Currently: Lifespan Monitoring for ECG Cables

Sophia Anderson¹, Sangyoon Back², Vivian Lu¹, Arush Sharma¹, Dawn Jorgenson², Christopher Zimny², Mark Fiebig², Edward Kompare², Steve Phillips²
¹UW Mechanical Engineering, ²Philips Automated External Defibrillator Team (Bothell, WA)

THE NEED

- 28.5M+ EMS dispatches/year in US¹, 16% are due to chest pain²
- Defibrillators and electrocardiogram (ECG) cables are used to conduct pre-hospital ECG in emergency medical services (EMS)

ECG cables endure a variety of stresses during use, including storage in saddle bags

8 Years
2-3 Years
10 min

Defibrillator monitor lifespan² ECG cable lifespan² Time to replace failed cables³ ⁴

Receiving a pre-hospital ECG reduces 30-day mortality rates from 8.2% to 7.4%⁵

THE MARKET

Table 1. Stakeholders impacted by ECG cable failures

<table>
<thead>
<tr>
<th>Primary Stakeholders</th>
<th>Secondary Stakeholders</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Biomedical Equipment Technicians</td>
<td></td>
</tr>
<tr>
<td>- Hospital Risk Department</td>
<td></td>
</tr>
<tr>
<td>- Clinical Users</td>
<td></td>
</tr>
<tr>
<td>- Medical Device Companies</td>
<td></td>
</tr>
<tr>
<td>- Emergency medical services</td>
<td></td>
</tr>
<tr>
<td>- Patients</td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Core functions vs. current solutions

<table>
<thead>
<tr>
<th>Core Functions</th>
<th>Current Solutions</th>
<th>AED Daily Self Test</th>
<th>Manufacturer Recommended PM</th>
<th>Single-Use Cables</th>
<th>Replace Cables at Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alerts When Replacement is Needed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Detects Premature Cable Degradation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Identifies When Cable is Put Into Use</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Benchmarking

- No current solutions for lifespan monitoring
- Most common method is replacing at failure
- Masmino Co. has patents to monitor status of SPO2 cables⁶ ⁷
  - Sensor attachment
  - Formulas based on prior number of uses

THE NEED STATEMENT

A way to address ECG cables being used past their lifespan in EMS and hospital settings so that patient care is performed with equipment that operates within manufacturer specifications.

Core Functions

An analysis of current solutions’ ability to meet the following core functions is shown in Table 2:

Table 2. Core functions vs. current solutions

<table>
<thead>
<tr>
<th>Core Functions</th>
<th>Current Solutions</th>
<th>AED Daily Self Test</th>
<th>Manufacturer Recommended PM</th>
<th>Single-Use Cables</th>
<th>Replace Cables at Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alerts When Replacement is Needed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Detects Premature Cable Degradation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Identifies When Cable is Put Into Use</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Design and Prototype

Design Constraints:

- Monitor wear and tear at cable connector points
  - Majority of cable failures occur at strain reliefs
- Additive design
  - No changes to current cable design or defibrillator software
- Intuitive, simple application method
  - Applied by user in clinical setting

Prototype Iterations:

1. Color degrading material
  - Difficult to engineer material to change color at correct time

2. Sacrificial wire coating
  - Application of these materials not suitable for EMS settings

Final prototype design:

- Sacrificial wire endures stresses put on cables
- Provides audiovisual alert when cable is nearing the end of its lifespan
- Electronic fail-safe on trunk cable connector
- Non-electronic sacrificial wire on lead end

Next Steps

- Designed cable failure test to determine which solid wire gauge will break (24, 26, 28, 30, 32)
- Philips testing standard
  - Motor speed: 30 cycles/min
  - Tension: 1.2lbs
- ECG cable guaranteed to survive 5000X flex at 45 degrees in each direction

Design Testing

Based on our testing criteria, we selected the 30 gauge as the sacrificial wire.

Table 3. Primary customer pains and gains

<table>
<thead>
<tr>
<th>Pains</th>
<th>Gains</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Unknown equipment status</td>
<td></td>
</tr>
<tr>
<td>- Risk of procedural failure</td>
<td></td>
</tr>
<tr>
<td>- Assured equipment function</td>
<td></td>
</tr>
<tr>
<td>- Reduced workload</td>
<td></td>
</tr>
</tbody>
</table>

Next steps

- Improve resting reproducibility
  - More cable failure tests to determine the average number of cycles until the wire breaks
- Tension test of 135 N
- Improve portability
  - Streamline electronics module in trunk cable design
- Improve user friendliness and comfort
  - Interview users (EMS technicians)
  - Explore methods of device attachment

Acknowledgements

We would like to thank the UW EIH faculty team of Soyoung Kang, Jonathan Liu, Eric Seibel, Kathleen Kearney and Shawn Swanson for their assistance with our project. Additionally, to the Buerk Center Holloman Health Innovation Challenge for prototype funding.