JOHN A. WILSON: For the next hour or so, we'll talk a little bit about the management of carotid artery disease. And certainly, we'll try to leave some time at the end for any questions that anyone has. So I do not have anything to disclose, no financial interests that would relate to this talk.

So stroke is a major problem, major health care problem in the United States. There are nearly 800,000 strokes that occur annually. One in four of those strokes are recurrent strokes. And of those 800,000, 130,000 people die each year from stroke, making it somewhere between the third and the fifth leading cause of death in the United States.

It's also one of the major causes of disability and is a tremendous utilizer of health care resources, costing the United States over $35 billion a year.

So there is an established benefit to carotid endarterectomy in terms of stroke prevention. And as you can see, with recurrent stroke being such a major issue, stroke prevention and recurrent stroke prevention in particular is a major, major goal of treating carotid disease. So we'll go over a lot of the studies that form the basis for treatment of carotid disease.

But when you get right down to it, the application of this information and the application of these studies really comes down to as much art as science. And I'll talk a little bit about how we're doing things at Wake Forest, and what our paradigm for management is.

So the basis upon which most of the carotid studies are situated, the foundation, if you will, is the NASCET study, the North American Symptomatic Carotid Endarterectomy Trial. This was a trial that occurred back in the '90s that came to an early conclusion-- excuse me, in the '80s, and came to an early conclusion in the 1990s. And they randomized patients with symptomatic carotid stenosis greater than 50%.

They had two arms, a moderate grade stenosis, a high grade stenosis. And the high grade stenosis trial was stopped early in 1992 because of a pre-determined endpoint that was reached. What they found was that there was a major benefit to carotid endarterectomy in terms of stroke prevention.

If you looked at the risk of ipsilateral stroke at two years in these groups of patient, in the medical arm, it was 26%. In the surgical arm, it was 9%. So there was a 17% absolute risk reduction, or a 65% relative risk reduction. But the really interesting thing about this trial, and one of the major points of the trial, was when you think about any kind of surgical trial, there's going to be a risk from the surgery upfront.

So by definition, the surgical arm of the trial is going to start out at a disadvantage. And those patients are going to do worse just because of the natural morbidity, mortality of the surgical procedure. So if there's going to be a benefit in the surgical arm, then hopefully the events will stay fairly flat after surgery. Medical events will continue to accrue, and at some point, there will be a crossover where the medical complications exceed the surgical complications.

And I think that the investigators thought that this may well happen in the NASCET trial. They thought that it may take a while for patients to really see the benefit of surgery. What they found was really that crossover occurred within two months of the onset of symptoms. So really, it was very early on.

And this drove a major change in the thinking about how we treated carotid disease. And so part of the reason for that was that in the medical group, the recurrent symptoms and the recurrent strokes seemed to happen very early on. So there had been a school of thought prior to this study where people who had had an acute stroke, you shouldn't intervene on their carotids because of the risk, the fear of reperfusing this injured brain and causing a bland infarct to turn hemorrhagic, or other problems related to reperfusion.

But in this trial, they actually randomized patients with significant but non-disabling strokes and again saw the benefit of early intervention in those patients. And so it kind of drove a change in thinking that it was important to intervene in these patients very early on. And in fact, when the National Institute of Health came out with an announcement about this trial, their statement stated that really, carotid stenosis in the face of symptoms, either TIA or non-disabling stroke, was a medical emergency. And that's more or less how we treat it in this day and age. We pretty urgently try to get those patients for revascularization and treatment of their carotid disease when it occurs.

The other interesting thing was that the degree of benefit in these patients was correlated well with the degree of stenosis. So that the higher the degree of stenosis, the greater the benefit, the greater the risk reduction. So in the 90% to 99% stenosis range, it was a 26% absolute risk reduction. So if you look at this in a different way, as long as the major adverse event rate is less than 6%, which they found in this trial, it translates to six patients that would be needed to treat in order to prevent a stroke over a two year period of time.

And if the event rate is kept as low as it is, less than 6%, then that would be one major adverse event for every 17 patients treated. So you can see again a tremendous benefit in terms of how you're helping these patients with the surgery.

The other thing is that, again, this was looking at it over a two year window. But if you find that the treatment is durable, which has subsequently been shown, then that benefit will continue to accrue over time. And again, the benefit occurs early on in the treatment process.

So that was the high grade stenosis group. The moderate grade stenosis group continued to accrue patients through the '90s and ultimately reached its end point, as well. And what they found was that basically patients with greater than 55% stenosis were found to benefit from surgical intervention with carotid endarterectomy in terms of reduction of the risk of stroke.

Now, you had to keep the peri-operative risks, the peri-operative risks of stroke or death, at a very low rate, or you would fail to achieve that benefit. And if you couldn't achieve those very good success rates with the surgical procedure, then really the patient may be just as well off being treated medically, or being treated at an institution where they can achieve those rates.

If you looked at it again, because the benefit correlated very well with the degree of stenosis, in this more moderate degree of stenosis, the tolerances were closer, and the benefit was smaller, but there was a benefit. But it was a 29% relative risk reduction over a five year period of time, as opposed to the high grade patients where it was, we'd call it a 66% relative risk reduction over a two year period of time. So again, it's a benefit, but not as significant a benefit as we found in the higher grade patients.

In the medically treated patients, they found that the risk of ipsilateral stroke dropped significantly over time. So again, if a patient is more than two years out from their original event, from the index event of their either minor stroke or TIA, then really their risks are the same as if they've never had a symptom at all. And it's essentially like an asymptomatic carotid at that point.

So again, translating this into a number needed to treat, what you find is that there's the number needed to treat is 15 patients in order to prevent one stroke over a five year period of time. Again, there's one major adverse event for every 17 patients treated. So you can see that you're still helping more patients than you're hurting. But the tolerance are much, much closer.

And so you really, when you're talking about these more moderate degrees of stenosis, you have to really tailor the recommendations to the specific circumstances of the patient. And if the patient is in a circumstance where their particular risk from surgery or any intervention may be higher than what is typical, you may get to a situation where they're just as well or perhaps better off being treated medically than they are surgically.

So one of the interesting things that came out of this particular arm of the trial was that there seemed to be a lack of significant benefit in women. Now, the trial wasn't specifically powered to look at gender differences. But this was a theme that seemed to be maintained over a number of different studies. And exactly why that is is unclear. But probably has something to do with the fact that the natural history is better in women in general, and for some reason in this study, the surgical risk was somewhat greater in women.

But if you look at the ipsilateral risk of stroke in the medically treated patients at a five year interval in men, the risk was 25%. In women, the risk was 15%. So you can see that they had a much better natural history which led to the lack of benefit.

Other factors that increase the risk of peri-operative stroke or death are things such as a contralateral carotid occlusion, a left side stenosis, doses of aspirin that were less than 650. This was very interesting, and this drove a significant change in our thinking, as well.

We've all been taught that 81 milligrams of aspirin pretty much blocked all the platelets. It should be as good as any other dose of aspirin. But in fact, there are a percentage of patients who are aspirin non-responders. And when you talk about aspirin non-responders, it probably is not an all or none phenomenon. But just a dose dependent response.

And so in that 20% subset of patients, they may not respond to 81 milligrams. But as you increase the dose, you're increasing that percentage of patients that you're capturing that you're getting to respond to the aspirin. And having some sort of anti-platelet agent on board when you do this carotid endarterectomy is vitally important. Because otherwise, the complication rate is going to go up tremendously.

And then, the other factors you can see there are pretty much what you might expect would increase the risk from surgical revascularization. So again, they found that the degree of benefit was correlated well with the degree of stenosis. So the lower the degree of stenosis, once you get down to 50%, the benefit is really quite moderate. And so you really have to consider both surgeon and patient specific factors when you're making recommendations to the patients about what to do with these very moderate grade stenoses, even when they're symptomatic.

Now, it's one thing to take care of a patient once they become symptomatic. But the holy grail is trying to prevent them from having a stroke, or prevent them from becoming symptomatic in the first place. And so a lot of work has been done looking at asymptomatic carotid stenosis. A lot of work has been done at developing carotid screening tools and trying to screen the population in general.

But what do you do with that information once you get it? And how can you translate that into stroke prevention? And so again, there was a thinking that a subset of these patients during some sort of carotid revascularization may help lower their risk overall. And so a number of studies were devised to look at this.

There was a European trial, the Casanova trial, the VA Cooperative study. But probably the most well-known of all these trials, and the results were fairly similar, was the ACAS trial, the Asymptomatic Carotid Atherosclerosis Study. That was a study that was led by Jim Toole from Wake Forest. So we were the lead institution on that trial.

And again, it was a trial that accrued patients through the late '80s and into the '90s and reached a predetermined end point in September of 1994. At that point, over 1,600 patients had been accrued that had a greater than 60% stenosis, and had been randomized to receive either best medical treatment or carotid endarterectomy.

Now, one of the key things to remember is that back at this point in time, back in the late '80s, early '90s, the best medical treatment was defined simply as 325 milligrams of aspirin. There was no other specific treatment that was prescribed.

So things have changed quite a bit. And we have to keep that in mind as we're evaluating these studies and evaluating some of the more current literature that we have. But regardless, this study showed that the five year actuarialized ipsilateral stroke rate in the medical group was 10.6% and 4.8% in the group that took aspirin plus endarterectomy.

So there was an absolute risk reduction of over 5%, and relative risk reduction of over 50%. And this was based on a very, very low institutional morbidity and mortality. So again, in this asymptomatic population, the morbidity and mortality of the surgical procedure was less than 3%. And once you exceeded that rate-- you can see, with an absolute risk reduction of 5.8%, if you even just got to the risk of a symptomatic patient, upwards of 6%, then very quickly you would lose the statistical benefit of the surgical procedure.

So this is just looking at those results graphically. And looking at the difference again between men and women. And so if you look, the medical treatment, the medical natural history for women was much better than it was for men with a 12% five year event rate for men, 8.7% for women, and a five year event rate in surgery of 7.3% for women. So you can see that in women, the difference was really very minuscule.

And again, this was a fact that was played out in a number of different trials, this significant gender difference that we saw. And it again drove a change in our thinking in terms of how we treat asymptomatic patients. And with women having such a much better natural history, the tendency is to treat them more medically than it is in the male group.

But you can see that the relative risk reduction in women was drastically different than it was in men. And again, it wasn't specifically powered to show a statistically significant difference. But it was validation of a continued trend that we had seen in a number of other studies.

Again, if you translate this to the number needed to treat, the number needed to treat over a five year period of time is 17 patients to prevent one stroke. And if you look at it in terms of the number needed to treat to prevent a fatal or disabling stroke, 40 patients. So that would mean you'd have to operate on 40 patients, put them all under the risk of a surgical procedure, in order to prevent one stroke.

You have to look at this in light of the fact that if you have a 3% morbidity rate for the surgery, 1.5 patients are having an event caused by the surgery in the same group that you are preventing one surgical procedure. So again, the benefit is quite narrow in this group of patients.

If you look at it specifically related to women, the number needed to treat over a five year period of time is over 70 patients. So again, in that overall group, you may be causing a stroke in three patients who were otherwise asymptomatic in order to have prevented a stroke in four patients who otherwise might have had one. So again, it really raises the question, particularly nowadays when we have other means of medically treating these patients, how to best treat the asymptomatic patients.

I think you have to keep in mind as well that this is in an era where there were over 150,000 carotid endarterectomies being performed annually. It was the third most common surgical procedure across the board. And so again, the vast majority of those are going to be in patients who are asymptomatic. And it really does call into question, and really you saw the statistics sort of mirror the results of some of these trials, in that the rates of endarterectomy have fallen since then.

So if you look at a little bit different analysis of this information, this was a post hoc analysis of the ACAS data. And there were a number of things that came out about the data that really even further questioned how much benefit we were really creating.

If you looked at the patients with the 60% to 99% stenosis who had a five year stroke rate of 16.2%, you have to really question, if 6% of those are lacunar or 2.1% of those are cardioembolic, carotid endarterectomy is not going to have an effect on preventing those events.

So really, about the only thing that you might be benefiting the patient is the prevention of that 9.9% large vessel territory stroke. So again, it just makes those tolerances and the benefit of the procedure in asymptomatic patients that much tighter, that much narrower.

As things evolved, we developed other techniques for surgical revascularization, if you will, of carotid disease. And there's been a trend towards more minimally invasive approaches. And that has held true in the treatment of carotid disease, as well.

And so there was the ability to do carotid angioplasty was developed. And then, carotid stents were developed. And this sort of mirrored the treatment of coronary artery disease, which evolved from CABGs to coronary angioplasty and stenting.

And so the question became, well, which is more effective for stroke prevention? Which is of greater benefit to the patients? Carotid angioplasty and stenting, or carotid endarterectomy? And this is where the CREST trial, the first CREST trial, came in.

And this was a study that looked at randomizing patients between carotid endarterectomy and carotid stenting. It was called the Carotid Revascularization Endarterectomy Versus Stenting trial. And in this trial, they really at the time that it was devised felt that they couldn't ethically randomize patients to a medical arm because of the previous trials with ACAS and NASCET.

And so what they did was they just randomized them between stenting and carotid endarterectomy, and essentially were using the previous trials as more or less historical controls. In retrospect, that probably wasn't the best idea because the medical treatment has evolved so much over the years. But at the time this trial was devised, that really was where the feeling was.

By then, it was simply a randomization between those two treatments. Initially, it started out purely with symptomatic patients. But as time evolved, they were having trouble recruiting patients. So they opened it up to asymptomatic patients, as well.

And what the primary endpoint of this trial was was any stroke, myocardial infarction, or death during the 30 day peri-procedural period or any ipsilateral stroke over the follow up 2.5 year period. Now, when you looked at that primary endpoint, there was no difference between carotid stenting and carotid endarterectomy.

The carotid stent group had a 7.2% rate of that primary end point. And the carotid endarterectomy was 6.8%. And so the conclusion that was drawn from that was that in health care settings with experienced staff, the peri-procedural and long term outcomes are comparable between carotid stenting and carotid endarterectomy.

And that is obviously a very true statement as it pertains to how the trial was designed. But the question is, does the primary end point, was that the best end point that could be selected for this trial? One of the things that really was key in this study was the inclusion of myocardial infarction as one of the primary end points.

You might say, well, this is a stroke trial. Why is myocardial infarction included? Well, we know that there is an association between coronary artery disease and carotid stenting. We know that-- excuse me. So we know that there's an association between carotid stenosis and myocardial disease and coronary artery disease.

And we know that there is a risk associated with surgical procedures in patients with coronary artery disease of myocardial infarction. So if myocardial infarction affected the patients' quality of life to the same extent that stroke did, then it would make perfect sense to include this in the primary end point. And thankfully, the investigators did include some secondary analyses within their trial that helped to sort of define that point. And they specifically even looked at quality of life measures.

But when you break it down, it's very interesting what the components of this composite end point, what those results looked like when you looked at them separately. And so if you looked at just stroke as an outcome, that the risk was nearly twice as much in carotid stenting as it was in carotid endarterectomy. On the other hand, MI was more than twice as much in the endarterectomy as it was in stenting. And it was the combination of these two components together to create the composite end point that resulted in the equivalency of the end points in the trial.

And so it does bear further looking to try to determine if that was the best selection of a primary end point. And so if you look at peri-procedural major ipsilateral stroke, you can see a fairly dramatic difference. Again, small numbers, so not statistically significant. But you'll see a trend here through a number of different end points, portions of the composite end point.

If you look at peri-procedural death, again more than twice the number of deaths in the stent group as opposed to the endarterectomy. Not statistically significant because of the small numbers. But again, part of a trend.

This was statistically significant, a greater than almost three times, two and a half times the rate of four year major ipsilateral stroke in the stenting group as opposed to the endarterectomy group. So if you look at this in another way in terms of the hazard ratio, if you look at this plot, on this line here, it would indicate that there is a one to one ratio of the risk of this event between endarterectomy and stenting.

And if the outcome falls on this side of that line, it would be carotid stenting is superior. If it falls in this side of the line, endarterectomy is superior. And then, you can see the confidence intervals here. So again, the primary endpoint, the composite endpoint, no difference.

If you look at stroke end point, stroke and death end point, clearly favors endarterectomy. MI clearly favors carotid stenting. Any death, no difference. Any stroke, major ipsilateral stroke, most of the stroke outcomes favored carotid endarterectomy over carotid stenting. Obviously, cranial nerve palsy, there's going to be no cranial nerve palsies essentially in stenting. So it's going to favor that group.

So they did try to answer the question of how then these component parts of the composite end point affected the quality of life. And so they looked at this through the SF 36, which has both a physical component scale and a mental component scale. And again, looking at the difference that these outcomes had on the patient's life.

This would be a negative difference. This would be a positive difference. And so if you look at the difference of a major stroke versus none, as you would expect, in the physical component, there was a significant difference to the negative. It didn't reach statistical significance in terms of the mental component. But if you look at minor stroke, it did.

The difference wasn't as great. But it was statistically significant. If you look at MI versus none, again, there was no statistically significant difference in either the physical component or the mental component scale in terms of the quality of life of these individuals.

So it does really bring into question the inclusion of myocardial infarction as a component of the primary endpoint. The other interesting thing that came out of this, and they specifically had intended to look at this, was the effect of age, and what effect that had on the outcomes relative to the selection of treatment.

And this kind of was turned on its head from what people had expected. People were thinking, well, you know, elderly, they aren't going to tolerate surgery very well. They're probably going to do better with stents. In fact, they found just the opposite.

If you look, the younger a patient is, the better they did with carotid stenting. And the older they were, the better they did with carotid endarterectomy. And that crossover where carotid endarterectomy became superior was right about the age of 69. This probably has to do with the fact that the older you get, the more atherosclerosis you have within the arch, and the more difficult it is to access the vessels to get the angioplasty and stenting equipment up there, which can result in strokes in and of itself related to the treatment. And so that was one of the very interesting findings out of this study.

So again, if you try to sum that up, there's a superiority of endarterectomy in terms of stroke outcome. There's the real question as to the significance of MI versus major stroke. And the other sort of question is that, why in this group that has the same demographics, they should have the same incidence of coronary artery disease, why would there be a difference in MI between the group that had had stenting and the group that had had an endarterectomy?

We don't know this for sure, but about the only significant demographic difference you could find between those two groups was the fact that 100% of the patients who underwent stenting were done under a regional anesthesia, just a local anesthetic at the site of the injection. And 80% of the patients that had endarterectomy underwent a general anesthesia. So we know that that undergoing general anesthesia, there is a risk associated with that as far as myocardial infarction.

So it begs the question then, if you will. Those patients that were done under regional anesthesia, were their outcomes as far as MI be similar to what that was in carotid stenting? And unfortunately, that has not been looked at yet. But I'm hoping that the investigators will look at that.

But you know, so there is an association with the risk factors of trying to do these endarterectomies under a regional anesthesia. So we find that very interesting relative to what our protocol is here. We were interested in looking at our results because we do the vast majority of our carotid endarterectomies under regional anesthesia.

And so we were interested in looking at it relative to the components of the primary end point of the CREST trial, as well as specifically interested in looking at it related to patients with contralateral carotid occlusion, which has been identified as one of the risk factors, the peri-operative risk factors. But it's something that we didn't really think that we noticed all that much in our patients.

There have been a number of studies that looked at endarterectomy in patients with contralateral carotid occlusion. And if you look at the literature, it's kind of all over the place. There are a number of studies that would indicate that it increases the risk, other studies that indicate that it doesn't seem to have much of an effect.

So there's no real definitive information about how contralateral carotid occlusion affects the risk. But we do know that the NASCET and the ACAS studies did show a tendency towards an increased risk of pre-operative complications in those patients with contralateral carotid occlusion.

That was both in the moderate and the severe stenosis patients in the NASCET trial. And then in the ACAS trial, as well, there was a trend, but it wasn't statistically significant due to a relatively small number of patients.

Our protocol has been a regional anesthetic. We use a superficial cervical plexis block along the sternocleidomastoid muscle. We keep the patient awake to allow for careful neurologic monitoring, and do a primary closure of the arteriotomy, except in those cases where it's a re-stenosis, or the native vessel is quite small.

They are monitored in the ICU post-operatively. It's interesting. Many of these patients tend to be hypotensive post-operatively, presumably because of the unmasking of the carotid baroreceptors. But that usually resolves relatively quickly, within 12 hours or so, and 93% of the patients are discharged from the ICU the following morning.

We do a selective shunting. Now, when you talk about doing an endarterectomy, you obviously have to stop the blood flow through the vessel while you're cleaning the vessel out. And there are people that believe in just empiric shunting, where you route the blood through a plastic tube outside of the surgical field during that period of time that you cross clamp.

There's some risk associated with that, risk of embolus just because of the material it's passing through. Risk of damage to the vessel from putting the shunt in. So there are those, including myself, that support a selective shunting.

So if you're going to do a selective shunting, what you're trying to do is identify those patients who are at risk of ischemia during that period of time that they're cross clamped, and only do the shunt in those patients.

And so there's a number of ways that have been looked at to try to figure out which of those patients do you need to put the shunt in? People have looked at stump pressure, EEG, somatosensory evoked potentials, all these, TCDs. All these have pros and cons. And all of them have relative degrees of sensitivity and specificity to ischemia related to the carotid cross clamping.

But really, when you get right down to it, an awake neurologic exam is probably about as sensitive a test as you can get. It really is 100% sensitive, even though it may not be 100% specific, because there can be other factors such as medication and what have you that might confound it.

But we found it very useful. We do selective shunting with this type of Pruitt-Inahara shunt. You can see this is how the shunts are fashioned. You have a balloon catheter that is placed into the proximate common carotid. Then, this is where you're working on the carotid here. It comes out of the vessel, and then goes distal above the stenosis.

We place the shunt if there's a change in the mental status or the patient has developed a focal neurologic deficit. So we rely heavily on our anesthesia colleagues who are there right with the patient, face to face with them, under the drapes, monitoring them continuously, talking to them, monitoring their contralateral strength.

We used to routinely do cerebral angiography. But we found that with the advent of CTA and with excellent noninvasive means we have of identifying carotid stenosis with our Dopplers and what have you, we've pretty much gone away from performing cerebral angiography.

There is a risk, some small but finite risk, associated with angiogram. And so by getting away from angiogram, we have saved the patient that additional risk. You see that you really get a tremendous amount of detail in these CTA scans. It really gives you a great roadmap where you can see where the calcification is, where the plaque starts and stops, where it is relative to the angle of the jaw, and the spine. And we found it to be extremely useful in the treatment of these patients.

This is how we position the patients. We create a little tunnel here so that the anesthesiologist can be looking directly at the patient while we're working on their neck over here. This is the block that's going in. It's going in just along the sternocleidomastoid muscle there.

We use bupivacaine, which is a little bit longer acting agent. These are the nerves that we're blocking. There are these cutaneous nerves that come over the sternocleidomastoid muscle. Ultimately, those nerves are sacrificed as you get in there. So people have a degree of numbness on the upper side of their incision. But that gets better over a period of several months.

We make the incision transversely, so it can be hidden in a skin crease. And then do our dissection longitudinally subsequent to that. It's a small thing, but it's something that patients really love. And they all come back and say, I can't even see my incision. But it's probably not as important as preventing their stroke. But they do love it anyhow.

So the nerve that's at greatest risk with the carotid endarterectomy is the hypoglossal. The carotid bifurcation is directly beneath the common facial vein here. The jugular is over here. And then, this little artery that goes through the sternocleidomastoid muscle tethers this nerve down. So you sacrifice this artery and vein. That gives you access to the full length of the carotid.

Here again is the hypoglossal-- the [INAUDIBLE] going up to the hypoglossal nerve. Here's the carotid bifurcation. We're blocking the carotid bifurcation here and putting some local anesthetic into the [INAUDIBLE] tissue of the vessel, as that is somewhat sensitive for the patients once we get down there. So we're able to get quite high with this approach.

This is the digastric muscle. We're able to dissect that digastric muscle and follow this internal carotid all the way up really to the skull base. Here's the hypoglossal nerve, again, the [INAUDIBLE] is coming in there. So with the retractor that I'll show you, we're really able to-- we don't really decline endarterectomies on the basis of a high bifurcation. Because we really are able to fairly effectively get to just about any location that the bifurcation is going to be.

So this retractor here certainly has been a benefit to the medical students and residents who no longer have to hold their retractors. But were able to get a great exposure of the entire bifurcation. You can see that the internal carotid here is very expanded, which is what happens as this plaque forms. And this is heavily calcified plaque here. And you can see the vessel really-- and it'll show a little better here on the next slide-- but the vessel coming back more to a normal diameter.

So the first thing we do once we have things exposed, we heparinize the patient and place the clamp on the internal carotid artery. We want to do that before we manipulate the bifurcation too much so that it would preclude any plaque or embolic material being knocked off and sent distally into the intracranial circulation.

And then, cross clamp the other branches. And so now, we've completely isolated this segment of the carotid bifurcation to allow us to operate there and clean out the flak.

This is the endarterectomy being performed. And so we-- I like to do an extra plaque dissection. So we stay on the outside of the plaque. We create this plane within the media vessel.

Now, the plaque will go all the way down to the aorta. And so at the proximal end, you'll have to sort of amputate the plaque. That will leave a little bit of a shelf. But that is with the direction of flow, so that doesn't create a problem.

The distal end is where we really focus our attention. And we are generally able to get up to where the plaque pretty much stops. And we follow that up as high as we need to get to a place where we really don't leave a shelf of plaque at all. But you'll see how we come across this plaque at the proximal end. This is the proximal end down here. So now, we'll amputate this.

And then, we'll evert the plaque from up the external carotid. There it's coming out of this superior thyroidal vessel. Here, we'll get it out of the external. But where we pay the most attention, you can see how dilated this proximal internal carotid is with all this plaque. So we'll go as far distal as we need to go to where we get to where there's really no more plaque, and just a smooth transition to the normal appearing distal intima.

And so you see here there's still all this material. We'll continue to follow that superiorly and just, this is where we spend a fair bit of time really cleaning all that out, getting to where it's just a really nice, smooth transition between where we've done the endarterectomy and where the distal vessel is.

I think this is a big area of concern in terms of the risk of restenosis, the risk of dissection, or even the risk of turbulent flow and potential formation of platelet aggregates and emboli that could contribute to post-op problems.

So once we've cleaned the vessel out, we'll suture it, and then we do a primary closure of the arteriotomy. And this is-- we just started at the distal end of the vessel here. Suture down, and then end up-- hopefully this will show it here in a second.

But we end up back bleeding the vessels so that this stagnant area of blood flow will be essentially washed out of the vessel before we open up the flow again to the brain. So here's the proximal end. So here we are back bleeding the vessel. And then, we'll tie that suture line. And there it is at the completion, the external, internal carotid artery. And that's the completion of the procedure.

So we've looked at this a couple times over the years. But in 2008, we had looked at this. There were 535 consecutive endarterectomy procedures specifically looking at complication rates, the impact of shunting on the overall outcome, and in particular an analysis of those patients who had a contralateral carotid occlusion.

And again, the demographics are pretty much what you would expect. A significant percentage of the patients were symptomatic, had the typical medical co-morbidities that you would anticipate.

So group one were those patients who had a contralateral carotid occlusion. Group two were those patients who did not. You can see that we did regional anesthesia in the vast majority of these patients.

And it's interesting. In the patients that we didn't do regional anesthesia on, a certain percentage of those were just patients who were going to be unable to tolerate laying on the bed, had ankylosing spondylitis, or significant arthritis, things that would just preclude them from being positioned in a way that would allow us to do it.

But a certain percentage of patients, when you cross clamp someone with a contralateral occlusion, occasionally they immediately develop profound neurologic symptoms. They just don't have any real collateral flow to that hemisphere. And so in those patients, it takes a few minutes to get a shunt in place to try to reperfuse that hemisphere.

So when we encountered that interoperatively, occasionally what we would do is convert that to a general anesthesia. Because we knew we were going to have to shunt them. So we put the temporary clamp on. They'd develop symptoms immediately. We take it off, reestablish the flow.

And then, the anesthesiologist would get under the drape, put the patient to sleep. And then, we could give them barbiturates, or propofol, some kind of neuroprotective agent to protect their brain for those few minutes that they would be ischemic during the period of time we were getting the shunt in place. So that accounts for some of these cases in which it was a conversion from regional anesthesia to general anesthesia.

And so again, the group with the contralateral carotid occlusion, there were 51 cases. There were 484 cases in which there were no contralateral carotid occlusion. And what we found, interestingly enough, is that we knew that there was a very low risk of people not tolerating the cross clamp when you have an open contralateral carotid.

Only 3% of those patients required a shunt. Surprisingly, even a person even in that group who had an occluded opposite carotid, still 77% of them tolerated the cross clamp just fine, had no neurologic symptoms whatsoever. So again, it sort of validated our choice of selectively shunting these people in that only 23% of them ultimately needed to have a shunt.

We looked at our complication rates. The medical complications were 1% overall. These were things such as pneumonias, UTIs, DVTs, those sort of things. The peri-operative stroke and death rate was 1.2%. There were two cases in group one, which was the contralateral occlusion. One was a hyperperfusion related intracerebral hemorrhage, and one was a stroke.

There were only two permanent cranial nerve palsies. One was the mandibular branch of the facial nerve, creating weakness in the corner of the mouth. The other one was a vocal cord paresis. And then, a 1.5% risk of wound complications.

So our conclusions were that endarterectomy under regional anesthesia with selective shunting is accomplished with an acceptable morbidity and mortality, and that patients with contralateral carotid occlusion are much more likely to acquire an in-dwelling shunt and develop symptoms of cerebral ischemia, but still at a relatively low rate that we thought validated selective shunting in that group of patients, as well.

So treatment guidelines that we utilize to a large extent, symptomatic patients that are greater than 75%, men or women are likely to benefit from surgery unless there are factors that dramatically increase their surgical risks. Symptomatic in the 50% to 75% range, men again have a very strong benefit. We tend to operate on them quite often. Women, age and medical co-morbidities need to be considered.

But again, in the symptomatic group, absent significant risks, we tend to recommend endarterectomy in that group, as well. In terms of the asymptomatic patients, we generally are focusing on the greater than 80%. If a patient progresses, either presents at a lower degree and progresses up to the 80%, or presents at 80% and progresses beyond that, we'll often use that as a trigger to recommend endarterectomy.

But the other thing is that currently, there is a trial called CREST II that we're enrolling patients in that we really encourage these asymptomatic patients to enroll in. CREST II really was designed to address some of the shortfalls of the CREST I trial, which basically was the lack of a medical control arm.

When you look at it nowadays, with the introduction of statins, with tight control of blood pressure and blood sugar, it's had a profound impact on the medical risk of stroke in these patients with asymptomatic stenosis. So we felt that it wasn't necessarily valid, particularly in asymptomatic patients, to compare what is current surgical management with either stent or endarterectomy to a historical medical management that probably has been dramatically improved upon with current techniques. So that's what CREST is looking at.

So the patients, there are two arms or two sort of parallel studies, if you will, that are going on. There is a stent versus medical management arm, and an endarterectomy versus medical management arm. And those are going in a parallel fashion.

So whichever the surgeon and the patient ultimately would prefer in terms of intervention, they go into that arm, either stenting or endarterectomy. And then, the patient is randomized, either the best medical management versus intervention. And they're being followed. So that study is just in its early stages, just has been enrolling patients over the last year. And we're really looking forward to that helping us answer some of the questions that remain about the treatment of asymptomatic patients.