CPB FMEA #14 Sweep gas circuit (SGC) failure

The AmSECT Safety Committee

Contributor: Gary Grist

Sweep gas circuits (SGC) are often the least thought about components of a heart lung pump. Some SGC are very simple; a gas line run from a wall flow meter/blender directly to the sweep gas port of the oxygenator. And there is certainly something to be said for simplicity. On the other hand, some SGC are installed on the pump itself with a sophisticated flowmeter/blender (sometimes electronically operated), a volatile anesthetic vaporizer, a scavenging system using wall vacuum, an ancillary CO2 infusion circuit as well as various sensors. The more complex the SGC the greater the risk of failure, but also the greater control the perfusionist has on ‘gas therapy’.

I think that at least some oxygenator change outs are related to a SGC failure rather than a defective oxygenator. When the blood coming out of the oxygenator quickly turns black, a perfusionist can make some bad decisions during an urgent situation and change the oxygenator without quickly and fully eliminating the sweep circuit as the problem. I have been at many programs that had no standardized procedure to immediately utilize a back-up oxygen source in such a situation. Some perfusionists are getting better about this, but there is still work to do to educate others.

The SGC is just as important during CPB as the anesthesia breathing circuit is during the non-CPB period. Anesthesia breathing circuits have multiple sensors and safety devices mandated by anesthesia organizations and governmental entities. But there is no such oversite on CPB SGC. So we are going to identify the SGC risks and offer some pre-emptive management and management solutions.

Note: If I haven’t mentioned this before, there is a group of retired or soon-to-be retired perfusionists who donate their time to review each FMEA. They are not compensated in any way other than having the satisfaction of contributing their experience and wisdom to younger perfusionists. Reviewing these FMEAs takes about 20 minutes each week or they can choose not to review any FMEA. There is no obligation of any kind. If you are retired or nearing retirement and would like to join this review group please contact me: garygrist@comcast.net

Also, if you have a suggestion for a new FMEA, please send me your idea.

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FAILURE: Sweep gas circuit (SGC) failure.

EFFECT:

1. Hypoxemia
2. Hypercapnea
3. Hypocapnea
4. Unnecessary oxygenator change out
5. Gas embolus
6. Room personnel exposed to anesthetic gas vapors.
7. Excessive or insufficient anesthesia.

CAUSE:

1. Defect, crack or leak in the oxygenator or sweep gas system.
2. Sweep gas system component (gas flowmeter, blender, anesthetic gas vaporizer) defective or connections loose.
3. Excessive scavenging of field CO2 flush by pump suckers can mimic oxygenator ventilation failure and hypercapnea.
4. Oxygenator not at lowest level in the blood circuit.
5. Obstruction of oxygenator gas outlet port.
6. Oxygenator blood compartment pressure lower than the sweep gas compartment pressure.
7. Incorrect volatile anesthetic liquid added to vaporizer.
8. Empty anesthetic vaporizer.
9. Unnoticed flow meter setting causing excessive sweep gas flow.
10. Ineffective or non-functional SGC scavenge system.

PRE-EMPTIVE MANAGEMENT:

1. Pressure test the SGC prior to CPB using an in-line pressure manometer to test for leaks (should be a checklist item).
2. Maximize sweep gas flow during priming to confirm that oxygenator outlet port is not obstructed.
	1. Only use oxygenators with secondary sweep gas exhaust ports.
3. Maintain an emergency O2 source; E-tank or O2 outlet from the wall or anesthesia machine with a gas line long enough to reach the oxygenator (checklist item).
4. Scavenge the sweep gas exhaust from oxygenator to the OR vacuum gas vent if an anesthetic gas vaporizer is used.
5. Perform visual assessment of the oxygenator exhalation port for a blood leak.
6. Visually confirm correct gas flow through air/O2 blender flow meter prior to CPB.
7. With blood prime visually confirm oxygenation of post-oxygenator blood by color change.
8. Consider the use of one or more of the following sensors:
	1. O2 sensor on sweep gas affluent line.
	2. CO2 sensor in the oxygenator sweep gas exhaust port.
	3. Pressure manometer on the affluent sweep gas line.
	4. Blood SAO2, paO2 or paCO2 sensors sampling from the oxygenator outflow blood line. (\*Without sensors the detectability RPN would be a 5, making the total RPN = 90).
9. Ensure that routine maintenance is performed on mechanical components; flowmeters, blender, anesthesia gas vaporizer, blender gas lines and wall connections, scavenge system, etc.
10. After routine maintenance by clinical engineering or manufacturer personnel on the SGC and its components, conduct a systems check before clinical use.

MANAGEMENT:

1. If conditions suggest the failure of the oxygenator, begin using back-up O2 E-tank connected directly to the oxygenator to eliminate the SGC as the cause.
2. If it is determined that the SGC is the problem, have back-up personnel trouble shoot the SGC after back-up sweep gas system is initiated so the primary perfusionist can maintain focus on the CPB system. (\*\*If there is no back-up help available increase the Harmfulness rating to 4.)

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 3, moderate. If there is no back-up help available increase the Harmfulness rating to 4.)

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

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

(This occurs infrequently, so occurrence should be 2, 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 easily detected using anyone of several sensors on the SGC or oxygenator, particularly a pressure manometer to test that SGC holds its pressure and has no leak. So the detection RPN should be 1, very high. Without sensors the detectability RPN would be a 5.)

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\*2\*1\*3 = 18. Without SGC monitoring and back-up personnel the RPN would be 4\*2\*5\*3 = 120.)