

POSTER PRESENTATION

Open Access

Turbulence mapping: a new CMR approach for assessment of aortic stenosis

Petter Dyverfeldt^{1,2*}, Michael D Hope¹, Elaine E Tseng¹, David Saloner¹

From 16th Annual SCMR Scientific Sessions
San Francisco, CA, USA. 31 January - 3 February 2013

Background

Pressure loss estimation based on the simplified Bernoulli equation frequently misclassifies the severity of aortic stenosis. Consequently, several investigators have on the basis of fluid dynamics theory derived pressure loss indices aimed at improving the clinical approach to pressure estimation [1-3]. However, CMR may offer a stronger alternative. The primary cause of pressure loss in aortic stenosis is dissipation of turbulent kinetic energy (TKE) into heat. New CMR methods permit direct estimation TKE [4]. We sought to evaluate the relationship between CMR-measured TKE and previously described pressure loss indices.

Methods

27 patients under evaluation for aortic valve replacement were enrolled. The patient population represents a broad range of aortic stenosis and aortic dilation. Aortic valve area was $1.6 \pm 1.7 \text{ cm}^2$ (mean \pm std dev), range: $0.4 - 6.4 \text{ cm}^2$. Peak velocity was $3.7 \pm 1.4 \text{ m/s}$, range $2.0 - 7.5 \text{ m/s}$. Maximum aortic diameter was $4.1 \pm 0.8 \text{ cm}$, range $3.0 - 6.1 \text{ cm}$.

TKE was estimated using a novel 4D Flow CMR method, as described in [4]. A measure of the total TKE (TKE_{tot}) was obtained by integrating the TKE per voxel across the ascending aorta. Each subject had clinical echocardiography and computed tomography studies done close to the CMR study.

TKE_{tot} was compared against three pressure loss indices (iPL) derived from the literature [1-3] (see table in figure 1). These indices represent different approaches to estimate pressure loss effects based on data obtainable with noninvasive imaging. The underlying theory has been compared favorably with catheter-based measurements in select settings [1-3].

Results

Scatter plots for TKE_{tot} vs iPL_1 , iPL_2 , and iPL_3 are shown in Figure 2. Correlation for TKE_{tot} vs iPL_1 , TKE_{tot} vs iPL_2 , and TKE_{tot} vs iPL_3 was 0.65, 0.87, 0.92, respectively. The slope was significantly different from zero in all cases.

Conclusions

This study used a novel CMR flow imaging method to measure the total TKE in the ascending aorta of patients with aortic stenosis. Strong correlation was found between TKE and pressure loss indices derived from fluid dynamics theory. By directly measuring the source of irreversible pressure loss, TKE mapping allows new avenues for evaluation of aortic stenosis with CMR. Future work will include a comparison between CMR-measured TKE and catheter-based pressure measurements.

Funding

Fulbright Commission

Swedish Heart-Lung Foundation

Swedish Brain Foundation.

Expression	Theoretical relation to pressure gradients	Described in references
$\text{iPL}_1 = \left(Q \frac{A_A - \text{AVA}}{\text{AVA} \times A_A} \right)^2$	$\text{iPL}_1 = \text{TPG}_{\text{net}}$	[1,2]
$\text{iPL}_2 = Q \left(1 - \frac{\text{AVA}}{A_A} \right)^2$	$\text{iPL}_2 = Q \frac{\text{TPG}_{\text{net}}}{\text{TPG}_{\text{max}}}$	[1,2]
$\text{iPL}_3 = 2Q \left(\frac{\text{AVA}}{A_A} - \left(\frac{\text{AVA}}{A_A} \right)^2 \right)$	$\text{iPL}_3 = Q \frac{\text{TPG}_{\text{net}}}{\text{TPG}_{\text{max}}}$	[3]

Figure 1 Table of pressure loss indices (iPL) used in this study, along with references from which they were derived. * TPG_{max} and TPG_{net} denote maximum and net transvalvular pressure gradient, respectively. Q = peak systolic flow rate, AVA = aortic valve area, A_A = aortic area at sinotubular junction. Q, AVA and A_A were obtained from MRI, echocardiography and computed tomography, respectively.

¹University of California San Francisco, San Francisco, CA, USA
Full list of author information is available at the end of the article

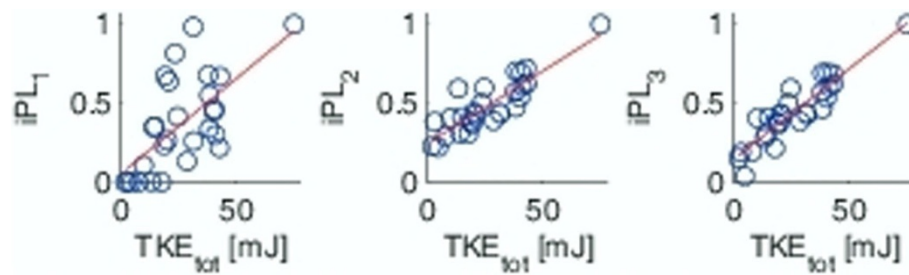


Figure 2 Total turbulent kinetic energy (TKE_{tot}) in the ascending aorta plotted against the pressure loss indices (iPL) described in Table 1. All indices were normalized to have a maximum value of $iPL = 1$. TKE_{tot} was obtained by integrating the TKE per unit volume across the entire ascending aorta. Solid line: estimated regression line.

Author details

¹University of California San Francisco, San Francisco, CA, USA. ²Linköping University, Linköping, Sweden.

Published: 30 January 2013

References

1. Garcia D, et al. *Circ* 2000.
2. Garcia D, et al. *JACC* 2003.
3. Voelker W, et al. *JACC* 1992.
4. Dyverfeldt P, et al. *JMRI* 2008.

doi:10.1186/1532-429X-15-S1-P110

Cite this article as: Dyverfeldt et al.: Turbulence mapping: a new CMR approach for assessment of aortic stenosis. *Journal of Cardiovascular Magnetic Resonance* 2013 **15**(Suppl 1):P110.

Submit your next manuscript to BioMed Central and take full advantage of:

- Convenient online submission
- Thorough peer review
- No space constraints or color figure charges
- Immediate publication on acceptance
- Inclusion in PubMed, CAS, Scopus and Google Scholar
- Research which is freely available for redistribution

Submit your manuscript at
www.biomedcentral.com/submit

 **BioMed Central**