

Questions of the webinar "Imaging in TAVI procedures"

Answered by Andreas Hagendorff, Victoria Delgado and Bernard Cosyns

1. The incidence in AR

I think that this question focuses on the incidence in AR after TAVI procedures. Mild to moderate aortic regurgitation is a common finding in TAVI patients treated with the former devices (CoreValve, Sapien). The incidence of post-procedural paravalvular leaks (> 2+) is reported in the literature with 20-25%. In general, there is a problem to quantify the severity of aortic regurgitation in TAVI patients, because normally small left ventricles with a pressure load will switch after non-optimal TAVI procedures to small ventricles with a volume overload due to aortic regurgitation. This scenario is completely different in comparison to a chronically dilated left ventricle with a chronic aortic regurgitation.

2. How we may detect endocarditis after TAVI ?

The typical lesions of endocarditis are vegetations and abscess formation. Of course it is easier to detect vegetations as floating structures by echocardiography - despite the artifacts of the device annulus or device cage. Using echocardiography it is an issue of the technical skill to visualize these structures - especially if they are small - within the artifacts. It is important to scan from multiple views in both techniques, the transthoracic as well as transesophageal approach. It is much more difficult to detect abscess formation after TAVI and prosthesis valve disease, because the paravalvular regions are normally altered by hematoma or the prosthetic annular structures. Thus, abscess formation is normally detected by multiple transesophageal investigations, in which a dynamic of morphology can be observed. Perhaps in future PET-CT will be helpful to diagnose abscess formation after TAVI.

3. What do you think about to measure the orifice effective area of aortic valve by 3D QLAB with color doppler?

The planimetry of the orifice area of the aortic valve in TAVI can be assessed in a high quality color coded 3D4D data set. Then it is possible to make a planimetry of the systolic jet area perpendicular to the main jet direction using postprocessing software like QLAB or EchoPAC FlexiSlice. However there are still problems due to the spatial as well as temporal resolution. I can recommend to use higher frequencies and no averaging to get sharper contours of the color flow and to get volume rates of more than 20 volumes/s using ZOOM function.

4. Continuity equation cannot be used if high output state or small body size/small aorta... but what about the gradients are they not of value then?

The continuity equation is a calculation, in which three measured parameters will be inserted. Per se there are a lot of possibilities to produce significant errors (mostly due to the wrong LVOT diameter and/or not exact PW and CW Doppler spectra). Furthermore the velocities will be determined after an extreme simplification of the Bernoulli equation. Thus, the phenomenon of pressure recovery is often not remembered to produce significant too high transvalvular gradients with the consequence of overestimation of the

severity of the aortic stenosis using the continuity equation. Therefore, if there is a high output stage and/or if there is a small body size, you have always to exclude the possibility of an error of overestimation of AS due to the mathematical simplifications - either by performing a TEE or other imaging modalities. If the aortic stenosis is really severe, the error due to the simplified continuity equation will become unimportant. Then, the results of the continuity equation are mostly correct.

5. Restenosis of biological aortic valve 10 years after first procedure at a 83 years old patient good clinical status in what condition will refer to TAVI ?

This is a clinical issue, which has to be decided according to the biological status of the patients, the morphology and size of the prosthesis, the calcification and size of the aortic root and the aorta, the risk of comorbidities and the risk of re-operation, and the circumstances of the access to the valve using the interventional approach. Normally, if a valve-in valve procedure is possible, and the risk of a re-operation is high, TAVI would be a good alternative to the second aortic valve replacement.

6. WHAT do you do when there is discrepancy of annular measurement between the TOE and CT?

Normally, a method is as good as the one, who is using the method. Thus, if the images of echocardiography are excellent and the measurements are performed at the correct sectional plane at the correct time point of the cardiac cycle, they should be correct. If the images of CT are excellent and the echo images are worse, then of course the CT images will be better to make a decision.

If both data sets are brilliant, try to find out the reason of the differences, which normally should not be present in this case. In this case, I prefer to trust the echo data because these data can be checked dynamically in the cine loop using postprocessing. And - if necessary - you should repeat the echo as well as the CT images and measurements to clarify the situation.

7. How would you assess a post-procedural aortic regurgitation? How much of AR is tolerable?

My opinion is to focus on regurgitant volume by LV planimetry and stroke volume determination using Doppler echocardiography measured by LVOT or RVOT VTI and LVOT and RVOT diameter. However, therefore excellent images and Doppler spectra are necessary. Normally LVOT and RVOT diameters for these assessments should be measured in TEE documentations. If you use TEE 3D4D data sets you can also perform a planimetry of LVOT and RVOT in 3D4D data sets to have the correct cross sectional areas for your measurements. I don't like semiquantifications using the crescent shape of the paravalvular leakage in relation to the prosthetic annulus. This approach is often prone to errors. Using MR is also an excellent alternative for the assessment of regurgitant volumes - if possible. If you detect a moderate AR due to the assessment of regurgitant volume, it is normally relevant and you have to think about additional procedures and therapeutical options.

8. What do you think about TAVI procedures with no TEE monitoring?

TEE is helpful during monitoring of all invasive procedures, because online measurements and the acute detection of complications is possible. However, if the patient is not sedated and intubated, there is a risk of aspiration and aspiration pneumonia in addition to a discomfort of the patient. Thus, the usage of TEE during TAVI is controversially discussed. I would prefer to perform TEE during TAVI with respect to the advantages. Aspiration can be avoided by careful suction protection - even if the patient is not intubated

9. Do you have tips and tricks how to make a good 3D image for aortic valve since for me it seems harder to make good 3D image compare with mitral valve.

It is correct that imaging of the aortic valve is much more difficult than imaging of the mitral valve by TTE and TEE. This is due to the fact that the reflection zones of the mitral leaflets are perpendicular to the scan lines of the ultrasound, and the aortic cusps are parallel to the scan lines. Thus it is better to visualize the aortic valve if the cusps are oblique to the scan lines. Furthermore, the contrast should be enhanced, and axial spatial resolution can be improved by increasing the scanning frequencies. Furthermore, for the detection of the orifice area it can be helpful to acquire the 3D4D data set when the primary scan plane (which will have the best spatial resolution) will be a short axis of the aortic valve. There are several further issues which have to be considered.

10. What is the role for non-radiating M.R.I. (?preferable unless I.C.D. pacemaker)?

MR should be used in every younger patients prior to CT to avoid x-Ray exposition. MR is excellent for quantification of the severity of AR.

11. Could you give some information about the measurement of aortic annulus with 3D TOE in TAVI cases.

The virtual annulus of the aortic valve should be measured at the hinge points of the cusps. Thus, you should center the aortic valve in the long axis in a 3D4D data set. During diastole the plane of the endings of the "crown" of the cusps can be easily visualized by the perpendicular plane to the center axis through the aortic valve. In a second step you have to rotate the short axis plane to confirm this sectional plane at the "crown" endings. Then, you have to translate this plane to the hinge points of the aortic cusps. Again you have to confirm this plane by rotating the short axis view.

12. How do you evaluate a patient after TAVI to assess its success?

During the procedure using all possible imaging modalities (angio, CT, echo)
After TAVI primarily by echocardiography: you have to assess the gradients and the possible para- and transvalvular leakages. You should try to measure directly the orifice area of the TAVI prosthesis.

13. Why not doing coronary arteriography to evaluate by-pass indication?

You have always to assess the state of the coronaries prior to TAVI to treat coronary artery disease, if present - either by CABG and AVR or PCI and TAVI.

14. In this last case What about a combination of techniques to evaluate not only the technical issues for the TAVI implant but also the residual myocardial function and perfusion conditions?

The evaluation of a AS patient should always be complete. Thus, we have to evaluate morphology and function of the aortic valve and the left ventricle (and of course - all other structures of the heart). In our institution all AS patients, in whom surgical or interventional treatment will be discussed, TTE, TEE and cardiac MR will be performed. Thus myocardial function is analyzed by deformation imaging and MR, perfusion normally by MR, in rare cases also by myocardial contrast imaging - if opacification of the LV is performed.

15. Why not doing coronary arteriography before deciding for TAVI or conventional surgery + by-pass surgery ?

see 13. You have always to assess the state of the coronaries prior to TAVI to treat coronary artery disease, if present - either by CABG and AVR or PCI and TAVI.

16. In which phase of the cardiac cycle we should do the measures of the aortic annulus?

Normally - according to the guidelines of aortic and pulmonary regurgitation of the EACVI you should measure the diameter of the annulus in the long axis view during systole. To determine the annulus in the short axis view in a 3D4D data set you should measure the cross sectional area of the virtual annulus during diastole and systole. You should start during diastole, because the labeling of the hinge points during diastole is easier. Then, during systole by translating the plane in flow direction. The distance of this translation should be the same as the differences of the distance of the endings of the commissures at the aortic root wall between diastole and systole.

17. Is it always important the assessment of the distance between aortic annulus and coronary ostia?

Yes, I think it is always important. I think prior to TAVI we have to assess this parameter as well as the length of the cusps to estimate the risk of coronary occlusion during the procedure.

18. Can MDCT miss some more soft thrombus compared with angiography?

I think both methods (as well as echo) can produce errors - especially in the described scenario. A soft thrombus can be partially covered and masked by contrast. Then, errors are possible.

19. This patient has been discussed by the heart team but wouldn't the peripheral artery disease (carotid and aortic) increase the risk for stroke in an aortic approach?

The risk of stroke is present in all TAVI procedures. We should generally think about the usage of brain protection devices in valvular procedures in the elderly.

20. Is correct to measure aortic annulus in parasternal long axis view in endsystolic frame (with aortic valve opened)?

see 16. Normally - according to the guidelines of aortic and pulmonary regurgitation of the EACVI you should measure the diameter of the annulus in the long axis view during systole. To determine the annulus in the short axis view in a 3D4D data set you should measure the cross sectional area of the virtual annulus during diastole and systole. You should start during diastole, because the labeling of the hinge points during diastole is easier. Then, during systole by translating the plane in flow direction. The distance of this translation should be the same as the differences of the distance of the endings of the commissures at the aortic root wall between diastole and systole.

21. We all know that small stature small LVOT will lead to overestimation to AS. But how you define -'small and in the case of the first pt-AVA on planimetry was 0.9 sq.cm - which by current guidelines is as severe AS.

In the described case the orifice area of the female patient (139cm) was 0.9 by planimetry, which is a moderate AS due to the indexed AVA of 0.68cm²/m² according to the guidelines. Due to the possible error using a small LVOT diameter in the continuity equation, you should check the cross sectional area in all LVOT diameters < 20mm. In addition pressure recovery has to be considered in all patients, in whom the sinutubular junction is <30mm (as in this patient).

22. There are several studies suggesting that energy loss index suggested by Dr. Pibarot is actually more prognostically correlated with prognosis especially for those patients with smaller aortic root. What is your position about it?

The parameter energy loss index is - according to my personal opinion - suitable to explain the phenomenon of pressure recovery in patients with moderate AS and small aortic root dimensions. Thus, it will be helpful to detect this cohort of patients. In clinical routine, however, all patients with small dimensions will be evaluated by an additional TEE to clarify the situation. Very important - also according to my personal opinion and some papers in the literature - is the parameter of the valvular-arterial impedance, which should be determined in every AS patient.

23. How can we establish, if a mitral regurgitation is too severe and contraindicates TAVI?

The combination of valvular diseases is inducing a complex assessment of the cardiac status using every imaging modality. Most important is the detection of the entity of mitral regurgitation which has an impact on prognosis. Normally if both, aortic stenosis and mitral regurgitation is severe, surgical intervention is the first choice. It is known, that even a moderate mitral valve regurgitation should be treated by the surgeon, if the patient is operated due to severe AS. In exceptional case - depending on the impairment of left ventricular function, the severity of AS significantly contributes to the severity of mitral regurgitation. In the literature, there are some cases described, in which mitral regurgitation disappears or reduces after TAVI procedure (however these cases describe moderate MR). In any case, treatment of MR and AS in patients with high comorbidities is a high risk treatment. Literature

24. Would you consider a smaller THV in patients with a discrepantly small LVOT in order to reduce the risk of permanent pacemaker implantation? Especially when you would have chosen a larger THV based on the annulus size.

In the balance of the pros and cons of a TAVI procedure I think the risk of aortic regurgitation is more important than the risk of permanent pacemaker implantation due to conduction disturbances after TAVI. Perhaps this issue can be partially solved by the new generation TAVI devices which will enable to recapture the device if the success will not be sufficient after deployment.

25. Methods of measurement of aortic annulus in 3d TOE

see 16. Normally - according to the guidelines of aortic and pulmonary regurgitation of the EACVI you should measure the diameter of the annulus in the long axis view during systole. To determine the annulus in the short axis view in a 3D4D data set you should measure the cross sectional area of the virtual annulus during diastole and systole. You should start during diastole, because the labeling of the hinge points during diastole is easier. Then, during systole by translating the plane in flow direction. The distance of this translation should be the same as the differences of the distance of the endings of the commissures at the aortic root wall between diastole and systole.

26. Because of risk of stroke is it better to work without general anaesthesia?

I think the risk of stroke will be the same during TAVI procedures. Due to the possibility to monitor the symptoms of neurological deficits after embolic events treatment of stroke can be induced earlier, if you work without general anaesthesia. I think we should focus on brain protection systems.

27. So if in case of tamponade you are sending the patient for surgery this does not mean that probably the patient should go to conventional surgery more than to TAVI ?

Pericardial tamponade after TAVI is a severe complication. Normally you can assume a rupture of cardiac structures which rarely can be treated conservatively by pericardial puncture and drainage.

28. Would you please tell us how to quantify AS severity in presence of atrial fibrillation?

The first very simple approach is the estimation of the AS severity by the velocity ratio between LVOT velocity and transstenotic velocity which can be normally determined in a cw spectrum with reduced gain. If this is not possible I prefer to evaluate the velocities and gradients of the LVOT and the AS in a representative cardiac cycle. This is a cardiac cycle, in which LV filling and LV contraction seems to be o.k. according to the principle of Frank Starling. Thus, I choose - if this is possible - a cardiac cycle with a normal or long RR-interval after a previous cycle with a normal or long RR-interval. However, in TAA this is often not possible. In these patients during high heart rates severity of AS is often overestimated like in patients with pseudo aortic stenosis. You should reevaluate these patients after normalization of the heart rate. The same choice of cardiac cycle during atrial fibrillation - a cardiac cycle with a normal or long RR-interval after a previous cycle with a normal or long RR-interval, I acquire in a real time 3D4D data set (mostly ZOOM data set in TEE) to perform the planimetry of the orifice area in patients with atrial fibrillation.

29. What is about the role of TAVI in cases of biologic prothetic valve severe stenosis?

Valve in valve procedures are possible and often described as successful.

30. How you could differentiate between thrombi and vegetations based on the echo findings?

Echocardiography cannot perform a histology. Thus, in case of free-floating structures in a valve prosthesis or after TAVI additional laboratory findings are important. If there is any constellation of inflammation due to the laboratory findings, you have always primarily to assume that endocarditis (vegetations) is present. You can never be certain to differentiate between thrombus and vegetations by morphology in echocardiography.

31. Which would be the best way to assess with TEE the degree of paravalvular regurgitation immediately after valve implantation?

It is not easy to assess the degree of paravalvular regurgitation directly after TAVI, because in aortography you will see contrast in the LV, which is very misleading in small LV cavities. The degree of contrast in angiography is like the size of the jet area in echocardiography. And according to the actual EACVI guidelines the jet area of AR is not recommended to quantify severity of the AR. This method is so-called "nonsense" for quantification of AR. Thus, there is only the possibility of semiquantification of AR by TEE (via orifice area, which is also not easy). The functional state should be evaluated by peripheral diastolic flow reversal - best by angio-sonography of the left subclavian artery. If you can evaluate regurgitant volume (but this is rarely possible by TEE in the acute situation) see 7. My opinion is to focus on regurgitant volume by LV planimetry and stroke volume determination using Doppler echocardiography measured by LVOT or RVOT VTI and LVOT and RVOT diameter. However, therefore excellent images and Doppler spectra are necessary. Normally LVOT and RVOT diameters for these assessments should be

measured in TEE documentations. If you use TEE 3D4D data sets you can also perform a planimetry of LVOT and RVOT in 3D4D data sets to have the correct cross sectional areas for your measurements. I don't like semiquantifications using the crescent shape of the paravalvular leakage in relation to the prosthetic annulus. This approach is often prone to errors. Using MR is also an excellent alternative for the assessment of regurgitant volumes - if possible. If you detect a moderate AR due to the assessment of regurgitant volume, it is normally relevant and you have to think about additional procedures and therapeutical options.

32. Don't you think that a coronary arteriography should be obtained before deciding for TAVI or conventional surgery ?

Yes - Exception in some cases patients with pre-renal failure. In these patients echo or MR can be discussed to avoid the usage and to reduce the dosage of angio contrast.

33. Could the evaluation of the reverse flow in descending aorta complementary and reliable for the assessment of aortic regurgitation after the procedure?

Yes, this is a very good approach for assessing aortic valve regurgitation. Due to the inhomogeneous flow profiles in the descending aorta (severe aortic regurgitation is fixed in patients older than 50 years by an enddiastolic reversal flow velocity of $>0.3\text{m/s}$) from my point of view and the point of standardization it is better to acquire the left subclavian artery flow profile. This approach is also described in the literature.

34. Why is the screen split up? It's very nice to see the speakers but the details on the PP is lost (hard to see the echoes and small text) even using fullscreen. Very nice talks though.

You have to ask B. Cosyns. I think we will consider this criticism.

35. What is the methodology used for the assessment of aortic regurgitation after the positioning of the prosthesis?

see 7, 30 and 33.

36. In patients with AF which one is the best method to acquire measurements?

see 28. The first very simple approach is the estimation of the AS severity by the velocity ratio between LVOT velocity and transstenotic velocity which can be normally determined in a cw spectrum with reduced gain. If this is not possible I prefer to evaluate the velocities and gradients of the LVOT and the AS in a representative cardiac cycle. This is a cardiac cycle, in which LV filling and LV contraction seems to be o.k. according to the principle of Frank Starling. Thus, I choose - if this is possible - a cardiac cycle with a normal or long RR-interval after a previous cycle with a normal or long RR-interval. However, in TAA this is often not possible. In these patients during high heart rates severity of AS is often overestimated like in patients with pseudo aortic stenosis. You should reevaluate these patients after normalization of the heart rate. The same choice of cardiac cycle during atrial fibrillation - a cardiac cycle with a normal or long RR-interval after a previous cycle with a normal or long RR-interval, I acquire in a real time 3D4D data set (mostly ZOOM data set in TEE) to perform the planimetry of the orifice area in patients with atrial fibrillation.

37. How do you assess severity of aortic stenosis in patients with concomitant mitral stenosis?

This is a special topic to assess mitral valve stenosis in combination of aortic valve stenosis. Normally - as a quick answer - the target lesion in valvular stenosis is the orifice

area. Thus, you have to determine the geometric or anatomical orifice area directly by planimetry (in both, mitral valve stenosis and aortic valve stenosis) or the effective or functional orifice area by Doppler estimations (in both, mitral valve stenosis and aortic valve stenosis). I think planimetry should be always prior to Doppler estimations - if the planimetry is reliable.

Keep in mind, that in patients with combined AS and MS, PTMC is contraindicated, because the mitral stenosis is the protection of the left ventricle against the left heart failure due to the AS.

38. In some patients with suspected severe aortic stenosis and ejection fraction

I cannot answer, because the sentence or the question is incomplete

39. As far as I remember Dr. Clavel published a paper this year stating that LVOT measurement by MDCT did not improve mortality prediction compared to AVA echo by continuity equation. Do you still suggest us to use 3D to measure LVOT?

As I mentioned - a method is as good as the one who use the method. To avoid complications due to mismeasurements of the LVOT and the aortic annulus I prefer still to evaluate the LVOT and the aortic annulus by excellent imaging techniques - either TTE, TEE or CT. I personally prefer to determine the cross sectional areas of the LVOT and the virtual aortic annulus by 3D-TEE.