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Preoperative Aortic valve Sizing. Is TTE enough? A case series of 54 cases of AVR performed in MCCCS

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Abstract:

Introduction; aortic valve replacement is a common wide spread surgical procedure performed worldwide. One of the main problems in such procedure is facing a small aortic ring to which the surgeon may not have a suitable size valve. So all efforts are made to try to measure the aortic ring preoperatively by different methods like transthoracic echocardiography, transesophageal echocardiography, CT scan and others

Objectives; the main objective of this study is to assess the ability of transthoracic echocardiography in successfully measuring the aortic ring in Mosul Center for Cardiology and Cardiac Surgery and comparing it with other measurement methods.

Methods; this is a retrospective clinical case series study conducted in Mosul Center for Cardiology and Cardiac Surgery over the period from June 2012 to February 2014. 54 patients were included in the study and were studied according to their sex and age distribution, type and cause of aortic valve disease, aortic valve morphology, echocardiographic and intraoperative aortic ring sizing.

Results; 48.1% of our patients had an echocardiographic and intraoperative aortic valve measurement within 1 mm difference while 28.8% had an echocardiographic aortic ring being 1-2.5 mm larger than the intraoperative aortic ring measurement and 23.1% had the echocardiographic measurements being more than 2.5 mm larger than the actual intraoperative size.

Discussion: these results were found to be comparable to other international results and also comparable to other studies that used other preoperative measurement methods

Conclusion; transthoracic echocardiographic measurement of the aortic ring is a safe, non-invasive and reliable method for measuring the aortic ring without the need for other invasive and expensive procedures however the surgeon should prepare at least one valve size smaller than the echocardiographic measured aortic ring for safety.

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Introduction:
Aortic valve replacement is a common surgical procedure performed throughout the world in almost all cardiac surgical departments. The size of the aortic valve prosthesis is usually determined intraoperatively by a sizing of the aortic annulus after excising and removing the aortic valve leaflets.

The aortic annulus is a virtual ring at the base of the aortic root. The level of the aortic annulus is defined by the three nadirs of the aortic cusps (lowest points of the 3 U shaped aortic valve leaflets).

As previously mentioned the size of the aortic valve annulus is assessed intra-operatively either by a manufacturer-specific annular valve sizers, these sizers are usually unique to the type of prosthesis to be implanted and therefore differs with the different manufacturers of prosthetic heart valves or by a Hegar dilator passed through the aortic valve annulus.

Because of the possibility of having a very small aortic valve annulus size to which no suitable prosthesis is available, measurement or assessment of the aortic valve annulus preoperatively is routinely performed in most of our countries cardiac surgical units to avoid the catastrophe of excising the leaflets and being faced with a small annulus size to which you have no suitable prosthesis. Aortic valve annulus – usually referred to as Aortic ring (AR) - is usually routinely assessed preoperatively in the cardiology department before referring the patient to the surgical department.

There are multiple techniques used for assessing the aortic ring or aortic annulus preoperatively.

The most common of these is through a trans-thoracic echocardiography study using a parasternal long-axis cross sectional view of the left ventricle outflow tract and the aortic valve. Other method includes trans-esophageal echocardiography which in some centers has been said to be superior to trans-thoracic echocardiography. Also conventional angiography has been tried and recently multi-slice computed tomography (MSCT) is being used as well.

Transthoracic echocardiography is the easiest of these methods and the cheapest. Transesophageal echocardiography requires an appointment and the patient to be fasting in addition to sedation and its relative discomfort to the patient. Angiography is an invasive procedure and although done routinely for all patients above 45 years old when referred for surgery, not all cardiologist do a Left ventricular study as it may be challenging and even dangerous in the presence of severe aortic valve stenosis or calcification. Multi-slice CT may be easier than conventional angiography but still requires preparation, carries its own risks and hazards in addition to being not cheap. [1, 2, 12, 13]

So we aim in this study to evaluate the value of using transthoracic echocardiography in assessing the aortic ring preoperatively. To determine whether it is enough or are more sophisticated investigations is really needed.

Patients and methods
This is a retrospective clinical case series study conducted Mosul Center for Cardiology and Cardiac Surgery (MCCCS) over the period from June 2012 to February 2014

All patients referred to our surgical department for aortic valve replacement or aortic valve repair were included in the study whether they were referred originally for aortic valve surgery or the aortic valve disease was discovered through the patient's workup.

All patients had a transthoracic echocardiography done by our cardiologist with the estimation of the aortic ring. Patients with echocardiography done not in our center or not by the centers cardiologist were excluded from the study. And patients who didn't do the surgery in our center were also excluded from the study.

Sex and age distribution:
The total number who met our criteria was 54 patients. The total number of male patients was (29) patients while the total number of female patients was (25) patients. So the male to female ratio was 1.16:1

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Our patient's age ranged from 7 – 77 years with a mean age of 43.8 years old. Male patient age ranged from 7 – 67 years with a mean age of 43.1 years. While female patient age ranged from 13 – 77 years with a mean age of 44.6 years. Figure (1) shows age and sex distribution of our patients.

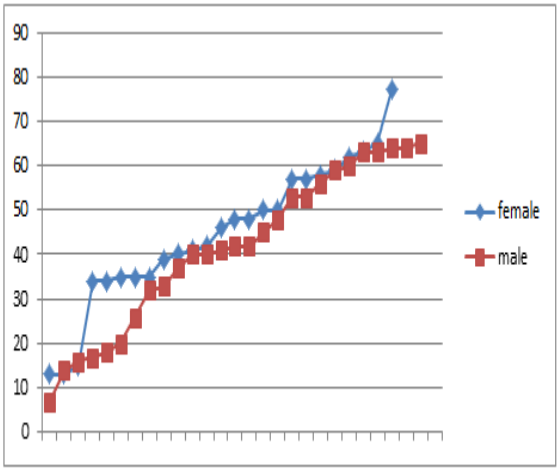

Figure 1; age and sex distribution

Type of aortic valve disease

Patients were being categories according to the type of aortic valve disease into three categories; patients with aortic valve stenosis, patients with aortic valve regurgitation, and patients with mixed aortic valve disease.

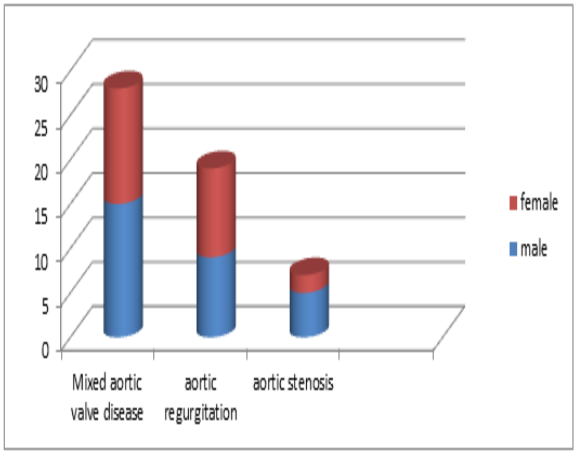

Figure (2); type of aortic valve disease

28 patients had a mixed aortic valve disease (stenosis and regurgitation) although one was usually predominant (stenosis or regurgitation). 19 patients had isolated aortic valve regurgitation while only 7 had isolated aortic valve stenosis. Figure (2) shows type of aortic valve disease

Aortic valve morphology

Patients were categorized according to the morphology of the aortic valve into tricuspid and bicuspid valves. This data was taken from the preoperative echo study and the operative data. Figure (3) shows the morphology of the aortic valve.

39 patients had a tricuspid valves (21 males and 18 females) while 9 patients had a bicuspid valve (6 males and 3 females) while in 6 patients the morphology of the aortic valve could not be determined neither by echo nor operatively either due to lack of data in the patients information sheets or due to severe calcification rendering the valve unrecognizable.

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It is worthy to mention that only one patient with a preoperative echo stating a tricuspid valve was confirmed to be bicuspid intraoperatively.

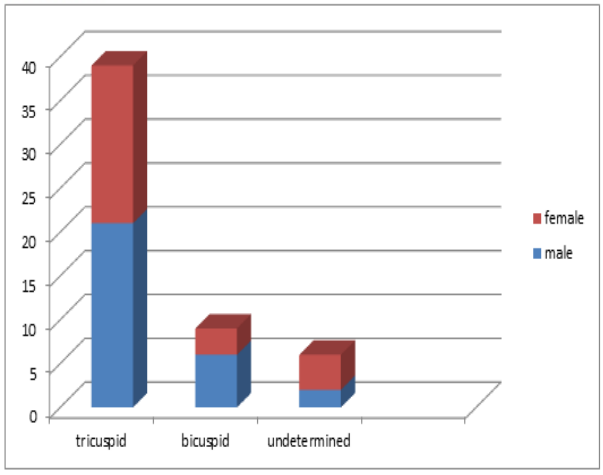

Figure (3); Morphology of the aortic valve

Cause of aortic valve disease:

In 33 patients the cause of aortic valve disease was rheumatic as suggested by patients echo study and history taken from the patients information sheet. In 7 patients the cause was considered degenerative. In 13 patients the cause was unknown and in 1 patient the condition was complicating a congenital heart disease (Double Outlet Right Ventricle).Figure (4).

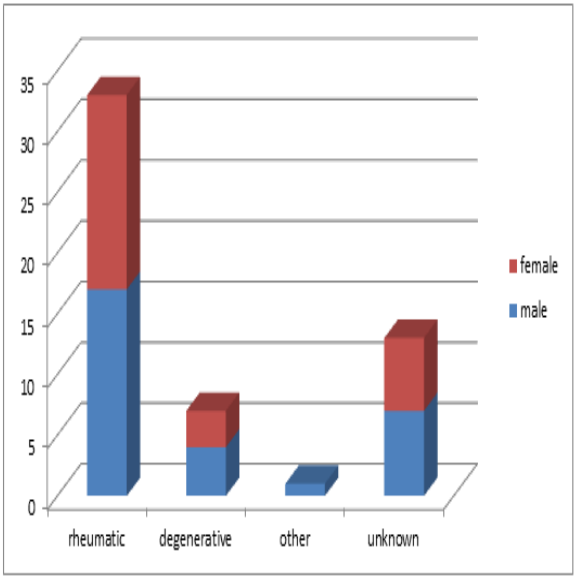

Figure (4); causes of aortic valve disease

Echocardiographic aortic ring versus operative aortic valve size:

The following table (table (1)) will show each patients echo measured aortic ring versus the intraoperatively inserted aortic valve size.

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	Echo measured aortic ring	Aortic valve size
1	16.5	17
2	17	17
3	17	17
4	18	17
5	19	17
6	19	17
7	21	17
8	23	17
9	18.5	19
10	18.5	19
11	19	19
12	19	19
13	19	19
14	19	19
15	19.5	19
16	20	19
17	20	19
18	20	19
19	20	19
20	21.5	19
21	21.5	19
22	22	19
23	23	19
24	23	19
25	24	19
26	24	19
27	21	21
28	21	21
29	21	21
30	22.5	21
31	23	21
32	23	21
33	28	21
34	21.5	23
35	22.5	23
36	23	23
37	23	23
38	23	23
39	24	23
40	24.5	23
41	25	23
42	25	23
43	27	23
44	23	25
45	25	25
46	27	25
47	27	25
48	28	25
49	29	25
50	27	27
51	29	27
52	30	27

Table (1); echocardiographic measured aortic ring versus the prosthetic valve size

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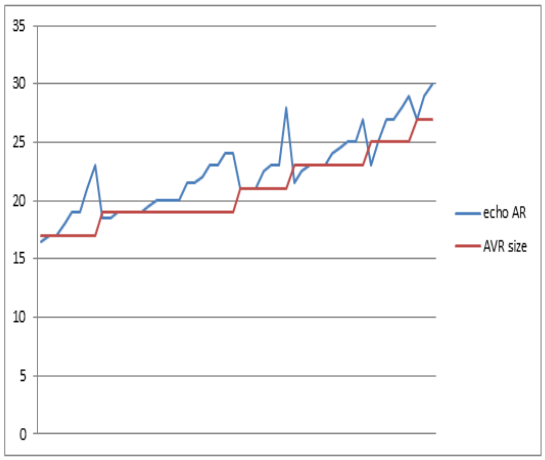

Figure (5); echocardiographic measured aortic ring versus the prosthetic valve size

2 patients were excluded from this chart as information was not complete due to lack of preoperative echocardiographic sizing of the aortic ring

The average aortic valve size was 20.9 mm while the average echocardiographic aortic ring was 22.4 mm. so the average difference between the aortic valve size used and the measured will be 2.5 mm in favor of the echocardiographic valve being larger.

Other findings
Cross clamp time and bypass time;
Average cross clamp time for AVR was 58.74 minutes, and our average bypass time (perfusion time) was 79.08 minutes

Average cross clamp time for DVR was 98.8 minutes, and average bypass time (perfusion time) was 123.07 minutes.

Results
Age and sex distribution:
29 male patients versus 25 female patients needed aortic valve surgery so the male to female ratio was 1.16:1.

Patient's age ranged from 7 – 77 years with a mean age of 43.8 years old. The youngest patient was a boy (7 years old) while the oldest was a lady (77 years old).

Type of aortic valve disease:
Most of our patients had a mixed aortic valve disease i.e.; aortic valve stenosis and aortic valve regurgitation even though one was usually more prominent. So the mixed aortic valve diseases composed 51.8% of our patients. While isolated aortic valve stenosis composed 35.2% and isolated aortic valve stenosis composed 13%.

Aortic valve morphology:
Most patients (39) had normal aortic valve morphology, i.e.; a tricuspid valve, forming 72.2% of patients,while 9 patients had a bicuspid valve, forming 16.7% of our study group. However in 6 patients (11.1%), the aortic valve morphology could not be determined. So the ratio of tricuspid to bicuspid aortic valve was 4.3:1.

Cause of aortic valve disease:
Most of our patients had rheumatic aortic valve disease composing 61.2%. 13% had degenerative aortic valve disease. 1.8% was complicating congenital heart disease (double outlet right ventricle). While in 24% of patients no sufficient data was available to determine the cause of the aortic valve pathology. So rheumatic fever is the leading cause of aortic valve disease in our study

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Echocardiographic aortic ring versus operative aortic valve size:
In 48.1% of cases the echocardiographic reading was exactly the same or very close to the intraoperatively measured aortic valve annulus (with the difference being within 1 mm diameter)

In 15 patients (28.8%) the echocardiographic aortic ring measurement was within 1 - 2.5 mm difference with the echocardiographic aortic ring being mainly higher than the actual measured aortic ring size

In 12 patients (23.1%), the echocardiographic measured aortic ring was more than 2.5 mm mostly larger than the actual intraoperative measured aortic ring size

Two patients were excluded from this study as information was not complete due to lack of preoperative echocardiographic sizing of the aortic ring

Cross clamp time and bypass time
Our average cross clamp time for AVR was 58.74 minutes, with the shortest being 34 minutes and the longest being 90 minutes. And our average bypass time (perfusion time) was 79.08 minutes, with the shortest being 61 minutes and the longest being 118 minutes.

Average cross clamp time for double valve replacement (DVR) was 98.8 minutes, with the shortest being 67 minutes and the longest being 132 minutes. And our average bypass time (perfusion time) was 123.07 minutes, with the shortest being 90 minutes and the longest being 140 minutes.

Discussion
Age and sex distribution:
Our male patient population was slightly larger than the female population. This differs from other studies [(5)] where the female population was larger and the male to female ratio was 1:1.65 compared to 1.16:1 in our study. However in another study male constituted 80% of patients with symptomatic aortic valve disease. [(3)] I think that one study settled this debut when it showed that age and sex distribution of aortic valve diseases greatly differs from one country to another depending on many factors like social class and economic condition. It even went to say that "there are differences in incidences even in populations within the same country". [(4)]

In our study females tend to be older than male (female median age was 44.6 years while male median age was 43.1 years) although not much of a difference but such results were also found in most other studies. [(3-5)]

Type of aortic valve disease:
Most of our patients had mixed aortic valve disease (constituting 51.8% of our study group) while aortic valve incompetence constituted 35.2% and aortic stenosis constituted only 13% of our study group. this differs significantly from [(3)] and [(11)] where aortic valve stenosis was the most common aortic valve disease. This may be due to the high prevalence of rheumatic valve disease in our country and its tendency to cause mixed valvular heart lesions.

Morphology of the aortic valve:
72.2% of our patients had a tricuspid valve while 16.7% had a bicuspid aortic valve and the valve morphology could not be known in 11.1%. The prevalence of bicuspid aortic valves in general population is about 0.5-2% [(14)]. Not much articles were found on the prevalence of a bicuspid aortic valve during an aortic valve surgery however one article published that bicuspid aortic valve was found in about 33-40% of patients with aortic valve stenosis and going back to our data 42.8% of our patients with pure aortic valve stenosis had a bicuspid valve. [(11, 15)]

Causes of aortic valve disease
Rheumatic aortic valve disease was the main cause of aortic valve disease in our study. This differs from American and western countries where degenerative aortic stenosis which account for about half of the cases with bicuspid aortic valve coming in second place and rheumatic heart disease accounting for only 10-15% of cases. [(16)]. Other authers did not consider a bicuspid valve as a cause for aortic valve disease - but actually a risk factor only - as some may not develop - neither stenosis nor regurgitation - throughout their lives. [(17)]. Our results are however are comparable to [(4)] which stated

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that "In developing countries, aortic valvular stenosis or regurgitation are typically caused by rheumatic heart disease or infective endocarditis".

Echocardiographic aortic ring versus operative aortic valve size:
As the intraoperative aortic ring measurement can only be done after the aortic valve cusps are excised and the root shaved from excessive calcification, a real problem will arise if we are to face a small aortic ring to which we do not have a suitable sized prosthetic valve. It is for this reason that in all valvular heart surgery it is accustomed to prepare a suitably sized prosthetic cardiac valve depending on the echocardiographic measured aortic ring with the preparation of another additional valve usually 2 mm smaller than the first one. The smallest prosthetic aortic valve supplied to our center was 17 mm diameter. So whenever we face a patient with an echocardiographic aortic root size of 17 mm we are hesitant, whether to do surgery or transfer him to another center probably outside the country

In 76.9% of our patients the echocardiographic study was very close to the intraoperatively measured aortic ring size (although the echocardiographic measurement was larger by about 1 - 2.5 mm) so that the preoperatively prepared valves were the same that were used. However in 23.1% of the cases the echocardiographic measured aortic ring was larger than the intraoperative aortic ring so that the preoperatively prepared prosthetic valves were larger and needed to be replaced by a smaller valve.

So in our study 48.1% of the echocardiographic readings was within 1 mm difference while 28.8% were about 1-2.5 mm larger than the intraoperatively measured aortic ring. Comparing this study with another study, which also used echocardiography for measuring the aortic ring, the results were comparable to our study although their echocardiographic measurement was closer to the intraoperative measurement but this may be due to their smaller study group if compared with ours [(10)].

In other studies which compared CT scan with TEE in aortic ring assessment showed better results of CT over TEE but these studies were mainly applied for patients in need of TAVI and not conventional surgical aortic valve replacement. Also the difference in the TEE and CT measurement were not that much with a mean difference of 1.1 – 1.7 mm only. [(6, 8)]

Another study also showed excellent results of the transthoracic echocardiographic measurement of the aortic ring and was comparable to our results. [(9)]

Another study also showed comparable results to our study concluding that TTE has excellent results with a preoperative annulus diameter by echo underestimated prosthetic diameter by a bias of 1.07 mm. [(7)]

It is also important to keep in mind that although the surgical techniques for aortic valve replacement are similar in our center but practice may differ from one surgeon to another in the sizing technique and in the technique of aortic cusp resection which may in some instances be the cause of the difference in the echocardiographic and the operative valve size.

Conclusion
Transthoracic echocardiography is excellent for preoperative measurement of the aortic ring in 77.6% of cases but the surgeon should prepare at least one valve size smaller just in case of error.

For those patients with small aortic rings measured by transthoracic echocardiography, other investigations may be needed to confirm the size like CT scan or transesophageal echocardiography.

Age and sex distribution of aortic valve diseases greatly differs from one country to another depending on many factors like social class and economic condition so don’t be shocked when finding different results in different studies

Mixed aortic valve disease (stenosis with regurgitation) was the most commonly found aortic valve disease in our locality as rheumatic valve disease is the main cause of aortic valve disease in our locality.

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