KYLE M. FARGEN: Well, thanks for having me. I'm going to be talking about stroke and talking about intervention for stroke using catheters to basically suck out blood clots. And I kind of want to present this with a historical perspective because a lot of interesting things have occurred over the last two decades and it kind of puts things into perspective as far as where we've been and where we're going and where hopefully we will be in the future.

So I have no relevant financial disclosures. So this is a patient who presented to us with sudden onset left facial weakness and arm weakness. And he's 78 years old and he has this CT angiogram, this is a coronal view. And there is a cutoff right here, which is the middle cerebral artery. And so that's the M2 segment of the middle cerebral artery. And so this gentleman presents with sudden onset symptoms, he goes to a local emergency room, they do a CT scan of his head and notice that there's no hemorrhage.

They administer IV tPA and then they send them to us. And he arrives at our center, he gets a CT angiogram showing this cutoff and his NIH stroke scale is 10. And so then we get a call, and so as the neurosurgeons or the neurointerventionalists, it's our job to do to determine when these people would benefit from going and taking the clot out. And so we look at the pictures and we discuss it with the on-call stroke neurologist and we decide that when we look at his perfusion imaging, which gives us an idea of the state of the brain, we can look at certain sequences like time to peak, which shows that he has this elevated time to peak in the superior division of the right MCA, which fits the occlusion that we saw.

This tells us that all of his brain is at risk and is starving for blood. And then we look over at the cerebral blood volume and we see that only a tiny little bit of his brain has actually died. So that tells us that this whole area right here is at risk and potentially will die if we don't intervene. But only a little bit of it has died already, and so this is a good candidate for an intervention. And so we wheel him to the angiography suite, we kind of strap him down on the bed, tie down the head, tape it up-- these patients are awake-- tie down the arms, and prep him out, get access in the right femoral artery, and bring a catheter up.

And this is an angiogram, and so this is a straight-on view of the head. So one orbit is right here, the other orbit's over here. So this is an AP view. And I've got the catheter in the right carotid artery. And so we inject dye and we watch the blood travel up over time. And usually, these are filmed as movies so we can actually see the blood traveling through, but in this case it's just a single shot.

And we see the inferior division of the M2 MCA coming this way and filling normally, but there's that cutoff right there. So we bring a big large bore catheter up as high as we can get it, put it up right next to where the clot is, turn on suction through this catheter, push it into the clot and engage it with the clot and then we pull it out. And then we take more pictures.

And here's an angiogram immediately afterwards, and now that blood vessel is open and all the distal branches are filling. And this guy actually went home neurologically normal two days later. And this is what the clot looks like. So here's this catheter and it's a large bore catheter. And sometimes you get these big red clots that just stick to and you just pull it all the way down. It doesn't always happen like this. This is not a representative image of the standard case, but that's sometimes what it looks like.

So here's the second example. This is a gentleman who is 70 and he presented with lower extremity weakness and then rapidly progressed to him being very confused and altered and then obtunded. And he was an outside center. He was given IV tPA for suspected stroke. His NIH stroke scale was 31 initially. When he was flown to us, he had improved somewhat to 23, but that's still a pretty poor exam. And he actually had fixed and dilated pupils, which is always a really bad sign.

And the stroke neurologist who was on, we debated whether or not we should intervene. basilar occlusions, which is what we were assuming this is based on the CTA, tend to have a very poor prognosis because the brain stem gets eschemic and there's strokes and brainstem strokes are not well-tolerated. But because of the fact that he had some exam and the CT perfusion looked OK, we decided to intervene.

And so now this is an angiogram of my catheters in the left vertebral artery. It's a straight-on view of the head. Inject dye, see the left vertebral artery filling. It becomes the basilar artery here and there's this cutoff, it just stops. And the same thing, catheter up, turn on suction, pull the clot out. That cutoff used to be here, now everything is filling distally normally.

And this guy, after we did this, was obtunded and intubated with fixed pupils and started moving arms and legs. His pupils became reactive and he ended up going home with home health therapy with a stroke scale of 3. So these are not completely representative of every case we deal with, but kind of shows the capabilities that we have. And everybody has their generic starting slide. You've probably heard this all day.

It's a leading cause of death, major disability, blah, blah. Huge cost to the health care system. So the key here is intervention that positively impacts the outcome would be of tremendous value to both patients treated and society at large. And so prior to this past year, the best evidence that we had for stroke treatment was with IV tPA. And that's based on these trials that were done in the 1990s.

And initially, within three hours of symptom onset that was eventually revised based on a pooled analysis several years ago to four and a half hours. So now, as you guys are aware, if a patient has a stroke and there's no hemorrhage and they don't have a contraindication and they arrive within four and a half hours of symptom onset, they're candidates for tPA. And that was the only treatment with Class 1 evidence. The problem is that hardly anybody gets it.

And so these are recent estimates. In 2011, only about 5% of patients who are candidates for it actually get it. And there's a number of reasons why they don't get it, but most commonly they wake up and they have symptoms and we don't know when they started. They present, for some reason, in a delayed manner or they take a while to get to the hospital, they're stubborn, they don't want to go, and they end up and it's too late. Or they have any number of contraindications to systemic thrombolitic.

And you guys have probably seen this list, it's very long. I don't have this memorized, but maybe some of the neurologists in the room do. But there's a ton of reasons why you can't get out. And the problem with tPA, besides just the fact that not very many people actually get it that could get it, is that it's not very effective in breaking down clots that are big. And so when we talk about mechanical thrombectomy for stroke, we're really talking about a clot that's blocking a large vessel.

And so we refer to it as a large vessel occlusion. The common acronym now is ELVO, emergent large vessel occlusion. But we're talking about very large blood vessels. So we're talking about internal carotid artery, the middle cerebral artery, M1 or M2 divisions, the vertebral artery, the basilar artery, the first division of the posterior cerebral artery. These are large vessels, and because they're large vessels it requires a fairly large blood clot to obstruct it.

So when people have an occlusion of one of these vessels, it tends to be a large blood clot, large mass of blood clot. And so from studies that have been done, we know that if you come in and your ICA is occluded, IV tPA only works about 10% to 15% of the time in opening it. And the MCA, which is a smaller blood vessel, it's about 30% to 40% to 50% of the time. And the longer the clot is, the less likely it will work.

And in fact, if that clot is eight millimeters or more, the chance is essentially 0% that it will be effective in opening the blood vessel. So if you have a large vessel occlusion, many people don't get tPA or can't get tPA. And if they do get tPA, it doesn't work very well. And this is a problem because if you have a large vessel occlusion and it doesn't open up, there is a devastating natural history associated with that. These are blood vessels that supply a large territory a brain, and so that brain dies and that causes significant problems.

And so from trials that have been done that have looked at patients who had a large vessel occlusion and then were not treated, either they got Heparin only or they weren't candidates for anything, 75% percent to 80% of these patients are dependent and there's a 25% to 40% mortality. So clearly, if we develop something that can open the blood vessel effectively, we have the potential of doing a lot of good for people.

And we know from studies that the faster and the better we open the blood vessel, the better for the patient. And the outcomes are better when the reperfusion is better and faster. And so we use this scale, which I'll mention as we go on. It's called the TICI scale. I don't know if you guys heard this. It's a derivation of the TIMI scale for heart attack. And basically, it's a 0 to 3 ranking scale where we document the amount of perfusion that we obtain beyond the clot.

And so if a blood vessel is blocked and there's this whole area of tissue downstream that's not getting blood, if we restore some blood flow, which is minimal, that would be a 1. If we restore incomplete perfusion, that's less than 50%, that's a 2A, to mean that less than half the territory is now getting blood. a2B would be greater than 50% and then a 3 is complete, like I showed you on those patients where blood is restored to every area downstream. And most of us actually use a 2C, as well, which basically means there's just a tiny little blood vessel distally that's still blocked, but for all intents and purposes it's nearly complete.

And so in the past when we used to be doing thombectomies, we really considered a 2 or better as being an acceptable outcome. And at this point, we no longer consider 2A an acceptable outcome. We know that having less than 50% doesn't really help them all that much and so we're really aiming for a 2B, a 2C, or 3. And I was talking about that timing is important, you guys hear time is brain all the time. But this is a study that was done from a randomized controlled trial earlier on.

They looked at the probability of good outcome and then the time from onset to getting revascularization after a thrombectomy. And basically, each 30 minutes goes by, they have a 10% lower chance of a good outcome. So that means if we're waiting to interpret the CTA and we're taking our time to look at it and decide what to do, we're taking our time to get the patient from the ER to the angio suite or we get them on the table and we're waiting for the nurse to come in or the tech to come or I'm lazy and I'm doing something else, each 30 minutes that goes by, that's a real 10% loss in good outcome. So we do everything very rapidly.

So now let's just shift gears and talk about how we treat the stroke and how we started and how things have sort of evolved. So these pictures are not terribly representative of what it actually is like in real life, but for the most part they give the gist of it. So in the late '90s is when we were using thrombolytic medications, so basically tPA through the catheter. And you put your catheter right next to the occlusion, you give tPA, and then occasionally it opens up like this.

And that's evolved into using an actual device to open up the blood vessel, and the first one was the MERCI clot retrieval system. And this thing is basically like a little corkscrew and you push it through the clot and then you pull the clot out. And this is the first device designed specifically for stroke, and it's actually also the worst device for stroke. It doesn't work very well and if the clot is really stuck in there, which it can be, you can tear the blood vessel, you can tear perforators, which can be disastrous.

And so that shifted towards using aspiration. And the aspiration catheters were originally designed to suck out pieces, not the whole clot all in one. And so you put the catheter up by the clot and there's this little separator device that you push in and out to break up the clot and then you suck out pieces of it. And this was also not terribly effective, but probably better than the device I just talked about. But really what has revolutionized the treatment of stroke and certainly been a big part in the recent trials that I'll talk about that showed benefit for these procedures is the Stentriever, or retrievable stent.

And this is a stent that spans in the clots and it's on a wire so you have a wire that comes off the catheter. And so what you can do is you basically put your microcatheter beyond the clot. You confirm that you're beyond the clot because you give contrast through it and you see filling of the distal vessels normally. And then you unsheathe the stent, and as unsheath it, it expands and it pushes the blood clot to the walls and it opens up a little channel in the middle. And you leave it open for a couple of minutes and then you pull it out.

And when you pull it out, it's highly effective at pulling out the clot with it. There are some bad things that can happen-- little pieces can break off and go downstream or you can tear-- but that's not very common. And now we use these very frequently. Oftentimes, we actually use them with suction catheters. And we also use suction catheters for a new technique called ADAPT, which is something we've been doing just for the last couple of years. And that's why I talk about just putting a really big catheter up as high as it will go, turning it on suction, pushing against the clot, and then sucking up the clot.

And this is actually my preferred first line technique for restoring reperfusion. If this doesn't work because the clot's stuck in there, you can use a stent then. So that's kind of how things have changed. Some years ago, we looked at the trials that had been done to kind of get an understanding of how this technology has affected our ability to open the blood vessel and this is just an image from that.

But if you look at the year of the study, so sort of following the evolution of the technology over time and the good angeographic outcome, we see that the rate has steadily been increasing with time. So we know the devices are getting better. And there's been a couple of randomized trials that have compared the Stentrievers versus that old corkscrew device, and both of them show significant benefit of the new devices over the old ones. I don't really want to spend any time with that, other than to say that the new devices work really well.

And so we can very rapidly restore flow with a low complication rate. And so things have changed dramatically in the last 10 years. And this is an example of using that Stentriever device. This is a straight-on view of the head and this is a lateral view. And this is a gentleman who presented with a basilar artery inclusion. And so here my catheter is in the right verterbal artery, I'm injecting dye, it comes up, and the basilar is cut off right there.

You can actually see retrograde flow down the other vertebral artery here but, it's cut off right there. And so here is my large guide catheter. I've got a small microcatheter coming out of the vertebral artery and now there's the stent, which is deployed. And the stent is radio opaque so you can see it. But there's the stent deployed in the basilar artery, the side view of that. And then with that stent deployed, you can inject contrast dye and do an angiogram.

There's actually flow now going through it and there's distal vessels that are now filling that weren't filling before. You can see how it's sort of hazy. That's all the clot, which is pushed to the side. So there's this tiny little channel in the middle that's open and that stent is pushing all the clot to the side. And then we turn on suction in that big catheter and we pull that thing down and the blood vessel's open now and all the distal vessels are open.

And so that's kind of how those stents work. And this is a picture of what it looks like when you pull it out. So there's a wad of stuff stuck in there. So several years ago, 2013, we were very excited because they were going to publish three *New England Journal of Medicine* randomized controlled trials comparing medical management versus mechanical thrombectomy. And we were very excited because we thought for sure they were going to be positive and they were going to show us that what we were doing was beneficial.

And all of us who do these procedures, we all have stories of where we're doing this on a patient who's aphasic and hemiplegic and you take the clot out and before you're even done with the procedure, the patient's moving their side and they're talking to you. And so you get these dramatic results where there's no possible way-- restoring blood flow like that cannot be of benefit. So all of us were convinced that these trials were going to support what we were doing. But they actually all were negative trials.

They all showed no benefit to primary outcomes with mechanical thrombectomy. And I don't want to spend too much time on this, but I want to hit on it because it's important to understand and kind of why these trials were disappointing and how the trials that have been recently published have improved on these and then shown us that we are doing the right thing. But there were three trials that were published. One was the interventional management stroke 3 trial, which is the most robust trial. It's US trial with a lot of centers, a lot of patients.

There's an Italian trial named SYNTHESIS, which was a terrible trial. And then there's a third one, which was a small trial using MRI scans to assist with selection. But basically, I had the pleasure of writing a comment on sort of the limitations of those trials that was adopted by the American Association of Neurological Surgeons, our Congress of Surgeons, and endorsed by a bunch of other groups as far as our official response to these trials when they were published.

And just to hit on some of the points from that, the important thing when you're studying a patient population and you're trying to determine whether or not a new treatment is a benefit, you have to select the correct patients for that trial. And so what we wanted to see or what you would want to study if you were trying to study whether mechanical thrombectomy is beneficial in patients who have a large vessel occlusion, those patients should have a large vessel occlusion before you randomize them to a treatment.

And it's funny, but in this case, it's not because these patients were randomized into the trial with just having a non-contrast head CT. And what happened is 20% of the patients from two of these trials, when they were randomized to get a thrombectomy, they go to the angiography suite and they do an angiogram and there's no blood clot. So all the blood vessels are open. So 20% of these patients never got a thrombectomy because they didn't need one because they never should have been the trial in the first place.

So these trials failed to identify the appropriate patient population. And when they actually went back, IMS 3, which was the largest of the trials, halfway through it started allowing people to have CTAs ahead of time. And when they went back and looked at those patients who had had a large vessel occlusion on the CTA and then got a thrombectomy compared to those who were treated with medical management, thrombectomy was associated with a better outcome, as you would expect.

However, that was a subgroup analysis and so it's not a primary outcome. And the MRI study, when they could actually obtain revascularization, meaning that they opened the blood vessel, the infarct progression was significantly reduced. And IV tPA is important. IMS 3 gave patients a reduced dose of tPA. So remember, you'll have one Class 1 treatment for a stroke, which is a standard of care dose of IV tPA. And the patients who were randomized to thrombectomy actually got a half dose of that.

So they're withholding the standard of care treatment, probably because they thought the interventionist would be giving intra-arterial tPA, as well, for the procedure and they didn't want to overdose the patient with tPA. But still, they were withholding the standard of care medical treatment in that group, or at least giving them a reduced dose. And then SYNTHESIS, which is the Italian study, didn't actually give tPA at all to those going for a thrombectomy. And so that's not really a great idea.

And then finally, the ability for them to open the blood vessel is really poor. Those trials I talked about where they compared the new Stentrivers to the old corkscrew device, so those trials they were getting 70% excellent or complete reperfusion, meaning that 50% or more of the territory was getting blood after they were done or higher in 70%. And that's really consistent with how we're doing in clinical practice. That's sort of standard results if you look at physicians doing this around the country.

But if you look at the results from the three trials that came out in 2013, 41% in IMS 3, which is well below what we would expect now. In the MRI study, it was actually 27%, which is miserable. And the Italian study didn't even report it, which is a really, really bad sign. And they were using a wire most of the time to try to break up the clot, which is very ineffective and so almost certainly these numbers were really, really bad.

So kind of into the conclusion, you should choose the right patients, those who have large vessel occlusions; you should give tPA to everybody who's a candidate; and then you should use modern devices and achieve modern outcomes. And importantly, even though there wasn't a benefit in primary outcomes for doing mechanical thrombectomy in these three trials, the procedure itself was safe so these patients weren't having increased rates of intracranial hemorrhage, poor outcome, or death, telling us that the procedure is at least safe.

So that was disappointing when all of this came out. But luckily, a number of trials have since been published that contradict those findings. And MR CLEAN was announced in October of 2014. These five have all been published since January 1 of 2015. And what's important about these five trials is that they really didn't suffer from the same limitations. So they did CTAs on everybody and they confirmed that there was a large vessel occlusion and that they limited it to just ICA or M1 occlusions. They gave everybody IV tPA who was a candidate at a standard of care dose and they used Stentrievers, the retrievable stents.

And I have all this information on the five trials. I don't want to spend too much time on it. Just real briefly, the first one was a study in the Netherlands with 500 patients, adults, moderate to severe stroke within six hours of onset and they treated them with a retrievable stent. And we talk about good outcome in these trials, we're really talking about a modified ranking score, and that's a score from 0 to 6 where 0 is you're essentially totally normal and a 6 is you're dead and a score of 2 or better or really means that you're independent and you can take care of yourself.

3 or higher means that you're dependent on someone else to help you or care for you. And so in all of these trials, 0 to 2 is what we're aiming for and that's our marker for a good outcome. And this trial showed that 1/3 of the patients in the mechanical thrombectomy group had a good outcome compared to 20% in the medical group. And this was replicated in all the trials that followed. And three of these trials were actually halted early because they were so effective that the Data Safety and Monitoring Board did an interim analysis and found that they had already reached statistical significance to show benefit so they halted them early.

And ESCAPE was a North American trial, 315 patients within 12 hours of onset, 53% good outcome in the thrombectomy group versus 29% in the medical group. EXTEND-IA is an Australian and New Zealand study. This one halted early with only 70 patients, which indicates that it was highly efficacious as far as the thrombectomy was. And similarly, 71% good outcome with thrombectomy, 40% in the medical group. SWIFT PRIME is the fourth one, 200 patients in North America and Europe randomized to medical versus a retrievable stent within six hours of onset.

60% Good outcome with thrombectomy versus 35% in the medical group. And the last one is a Spanish study, 200 patients within eight hours, similar treatment and randomization and 44% in the thrombectomy, 28% in the medical group. So all of these highly statistically significant supporting mechanical thrombectomy. And just to summarize this, a couple of meta analyses have been done since these have all been published.

The first one, which looks at the five recent trials and then throwing IMS 3 in, which is the large study that was negative in 2013. And if you compile all that together, there's a 2.2 greater odds of a good outcome with thrombectomy compared to medical management. And then another group went so far as to study every single trial looking at intra-arterial intervention for stroke. We're talking about all the way back to PROACT II in 1999 and some of the early ones in the early 2000s.

And if you look at all these patients lumped together, including the three negative trials, there's a 1.8 odds of better outcome with mechanical thrombectomy compared to medical management. And this is reflected in the new guidelines. So these are from June of 2015, the American Heart Association and the American Stroke Association provided these new guidelines for the measurement of stroke patients. And first off, patients eligible for tPA should still get it, even if you're planning on doing a thrombectomy.

That's a class one level of evidence A, that's the highest recommendation. And then number two here, patients should receive endovascular therapy with a stent retriever. And they go on to say all the different criteria, and those are based on the study population from the studies. But the key here is this is a class 1 level of evidence A, so we're talking about the highest level of evidence now supporting thrombectomy. And they say, all eligible patients should receive tPA and mechanical thrombectomy.

So this is a drastic change from just a couple of years ago. And an important point, if you look at the outcomes from the old trials where there was no benefit to intervention and you look at their ability to open the blood vessel and then you compare it to the new trials, it's fairly obvious that when you're opening a blood vessel, anywhere between 60% and 80% of time the outcomes are likely going to be better and they are better. But an important point here is it's not just the device.

And so this is a paper that we wrote with the principal investigators of those five trials. And essentially, the comment here is that stroke systems, not just devices, makes the difference. And even though anybody who is trained in endovascular procedures at any hospital can get one of these devices on their shelves and put in a Stentriever device, really what makes the difference is the fact that you have a robust stroke system with rapid triage, with neurointerventional fellowship trained physicians who do a lot of stroke, with stroke neurologists who do a lot of stroke making the right decisions, then rapidly triaging these patients to IR, taking out the clot rapidly, then transferring them to an ICU where you have neurocritical care physicians and then to the floor where you have rehab and the people that are trained in taking care of strokes so these patients can get better.

Every hospital that treated these patients in these randomized controlled trials was a comprehensive stroke center or a facility that was a European equivalent to a comprehensive stroke center. And so just because you have experience doing a couple of angiograms a year and you happen to have a device on your shelf doesn't mean you should be treating these patients at your center. You should really leave this to the people who do this all the time. So now that these trials have been published, we wanted to kind of see how it's affected volumes and how people around the country-- whether they're seeing an increase in patients being sent to them, if they're doing more thrombectomies.

And so we did a survey of physicians who are trained in the procedures that I do. And I don't want to spend much time on this, but basically, inpatient consultations, hospital-hospital transfers, and procedure volumes have all increased modestly, as you would expect now that we have evidence. And not only that, physicians are increasing their aggressiveness, meaning that they're treating patients who are older and they probably wouldn't have treated before. But even through they're 85 or 90, maybe we should go ahead.

They're treating patients with less severe strokes. So before when you were using an NIH stroke scale of eight as a cutoff, where you didn't really want to intervene if they were lower than, that now four or five if they have a significant deficit. If they have an occlusion or we feel like we can get open, we'll take those patients and we'll try to make them better. And so people are busier doing strokes and we're more aggressive now treating the stroke.

And also, we've really shifted. In the past, we used to do these cases under general anesthesia, which was quite a delay because you had to wait for the anesthesia people, they'd put them to sleep, get the ET tube secured. And the patients don't move as much when they're under anesthesia, but there's a delay. And a lot of people have now studied this and they're showing that their outcomes are better with conscious or minimal sedation. And we think that's because not only have we removed the delay, but also that the intermittent hypertension that occurs with patients getting anesthesia is avoided.

So the hemodynamic changes that result from anesthesia, that drop in the blood pressure for a period of time, that stuff is avoided. So what's the consequence of being too aggressive? And now that we know the procedure is safe and we know it's beneficial, why not just do thrombectomies on everybody who comes in with a stroke? And so there's a couple of reasons not to. But this is a study that we just published looking at vessel perforation, which is probably the worst potential complication from doing a thrombectomy.

And if you review the literature, it's somewhere about 1% or 2% chance that this happens. And sometimes it's unforeseen, sometimes you force things too much and the catheter or the wire goes in a place where it shouldn't and it perforates a vessel, sometimes you just do the case as you would any standard situation and when you pull the Stentriever out, something tears and there's not much you can do about that. But it's rare, but if it happens there's a 60% chance the patient dies in the hospital and the poor outcome at 90 days is fairly high.

And when this happens, basically your hands are tied because you actually have to try to stop the bleeding and you're working in a vessel where there was a blood clot. And so first off, the procedure is aborted because you're no longer going to try to shove devices and catheters through a bleeding vessel, but also you have to try to block that blood vessel with a balloon or something to stop bleeding, try to drop their blood pressure so they don't bleed, and they're having a stroke and the last thing you would want to do in a normal situation is drop their blood pressure and so you're probably going actually make the stroke worse.

So it's a bad situation to be in. And so here's an example of that. This happened not too long ago. This is an 86-year-old male with aphasia, sudden onset, strokes scale of 10. So he's got a real deficit. He's 86. If he progresses to infarct, likely it will be a terminal problem. This is not something than an 86-year-old will likely recover from. And so you're looking at him spending the rest of his days in a nursing home, not being able to understand or communicate with family. So it's sort of a miserable potential outcome.

So I made the decision to try to intervene and get it open. And as people get older, their blood vessels get twistier and harder to navigate, and so here's the angiogram of the head. The left internal carotid artery, here's my catheter. And we see that this branch right here, the inferior division of MCA, is occluded right there. It's hard to maybe tell in this view, but if you wait a couple of seconds, you actually see stagnation of contrast right before the blood clots. So the blood clots right here, which is right here.

And so here's a side view. That blood vessel comes up and wraps this way and then comes here and it's occluded here. There's no flow or very poor flow distally. And I put a Stentriever out, the retrievable stent, which is sitting right here. And then when you pull that out, some blood clot comes with it but the vessel's still not that open normally. But when you look in a delayed manner, you're seeing this haziness right here, which is contrast which shouldn't be there. Contrast should always be in blood vessels. When you don't see the blood vessels, that's a problem.

And so then we move into damage control mode. And so this is an unsubtracted view of the head. And so now I've got a catheter up here, a balloon catheter which I've inflated, to actually block blood flow through that artery because you see this dark haziness here which is not visible over here? That's contrast which has seeped out of the blood vessel in the Sylvian fissure and is sort of the beginning of a hematoma in his brain.

And so you inflate the balloon, you wait, you drop the blood pressure, and then you cross your fingers. And then we took some more pictures and it looked like the bleeding had stopped and at that point in time the procedure was over. I'm not going to try to get that blood vessel open. So he's now going to have a stroke involving that area of the brain that was blocked. That will progress to infarct, but now he also has this hematoma that's forming and who knows how bad that will be.

So we transfer him out to the angiography suite to the ICU and then did a head CT and this is all blood. So this is a fatal bleed. So this is the downside of trying to be overly aggressive. Which brings up a good question, so what about those patients, then? How do you determine what patients to intervene on, especially those who don't fit the standard bill? If you know anything about randomized trials, what we do is we cherry pick patients. You try to find the best possible patient that represents the disease process and that when you treat them is going to do as good as possible so that it shows that your treatment is effective.

So you're cherry picking people. These tend to be adults with a cutoff of like age 85 or 80 is the highest age. They have ideal imaging characteristics. And in the case of the trials I talked about, they're internal carotid artery or middle cerebral artery strokes. What about patients that don't fit that bill? So this is an eight-year-old who had inclusion of his basilar artery. He's eight.

He went to school one day and was on the bus and started falling to one side. And so they took him to the school nurse and then sent him to the hospital and then he ended up getting an MRI scan. They found he had a cerebellar stroke and has a basilar reclusion, so they sent him to us. So what do you do on this patient? He's eight, he has clots, we have catheters. And do you give him just tPA? There's no evidence supporting what we're doing in children.

So we shove a big catheter in there and we suck out the clot, and this kid did really well. But it brings up a point, so what do we do with these people? We don't really have evidence to guide our decision-making. So there's kids, there are people that are advanced age. One of my colleagues at West Virginia published a case report of a 103-year-old with a left MCA occlusion that he did a thrombectomy on and she is normal now.

So that's the oldest age I know of. It's probably actually a bad thing because now we're like, oh, well let's keep pushing the envelope. So what do you do when a patient is 86 or 85 or 90? What about patients who present in a delayed fashion who don't get tPA or that present in a delayed fashion and they still have a CTA showing salvageable brain, meaning that they haven't progressed to infarct, they have good collateral blood supply? And my tendency is to intervene because we can and we can restore blood and we can make them better, but there's really not evidence for that.

What about those who have basilar artery occlusions or verterbral artery occlusions or distal MCA occlusions? For instance, what if somebody presents with a MCA occlusion that's really far out but the blood vessel that's what happens to be the blood vessel going to the motor area and so they're very weak on the other side of the body? What about those patients? Do we intervene on those? If they have a stroke, they may be weak forever but the blood vessels are very small out there. So we don't really have evidence to guide us in those situations.

And those patients who have underlying stenosis, what do we do with them? And so there's more trials underway to hopefully answer these questions looking at new devices and techniques, imaging modalities. Patients have delayed from onset of presentation, other locations. There's actually a randomized controlled trial comparing general anesthesia to conscious sedation and hopefully that will tell us more.

Just a few to talk about briefly, one trial is looking at direct aspiration versus Stentrievers and hopefully that will show that both techniques are very effective. Another trial looking at patients who present in a delayed manner, and still those who are six to 12 hours out but still have favorable perfusion imaging. And hopefully, that will show that intervening is the right thing to do. Another trial, same type of situation, six to 24 hours or those who wake up with a stroke. And hopefully, that will help us know what to do with those patients who wake up and have symptoms and we don't know when it started.