**Presentation Date/Time:** Friday, April 1, 2016; 6:30am-7:40am  
**Table #:** 8 - *Oxygen pipeline contamination in radiation oncology suite*  
**Moderators:** Dante Cerza, MD., Jorge Gálvez, MD.  
**Institution:** The Children’s Hospital of Philadelphia, Philadelphia, PA.

**Goals**
- Discuss anesthetic considerations for children undergoing various modalities of radiation therapy (i.e. Proton Beam, Total Body Irradiation).
- Identify equipment that can be used to replace anesthesia machines when the latter becomes unavailable.
- Describe necessary procedures for assessing the safety of medical gas supply lines.
- Discuss radiation therapy treatment protocols for pediatric oncologic diagnoses, with specific attention to scheduling requirements, and flexibility in treatment alternatives such as photon versus proton radiation therapy.

**Case description**
The radiation therapy facility is located in the basement of the hospital and consists of a proton beam center, conventional radiation therapy and a diagnostic imaging complex. There is a pediatric wing dedicated to pre- and post- anesthesia care for children receiving radiation therapy. Anesthesia resources in the facility consist of 5 anesthesia machines, 10 radiation therapy rooms (5 Proton suites and 5 photon suites), and two CT scanners.

At 6:30AM on Monday morning, during pre-procedure device checks, the anesthesia team discovered that the wall oxygen supply was not active at the Radiation Oncology treatment facility. The team learns that the facility experienced an unscheduled shutdown of oxygen supply line during construction at an adjacent building over the preceding weekend. No one on the team was notified of these events or that the medical oxygen gas supply would not be operational. At this point, it is not possible to reinstate the oxygen supply.

**Questions:**
- Would you cancel all radiation therapy for the day?
- What are the implications for missing radiation treatments at this point?
- What alternatives would you consider to enable safe delivery of general anesthesia under these circumstances?

In order to prevent unscheduled radiation treatment interruptions, the anesthesia team secured E and H cylinders to operate all the anesthesia machines and ensure that the patients would have supplemental oxygen when needed for the duration of the treatment. The oxygen supply lines remain offline for the rest of Monday and Tuesday. On Tuesday afternoon, the anesthesia team is notified to continue using the E cylinder oxygen supplies until instructed otherwise.

On Wednesday morning, the team discovers that the wall O2 supply is now
operational. However, no one in the care team received communications that the lines would be re-activated. At this time, the anesthesia machine passed the automatic machine test.

Questions:
- Would you conduct any additional tests to ensure that the medical gas supply was safe?

The team uses the gas sample line and gas analyzer to evaluate the oxygen content and detects > 99% oxygen on the inspiratory limb. You notice an unusual pungent odor emitting from the breathing circuit. All vaporizers are in the off position and only oxygen is flowing. The team performs additional tests in the other anesthesia machines located in different rooms and detect the same scent coming from the breathing circuit. Simultaneously, the nursing staff reports unusual scents coming from the wall oxygen supply in patient exam rooms.

Questions:
- Now that you identified that the anesthesia machines are compromised, how do you proceed?

There are 7 patients on the schedule, one of which is scheduled to begin total body irradiation in preparation for a bone marrow transplant. This patient is diagnosed with relapse acute myelogenous leukemia with brain metastases and is scheduled to undergo a bone marrow transplant. The radiation treatment for TBI consists of two sessions per day for three consecutive days. Each session must be separated by at least 6 hours from the end of the previous session. Three of the treatment sessions require that the patient be placed in prone position.

Questions:
- Would you cancel treatments for the day?
- What equipment would you need to proceed with general anesthesia care safely? Does it matter if patients are breathing spontaneously or require positive pressure ventilation?

The facilities team communicates that they installed a temporary oxygen delivery solution. This solution involved severing the existing oxygen pipelines to the central oxygen supply to the building. The oxygen line was diverted to a temporary oxygen cylinder with medical certification for 100% oxygen. They perform testing of medical gas from the anesthesia machines and do not find any apparent contaminants. However, the machines continue to emit the unusual smell.

Questions:
- How would you assess whether the anesthesia machines and medical gas supply lines are operational and safe to use?
Despite the initial testing results, the anesthesia machines were deemed to be unsafe to use for patient care. The biomedical engineering team and the device manufacturer were engaged to test and certify that the machines were operational. In the meantime, the respiratory therapy department provided a respiratory therapist and access to LTV 1200 ventilators until the anesthesia equipment became available. Temporary oxygen supply was supplied via E and H cylinders. Patients were anesthetized with total intravenous anesthesia and monitored by the anesthesia care team. The radiation oncology team and anesthesia teams reviewed each scheduled case for potential to re-schedule the radiation treatment.

Discussion

Medical gas contamination is a rare and potentially catastrophic event that we must always be aware of. Gas analyzers offer protection against hypoxic gas mixtures, but do not detect contaminants that could potentially be introduced to the medical gas supply. In our case, despite extensive gas sampling we were not able to identify the specific contaminant. There are several reports that describe contaminants with substances including Argon and cleaning solutions that are airway irritants and highly carcinogenic.

Our team practiced with a questioning attitude. When we learned that the oxygen line was active on Wednesday morning, we questioned whether the gas was safe for use. The team suspected that there was a problem when the ventilator circuit emitted a pungent smell when only the oxygen was turned on. This was replicated in the anesthesia machines throughout the facility. As a result, patients were not exposed to the potential contaminant and alternative ventilators were secured to deliver positive pressure ventilation.

Pediatric radiation therapy protocols are applied for a range of oncology diagnosis, ranging from central nervous system and other solid tumors to hematologic malignancies such as leukemia and lymphoma. Treatment protocols may consist of proton, photon or electron beam therapy. The protocols are delivered over the course of days to weeks and are repeated on a daily or twice-daily schedule. Patients must remain alone in the treatment room for up to 20 minutes at a time while radiation is delivered to protect the treatment team from radiation exposure.

Radiation therapy is most effective against fast-growing tumors that have a large proportion of cells that are actively dividing. Radiation treatment interruptions may allow tumor cells to continue to grow and repair some of the damage caused by previous treatment sessions. In some cases, treatment effectiveness has been associated with uninterrupted therapy.

Proton radiation therapy is appealing for pediatric oncology because it can be used to deliver a maximal dose of radiation to the target structure while minimizing exposure of healthy tissues. In contrast with conventional radiation therapy, proton beams expose tissues as they enter the body and deliver the highest energy at the target area, but do not continue to penetrate tissues beyond the target. Treatments are uniquely tailored to each individual, thus considerations for cancelling a treatment session should be discussed with the radiation treatment team.
Anesthesia machines are quite versatile and functioned well in our case where the main oxygen supply was unavailable. Treatment continued for two days using a temporary oxygen supply of E and H cylinders. However, the machines remained connected to the wall oxygen supply while relying on the oxygen tanks. When the temporary oxygen tank was connected to the oxygen pipes, the machines received pressure via the wall oxygen supply. Any contaminants that remained in the piping were not flushed and presumably contaminated the anesthesia machines. We took all of the anesthesia machines in the facility offline for additional evaluation by biomedical engineering and the manufacturer.

In the meantime, we explored alternatives to deliver anesthesia to the scheduled patients without compromising their safety. We consulted the Department of Respiratory Therapy and acquired portable ventilators for the facility. We used the Carefusion LTV (long-term ventilator) devices to provide back-up positive pressure ventilation while the patients were in the treatment room receiving radiation therapy. Although most patients in our practice breathe spontaneously throughout treatment, there are scenarios where controlled ventilation is mandatory, such as patients that require prone positioning. Even if patients are breathing spontaneously during treatment, it is important to have a device capable of delivering positive pressure ventilation.

In summary, radiation therapy requires repetitive treatment that often requires general anesthesia in pediatrics. Anesthesiologists must be prepared to provide positive pressure ventilation with either an anesthesia machine or ventilator in the treatment room, since the patients cannot be accompanied while radiation is being delivered. Lastly, every effort must be made to adhere to the prescribed schedule of radiation therapy to maximize the effectiveness of the treatment.

References:
