322  
**Age:** 66  
**Sex:** M

<table>
<thead>
<tr>
<th>Lead</th>
<th>HR (bpm)</th>
<th>Abnormal ECG</th>
<th>PR (ms)</th>
<th>QRS (ms)</th>
<th>QT (ms)</th>
<th>Other Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>12-Lead</td>
<td>149</td>
<td>Abnormal ECG <strong>Unconfirmed</strong></td>
<td>PR 0.116s</td>
<td>QRS 0.068s</td>
<td>QT 0.284s/0.415s</td>
<td>Nonspecific ST and T wave abnormality</td>
</tr>
</tbody>
</table>

**Comments:**

**Medtronic, Inc.**
Some assorted ruminations...
We cannot assume that medics maintain a high degree of skill in this area.

Must be submitted to QA and training.

Especially for complex rhythms and brady rhythms.
We must develop a quality control path for interpretation and management of more difficult rhythms.
The end users in the system must always remember that technical capability NEVER replaces good sense clinical care.
ECG Transmission is a piece of the puzzle, not the puzzle itself.
Understanding tachycardia, for example
Baby = (220 - 0) = 220

Snerd = (220 - 53) = 167

Aunt Minnie = (220 - 70) = 150
What is this rhythm?

Correct answer: “This HAS to be an arrhythmia”
What is this rhythm?

Correct answer: “It COULD be sinus tach”

220 – 55 = 165
...and what Medics MUST know:

Remember that patients having near maximum sinus tachycardia at rest are dying!
REAL Time
Data Transfer
Tucson should be live with one of the first implementations in the near future using a city-wide router system.
What ELSE can you capture?

- Every single heartbeat on every patient put onto a monitor.
21:44:54 Paddles

21:45:07 Paddles

21:45:19 Paddles Medtronic, Inc.
Synthesis
The shortest book ever written:

Promises kept by hardware and software vendors
Make SURE that you see the equipment and software running, AS PROMISED, BEFORE you buy it!
The Job of I.T. People is to say “NO!”

Imagining what COULD be is not necessarily in their line of work.
Whining about the problem doesn’t work
Legacy Systems will always be a problem, requiring “work-arounds”
Can we make it make sense?

Will we leave a “lasting” impression?
Questions?
Comments?
Eructations?