CPB FMEA #36 Accidental, non-drowning hypothermia

Friends-

Accidental hypothermia (AH) is a rare occurrence and the few perfusionists who have such a case may only have one shot in their entire career of getting this right. I have never pumped an AH case before, but I saw a few cases back in the early 90s (mountain climbers caught on the top in an ice blizzard).

Malignant hyperthermia (MH) is also rare, but I have pumped three of those MH arrest cases in the last 35 years. Which shows that the longer you hang around, the more likely something like this will come along. When I did those MH cases, I had no guidelines to help me. So I wrote some articles about pumping MH arrest cases and did an FMEA to act as an institutional memory for future perfusionists. The purpose of this AH FMEA is a lot like that. Also, I limited this FMEA to AH without drowning. Drowning has a different and more profound impact on patient survival that deserves its own FMEA.

Since I have never actually pumped one of these AH cases I was aided greatly by the FMEA volunteer reviewers. In particular I would like to thank Thore Pedersen who provided methods developed at the program in Tromsø, a Norwegian town above the arctic circle. And to Thomas Muziani and Don Floyd for their valuable input as well.

The articles I read on AH offer very little in the way of perfusion techniques to revive AH patients. They just said that the pump is used for rewarming. But as you all know, the means that the perfusionist uses to normalize the physiology and deal with the reperfusion injury may be the key to survival. My cases involving MH had profound problems with electrolyte and fluid imbalances and reperfusion issues like those that can be expected in severe hypothermia patients.

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FAILURE: Failure to revive a patients from accidental , non-drowning severe hypothermia.

EFFECT:

1. De-ranged electrolytes including:
2. Low pH
3. Low bicarbonate (HCO3)
4. Negative base balance
5. High potassium (K+)
6. High sodium (Na+) usually due to excessive Na HCO3 administration during pre-pump resuscitation.
7. High osmolarity: >300 milliosmoles usually due to hypernatremia.
8. Excess administration of epinephrine, vasopressin and calcium may prevent adequate ECLS perfusion and aggravate reperfusion injury.
9. Pulmonary edema, partially from pre-pump resuscitation fluid administration.
10. Systemic capillary leak syndrome resulting in hypotension and anasarca.
11. Failure to wean from CPB.
12. Extended ECLS support required after CPB.
13. Coagulopathy.
14. Extensive brain and other organ damage.
15. Death

CAUSE:

Swiss hypothermia classification:

I: Awake and shivering (usually 35-32 C).

II: Reduced conscience, no shivering. (32-28 C).

III: Unconscious, no shivering & w/ Vital Signs (VS) (28-24 C).

IV: No VS. (<24).

V: Dead by hypothermia. (< 13 C).

Accidental hypothermia classification:

Mild; > 34C (932.F), <36C

Moderate; >30C (86F), <34C

Severe; <30C

1. Usually environmentally induced including immersion in water but not submersion (drowning).
2. Frequent contributing factors:
3. Trauma
4. Drug overdose
5. Alcohol consumption
6. Hypoglycemia
7. Advanced age (adults)
8. Low body mass index (children)
9. Non-drowning hypothermia slowly precipitates bradycardia to cardiac arrest limiting organ (brain) hypoxia compared to drowning.
10. Poor perfusion during severe hypothermia leads to physiologic disturbances that may or may not be reversible during CPB.
11. Excessive osmolarity from NaHCO3 or mannitol administration may result in organ damage: >320 = kidney damage, >360 = brain damage.
12. Reperfusion and rewarming with CPB may precipitate a lethal reperfusion injury.

PRE-EMPTIVE MANAGEMENT:

1. There is no pre-emptive management to prevent accidental hypothermia.

2. Peripheral vascular vasoconstriction may make arterial pressure monitoring and pulse oximetry unreliable.

3. Prior to CPB, use slow, methodical manual or automated chest compressions (adult 40-50 bpm) to provide better peak pressure to the brain with a hypothermic vasoconstricted periphery.

4. Consider cerebral oximetry monitor even though a normal baseline is unobtainable.

5. Consider taking patient to surgical suite to implement extracorporeal support with all the anesthesia and CPB accoutrements.

MANAGEMENT:

1. Prepare for sternal, femoral (adult) and neck (child) cannulation. Unknown anatomy may prevent femoral or neck cannulation.
2. Do not delay ECLS to wait for arterial monitor or central line placement.
3. Opt for CPB equipment over ECMO if time allows. CPB offers greater flexibility for temperature control, ZBUF use and circuit volume manipulation.
4. Use esophageal thermometer for core temperature measurement.
5. With a functioning peripheral arterial monitor; MAP ≥50 torr goal (adult).
6. Perform ongoing tests for electrolytes and osmolarity.
7. Electrolyte rebalance; use aggressive ZBUF of ½ NS w/ 50 mEq NaHCO3/L added. Reduces K+ and restores HCO3 without increasing osmolarity from hypernatremia.
8. Monitor venoarterial CO2 gradient to assess CO2 tissue retention; <15 torr goal.
9. Hemodilute to 25 % Hct to improve capillary perfusion during rewarming.
10. If no early return of cardiac function, perfuse lungs with gentle CPR or open massage. This helps to normalize pulmonary vasculature physiology.
11. Don’t fully rewarm; target temperature = 33C +/- 1. Maintain mild hypothermia for 24-48 hours.
12. If ventricular tach (VT) or V fibrillation (VF) is present, defibrillation should be attempted once. Proper time/temperature to attempt defib is unknown, but repeat attempt at 30C.
13. During hypothermia, drug metabolism may be reduced. Medications (epinephrine, vasopressin) given during earlier resuscitation efforts could accumulate to toxic levels in the peripheral circulation.
14. Consider phenylephrine, lasix, steroids during rewarming.
15. Rewarm at 1 degree/15 minutes or slower if correction of physiology lags.
16. Prepare to implement ECMO for at least 24 hours after rewarming and after the correction of electrolytes and other physiology.

RISK PRIORITY NUMBER (RPN):

A. Severity (Harmfulness) Rating Scale: how detrimental can the failure be:

1) Slight, 2) Low, 3) Moderate, 4) High, 5) Critical

(I would give this failure a Critical RPN, 5.)

B. Occurrence Rating Scale: how frequently does the failure occur:

1) Remote, 2) Low, 3) Moderate, 4) Frequent, 5) Very High. (The Occurrence is Remote. So the RPN would be a 1.)

C. Detection Rating Scale: how easily the potential failure can be detected before it occurs:

1) Very High, 2) High, 3) Moderate, 4) Low, 5) Uncertain. (The Detectability RPN equals 5. There is no way for a perfusionist to detect if a patient will develop accidental hypothermia.)

D. Patient Frequency Scale: 1) Only a small number of patients would be susceptible to this failure, 2) Many patients but not all would be susceptible to this failure, 3) All patients would be susceptible to this failure. (Only patients who have already developed accidental hypothermia would be at risk. So the Frequency RPN would be 1.)

Multiply A\*B\*C\*D = RPN. The higher the RPN the more dangerous the Failure Mode.

The lowest risk would be 1\*1\*1\*1\* = 1. The highest risk would be 5\*5\*5\*3 = 375. RPNs allow the perfusionist to prioritize the risk. Resources should be used to reduce the RPNs of higher risk failures first, if possible. (The total RPN for this failure is = 5\*1\*5\*1 = 25.)