Learning From Others:

# A Case Report From the Anesthesia Incident Reporting System

Anesthesia Quality Institute
ANESTHESIA INCIDENT REPORTING SYSTEM (AIRS)

*Detailed review of unusual cases is a cornerstone of anesthesiology education. Each month, the AQI-AIRS Steering Committee will abstract a case and provide a detailed discussion based on a submission to the national Anesthesia Incident Reporting System. Feedback regarding this item can be sent by email to* **r.dutton@asahq.org**. *Report incidents to* **www.aqiairs.org**.

## Case 2014-01: Power Failure

During massive hemorrhage in a liver transplant procedure, the rapid infusion system was set to deliver 500 mL/min. Despite this, the patient became increasingly unstable. After several doses of pressors were given to address hypotension, the infusion system was noted to be delivering only 50 mL/min. Attempts to troubleshoot the device were unsuccessful, and it soon failed completely. The infuser was abandoned, additional manpower was recruited, and fluids and blood products were administered by hand. The patient suffered no long-term ill effect.

A root cause analysis of the event determined that, although plugged into an extension cord connected to a wall outlet, the infuser had been running on back-up battery power from the beginning of the case. Complete failure occurred when the battery drained. The operating room (O.R.) electrical supply was found to be inadequate for the power demands placed on it. Testing revealed the infuser was not able to draw enough power through the extension line to function normally. The device responded to inadequate power as intended, with a reduction in maximum infusion rate, an alarm tone (not audible in a noisy O.R.) and a small display on the control panel (not noted by the operators).

## Discussion

This case includes interacting elements of technical design and human performance. The "system" here, like most in health care, is a socio-technical system whose components cannot be isolated. Technical issues include the design of the O.R. power system and the infuser. Knowledge issues include the possible failure modes of the infuser and thinking of failure to deliver volume as a contributor to hemodynamic instability. Human factor issues include O.R. design and maintenance, alarm ergonomics, task overload and O.R. noise pollution.

The most proximate cause of this near-miss was failure of the infusion system, due to inadequate electrical supply in an older O.R., complicated by a knowledge gap on the part of the providers (i.e., what the consequences of reduced power would be). Power failure in O.R. equipment is likely a common but under-recognized issue in many hospitals. Forty-year-old O.R.s were not designed to support modern laparoscopic technology, electrocautery units, suction systems, patient warmers, rapid infusers, diagnostic monitors, information technology, video displays, lithotripters, lasers, piston-driven anesthesia ventilators and golly-gee-whiz surgical robots.

Compared to conventional intravenous (I.V.) infusion pumps, designing a functional battery backup for a high-volume fluid infuser involves significant challenges. A rapid infuser has, in addition to a much larger, faster and more powerful pump, a large heating element that draws far more energy than does the pump component. The length of time that an infuser can function normally on battery backup is limited. The engineering compromise is to power down into a minimal flow mode, maintaining I.V. patency but not heating fluids or driving the pump at maximum capacity.

For this particular model, infusion rate is maximized at 50 ml a minute rather than 1,500 when on battery power. Additionally, the heater is switched off. Visual and audible alarms signal the loss of power and the onset of battery backup mode. The battery is rated to provide this limited functioning for 30 minutes, after which the infuser will power off completely. The volume of the audible alarm is programmable, and at the time of this episode

it was set to relatively low volume and was not noticed. The visible alarm appears on the same screen as other routine communications and warnings and does not draw attention to itself. Furthermore, the practitioners were not aware of the conditions under which the battery backup functions.

Dated electrical wiring can be problematic for several reasons. Old wiring may not be up to codes designed to prevent electrical fires or loss of power due to short circuits. Splitting adapters may be necessary because too few wall outlets are present. These can encourage dangerous overloading, leading to mechanical and electrical hazard, including loss of line isolation. A lack of outlets may also encourage use of extension cords, which are inherently unsafe for several reasons. They create a trip hazard, and the tripping can have the double effect of injuring a practitioner and disconnecting an important device. If the extension cord has only a two-prong plug, it can defeat the three-prong grounding plug of the equipment and create a risk for macroshock. The multiple plugs on the input side of an extension cord encourage plugging in multiple devices, further increasing the electrical load. Finally, it creates another point of failure due to fraying and kinking, especially when repeatedly run over by all of the other equipment in the O.R.

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The ASA Statement on Non-operating Room Anesthetizing Locations calls for: "in each location, sufficient electrical outlets to satisfy anesthesia machine and monitoring equipment requirements, including clearly labeled outlets connected to an emergency power supply." Anesthesiologists should be aware of the power demands of appliances in the O.R. as well and should understand which devices can be safely plugged into peripheral outlets and which require more dedicated circuitry. A routine annual risk assessment of potential power supply issues will improve patient safety and may be a useful collaborative exercise for nursing, anesthesia and biomedical engineering.

Beyond simple engineering recommendations, however, this case illustrates how a single point failure can escalate to the level of a critical incident. Failure of the mechanical device was exacerbated by human failure to recognize the problem and promptly address it. It is unfortunately common that anesthesiologists are not fully conversant with the intricate operating details and complexities of the equipment we use. Most anesthesia departments have no standards for technical training of their providers or any mandatory requirement for re-training when devices are modified or upgraded. Traditional "in-service" training is seldom rigorously evaluated, and personnel are not typically audited for attendance or retention of information. It is perhaps not surprising that the providers in this case did not know the consequences of a rare mechanical failure in a device that is used infrequently.

It is easy to assert human error in this case, based on the fact that increased awareness on the part of the anesthesiologist could have identified the infuser failure sooner. However, anyone who has cared for a patient during rapid hemorrhage knows it is unrealistic to expect perfect attention to every element of a complex and dynamic situation. As anesthesiologists, we understand the limitations of vigilance. Assertion of human error during the root cause analysis of a case such as this one would be a demonstration of hindsight bias: knowing the device failed, it is too easy to ask why this was not recognized and addressed.

The facility and the care team appropriately performed a root cause analysis following this event. Despite the name for this activity, there is rarely only one root cause to an adverse event or near-miss. Failure in a complex system is usually due to multiple contributing factors, each necessary and only jointly sufficient, even if there is a single point of failure at which they converge. In our case, the reporter states that the finding of the analysis was electrical wiring insufficient for the surgical procedure. However, this could be taken further. There was also a failure to audit the energy demands of the O.R. on a regular basis and a failure to update the wiring. All physical systems of a hospital are known to require periodic maintenance, and perhaps maintenance was neglected. Was this due to limited biomedical engineering resources? Limited resources are the rule, not the exception. Perhaps the need to regularly address the adequacy of the electrical supply for the demands of contemporary intraoperative equipment was not even recognized. Was there a maintenance committee to assist in prioritizing needs? Did it include clinicians? Does the chain of accountability for maintenance lead to an administrator who had the responsibility but lacked the authority to do what needed to be done? Were there insufficient resources to regularly assess and update the facility? In truth, almost any clinical safety event can be peeled like an onion to reveal deeper and deeper layers of contributing factors, and there are almost always multiple contributing causes. How far to take a root cause analysis is itself a resource-limited process and illustrates a central truth: Quality management is the artful application of finite resources to an infinite problem.