Correlating data from different sensors to increase the positive predictive value of alarms: an empiric assessment

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High false alarm rate is a well-described phenomenon in intensive care units. Our goal is to develop an algorithm that replicates the ways clinicians discriminate artifact from real signal, and thus suppress false alarms.

### Background

- Alarm systems in clinical medicine suffer from a very high false positive rate.
- False positive alarms have multiple causes, including 'low threshold' settings, motion interference, and false signals generated from a variety of clinical activities.
- The high false alarm rate cause alarm fatigue - a phenomenon where practitioners come to ignore alarms.

### The Proposed Solution

- Advanced software could be programmed to replicate the logic that caregivers utilize to discriminate real conditions from artifact.
- This software can increase the clinical utility of alarms by making the monitor analyze data across sensors to verify the alarm condition.

### Methods

- Philips Event Surveillance software was installed on the monitors of a 10 bed cardiac surgery Intensive Care Unit.
- It was operational in parallel with the factory installed monitors for the purpose of determining the incidence of true positive events as compared with false positive events.
- Five clinically important alarm scenarios ('smart alarms') were programmed in to the bedside monitors using the Event Surveillance software.
- When any alarm (factory installed or event surveillance software) was triggered, a log of monitor data from the event was stored in the central monitoring station.
- Every day, the log file of events from the previous 24 hours was reviewed with the ICU physician (attending or fellow), and all events were classified.

### Results

<table>
<thead>
<tr>
<th>Group</th>
<th># Events</th>
<th>Tru Pos (pts)</th>
<th>FP art</th>
<th>FP def</th>
<th>PPV</th>
<th>FN</th>
</tr>
</thead>
<tbody>
<tr>
<td>SVT+BP</td>
<td>221</td>
<td>170 (10)</td>
<td>17</td>
<td>22</td>
<td>0.8</td>
<td>9 (7)</td>
</tr>
<tr>
<td>Vtach+BP</td>
<td>1</td>
<td>1 (1)</td>
<td>0</td>
<td>0</td>
<td>1.0</td>
<td>0</td>
</tr>
<tr>
<td>LVshock</td>
<td>42</td>
<td>34 (6)</td>
<td>8</td>
<td>0</td>
<td>0.81</td>
<td>1</td>
</tr>
<tr>
<td>Tamponade</td>
<td>24</td>
<td>1 (1)</td>
<td>23</td>
<td>0</td>
<td>0.04</td>
<td>1</td>
</tr>
<tr>
<td>Hypovolemia</td>
<td>29</td>
<td>8</td>
<td>21</td>
<td>0</td>
<td>0.27</td>
<td>2</td>
</tr>
</tbody>
</table>

For example, tachycardia associated with a precipitous decline in blood pressure is clinically different and more significant than tachycardia associated with no change in blood pressure.

### Conclusions

- The data we have collected suggests that information correlated across sensors might generate more reliable alarms.
- Correlation of information across sensors can be used to detect and suppress artifact in a manner similar to how human operators analyze data.
- Simple algorithms can generate alarms with a much higher positive predictive value than simple single-sensor alarms.
- The ability to correlate information across sensors may allow the monitor to detect important clinical conditions in manner similar to human operators.