

Hazards of the Anesthesia Workstation

2016

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Dr. Alan Jay Schwartz: Hello. This is Alan Jay Schwartz, Editor-in-Chief of the American Society of Anesthesiologists' 2016 *Refresher Courses in Anesthesiology*, the latest research and education information. The focus of the new online format of the *Refresher Courses in Anesthesiology*'s CME program, and the modules featured, is to educate learners on current developments in the science and clinical practice of the specialty of anesthesiology, critical care medicine and pain management. For the first time ever, we will be speaking directly with individual authors to learn about their expertise, perspective and insight regarding their featured module.

Today, we are pleased to present the following one-on-one conversation with fellow *Refresher Courses in Anesthesiology* Editor, Dr. Laurence Torsher, and author Dr. James Eisenkraft. They will be highlighting the module titled, "Hazards of the Anesthesia Workstation."

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Dr. Laurence Torsher: Welcome. My name is Laurence Torsher, an anesthesiologist at Mayo Clinic, Rochester, and one of the editors of the ASA *Refresher Courses*. Our guest today is Dr. James Eisenkraft, Professor of Anesthesiology at the Icahn School of Medicine at Mount Sinai in New York. He is the author of the module entitled, "Hazards of the Anesthesia Workstation." Welcome, Dr. Eisenkraft.

Dr. James Eisenkraft: Thank you.

Dr. Laurence Torsher: Can you review some critical incidents or adverse outcomes that are associated with anesthesia workstations?

Dr. James Eisenkraft: Yes. I'd just like to begin by saying that the pure failure of equipment—in other words, the anesthesia machine, slash, workstation—is relatively uncommon. What is much more common is use error. In other words, problems with the user, or the way in which the user is using the equipment.

So, bearing that in mind, some examples of critical incidents – and incidentally, a critical incident, we define as a human error or equipment failure that could have led, if not discovered or corrected in time, or did lead, to an undesirable outcome, ranging from increased length of hospital stay to death. Some examples of critical incidents would be a breathing circuit disconnect. And of course, if that's picked up soon enough, then there is no adverse outcome. But if it's not picked up, then there have been reports of adverse outcomes.

And just by one example, a young patient goes for a laparoscopic hernia repair. The lights are turned down in the operating room. After a while, the surgeon tells the anesthesiologist, the blood in here looks rather dark. The anesthesiologist realizes that there is a ventilator disconnect, but unfortunately the patient has an adverse outcome. And why was this not picked up? Because the low pressure alarm in the breathing circuit had not been turned on, and the pulse oximetry and capnometry alarms were also not turned on. So, that's clearly a case of user error, or use error.

Another example would be the surgeon perhaps asking the anesthesiologist to shut off the ventilator while he does a median sternotomy, and then the

anesthesiologist forgets to turn the ventilator back on afterwards. And I can think of one good example that was rather close to home, and that was just that: that the surgeon asked for the ventilator to be turned off, and it was not turned on, and some 20 minutes later the patient developed an arrhythmia. And then another anesthesiologist was called in and noticed that the patient was not being ventilated. And fortunately, it was a cardiac case, so that the patient's breathing circuit was still connected to a source of oxygen. And so, even though the ventilator was turned off, the patient was getting apneic oxygenation. So, that was fortunate in terms of avoiding a bad outcome.

Other adverse situations have involved circuit obstruction. In other words, you go to ventilate the patient's lungs and you find that you're unable to ventilate the lungs. And in many cases, the anesthesiologist will intubate the patient or reintubate the patient, and then still find that they're unable to ventilate, and assume that the patient has bronchospasm, when in fact there's a breathing circuit obstruction. This could be due to the plastic wrapper occluding one of the ports in the breathing circuit, or maybe a stuck inspiratory valve; but either way, the patient gets no ventilation, no oxygenation, and, of course, if the patient's then being treated for bronchospasm rather than what the real problem is, then we have a number of bad outcomes resulting from that.

More recently, the ASA Closed Claims Study has looked at adverse outcomes. There are not a lot of them in the Closed Claims Study, but interestingly, in the latest report from 2013, the leading problem was vaporizers. And in relation to vaporizers, the problems were either under-dosing—there were a fair number of cases of patients having awareness because the vaporizer was either empty, had been turned off to be refilled and not turned back on again; and there are a few cases of anesthetic overdose from the vaporizer being turned up too high. And, again, these really are user errors rather than pure problems of the equipment.

Dr. Laurence Torsher: So, Dr. Eisenkraft, given that they're both equipment as well as user issues, but primarily user issues, what are some of the strategies that one can use to prevent workstation problems?

Dr. James Eisenkraft: Well, I think the most important thing is to learn about the workstation that you're using in principle. You don't have to be an engineer, but follow the source of the gases from the wall or the tank, through the various components of the machine, through the breathing circuit, and then out to the scavenging system. And think of it like the cardiovascular system, the way we think about blood flowing around the body. You know, think about the gases that are flowing through the system, so that you have a mental model. And I think that's perhaps the first step; and to learn about your own particular machine that you use every day.

The next, I think, most important thing would be to do a proper pre-use checkout. The last ASA Closed Claims Study found that 35% of the adverse outcomes were avoidable if a proper pre-use checkout had been done. Now, in some of the newer workstations, the checkout has been semi-automated. What that means is that there are certain things that the user—the operator of the workstation—has to do, because the machine cannot do that for them.

And then, once they've been done properly and met the requirements, then you switch to the auto-checkout, where the machine checks out various other things, such as checking for leaks; measuring the compliance of the breathing system; checking the vaporizer, if it's an electronic vaporizer. But all of those things cannot be automated. And when you think about the machine checkout now, you have to think about the part that the user has to do, the manual checkout, which is often prompted from a menu. And then, once that's done, you do the automated checkout; and then if the machine checks out, then, you know, that's good.

The next most important thing, I think, is the use of monitors and alarms. Our new workstations have wonderful monitors and alarms, and the previous ASA Closed Claims article from 1997 found that 78% of the adverse outcomes in that particular study could have been avoided by the use of – better use of monitoring.

So, we've got the monitors. We should use them, and we should set the alarm limits appropriately, and make sure that the audio alarms are turned on and set at a volume that we're going to be able to hear in the event that one of the parameters is exceeded. Because I know that many people work in operating rooms where the surgeons like to have music playing, or other loud noises. I think we have to either ask them to turn that down, or make sure that our alarms will be audible to us. I know of at least one bad outcome, resulted from the anesthesiologist not hearing the alarm because of all the other noise in the operating room.

And then, last but certainly not least, is that you must have a self-inflating manual ventilation device—in other words, an Ambu-type bag—immediately available and functioning. So, when it comes to checking out the anesthesia machine, the first thing you should do is, one, make sure that you have an Ambu bag or the equivalent; and, two, that you check it. I've seen two cases, one in which the bag was needed and it wouldn't generate pressure, and another one where the expiratory valve didn't work, so that what happened was, when the patient was being ventilated with the bag, the patient had positive pressure barotrauma and pneumothoraxes—tension pneumothoraxes.

So, you know, the Ambu bag or self-inflating manual ventilation device, I think is perhaps the most important thing to check in the pre-use checkout. And if you look at the wrapper in which it comes, the manufacturers instruct you that the device should be checked before being put into use.

The other thing I would say is that, for those people who work in a freestanding facility, make sure that you have more than one Ambu bag. Again, you know, I get to see a lot of cases, and in one case somebody was in an office-based situation, needed to ventilate the patient, and the Ambu bag didn't generate any pressure. So, again, important to check that you have an Ambu bag and that it's appropriate and that it works; and sometimes, you know, if one is good, two is better.

Dr. Laurence Torsher: Well, that's most interesting. One of the other things that I was curious about is, what are some of the biggest changes you've seen in the evolution of the anesthesia workstation over the last 20 years?

Dr. James Eisenkraft: Well, the anesthesia machine (sounds like: was) basically the gas machine with the vaporizers on it, was a pretty simple device. And they were all, in principle, very much the same. And in fact, the FDA in 1987 came out with a generic checkout that really applied to all the anesthesia machines at that time.

Well, since then, the machine has become more complicated, and we now call it a workstation, which is the machine, vaporizers, ventilator, scavenging system, monitors and alarms. It's become a complex, computerized device. And so, it's much more sophisticated. It requires learning. You know, one needs to be educated in the use of these things. Many new components replace old ones. For example, many of the new workstations don't have the familiar needle valves and rotameter flow tubes that people had on the older machines, and they've been replaced by gas mixers or, you know, other equivalent devices. So, that's one of the biggest change.

Also, as the anesthesia machine manufacturers become aware of problems, whether they were user problems or device problems, they have attempted to address those in their new workstations. So, for example, the new workstations

will have high pressure limits on the ventilator, so that you should not be able to generate too high a pressure. Some of the alarms will be automatically enabled when you turn on the machine, and the oxygen analyzer's working automatically. Some of the machines, if they detect a capnogram, will warn you if there's no fresh gas flowing. So, these are some of the changes.

And also, I think there are more changes happening now. We've gone from the old, familiar bellows ventilator, whether it was the standing or a hanging bellows. We now have piston ventilators from one of the manufacturers. And now, you'll see that the – perhaps the pistons and the bellows will disappear and be replaced by, in one manufacturer's case, an impeller—a little rotor that spins 20,000 revs per minute and impels gas around the circuit; and also another one that uses a reflector. So, these are machines or workstations, actually, that don't have bellows or pistons. So, you know, our concept of ventilation will be changing.

The other thing to realize is that these are computerized systems. They require electricity. And so, in all these sophisticated systems, there has to be some sort of simple backup so when it comes to the gas flows, they usually have a common gas flow rotameter that's obviously not very accurately calibrated, but at least you can see the gas flowing. And since these are electronic devices, I think we have to have a plan in place for failure. What are you going to do if the electricity goes out or the system just shuts down?

And I think that brings us right back to the beginning, or at least the most important point, which is, you must have a self-inflating manual ventilation device immediately available and functioning. So, in that way, whatever happens to your anesthesia workstation, at least you have a plan B.

Dr. Laurence Torsher: Well, thank you very much, Dr. Eisenkraft, for sharing your perspective, both on challenges that can arise from the workstation as well as approaches to managing those challenges.

Dr. James Eisenkraft: Well, thank you very much.

Dr. Laurence Torsher: And now back to you, Dr. Schwartz.

Dr. Alan Jay Schwartz: Thank you for joining us today and participating in this insightful conversation with this month's featured author. Be sure to join us for next month's one-on-one author interview, presented in this new, exciting format.

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