Author’s response to reviews

Title: Dynamic 3D echocardiography in virtual reality.

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Author’s response to reviews: see over
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Rotterdam, 21 November 2005

Dear Doctor Picano,

Thank you for the positive review of our manuscript. Herewith we offer you our revised manuscript ‘Dynamic 3D echocardiography in virtual reality.’ for publication in the Cardiovascular Ultrasound Journal.

We thank the reviewers for the constructive and valuable comments. We have tried to incorporate the suggestions and altered the manuscript to meet most comments.

All authors have seen and approved the revised paper. The authors do not have any conflict of interest, pecuniary or otherwise in publishing this paper. This work has not been and will not be published elsewhere, while it is evaluated for the Cardiovascular Ultrasound Journal.

We hope you will accept the manuscript for publication,

Yours Sincerely,

Annemien van den Bosch, MD

Folkert Meijboom, MD, PhD.
Responses to reviewers

We thank the reviewers for the positive and valuable comments. We have answered all questions and have indicated specifically if and where we have changed the manuscript. In our opinion, this has certainly improved the quality of the manuscript.

Reviewer 1:

Discretionary comments

Please discuss very briefly:
Ad 1. Advantages and disadvantages of "virtual reality".

Answer:

**Advantages of Virtual Reality**

Efficiency: Although virtual reality simulators can never replace experience gained by actual training in real patients, it eliminates the risk of harming the patient while trying to learn a new skill. It also eliminates the time restraints on waiting for types of cases to come up and allows the trainee to practise independently. After training with a 3D virtual reality simulator, a trainee will be prepared when starting with a procedure in humans.

Effectiveness: Using virtual patients to train on are less expensive and offensive than training on animal models.

**Disadvantages of Virtual Reality**

Cost: Currently, this new technology is expensive. The high costs of developing hardware and software will limit its widespread implementation for the application of virtual reality technology. Computer instrumentation is expensive after introduction but has always decreased over time; so we suspect as this occurs virtual reality will eventually become more commonplace in Medicine.

Restraint: Presently the equipment used to create a virtual environment is restrictive to specialist centre. In order to be integrated into clinical practice, this application should be able to run on smaller virtual reality systems, either based on a single projection surface, or on a monitor (CRT or LCD).

Ad 2. The future of the tool for training and education, how early should we use it in our procedural cardiologic carrier?

Answer:

The new technologies as 3D echocardiography and virtual reality are developing very rapidly. We expect that in the next 5 to 10 years virtual reality can be integrated in clinical practice.

Ad 3. Future development of this technique, usefulness for interventional procedures (PFO closure, electrophysiologic procedures)

Answer:

With the growth of minimal invasive cardiac surgery and interventional procedures, the interest for simulation of the heart hologram as a training tool has increased. Dynamic 3D echocardiography in virtual reality can provide a preview of real intracardiac anatomy of a patient to the interventional cardiologist or surgeon before the planned procedure. A better-prepared procedure by a better-informed physician might lead to shorter procedure time and less unexpected problems.

Ad 4. Please add the information (results):
Resolution (time and space) of virtual reality and costs of development and the technical demands

Answer:

* The virtual reality system has a resolution of 1280 by 1024 pixels per projector. This is comparable to or greater than the resolution of the CRT monitors and LCD flat panels used in ultrasound systems
and with workstations. The ultrasound data generated by the Sonos 7500 has a resolution of 144x160x208 pixels; therefore we do not lose spatial resolution when displaying the data on the virtual reality system. Because we project on 2.60m x 2.08m (8.5’ x 6.8’) screens the perceived “sharpness” of the images may be less than when these images are viewed on a much smaller computer screen. However, the large size of the display will bring out small details and also allow multiple viewers a clear and unobstructed simultaneous view of the data.

The remark of the reviewer has been revised in the manuscript.

* Several vendors offer both single and multi screen projection based virtual reality systems that can be used for this type of application. These systems can range from tabletop displays, to fully immersive rooms with projections on all walls, floor and ceiling. Apart from the intended audience (a single person or a whole department), the cost and the available space will determine what kind of system can be installed. The new generation LCD and DLP projectors are capable of generating very bright images, but in general installation in a room in which the light(s) can be dimmed is advisable. When multiple projectors and therefore a single large or several smaller computers are being used, the electrical installation and the air conditioning will have to be capable of handling the increased load.

Reviewer 2:

Major compulsory comments

The Authors presented 3-D echocardiographic datasets with normal or pathological mitral valves to 10 observers with different expertise. The authors might wish to address the following points:

Ad 1. How were the observers instructed to assess mitral valve anatomy/pathology and function?

Answer:
The observers were instructed to create several cut plane in each 3D data set. For the analysis of the mitral valve, two opposite views were reconstructed: 1) a view from the left atrium towards the atrioventricular junction, allowing a “surgical view” of the mitral valve, and 2) a view from the left ventricular apex toward the mitral valve. The observers were asked to assess in these views, the anterior and posterior leaflets, and subvalvular apparatus for possible pathology. The remark of the reviewer has been revised in the manuscript.

Ad 2. How was defined the correct assessment of the normal and pathological mitral valve? There were any standardized criteria of interpretation that the Authors used as references?

Answer:
The assessment of the normal or pathological mitral valve was correct if the diagnosis made on the holographic data set was the same as the 2D echocardiographic or surgical diagnosis. Assessment of the mitral valve included:

- Visualisation and determination of the anterior and posterior leaflet together with the diastolic and systolic movement. This was performed from the atrial as from the ventricular view.
- Each leaflet was assessed for anatomic substrate for valve stenosis or regurgitation, including valve prolaps, calcifications and/or congenital malformations.
- If pathology was present, the specific segment of the leaflet was observed.
- The arrangement of the papillary muscles and chordae attachment were evaluated

Ad 3. Were there any differences in the correct interpretation among the different expertise of the observers?

Answer:
All observers are very experienced in the assessment of echocardiographic images of mitral valve pathology.
The thoracic surgeons were faster in assessing the mitral valve anatomy/pathology than the cardiologists. Probably this is due to the fact that surgeons already think 3D and the mitral valve is visualised in a surgical view. For the cardiologists (in training) it was more difficult to make the transformation of 2D to 3D images, but could easily make the diagnosis within 10 minutes.

Discretionary comments

Ad 1. An additional movie depicting one of the findings reported in the results could be highly desired.

Answer:
A movie is added of a normal mitral valve viewed from the left ventricular apex.

Technical revisions

All requested format changes have been revised in the manuscript.