CPB FMEA #15 : acute, iatrogenic ascending dissection of the aorta (AO) after initiating cardiopulmonary bypass (CPB).

The AmSECT Safety Committee

Contributor: Gary Grist

Friends. Here is the next FMEA . This FMEA was inspired by the Society of Cardiovascular Anesthesiologists. 14th Annual Update on Cardiopulmonary bypass. Whistler, BC. March 2009, Workshop Case #3: Aortic dissection at onset of CPB by Groom, Hess and Hessel. This can be viewed on-line at <://www.scahq.org/sca3/events/2009/cpb/syllabus/submissions/sun/Aortic%20dissection%20at%20the%20onset%20of%20CPB%20-%20Hessel-Hess-Groom.pdf>.

My last run in with an ascending aortic dissection in an adult occurred in the 1960's or 70's. It was so long ago I barely remember. They involved two different patients and occurred before pressure servo-regulation was available on CPB pumps. We used to 'feel' the arterial outflow pump line with one hand while increasing flow with the other. We were attempting to detect dangerous pressure changes so we could stop the pump before anything blew up. I continued to 'feel the line' out of habit long after servo came to be standard on pumps. In later years, I remember students asking me why I was touching the line at the beginning of CPB. It took me many years to break the habit. Back to the story, both patients died intra-operatively. By the time the surgeon could figure out what was happening, it was too late.

I have seen aortic dissections in peds, but they always occurred days or weeks after the initial surgery and were fixed in the cath lab. Those kids usually had some kind of congenital or genetic vascular defect.

This FMEA will deal only with acute, iatrogenic ascending aortic dissections. We will look at femoral dissections with a separate FMEA. So look this one over and send me any suggestions you might have. For example, the RPN number for this FMEA is 75. What things could be done to reduce that number? Do you agree that the Detectability score should be a 5 even if TEE is available, or should it only be a 5 if TEE were not available?

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FAILURE: acute, iatrogenic ascending dissection of the aorta (AO) after initiating cardiopulmonary bypass (CPB).

EFFECT:

1. Hypotension
2. Loss of venous return
3. Elevated pump arterial line pressure
4. Oliguria
5. Dilated pupils
6. BIS (bispectral index) changes
7. EEG changes
8. Cerebral oximeter changes
9. Transcranial Doppler (TCD) changes
10. ECG changes
11. Systemic acidosis
12. AO blue discoloration
13. AO distension
14. Bleeding from needle holes, arterial incisions, and cannulation sites.
15. Intra-luminal blood within split wall of the AO
16. Dissection usually in the direction of flow
17. Loss of pump flow.
18. Acute rupture of the AO with uncontrollable hemorrhage.
19. Death.

CAUSE:

1. Dissection incidence is 0.06-0.09 for ascending AO cannulation.
2. AO cannulation site most common.
3. Other sites
   1. AO cross clamp
   2. Antegrade CP cannula
   3. Partial occluding AO clamp
   4. Anastomosis of coronary grafts
   5. Aortotomy.
4. Dissection due to:
   1. Direct trauma from cannula insertion or manipulation.
   2. Indirect trauma from the high velocity jet lifting atheromatous endothelium
5. Risk factors include:
6. Patients with an existing aneurysm or a history of one.
7. Location of cannulation
8. Advanced age (pediatric dissections also occur)
9. Chronic hypertension
10. Diseased/dilated AO
11. Atherosclerosis
12. Cystic medial necrosis
13. Hypertension during decannulation

i. Application/removal of AO clamps

j. Cannulation technique.

k. Antegrade CP cannulation

l. High line back pressure during CP administration.

PRE-EMPTIVE MANAGEMENT:

1. The perfusionist should always be in the room during sternotomy.
2. Lower the mean arterial pressure (MAP) during cannulation/ decannulation and application/removal of AO clamps. Lowering MAP during cannulation is an anesthesia responsibility. If the pressure is high the perfusionist must exercise due diligence for a dissection possibility.
3. Use extreme care with the insertion of a properly sized AO cannulae
4. Check for pulsatility and correlation of pump arterial line pressure to the MAP.
5. Check for resistance/line pressure with a pump test infusion before CPB
6. Use a narrowly set high pressure servo regulation audible alarm with pump shut off
7. During retrograde arterial auto-priming observe fluid return flow for normalcy. Hesitation or slow return may indicate an arterial cannula tip trapped in the AO wall.
8. Have TEE or epiaortic scanning available to monitor the AO PRN.
9. Evaluate hypotension causes during the initiation of CPB. If there is a loss of volume, ask the surgeon to quickly assess.
10. Do not commit patient to CPB support by quickly cooling, giving cardioplegia or opening the heart until dissection is ruled out.
11. Do not release venous line quickly. Release it slowly while infusing at the same time, keeping the volume in the patient should a dissection occur. If the patient’s blood volume drains into the venous reservoir there is no way to quickly return it to the patient if the AO dissects.
12. Continue to visually inspect the AO cannulation site.
13. Patients with a history of aortic aneurysm are usually on beta blockers and always on antihypertensive agents and are safer using a lower MAP.
14. If using a centrifugal pump, do not clamp arterial pump line and quickly release at high RPMs. This increases shear stress by fluid jet and may dissect a weak AO wall.
15. With high risk patients consider:

a. having femoral cannula, connectors and extra tubing readily available and in the room.

b. having blood PRBC’s checked and in the room

c. having a hemoconcentrator available

d. having extra heparin drawn up and available

1. having extra IV fluids on the pump

MANAGEMENT:

1. When the ascending aorta is the site of the initial cannulation, CPB should be stopped immediately and flow reinitiated via the femoral, subclavian or innominate artery (after assuring that the dissection has not extended into these vessels) or re-cannulate into the true lumen in the AO arch through the flap (perhaps with the aid of ultrasound and a guidewire).
2. With femoral cannulation, asses both forward flow and retrograde flow to confirm that the cannula is not in a false lumen.
3. After CPB is safely established consider the initiation of deep hypothermia in anticipation of need for circulatory arrest to repair the ascending dissection.
4. Use cerebral protection by selective cerebral perfusion if the dissection is extensive and involves the arch vessels.
5. Repair may only require closed exclusion suturing or more complex patch or graft replacement of the ascending AO and arch.

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

(The problems that this failure causes are 5, critical.)

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

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

(This occurs very infrequently. So occurrence should be 1, low.)

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

(This problem can be very difficult to detect until after the damage has been done. So the detection RPN should be 5, uncertain.)

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 5\*1\*5\*3 = 75. )