CPB FMEA # 29 Hyperkalemia

Friends-

This is the next FMEA concerns preventing hyperkalemia. This FMEA was originally written to address hyperkalemia at my former pediatric program that only used high K+ cardioplegia. I think that in adults there may be more complex situations that result in hyperkalemia. There are other forms of cardioplegia that cause other forms of electrolyte abnormalities. I will try to address those at another time.

In peds it is very easy to overdose on high potassium cardioplegia. Since their kidneys don’t work very well it is more difficult for a child to innately deal with it. In adults it takes more of a concerted effort to overdose. However I have been told, by folks who know, that the use of a myocardial temp probe has led to cardioplegia overdose fairly frequently because excess cardioplegia is given to achieve a specific cardiac muscle target temperature. I used cardiac temp probes many years ago. We stopped using them because the rising cardiac temperature prompted frequent repeat doses. This interrupted the surgeon’s work (which is never good thing to do) and the surgeon was concerned with overdose. We finally concluded that as long as the ECG remained quiescent we were good-to-go, giving subsequent doses at prescribed time intervals.

Another thing I discuss is the danger of hyperkalemia from hemolysis. I think it is unlikely that hemolysis from pump damage or RBC infusion would be the primary cause of hyperkalemia during CPB, but it could very well be contributory.

AmSECT Safety Committee

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FAILURE MODE AND EFFECTS ANALYSIS: CPB FMEA # 29 Hyperkalemia

FAILURE: Failure to prevent hyperkalemia.

EFFECT:

1. ECG progresses from peaked T waves and shortened QT to lengthening PR and loss of P waves followed by QRS widening with sine wave morphology.

2. Cardiac ventricular fibrillation, wide complex PEA and asystole.

3. Failure to wean from CPB.

CAUSE:

1. Cardiac repolarization failure.
2. Excess administration of high potassium cardioplegia (HPCP) solution.
3. Accidental overdose of HPCP solution.
4. Patient with end-stage renal failure or acute renal failure.

4. Excessive hemolysis of red blood cells.

5. Excessive administration of banked red blood cells that have not been washed.

6. Heat exchanger leak.

7. Procedurally necessary low flow state during normothermia or hypothermia that reduces renal function and may lead to hyperkalemia.

PRE-EMPTIVE MANAGEMENT:

1. Administer appropriate HPCP dose during appropriate time period.

2. Double clamp HPCP source tubing when not in use.

3. Fill cardioplegia holding container with only enough HPCP solution to administer the appropriate dose.

4. Maintain adequate perfusion pressure during full flow period for proper renal function.

5. Minimize air/blood interface in suckers & vent by using only the minimum pump speed needed.

5. Use only minimum vacuum assist needed.

6. Use fresh (less than 7 days old) RBCs for transfusion if available or washed cells.

7. Test for heat exchanger (HE) leak prior to CPB.

8. Monitor urine output during CPB w/ a goal of 1-3 ml/kg/hr.

MANAGEMENT:

1. Intravenous calcium chloride or calcium gluconate can quickly block hyperkalemia effect on cardiac myocytes by restoring a balanced electrical gradient across the cellular membrane.

2. Administer diuretics prophylactically if urine output < 1 ml/kg/hr during CPB.

3. Alkalize blood with NaHCO3.

4. Administer normal saline in 250 mls aliquots and remove excess volume by ultrafiltration (UF); (zero balance ultrafiltration, ZBUF).

5. Recheck K+ level and repeat 2, 3 and 4 as necessary.

6. If K+ fails to drop consider glucose-insulin therapy.

7. Treat anemia or high K+ from hemolysis by UF fluid removal and/or added RBCs.

8. Use diuresis; furosemide if renal perfusion is good and mannitol plus UF if it is not.

8. Change out oxygenator if the heat exchanger is defective using a PRONTO line. If a PRONTO line is not in standard use, increase the Harmfulness RPN to 4. This would give a total RPN of 4\*2\*2\*3 = 48.

9. Hemodialysis during or immediately after CPB.

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 Low RPN, 2. However if a PRONTO line is not in standard use to assist in replacing a defective oxygenator heat exchanger, increase the Harmfulness RPN to 4.)

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

1) Remote, 2) Low, 3) Moderate, 4) Frequent, 5) Very High

(The Occurrence is low, so the RPN would be a 2.)

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 2 in this example.)

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.

(All patients using potassium cardioplegia would be at risk. So the Frequency RPN would be 3.)

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 2\*2\*2\*3 = 24. However if a PRONTO line is not in standard use to assist in replacing a defective oxygenator heat exchanger, the total RPN would be 4\*2\*2\*3 = 48.)