

CPB FMEA # 5: Inadequate cerebral oxygenation as indicated by cerebral oximetry.

The AmSECT Safety Committee
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Friends-

This week's FMEA is prompted because cerebral oximetry monitoring is not yet utilized by all programs as the standard of care during CPB. In the 1960's patients undergoing CPB frequently had temporary or even permanent post-op neurological impairment. We called this "pump head". The prevailing theory was that microemboli generated by the pump (and loose plaque in the AO) flowed to the brain and blocked many capillaries. Fortunately our equipment and techniques have gotten better. So the frequency and degree of pump head is much less in the 21st century.

When the cerebral oximetry monitors came along, one of the reasons for the variations in neurological outcomes post-CPB became readily apparent. Despite normalized perfusion parameters during CPB, many patients demonstrate profound cerebral oxygen desaturation for lengthy periods. Surgeons may need to adjust the arterial cannula. If that doesn't work, perfusionists try several other things to reverse the desaturation such as higher flow, higher perfusion pressure, drugs, temperature modification (going colder), reducing hemodilution and increasing the FiO₂. One modification that frequently works is changing the CO₂ levels in the blood; i.e., going from alpha stat to pH stat, or vice versa, sometimes reverses the cerebral desaturation. Even during normothermia increasing the arterial CO₂ often reverses the desaturation. Sometimes, unfortunately, nothing works.

The cerebral oximetry monitor is one of those perfusion safety gadgets that can greatly reduce the risks. Without a monitor I think the risk of cerebral oxygen desaturation is $4*3*5*3 = 180$ because cerebral hypoxia during anesthesia is almost impossible to detect. With a monitor the risk is only $4*3*1*3 = 36$. This is a strong argument that a program can use to justify the purchase of these monitors. Some would say that there is not enough evidence that cerebral oximetry is beneficial enough to justify the expense. I remember when people said that about automated BP cuffs, pulse/oximeters and end-tidal CO₂ monitors. I am old enough to remember anesthesiologists arguing over the use of the OR's single automated BP cuff, or pulse/oximeter or capnometer that was being passed around to patients with the highest risk. Even before that, in olden days, I worked on cases that did not employ any of those things. Nowadays in the developed nations, nobody would agree to do a case without all three of these indispensable gadgets. Let's make the cerebral oximetry monitor the fourth indispensable gadget.

-Gary Grist

This week's Failure Mode is below:

I. Failure Mode: Inadequate cerebral oxygenation as indicated by cerebral oximetry.

II. Potential Effects of Failure:

1. Greater than 20% drop from baseline or a decline to less than 50%.
2. Cerebral hypoxia and subsequent brain damage.
(Can you suggest other problems that can occur?)

III. Potential Cause of Failure:

1. Improperly placed or loose sensors.
2. Improper aortic cannula placement.
3. Inadequate perfusion pressure.
4. Inadequate pump blood flow
5. Low paO₂
6. CO₂ imbalance
7. Inadequate anesthesia
8. Hemodilution
9. Diabetes
10. Severe cerebrovascular disease

(What other things can cause this particular failure?)

IV. Interventions to Prevent or Negate the Failure:

PRE-EMPTIVE MANAGEMENT:

1. The cerebral oximetry monitor is the only pre-emptive intervention available to prevent or quickly reverse cerebral oxygen desaturation. Without it the RPN would be $4 \times 3 \times 5 \times 3 = 180$.
2. Ensure that sensors are properly placed.
3. Record intervention to reverse desaturation.

MANAGEMENT:

1. Check head & cannula position.
2. Increase the mean arterial pressure.
3. Increase pump flow rate.
4. Increase systemic oxygenation.
5. Increase paCO₂.
6. Increase volatile anesthetic depth or administer IV anesthetic bolus.
7. Increase hematocrit by ultrafiltration
8. Consider hypothermia.
9. Consider PRBC transfusion for low hematocrit.
10. In cases w/ diabetes or severe cerebrovascular disease, all these interventions may fail. This warns of a higher risk of post-op neurologic deficits or stroke.

V. Risk Priority Number (RPN): (select the number from each category that you feel best categorizes the risk).

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

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

(The problem that this failure can cause is brain injury. So the harmfulness rating should be 4.)

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

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

(This is a common problem. So occurrence rating should be 3.)

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 becomes immediately obvious as long as cerebral oximetry is being used. So the detection rating should be 1.)

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.

(This could happen to any patient. So the patient frequency rating 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 $4*3*1*3 = 36$. Without cerebral oximetry monitoring the RPN would be $4*3*5*3 = 180$.)