Improving Patient Outcomes with Quantitative TOF Monitoring

CMEO Podcast Transcript

J. Ross Renew, MD:

Hello. On behalf of CME Outfitters, I would like to thank you for joining us for part one of this podcast series, Improving Patient Outcomes with Quantitative Train-of-Four Monitoring. Today's activity is supported by an educational grant from Merck Sharp & Dohme Corporation. I'm Dr. Ross Renew. I'm an associate professor of anesthesiology at the Mayo Clinic College of Medicine and Science in Jacksonville, Florida. I'm also the vice chair of research for our department. I'm really happy to be joined today by Dr. Debra Faulk. Deb, tell us a little bit about yourself and your practice.

Debra Faulk, MD:

Hi, Ross. Thanks for having me today. I'm excited to be here. I am working in Colorado. I am a pediatric anesthesiologist, board certified at the University of Colorado, specifically at the Children's Hospital in Colorado. And really excited to be here today and talk a little bit about quantitative monitoring.

J. Ross Renew, MD:

Great. I'm excited, too. I know you've done a lot of work in this area, and I've had the opportunity to read a lot of your work. And hopefully some of the members of our audience are familiar with some of the contributions you've made in this field as well. I do have a couple of learning objectives for today's podcast. At the end of the discussion, we hope that you will have a better understanding of the effects on clinical assessment, qualitative assessment, and quantitative neuromuscular monitoring as it relates to the incidence and complications associated with residual neuromuscular blockade. Well, let's get into it. Dr. Faulk, what do you think are some of the most common complications that our anesthesia audience might identify or might see in their clinical practice associated with postoperative residual weakness?

Debra Faulk, MD:

Well, that's a really interesting question, Ross, because I think that most folks, and you've probably experienced this as well, would say that there's no complications. Their patients are all fine and they can tell that they're strong enough and there's really no issue with residual blockade. But contrary to that, there have been multiple studies, of course, that have shown that there can be significant issues when patients are brought out extubated with residual blockade on board and are brought weak into the PACU. So we know that pulmonary complications can occur. We can see hypoxia, airway obstruction, need for reintubation. There have been some reports of postoperative complications in terms of atelectasis and pneumonia. And of course, other potential issues in terms of patients just needing more care, staying in the PACU longer, just feeling generally crummy. Who wouldn't feel crummy if they were weak? So there are a lot of things I think that can be seen in patients, even though the majority of clinicians probably ignore that and really believe that nothing is going on.

J. Ross Renew, MD:

Yeah, I think you bring up a couple good points, and that it seems that it's on a spectrum, ranging from innocuous is just feeling crummy, like you mentioned, to the overtly weak patient who has to get reintubated. Certainly that stands out as something. But unless this complication is on your radar and you're checking the level of blockade or using one of these monitors, it can be... A lot of times I think clinicians chalk it up to other things, "Oh, they were too sleepy when we extubated or they got too many opioids." And sometimes we don't make that connection that it was due to inappropriate neuromuscular blockade management.

And while not all clinicians identify patients that have postoperative residual weakness, I observe a great deal of variability in how we describe a number of key features in nomenclature associated with this topic. Looking through the literature, there doesn't seem to be great consensus on how we're going to refer to varying levels of blockade or even how we're going to assess the level of blockade in many of our patients. Could you describe the differences between clinical assessment or the use of a peripheral nerve stimulator and contrast that with objective or quantitative neuromuscular monitoring?

Debra Faulk, MD:

Yeah, absolutely, and I think that this is a great point of education for a lot of us. I remember in residency, I could probably spit out the, yes, the threshold for recovery should be a TOF ratio of 0.9, but honestly never knew or saw a quantitative monitor during my training, so what that meant to me was pretty unclear. But there are a lot of ways that we as anesthesiologists can look at our patients and see how strong or weak we think they might be or they actually are. And I think that most people will fall back on that time-honored approach of just looking at clinical signs of weakness in their patients. So those are the things like, oh, they're triggering the vent, they have adequate tidal volumes. At the end of things, can they hold their head up for five seconds? Can they squeeze my hand?

Those are really the things that I think most anesthesiologists grew up with in terms of determining the strength of their patients, although it's been shown that all of those things can be done when patients are still extremely weak. And so really clinical assessments as such are not good for getting an accurate assessment of strength. The next thing that people will go to, and it's probably available to the majority of people in their practice, are peripheral nerve stimulators, as you say. And those are devices, we all have used them, I think, that you can use to stimulate a nerve and see what the muscle response is to that stimulation. And most of us are either assessing that visually or tactilely. Many people will look at that and believe that they can tell with a train-of-four stimulation, which is what most of us are used to, that there is four strong responses versus maybe some fade to that response, fade indicating that your patient is still weak.

But unfortunately, again, still not accurate. We as humans, which we all are, can't tell if there's fade until our train-of-four ratio drops below about 40%. And we all know that the train-of-four ratio of 90% is what we need to tell that our patients are adequately recovered. So moving into quantitative monitoring, which is different than clinical assessment or what we call subjective assessment with these peripheral nerve stimulators, quantitative monitoring really gives us an objective tool to look at the strength of our patients. That is where the train-of-four

ratio comes from, and that is really the only way that we can tell if there's weakness in our patients between that minimal area of weakness where patients are in a train-of-four ratio somewhere between 40% and 90%, and we want to get them to at least 90% before they're extubated.

J. Ross Renew, MD:

Yeah, I agree with that take. I also had a training program that the exposure to these objective monitors was infrequent, certainly, and I think that kind of mirrors the rest of the anesthesia community at that timeframe. Ten, 15 years ago, there was not a whole lot of devices out there available. And when I start thinking about clinical assessment, unfortunately, a lot of these efforts, these physical exam techniques, require a cooperative patient to tease out, certainly the five-second head lift or squeezing the hand. And that doesn't happen a lot of times as our patients are emerging from anesthesia. And I view the peripheral nerve stimulator at this point, and I think that there's mounting evidence for this, and certainly our recent ASA guidelines touch on this, is the peripheral nerve stimulator probably really should be treated as a transition tool. And it's a tool that you use while you gain comfort and familiarity with some new objective quantitative neuromuscular monitors that are available so that we can deliver the highest level of care.

Like you said, I think it's important to remember a peripheral nerve stimulator is not a monitor. The provider is tasked with determining the response to neurostimulation. And from a variety of papers, Stephan Thilen and his group in the Canadian Journal several years ago looked at acceleromyography and the ability of clinicians to correlate that quantitative monitor with a peripheral nerve stimulator level of blockade, and there was significant overestimation on the degree of recovery when using a peripheral nerve stimulator.

My group this past year completed a similar work, also in the *Canadian Journal of Anesthesia*, where we used electromyography and blinded our clinicians to the response to neurostimulation and used it analogous to kind of a peripheral nerve stimulator. And again, we found that we're consistently overestimating the degree of recovery in our patients when using a peripheral nerve stimulator, and this can have consequences on leaving patients with postoperative residual weakness and the subsequent complications that you alluded to. I alluded to this a little bit ago, but there are some new monitors and new advances in this realm of objective monitoring, and I know that you're familiar with several of them, Dr. Faulk. Could you talk on that a little bit for me?

Debra Faulk, MD:

Yeah, so it's, I think, a really interesting time right now because we are getting more and more of these monitors that are coming out that are available. They really have some nice user interfaces, they're portable, and it's a great time to be looking at integrating these into your practice. If people remember way back when, and I actually never used these clinically, but I've used them in research capacity, the TOF-Watch is an acceleromyography device, which acceleromyography looks at tissue acceleration in terms of muscle strength, and they're really finicky. They're kind of hard to use, and I can see why, if this is what was available to you for clinical practice, it never really gained any traction. But since then, there have been a lot of new devices that have come on in the AMG realm that have taken care of a lot of the signal-to-noise issues that they've had, calibration issues that they've had. They're much more user-friendly.

And then on top of that, in the last couple of years, AMG, at least in my world, is not great because you have to have a free thumb to look at that tissue acceleration. And for pediatric patients, the majority of them, even if they don't need to have their arms tucked to the side for surgical exposure or for the surgeons to be able to actually get up close enough to the patient to reach them. And so you can see where AMG, if I need a free thumb, is not going to work. But EMG is a great option in the pediatric realm that looks at compound muscle action potential, so you don't really need to worry about a free thumb. And a couple of new devices have come on the scene in the last couple of years, which I think give a lot of hope to those of us in pediatric practice that there will be devices that will be easy to use and implement into our practice.

J. Ross Renew, MD:

Yeah, I get this question often when talking with clinicians about quantitative monitoring specifically in the pediatric population. And I'd like to delineate that I am in an adult-only practice at Mayo Clinic in Jacksonville, Florida currently. And at least looking on the internet and looking at manufacturer's website, I think they make very... A lot of these manufacturers are coming around to developing some adapters and different pediatric-specific monitors. Can you talk about some of the monitors that are out there that have pediatric-specific capabilities, since that's your realm?

Debra Faulk, MD:

Yeah. I'm not as familiar with the acceleromyography devices in terms of any pediatric-specific modifications that they've made to those devices. But I would anticipate that as long as the sensor is small enough to not impede thumb motion that they can be used in the pediatric realm. For the two new EMG devices that are out there and available, they have recently in the last year developed pediatric-sized electrodes, which are great, because for those of us in the pediatric world, they're not just small adults, and so we have all different sizes of every single equipment that you can have. So we have the appropriate things in front of us for the specific age and size of the patient. So some of these newer electrodes that are now small enough to fit on even newborns are incredible to see.

J. Ross Renew, MD:

Neat. And I definitely have to give a recommendation for your large survey that you conducted in *Anesthesia & Analgesia* last year, looking at surveying pediatric anesthesiologists and their practice as it relates to neuromuscular blockade management and whether it be monitoring or antagonists. I think it gives an excellent glimpse into the realm of neuromuscular blockade management amongst the pediatric anesthesiologists currently. You mentioned AMG versus EMG, and I think that it's really telling that there's been significant interest in this area recently, and it's evident when you go to our major national meetings and walk through the exhibitor hall. I can remember being at the American Society of Anesthesiologists meeting seven, eight years ago and there being one booth available with a vendor who manufactures one of these devices. This past year, I believe I counted six different manufacturers available, and we used to be able to point to a paucity, a scarcity of clinically useful, user-friendly objective monitors as a reason why this has been slow to adopt quantitative monitoring, despite the evidence suggesting that it's best practice, optimal patient practice.

And so it's been interesting to see the response from industry in developing some of these. You mentioned two of the modalities, AMG, you mentioned EMG as it measures action potential and works in the tucked arms position. I've played around a little bit with KMG would be the other commercially available one out there Kinemyography. And for our audience, I'd like you to just kind of categorize that analogous to AMG, or acceleromyography. So KMG also has a hand adapter that wedges between the thumb and index finger, and then following neurostimulation that piezoelectric sensor between the thumb and index finger bends. And that degree of bend then is translated into an objective measurement. You still need a freely moving thumb for this, and so this can fail in the tucked arm position as well. But yeah. And then like you mentioned, Dr. Faulk, EMG has the ability to work when the arms are tucked. Is there any downside to EMG monitoring?

Debra Faulk, MD:

Well, EMG monitoring because of the nature of the signal itself, can certainly be more prone to interference from electrical signals otherwise in the operating room. So I certainly have seen noise be a problem, trying to discern true signal from noise. And it's interesting when you talk about Kinemyography and acceleromyography and thumb positions and all of that kind of thing. Obviously, in the pediatric world when we're predominantly tucked, EMG is really the most sensible thing for us to be using.

But certainly, and I've also seen this in operating rooms where, for a variety of reasons we can talk about, a monitor did not get on the patient and then they've received some neuromuscular blocking agent and it's kind of like, "Well, we didn't get it on." So I always say, "Okay, well you didn't put it on and that's okay, but when you can get to the arm, why don't you put it on and see what you got?" And so for me, it's the same kind of thing. We can talk about all of the upsides and downsides of the different monitors, and obviously a free thumb or limb is going to be really important for AMG and Kinemyography. But if that arm is tucked, you can still put it on when you're at the end and the arm can come out and be free and see what your patient looks like, and that will help guide you in terms of your antagonist and reversing that block.

J. Ross Renew, MD:

You have touched on one of my biggest pet peeves when I'm bringing new monitors to our practice or talking about, and someone calls me and say, "Dr. Renew, your monitor doesn't work." And I say, "Oh, what was your baseline? What was the measurement?" "Oh, well, we put it on after we gave a big slug of rocuronium." And it makes troubleshooting these devices very, very hard if that's your practice. I think we need to get these monitors on prior to induction so that we can obtain a baseline, make sure everything's connected appropriately so that when we are at deep levels of blockade following our induction dose of rocuronium, we're confident that zero, that train-of-four count of zero, even that PTC count of zero is accurate and it's not that the monitor was connected incorrectly. It just makes troubleshooting much, much tougher.

One active area of research that I'm looking at right now is trying to use it to guide when intubation conditions are optimal. So more to come on that, but it's something that I'd like to see the utility of these devices really expand beyond just confirming adequate recovery. I think there's significant utility during the maintenance phase of neuromuscular blockade. If you're targeting certain levels of blockade, maybe it's a robotic procedure that you want a deep level of blockade to keep the diaphragm paralyzed. Certainly having a reliable monitor in that setting is going to be very, very important.

Debra Faulk, MD:

Yeah, absolutely. And I think that that is one of the big areas of education just in even the management of neuromuscular blocking agents that people aren't as well aware of because I think most practice and situations, what people will do is they shun the monitor and then they say, "Oh, my patient is triggering the vent. I better give more neuromuscular blocking agent," not understanding that that diaphragm can move at very deep levels of blockade when you only have posttetanic counts left. So then they're looking at the monitor saying, "Well, I have no twitches, but my diaphragm is moving. This monitor is no good." So it's just the education about neuromuscular blockade management in general and how we look at the monitors to be able to guide that I think is really important.

J. Ross Renew, MD:

Yep. And that ties to a principle that you mentioned earlier. The diaphragm is tough to keep paralyzed, and it recovers first. And so when clinicians are using clinical assessments, "Hey, that was a 600 cc tidal volume, this patient must be reversed." Well, the diaphragm can be back, but there are so many other more important muscles than the diaphragm at this point, particularly when we're trying to prevent aspiration pneumonia among our patients. So I would think with all these new advances that we're going to start seeing a decline or have seen a decline in the incidence of postoperative residual weakness, but I haven't teased that out in the literature yet. Do you think that's going to happen, or do you think that we're going to keep doing kind of what we've been doing in the incidence of weakness will be anywhere from 30% to 60%, depending on the literature you read?

Debra Faulk, MD:

Well, I think that's a really interesting question, and it could go either way. I think that with the new evidence-based guidelines coming out, hopefully this is going to be higher on people's radars and they're going to pay a little more attention to it, which gives me some hope that on the horizon we can see some improvement. The flip side of that, at least in my mind, is what we've seen with the introduction of sugammadex into practice and how that has really created a mindset in a lot of people.

And we saw that in the survey that we did of our pediatric anesthesia society a couple of years ago, that those that had trained since the introduction of sugammadex really don't monitor as much as those that trained before then. And so I think it really creates this instance where people believe sugammadex is so reliable and so efficient that they don't need to monitor anymore. What I try to instill on my folks here at Children's is that, yes, it's efficient, and yes, it's reliable, but it can still fail. We've seen that in several reports in the literature. It can still fail, especially if you're not monitoring. And the dosing that you need to use of sugammadex is actually based on that monitoring. So you can't just guess at a dose and believe that it's going to work and have that be so.

J. Ross Renew, MD:

Absolutely. I would refer our readers to a couple articles that are out there and available. I think the most commonly cited one is by Dr. Kataki out of Japan in which his patients, his research patients were given big slugs of sugammadex without monitoring, and I think there was up to 9% of these patients still had some level of residual weakness. I can't think of any other drug in anesthesia where we would just give it and assume that it works. That's really not in our nature. We give a medication to help out to treat hypotension, whether it be phenylephrine or ephedrine, and then we repeat the blood pressure measurement. It seems odd that this would be a drug that we would just give and assume that it had its desired effect. We know that patients respond differently to all of our medications, and there's significant heterogeneity in this response, it's a bell-shaped curve, and we should be using our monitors to confirm that our neuromuscular blockade antagonist had the results that we wanted it to.

Debra Faulk, MD:

I think one of the most telling pieces of data that's come out in that respect was Dr. Andy Bowdle's article recently in *Anesthesiology* where he looked at dosing of sugammadex and saw that, yeah, most people fell within the range that's indicated. Some needed less, but more concerning that some needed more than the indicated dosing that you would never know if you didn't have a monitor on them.

J. Ross Renew, MD:

Yeah, I definitely also recommend that paper. I think it's pretty neat, and it's introducing this idea that I think a lot of us have had for a while in that sugammadex is titratable, could be potentially titratable if you have a reliable monitor. I know that I get a lot of questions about the morbidly obese patient and do I really need to give them a dose based on their actual body weight? And my take on any of these dosing deviations is you can feel empowered by having a monitor to help guide you that your drug's having the response that it needs. But I think, like you mentioned, that's a really important paper as well.

Debra Faulk, MD:

Yeah. So here's a question for you, Dr. Renew, because what I see is in that respect, a lot of times I'll see way more neuromuscular blocking agent administered than is necessary. So just because the math is easy, everything in pediatrics is weight-based, and so it's easy to think about, "Oh, I'm just going to give one milligram per kilogram of rocuronium to this patient for intubation." But then all of a sudden things are done and you still are in complete blockade with zero posttetanic counts. And my teaching to my trainees and colleagues is just because it's easy doesn't mean it's without risk, because once you're in that complete area of blockade, even titrating to a monitor, you can't know that the recovery that you see is sustained. Have you encountered that, or what are your thoughts to that?

J. Ross Renew, MD:

Yeah, so deep levels of block end up pushing you towards giving more sugammadex, and I don't know that the numbers have been completely hashed out, but certainly the recurrence of neuromuscular blockade has been reported when deeper levels of blockade are administered because maybe some of the neuromuscular blocking agent was sequestered, or particularly if you're using a different, like vecuronium for instance, that doesn't have as high of a binding affinity as rocuronium. There's the potential for the drug to dissociate in the recovery room. And the instances where that happens is predominantly when you're giving less than the manufacturer recommendations for it. And so there's still potential and risk, and I think you need to have a high index of suspicion. Actually, what we try to do is leave... If we're using EMG monitoring, we leave the electrode on into the recovery room so that if one of our patients looks like they could be getting into trouble, we can just take a monitor over there and quickly exclude or include that that patient has some residual weakness and give an additional sugammadex.

But I'm also concerned about this empiric administration of sugammadex. Certainly one of the concerns with its getting FDA approval are hypersensitivity reactions, and while it doesn't appear to be exactly dose-dependent, higher doses, these hypersensitivity or even anaphylactic reactions tend to occur more frequently at higher doses. And it makes sense that it's not a magic wand, and it certainly has made us a little sloppy. I remember the challenge for me when I was training was trying to learn how fast it was going to take my surgeon to close fascia so that I could have the option to administer neostigmine at the end, and it was much, much less forgiving.

I think some of our trainees that practice and really becoming in tune with the timing of the operation, some of that has deteriorated and gone away because you could just give a bigger dose of sugammadex, like you see so frequently. And there's cost considerations to that also. It's not free. It is one of the most expensive drugs we have on our cart, and when you start switching from one to two vials, now we've doubled the cost of that. So there's important implications with that. So with the availability of sugammadex and the idea that the drug is titrated, or can be titrated with an objective monitoring, do you see any obstacles to a practice maybe that only has access to a peripheral nerve stimulator currently and wants to implement and introduce quantitative monitoring into their practice?

Debra Faulk, MD:

Well, I think that maybe one of the obstacles has already been passed if they have peripheral nerve stimulators, but they're wanting to implement quantitative monitoring, and that is just the reluctance and the perception that people have that they're good enough and they don't need any of these devices to correctly assess their patients. So I think for implementing monitoring into your practice, that's probably the biggest hurdle that you have to get past in terms of people wanting to adopt these monitors. Other issues I think that people struggle with, the big ones, are cost concerns, and that can come into play with sugammadex, too, as you just discussed, but cost concerns of acquisition of the monitors. If you're talking about EMG monitoring that has specialized sensors that are a cost, a recurring cost in and of itself, then that can also come into play. And then there's just kind of the adoption of new monitoring in general.

There are some, they talk about early adoption of people that are just like, "It's something new and shiny to play with, give it to me and I'm going to run with it." But the next level of people that say, "Show me the money, show me the evidence that this is going to do something for me." And then those that are just resistant across the board. But when you get in there, I think that those that need a little more help will come up with other reasons, such as this takes too much time, it's too finicky, it fails all the time, and it really impedes my workflow, so it's not worth it for me to put that in. And I've seen that in our practice where people are starting their case and I'll be like, "Oh, do you want to put a monitor on the wrist?" And they're like, "I'll do that later. I don't have time for that right now." But clearly, and you've studied this, I know, it does not take that long to put that sticker on the wrist. It was like, what, 20 seconds?

J. Ross Renew, MD:

Yeah. Yep. 19 seconds. Its minimal amount of time for significantly improving the safety profile. And that person who's rushing who wants to cut that corner, they're going to be the person that says, "Well, I put it on after induction and it's not working because the train-of-four count is zero." And then again, we don't have any way to troubleshoot that because we don't know if it was connected appropriately also. And now the arms are tucked and you're having a tough time getting into there to adjust it, unfortunately.

Debra Faulk, MD:

Yeah. And I will say, at least in the world of pediatrics where all of the kids will go to sleep, breathe in an inhalational gas, and then we'll put in an IV because we can't poke kids when they're awake, in the time period that it takes somebody who says, "I don't have time to do that," as the kid's getting off to sleep, I've got the sticker on the wrist and have gone through the startup before they've even gotten the IV in. And once they're ready to push some stuff, I say, "You're great. Your stimulus strength looks perfect. You're good to go." And they look at me and go, "Oh, really? That was fast." Like, "Yeah, it doesn't take much time."

J. Ross Renew, MD:

It doesn't take that much time. I think there's other creative ways that I've talked with, compared notes with other folks and seen. So we have a couple very experienced OR nurses, and they'll put the monitor on for us at the start of induction very frequently, and we've got a couple pre-op nurses as well that if we're going to be using EMG monitoring for that case, I feel comfortable leaving the electrodes with them and they'll connect it for me so that when we get into the operating room, it's connected and it works, and we can be a little faster and more streamlined when we do it.

What's also nice about that as it gives the electrodes a little bit more time to cure, and I think they can work a little bit better if they've been on for 30 seconds. So with some of the obstacles identified to implementing and utilizing monitoring, we've talked a lot about pediatric patients, which is certainly a special population that has specific considerations that you've adequately gone through and discussed in great detail. Are there any other special populations that have certain monitoring considerations that concern you or things that someone who may not be used to monitoring should consider?

Debra Faulk, MD:

Yeah, I think any time you're talking about monitoring neuromuscular strength, you have to think about patients whose neuromuscular strength could already be impaired and what that means to your monitoring and the accuracy of the results that you're seeing. So patients with degrees of paralysis or neuropathy, things of that nature. I always think in those patients, do I even need to be using neuromuscular blockade at the outset of things? But if you do, you always have to take those things into consideration. And for me, it's looking at... That's when it's really important to put the monitor on first, despite everything that we've talked about and people's reluctance to do that, and just putting it on after.

Understanding where you're starting from with those patients is very important. Patients, I think, who are larger, so have issues of obesity, can also be a problem. You have to understand that, especially with EMG, what you're looking at is capturing the muscle action potential, and if you have to go through layers and layers of your patient to make sure that your signal is getting through and what you're seeing is correct, that can be an issue. And you may have more information on that population. I don't have a lot of big kids here.

J. Ross Renew, MD:

Yes, this is a patient population that's near and dear to my heart, and certainly there can be obstacles with monitoring the obese patient, like you were alluding to. There's some prep work you can do to try to increase your chances of success in these patients. Getting the monitor on early allows the silver, silver chloride electrodes to cure. Certainly if there's a lot of hair over the ulnar nerve, I've clipped the hair from there with one of our disposable razors in the pre-op area to get good contact. Then I think this also lends itself to discussing calibration. So a lot of the devices now are coming out with more manual modes that don't require calibration. So calibration tries to find the optimal current that gives the best signal-to-noise ratio, and it teases out what the super maximal current will be. And one manufacturer of AMG device in particular, the ToFscan, the manufacturer doesn't even recommend calibration.

The device just defaults to 60 milliamps and a 300 pulse width, 300 microsecond pulse width, and it's kind of the... Think of it as taking your peripheral nerve stimulator and cranking it up to 10 each time on that analog dial, because really when we're trying to use these devices for routine clinical care, getting an adequate neurostimulation is the most important thing, not necessarily what current you did it at. Certainly for research purposes, I think performing calibration isn't going to be important, but not necessarily. It doesn't have to be done for routine clinical care. So my obese patient, I'm skipping calibration, I'm turning it up as high as the thing can go, because like you mentioned, that the nerve is buried underneath more tissue than a patient who's not obese. I've played around with monitoring on the feet as well, and I think when we start thinking about neuropathy, particularly in diabetics, we under-appreciate the incidence of it and the impact of trying to monitor at the feet.

Certainly any disease process that insults the neuromuscular unit, such as diabetic neuropathy, is going to preclude you from reliably monitoring these patients, like you had mentioned. In addition to calibration, there's also the step of normalization, which has some importance with AMG monitoring. You'll see with AMG

monitoring, the baseline values could exceed 100%, and when you start considering recovery train-of-four ratios, the process of normalization puts that recovery train-of-four ratio in the context of the baseline, which again may exceed 100%.

So you want to... While the thought is to have a 90% train-of-four ratio at the adductor pollicis for recovery, it may actually have to be higher than that when we normalize with AMG monitoring, because the baseline values often exceed 100%, and I've seen it documented as high as 141%. And that's just a caveat to AMG monitoring that I want folks to consider. But regardless of the modality that you're interested in, I think we've gone over a variety of different monitoring modalities and patient populations, different settings where we may find utility in one versus the other. Dr. Faulk, do you have any closing tips or pearls for our audience who may be interested and motivated now to introduce monitoring into their practice?

Debra Faulk, MD:

Yeah, I would say for those interested in bringing it in, find that group with you that is motivated, that understands the monitoring, how it works, and can really champion that in your group to be successful at bringing it in. Implementation science, as we've seen in several reports of late, the latest I think came out from Dr. Wade Weigel a year or two ago, was very specific about all of the things that needed to be done in that group to be successful in implementing monitoring in the practice, in terms of education, protocols, and whatnot. And so getting past that resistance that people have is difficult. So find the motivated group that you have, learn about the monitors, and just be consistent to drive it forward.

J. Ross Renew, MD:

I love it. Hopefully, some of those motivated local champions are in the audience right now. CMEO programs always include SMART goals to help you translate information into action. SMART stands for specific, measurable, attainable, relevant, and timely. Our SMART goal for this program is for you to identify opportunities for implementation of quantitative neuromuscular monitoring in patients receiving neuromuscular blockade. Please join us for episode two in which we discuss best practices in neuromuscular monitoring with a specific focus on the 2023 ASA guidelines, as well as episode three in which we discuss best practices in the pharmacologic reversal of neuromuscular blockade. All three podcast episodes, plus a variety of educational activities and resources can be found online at the CME Outfitters Virtual Education Hub. To receive continuing education credit for this activity, participants must complete the post-test and evaluation online. Thank you, Dr. Faulk and all of our learners out there for joining us today. Be sure to stay safe and take care.