

## **Atrial Fibrillation and Underestimation of Aortic Stenosis Severity**

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Dr. Bell: Welcome everybody. My name is [Malcolm R. Bell, M.D.](#) I'm the vice chair of the Department of Cardiovascular Medicine here in Rochester, Mayo Clinic. And I'm very pleased to have with me today my friend and colleague, [Vuyisile T. Nkomo, M.D., M.P.H.](#) Dr. Nkomo is a professor of medicine and he has a joint appointments and the divisions of structural heart disease and our cardiovascular ultrasound division. So welcome, Vuyisile.

Dr. Nkomo: Alright. Thanks, Malcolm. Thanks for having me.

Dr. Bell: Yeah. So you're here to talk with us today about diagnosing the severity of aortic stenosis in patients who have atrial fibrillation. But perhaps before we talk about the atrial fibrillation aspect of this, perhaps you could just remind our audience so what are the echo Doppler criteria for diagnosing the severity of aortic stenosis?

Dr. Nkomo: Right. So as you know, Malcolm, aortic stenosis is very common in the general population. And currently, echocardiography is the primary tool that we use for assessing severity of aortic valve stenosis. And the current guidelines say a peak velocity of four meters per second, or a mean gradient of 40 millimeters of mercury across the aortic valve, is consistent with severe aortic valve stenosis. And this will typically occur in the setting of a small valve area about one square centimeter, or if indexed to body surface area, around 0.6 or 0.65 square centimeter per meter, ah, square meter.

Dr. Bell: So, Vuyisile, is there a hierarchy in those guidelines you just gave?

Dr. Nkomo: Yeah. I think the current guidelines emphasize the peak velocity and mean gradient. Typically a peak velocity of four meters per second will correspond to mean gradient of 40 millimeters of mercury. And so once you have a peak gradient of four meters per second, or a mean gradient of 40 millimeters of mercury, that is consistent with severe aortic valve stenosis. And the current guidelines will say irrespective of your aortic valve area. So the aortic valve area, a small aortic valve area, is not a necessary criteria to diagnose someone as having severe aortic valve stenosis. As long as the peak velocity mean graded meet criteria, then that patient likely has severe aortic valve stenosis.

Dr. Bell: And of course, the valve areas also could depend on your measurement of that outflow tract. Which with some errors are —

Dr. Nkomo: Correct. I think there's more, there's more that goes into calculating the aortic valve area. And so there's more chance of error in doing that, but it's still an important parameter.

Dr. Bell: Sure. And then the, the peak velocity, and obviously the gradient — you, in general, it shouldn't be overestimated. It potentially could only be really underestimated when using Doppler. Is that correct?

Dr. Nkomo: Correct. Unless you have a falsely high signal or at least a signal that you think is from aortic stenosis, but it's, it's from vascular stenosis. Now this can be a potential problem in elderly patients, particularly when we scan sort of every possible window with echocardiography, that we run into vascular stenosis. And sometimes that signal of four meters per second or 40 millimeters of mercury might look like aortic valve stenosis, but it's actually a vascular stenosis situation. So, but as long as you, as you get that velocity main gradient across the aortic valve, you can't really overestimate it. Of course, there's some technical things, that you shouldn't over-trace the signal and so forth. But if you, if you get four meters per second, 40 millimeters of mercury, well-traced signal across the aortic valve, then it should be consistent with severe aortic valve stenosis.

Dr. Bell: So it all sounds pretty simple and straightforward. So what about the patient now with atrial fibrillation? Because all those beautiful Doppler signals that we see traced out seem to come from patients with good signals, but particularly patients with normal sinus rhythm. So, how does Doppler echocardiography underestimate severity of aortic stenosis?

Dr. Nkomo: Right, now it's a very good question. So it turns out that the major determinants of the gradient across the aortic valve are a valve area as well as forward flow across the valve. And atrial fibrillation, just the rhythm of atrial fibrillation and the patient being in a rhythm is associated with a lower forward flow state compared to sinus rhythm. And so it means for the same aortic valve area, a patient in atrial fibrillation versus the one in sinus rhythm may not be able to generate the same peak velocity or mean gradient across the aortic valve because of a lower flow state. And some of these patients with atrial fibrillation actually have very low forward flow, because in addition to the rhythm being abnormal, which in and of itself is associated with low, low forward flow, some of these patients, especially the ones with persistent atrial fibrillation, will have mitral valve regurgitation as well as tricuspid valve regurgitation from functional atrial enlargement. So they have this functional valvular regurgitation, which then further lowers the forward flow and sort of impedes the generation of a high signal across that narrow, narrowed valve.

Dr. Bell: So obviously, maybe a lot of things at play here. Pick a — maybe just focus on the arrhythmia itself, here. So obviously atrial fibrillation, irregularly irregular. So you're going to have some short RR intervals, some longer RR intervals. Walk us through that, how that may impact the, the signals that you're receiving on Doppler.

Dr. Nkomo: So that's a very, it's a very good question. So currently, you know, the work around this issue of variable cycle lengths and variable peak velocities and variable mean gradients is to average about five consecutive signals, to get an average of the mean gradient across the aortic valve. And then we use that one to say how severe the aortic valve stenosis is. But the, in general, just being in atrial fibrillation, as I said, is associated with impaired cardiac function just because of irregular cycle lengths. And so, while a patient might have severe aortic valve stenosis with the narrowed valve, some of the signals might be consistent with less than severe

aortic valve stenosis and some of them might be consistent with severe aortic valve stenosis. And that sort of depends on the cycle length and LV filling and contractility and, and all of that. Because some of these higher signals are generated from cycle lengths associated with a normal or more near normal forward flow. And the lowest signals are generated from cycle lengths that are associated with abnormal flow. So lower flow. And lower peak velocity mean gradients are not necessarily reflective of less severe aortic valve stenosis. It's just that the patient cannot tell you that they have severe aortic valve stenosis because the signals are coming from this sort of low flow generating cycle lens. And so this is where the problem becomes. And I think averaging five of those signals lowers sort of the mean gradient. And so if you have this high signals consistent with severe aortic valve stenosis, if the average falls below the threshold for severe AS and the patient ends up being labeled as sort of low gradient aortic valve stenosis, while sometimes they are able to generate this high signals consistent with severe aortic valve stenosis.

Dr. Bell: Would it be fair, though, that if you had one or two signals that showed that you had very high peak velocities gradients, that that's enough to make the diagnosis of severe aortic stenosis?

Dr. Nkomo: Yeah. You know, some of us think that should be the case where the highest single highest mean gradient or single highest velocity should be the one used to determine hemodynamic severity of aortic valve stenosis, because when you compare the sort of flow-dependent measurements like the peak velocity mean gradient from echocardiography to either measures of severity of AS like CT scan aortic valve calcium score, for instance. And we're now also looking at the excised aortic valve weight. The, the highest mean gradients or the single highest mean gradient seems to correlate well with the degree of aortic valve stenosis by those other nonflow-dependent measures of, of severe AS.

Dr. Bell: So in a minute or so left to us, so in these patients that it's not clear, you're not getting that, you know, that those highest signals, but you're certainly suspicious of severe aortic stenosis. What are the next steps that you're going to recommend? It seems as though you need to average at least 5, 6, 7 beats perhaps? But, but if you still don't have your answer there. How do you reconcile that? What are your next steps? You talked about CT here.

Dr. Nkomo: Now it's a good question. So I would say the clue is really in that highest peak velocity and mean gradients. And so once you have this high signals and high mean gradients, especially the ones that meet criteria for severe aortic valve stenosis, then you should really think that the patient probably has severe aortic valve stenosis. But the next go-to test for me is a CT scan. So, computed tomography aortic valve calcium score, because they can tell you the calcium load on aortic valve and the thresholds are different for men and women, because men tend to have more calcium deposition during progressive aortic valve stenosis. And a calcium score of 2,000 or more in men is consistent with severe aortic valve stenosis. And a calcium score of about 1,200 or 1,300 in women is consistent with severe aortic valve stenosis. And so in a situation where you have a discordant small aortic valve and a low gradient. ask yourself, is the patient in sinus rhythm or in atrial fibrillation? Because if they're in atrial fibrillation, there's a high likelihood that the patient has severe aortic valve stenosis, at least by calcium score data.

And if they're in sinus rhythm, the probability of severe aortic valve stenosis by calcium score is about 50 percent. Whereas in the atrial fibrillation patient, it's about 80% or more.

Dr. Bell: Are there are other tests that you would then go to if you're still unsure of it? For example, these patients end up in the cardiac cath lab having hemodynamic studies or are there other things that you do before that?

Dr. Nkomo: Right. So the hemodynamic cardiac catheterization is also another important test. Obviously, it also rules out some other things that may be potentially wrong with the patient, and causing symptoms. But in the cath lab, the measurements they get in terms of the gradients are also flow-dependent. And we've been in conversation with some of the colleagues in the cath lab about how they actually do that. Echo correlates very well to cardiac catheterization. But if we're averaging signals during the cath lab and also averaging signals during echo, so we may both be not doing sort of the right thing by that patient. But yes, cardiac catheterization is another potential test one can use for this.

Dr. Bell: Ok. And then if the patient who may not have any severe underlying heart disease or other significant valvular disease. Do you have studies of patients who have an echocardiogram that they're in sinus rhythm and then a short time later during atrial fibrillation, and then you have the opportunity to measure those Doppler signals and then compare them. Essentially looks as though you've been involved in those studies. Could you give us the findings there?

Dr. Nkomo: I know. It's a very good question. So we looked at and we published a case series of a few cases that were, both saw, the same patient was both in sinus rhythm and in atrial fibrillation at two different times within a few weeks of the studies. And the patients had severe aortic valve stenosis. And it turns out that when they're in atrial fib, atrial fibrillation, versus sinus rhythm that calculated valve var is about the same. But the hemodynamics across the valve when the patient is in atrial fibrillation are much lower. So the peak velocity is lower and the mean gradient is lower. Because of the stroke volume, the forward stroke volume is lower and the forward flow rate is lower during atrial fibrillation. And when the patient is then cardioverted back into a normal sinus rhythm, the stroke volume index improves, the forward flow rate improves, and the peak velocity and mean gradients go way up and actually meet criteria for severe aortic valve stenosis. We're actually surprised in some of these patients because the difference in the mean gradients could be 10 to 15 millimeters of mercury difference. Which is, which is a lot. And so you have someone in atrial fibrillation with low, low-gradient aortic stenosis with a normal ejection fraction. And then that same patient, when you cardiovert them, they add about ten to 15 millimeters of mercury to that gradient. So you can't really say that the patient has, you know, less than severe aortic valve stenosis when they're in atrial fibrillation and that they have severe aortic valve stenosis when they're in sinus rhythm. I mean that patient has severe aortic valve stenosis during atrial fibrillation. They just can't tell you that they have it because of impaired cardiac performance.

Dr. Bell: Yeah. There are really important observations of yours that could be very important for managing these patients. And maybe just in the last 30 seconds here, what are the implications of underestimating the severity of AS in these patients with atrial fibrillation?

Dr. Nkomo: Right. So, good question. I mean, the immediate ones, the immediate consequences would be underrecognition of severe aortic valve stenosis. So, underdetection of severe aortic valve stenosis and then delayed, sort of, diagnosis of severe aortic valve stenosis, which will then lead to delayed referral to aortic valve intervention for those patients that are candidates for an aortic valve intervention. And in fact, when you looked at, when you look at outcomes in these patients by rhythm, in the patients that have atrial fibrillation without aortic valve replacement, they do worse than the patients in sinus rhythm. And after aortic valve intervention, be it surgical or TAVR, patients in atrial fibrillation don't do as well as patients in sinus rhythm. And part of that is related to some of these things we mentioned, you know, the additional structural heart disease associated with patients in atrial fibrillation. And when you look at the, the ones that do go for TAVR, for instance, we found that the aortic valve calcium scores are much higher in the patients in atrial fibrillation than in patients in sinus rhythm, for a lower peak velocity mean gradient in the patients that are in atrial fibrillation. So the mean gradient doesn't really tell you how severe the aortic valve stenosis is and it's much worse than we think it is by the time we refer them for aortic valve intervention.

Dr. Bell: Yeah, so, maybe just another example that when atrial fibrillation accompanies other heart disease, it has really sort of grave consequences unless it's treated appropriately. So Vuyisile, thank you so much for taking the time to share the experience of you and your colleagues in the valve clinic. It's so important. And I think there's a very important, a number of important messages that you have provided today. So thank you so much.

Thanks, Malcolm.

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