CPB FMEA # 19 Cephalic artery hyperperfusion

Friends-

This week’s FMEA is about cephalic vessel hyperperfusion and was inspired by a presentation, “CPB Disaster Management or When Things Go Wrong, Don’t Scream!”, from Eric Jenkins, CCT, CCP, FPP and Kevin Griffith, CCP, Cardiovascular Perfusionists at University of Michigan Medical Center. In the presentation Eric says this. “Disasters aren’t planned, but you can plan for disasters.” This is exactly what FMEAs do! A good illustration of how a misplaced aortic cannula can cause hyperperfusion in the brain while causing systemic hypoperfusion can be found in Hensley’s “A Practical Approach to Cardiac Anesthesia”, 4th edn. Philadelphia: Lippincott Williams & Wilkins, 2008: 207.

To check for cephalic vessel hyperperfusion, one of the pre-emptive management processes is for Anesthesia to assess bilateral carotid pulses, bruits and thrills before cannulation to evaluate for prior carotid stenosis and for comparison post-CPB. During CPB, excessive or unbalanced bruits and thrills could indicate hyperperfusion. Assessment after CPB might detect carotid damage from hyperperfusion. I honestly don’t know how often this is done or if it is even routine among anesthesiologists. Perhaps this FMEA will raise the awareness of perfusionists on this point when they communicate with Anesthesia during a case.

I can’t say that I have ever seen a full blown case of cephalic hyperperfusion. But I have seen many patients with edematous faces after CPB and some who woke up looney and a few who never woke up at all. One of the indicators for hyperperfusion is excessive aortic cannula back pressure. This may work in adult sized cannulae. But in my experience in pediatrics, this doesn’t work. It is not unusual in peds to have cannula back pressures of 300-400 mmHg. This is because the cannulae are small and as we all know the flow resistance increases exponentially as the cannula diameter decreases fractionally.

IMHO, the most beneficial device for detecting abnormal blood flow to the brain is bilateral cerebral monitoring. It is, by no means, fool proof. It only tells you if there is an imbalance in cerebral oxygenation, but not if it is caused by hyperperfusion. However this should be enough to ask the surgeon to adjust the aortic cannula. There have been many times when I asked the surgeon to adjust the cannula to improve the NIRS readout.

I think this is the kind of accident that can occur without anybody even knowing it is happening. It's not until the patient gets to the ICU that anybody realizes that something terrible has happened. Then the perfusionist racks his/her OWN brain trying to figure out what went wrong. Blood flow and perfusion pressure abnormalities may be obvious enough to alert most perfusionists. But I don't think that it should be the only indicator for perfusionists. Since Anesthesia should be doing the carotid assessment and cerebral oximetry monitoring, they should be involved as well. Quick detection is important because I don't think a brain could last long with grossly elevated perfusion pressure. For prevention of bad outcomes, it is important to include a comprehensive approach to the care of the CPB patient, to include all participants.

I wonder, how many perfusionists even think about this problem? How much instruction do perfusion students get about this problem? Many, if not most, will never see this problem even as practicing perfusionists. I am hoping that all perfusion programs would discuss one FMEA each week for 52 weeks and then start over again the next year. This should be one for repeated annual discussion since it is rare. For example, the discussion of centrifugal versus roller pump could play a role in prevention. Although anyone using a C-pump should not have a false sense of security concerning this failure.

The AmSECT Safety Committee

Contributor: Gary Grist

CPB FMEA # 19 Cephalic artery hyperperfusion

FAILURE: Cephalic artery hyperperfusion

EFFECT:

1. Vaporous cavitation from trapped arterial cannula turbulent flow with formation of gaseous emboli.

2. Misdirected or inadequate blood flow to the brain or other organs.

3. Unilateral facial edema

4. Lacrimation

5. Petechiae

6. Serosanguineous otorrhea

7. Rhinorrhea

8. Metabolic acidosis

9. Cerebral edema

10. Carotid arterial rupture

11. Carotid intimal flap obstructing arterial flow.

12. Blanching of the face

13. Pupillary dilation

14. Conjunctival chemosis.

15. Low BP measured by left radial or femoral arterial catheter.

16. Unequal cerebral O2 concentration by cerebral oximetry.

17. Post-operative delirium.

18. Post-operative brain damage.

19. Death

CAUSE:

1. Arterial cannula positioned or perfusion jet directed into a carotid artery.
2. Arterial cannula too small for flow resulting in excessive force of high pressure blood jet.

PRE-EMPTIVE MANAGEMENT:

1. Once tubing is connected to the arterial cannula, monitor the arterial line pressure for appropriate pressure reading.
2. Perform test turn to check for cannula obstruction.
3. Notify surgeon of status of the pressure in the line before initiating CPB and as flow is increased.
4. Observe cerebral oximetry monitor for any change after cannulation.
5. Use TEE to check arterial cannula position.
6. Check by Anesthesia for bilateral carotid pulses and bruit before and after cannulation and for excessive or unbalanced bruit after the initiation of CPB.
7. Transcranial Doppler (TCD), if available, can be utilized to detect vaporous cerebral emboli, improper cannulation or improper clamping of aortic arch vessels.

MANAGEMENT:

1. Reposition arterial cannula.

2. Consider mannitol, steroids, barbiturates & hypothermia to reduce cerebral damage.

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 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 1 only if all pre-emptive management processes are used: pressure/flow assessment, cerebral oximetry, TEE, carotid palpation/auscultation and TCD. Add one point for each item not used.

If no pre-emptive management processes are used the Detectability RPN would be 5, making the total RPN 45, five times higher risk.)

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\*1\*1\*3 = 9. Without all the pre-emptive management processes the RPN would be 3\*1\*5\*3 = 45.)