Preventing ECMO Patient Harm While Using Remote Monitoring: A Case Report

Emily Thunstrom
Disclosure

• I have no disclaimers
Outline

• Alarms
• Perfusion alarm management
• ECMO Alarms and Rounding
• Case Report
• Conclusion/Possible Improvements
Clinical Alarms

- Audible and Visual Clinical Alarms
  - First indication of immediate or potential adverse conditions

- Alarm Information
  - Local
    - Pump
    - Viper
  - Transmitted to a remote location (LiveVue)

- Alarm Levels
  - High priority- an alarm that requires immediate attention to equipment or patient
    - Tight alarm limits
  - Low Priority- Potential problems with the equipment or other non-life-threatening situations
    - Relaxed alarm limits
Alarm Parameters

Anesthesia Monitor

Alarms

- Heart Rate
- MAP
- CVP
- PAP
- Skin Temp
- Naso Temp
- SPO2
Alarm Parameters

Spectrum VIPER

Alarms
- Art Flow
- Venous Flow
- Arterial Saturation
- Venous Saturation
- HCT
- Sweep
- FiO2
- PaO2
- PCO2
- Compliance Alerts (CA)
Nuisance Alarms

• Alarms that are inadvertently triggered or have no clinical significance
  – Examples
    • Arterial and Venous Line Pressure
      – zeroing transducer
      – repositioning the patient
    • CVP
      – medication
  • EKG and Heart Rate
    – lead off
  • SPO2
    – signal
    – no or poor signal
  • PaO2 and PCO2
    – calibration
    – malposition
  • FiO2
    – weaning

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Morgan Stanley Children's Hospital
Decreasing The Number Of Nuisance Alarms

- Create Situational Alarms
  - Alarms that needs to be adjusted based on clinical situation
    - Blood Flow
      - Weaning
    - Blood Temperature
      - Cooling Protocol (34 C)
- Eliminate Alarm Repetition
  - Alarms that can be incorporated into other alarms
    - Blood Flow (ECMO)
      - Arterial Line Pressure
      - Venous Line Pressure
    - Arterial Saturation
      - FiO2
      - PaO2
Perfusion Alarm Management

- Pump
  - Built-in Alarms
  - Spectrum Medical (Fort Mill, SC)
  - VIPER (Variable Input Perfusion Electronic Record)
    - Pump mounted computer monitor
      - Data collection from integrated and external devices
      - Critical Care Parameters
        - Arterial flow, Venous flow, Arterial Saturation, Venous Saturation, PaO2, PCO2
      - Compliance Alerts – Pop-up notification of clinical parameter outside of predetermined range
Perfusion Alarm Management

• Vision
  ➢ Hospital server based data processing system
    ❖ Compliance reports
    ❖ Transfer of patient records (end of case and real time)
    ❖ Storage and retrieval systems for complex clinical data sets.
  ➢ Limited value for real time clinical performance and improved patient care

• LiveVue
  ➢ Allow for the remote viewing of live clinical data from a remote location
  ➢ Allows for monitoring of multiple patients
Compliance Alerts (CA)

- Compliance Alerts – Pop-up notification of clinical parameter outside of predetermined range
- Devices include: patient monitor, heart lung machine, Critical care parameters, ancillary devices (iStat, Hemocron, cerebral oximetry)
- Acknowledge the alert “OK” or “Snooze” the alert and continue in a non-compliance mode
Utilizing CCPs and CA with ECMO

- ECMO (Rounding)
  - Want audible alarm for critical parameters
    - High priority alarm
    - Quick response
  - LiveVue Remote monitoring
    - Visual alarm
    - Multiple patients
ECMO Alarms (Rounding)

- High Priority
  - Blood flow
  - Arterial saturation
  - Venous saturation
  - Blood temperature
  - Delta Pressure
ECMO Alarms (Rounding)

- Low Priority
  - Line pressure
    - Pre-Oxygenator
    - Post Oxygenator
    - Venous pressure
  - HCT
  - PaO2
  - FiO2
  - Sweep
  - Heart Rate
  - SPO2
  - MAP
  - CVP
  - PAP
Remote Monitoring

ECMO Handoff

LiveVue
Remote Monitoring

![Remote Monitoring Image]

- **Blood Gas**
  - Location: Venous
  - Time: 05/24/2016 11:44:18
  - pH: 7.38
  - pCO2: 38
  - pO2: 33
  - HCO3: 21.4
  - BE: -3.8
  - O2 Sat: 60.3
  - Hct: 43
  - Glu: 0.43

- **Procedure**
  - Cardioplegia - Venovenous ECMO

- **Patient Information**
  - Patient from Lincoln Medical Center - Bronx

- **ECMO Display**
  - **Hct**: 22%
  - **SaO2**: 98%
  - **SvO2**: 78%
  - **Pump Flow**: 3200 LPM
  - **Art Flow**: 4370 LPM
  - **Van Flow**: 4250 LPM
  - **Cardiac Index**: 5.18 L/min
  - **Bld Temp**: 37.5°C
  - **PO2**: 23.9 mmHg
  - **PO2**: 577 mmHg
  - **Sweep**: 5.55 L/min

- **Additional Parameters**
  - **FiO2**: 21%
  - **Delta Press. Venous Press**: -86 mmHg
  - **ECG HR**: 96 bpm
  - **SpO2**: 91%
  - **RPM**: ---
  - **ABP Mean**: 67 mmHg
  - **CVP**: 177 mmHg
  - **P1**: 156 mmHg

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High Priority - Tight alarm limits

Low Priority – Relaxed alarm limits
Perfusion ECMO Rounding Protocol

- Beginning of each shift
  - Bedside Shift and SBAR Checklist

- Rounding
  - 2-4 hours, patient specific
  - Always available via pager/cellphone

- One person always in house for all adult ECMO Coverage
  - Additional person in house for each floor of pediatric ECMOs
**Nursing ECMO Circuit Checklist**

**Power**
- Battery charge light is on
- A/C power is connected to emergency red outlet
- Voltage/ battery life confirmed
- Proper mode set (Free/ ICU)
- Confirm proper RPMs and flow
- Confirm proper sweep and FDO₂

**Settings**
- All chain intervention/ servo regulations are off
- Global/manual override is off
- Bubble detection regulation is off (ask perfusion)
- Flow limits set 1 LPM above and below
- Press. limits set 50 mmHg above and below (ask perfusion)

**Alarms**
- Hand crank available
- 4 clamps available
- Back-up cart available
- Spare console available and charging
- Oxygen tank available

**Circuit**
- Trace circuit (no kinks present)
- Circuit tubing lines secured
- Cannula marking noted/ secured well/ dressing clean
- Visually inspect for clots in the circuit
- Connections tie-banded
- Oxygen tubing connection secure
- Heat exchanger connected/water level appropriate

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**Circuit Trouble Shooting Card**

<table>
<thead>
<tr>
<th>Trouble</th>
<th>Possible Cause</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circuit disconnect</td>
<td>Displaced tubing</td>
<td>Clamp, reconnect (air free) resume flow, contact perfusion</td>
</tr>
<tr>
<td>Oxygenator blood leak</td>
<td>Broken fiber (slow leak)</td>
<td>Contact perfusionist for change-out</td>
</tr>
<tr>
<td>Blood not oxygenated</td>
<td>Check gas lines from wall and blender</td>
<td>Reconnect, contact perfusionist</td>
</tr>
<tr>
<td>Delta pressure change</td>
<td>Possible oxygenator failure</td>
<td>Contact perfusionist</td>
</tr>
<tr>
<td>Temp alarm</td>
<td>Check heater/cooler</td>
<td>Contact perfusionist</td>
</tr>
<tr>
<td>Clotting in circuit</td>
<td>Inadequate anti-coagulation</td>
<td>Monitor Delta-Pressure, contact perfusionist</td>
</tr>
</tbody>
</table>

**PERFUSION 305-8085**
Case Report Patient H & P

- 78 year old Male
- CHF
- Cardiogenic Shock
- Peripheral Vascular Disease
- EF 35-45%
- Severe AI

- Moderate MR
- Aortic and Mitral Valvuloplasty
- Bypass 264 minutes
- X-Clamp 202 minutes
Case Report

- Full Flow 4.95 L/min
- Failure to Wean
- VA Fem Fem ECMO Initiated
  - 17 Fr Arterial Biomedicus RFA
  - 23 Fr Venous Biomedicus RFV
  - 8 Fr Maquet Distal Perfusion Catheter
- NIRS Placed on both legs and head
Case Report

- After transport to CTICU from the OR, patient left on oxygen tank.
- Oxygen tank ran out after approximately four hours, yielding no gas flow
- Viper system alarmed via LiveVue remotely in the perfusion pump room
- Viper showing arterial saturation dropping to 64% for 4 minutes, and back up to 100% within 8 minutes.
NIRS showing that cerebral saturations did not drop from baseline
Case Report

- The patient was successfully weaned off ECMO after 30 days, and eventually discharged on day 138.

- Before discharged, a complete neurological exam was done and showed no deficits.
Conclusion

- ECMO Safety Standards

- What we do now for future prevention
  - Transport checklist
Post-Transport Checklist

Clock: 10:17:33 Apr/06/17

Stage
- Patient
- Initiate ECMO
- Post-Transport
- SBAR, Handoff
- Shift Checklist
- Post ECMO

Oxygen - Switch from O2 tank to O2 Blender. Confirm yellow and green gas lines to wall, Trace O2 line from blender to oxy

Power - Confirm Pump is on AC power on Cardioplegia display, trace power cord to emergency Red outlet

Heater Cooler - Recirculate water before connecting water lines, Confirm desired temp is set and achieved, line valves are open

Tubing - secured to the bed, Confirm tubing labels are present (i.e. Ao, FA, FV, Ax, etc). Confirm tie-bands present

Connectivity - Confirm all “Devices” are connected (i.e. Intellivue, Cardioplegia, VIPER green connectivity)

Distal Perfusion - Confirm distal pulse, evaluate for distal perfusion catheter if necessary

Confirmation - All settings are correct, document transport in “intervention” nurse handoff is completed

Patient Details
Pre-Op Stats
Personnel
Priming
Disposables
Equipment
Checklists

Operation Manager
Events
Admin

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AMAZING THINGS ARE HAPPENING HERE

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Possible Improvements: Smart Alarm Technology

- Ability to set alarm priority
  - Low, medium, high
  - Assign different audible alarms
- Couple Alarms
  - Increase CVP and MAP and decrease in blood flow
    - Tamponade physiology
- Time Sensitize alarms
  - MAP < 50 mmHg for > 20 sec
- Direct notification system
  - Pager
  - Cell Phone
Thanks!
Questions? Comments?