CPB FMEA # 20 Failure to prevent hypotension following CPB initiation, Level 1.

Friends-

The FMEA this week is again suggested by material supplied to me by Eric Jenkins, CCT, CCP, FPP and Kevin Griffith, CCP from Ann Arbor. Much of this material comes directly from their fine PowerPoint presentation "CPB Disaster Management or When Things Go Wrong, Don’t Scream!" Specifically they define hypotension following CPB initiation, during CPB or in hypotensive failure to wean problems with three different categories depending on the types of actions and medication needed to counter-act it. I have termed these categories as Levels I, II and III. This FMEA will examine Level I. Subsequent weeks will describe Levels II and III.

CPB initiation hypotension may be one of the more serious issues we will consider. This is because it occurs so frequently and nobody really knows the sequelae from its occurrence. Initiation hypotension is something we have all seen frequently and routinely. I have seen it but did not pay it too much concern since it usually goes away with blood flow manipulation after a few minutes. On reflection, that is a cavalier attitude on my part of which I am not proud.

One FMEA reviewer suggested slow venous drainage combined with rapid flow increase to control the hypotension. Some surgeons who want the heart quickly emptied to prevent ventricular distension will complain about this technique. This also requires a greater venous reservoir volume than some perfusionists would like because it increases hemodilution. It’s funny, but peds respiratory ECMO patients don’t seem to get very hypotensive when they go on pump. Since ECMO is a closed system and does not change the right atrial volume radically, I am inclined to think that the rapid draining of the right heart during CPB initiation causes hypotension. This may be caused by an unintended increase in the atrial natriuretic factor (ANF) concentration. But I am just speculating.

Even peds cardiac ECMO patients don’t demonstrate much unresponsive initiation hypotension. I guess that is because they are already loaded with drugs even before ECMO starts. I have started cardiac ECMO patients with so much epi on board that I could not advance the blood flow without causing their blood pressure to go sky high due to the vasoconstriction. Gradually they would vasodilate, possibly due to the dilution of the catecholamines by the pump prime. That lends credence to the idea that it is catecholamine dilution that causes the hypotension in patients who are not receiving catecholamines prior to CPB. But again, I didn’t see much initiation hypotension in respiratory ECMO patients (particularly VV patients) who received just as much catecholamine hemodilution from the circuit prime as many CPB patients.

I am also wondering if something like a short acting drug could be added to the CPB pump prime to counter act the initiation hypotension as a pre-emptive process. One FMEA reviewer started an epi drip prophylactively at the initiation of CPB as a pre-emptive management process. I never added anything to the prime specifically to prevent initiation hypotension except perhaps calcium gluconate when I worried that citrate in a blood prime or a calcium free crystalloid prime would cause the ionized calcium to fall to a low level and cause ventricular distension.

Nobody really knows how dangerous routine CPB initiation hypotension really is. If a conscious person were to become hypotensive for two or three minutes, s/he might faint due to lack of blood flow and oxygen to the brain. Is this detrimental? Remember that other things are happening during CPB, such as particulate and gaseous emboli going to the brain and reduced brain flow due to carotid disease. I will be interested on what others think about this low risk condition.

The AmSECT Safety Committee

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FAILURE MODE AND EFFECTS ANALYSIS

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FAILURE: Failure to prevent hypotension following CPB initiation.

EFFECT: Initiation hypotension can be classified as iatrogenically induced clinical shock which commonly lends itself to postop morbidities such as acute renal injury.

1. Hypotension

2. Indeterminate effect on organ systems.

CAUSE:

1. Hemodilution causing low blood viscosity.

2. Catecholamine dilution.

3. Atrial natriuretic factor increase.

4. Loss of pulsatility.

5. Aortic baroreceptor vasodilation.

6. Chelation of iCa+2 by citrate in the pump prime or cardioplegia solution.

7. Dilution of iCa+2 by a calcium free pump prime.

8. Incorrectly performed autopriming techniques.

PRE-EMPTIVE MANAGEMENT:

1. Draining the venous system slowly and initiating pump flow rapidly may stymie hypotension development.

MANAGEMENT:

1. Increase blood flow

2. Increase blood viscosity by ultrafiltration

3. Reduce arterial pCO2 for systemic vasoconstriction

3. Consider giving phenylephrine or norepinephrine. A phenylephrine or norepinephrine drip can usually counter act this problem.

5. Co-ordination of the drip and blood flow is best performed by a single operator; the perfusionist.

6. For persistent hypotension see FMEA Level II.

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 a 3, moderate.)

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

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

(The occurrence is frequent so the RPN would be a 4.)

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 1 because it is easily to detect the presence of hypotension once CPB begins.)

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 are at risk. So the Patient Frequency RPN should be a 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 3\*4\*1\*3 = 36. If autopriming techniques are commonly used the Occurrence RPN would be 5; the total RPN would then be 3\*5\*1\*3 = 45.)