Sensitivity and Specificity of a new Echocardiographic Doppler Method for Detection of Significant Aortic Stenosis

CİDDİ AORT STENOZUNUN SAPTANMASINDA YENİ BİR EKOKARDİYOGRAFİK DOPPLER METODUNUN SENSİTİVİTE VE SPESİFİTESİ

Hakan KARPUZ*, Nicole AEBISCHER*, Xavier JEANRENAUD*. Nadia DEBBAS*, Eric EECKHOUT*, Jean-Jacques GOY*, Lukas KAPPENBERGER*

*MD.Division of Cardiology, Centre Hospitalier Universitaire Vaudois, Lausanne, Switzerland

SUMMARY

Doppler echocardiographic methods based on the continuity equation can accurately determine aortic valve area in patients (pts) with clinically significant aortic stenosis; however, measurement of the left ventricular outflow tract diameter used in continuity equation may not be technically feasible in all subset of pts. The purpose of this study was to evaluate prospectively a simpler noninvasive method for identifying pts with significant aortic stenosis (aortic valve area <1cm2 or <0.53 cm^2/m^2) determined by the Gorlin formula at cardiac catheterization. This marker called fractional shortening-velocity ratio, is obtained by dividing the percent of fractional anteroposterior shortening at the midventricular level by $4V^2$, where V is the peak instantenous Doppler-derived flow velocity across the aortic valve. Pts with coexisting severe mitral or aortic regurgitation and those in whom the aortic valve could not be passed during cardiac catheterization, were excluded from this study. Forty-five pts (9 women, 36 men, mean age 59±14) were included. Fractional shortening-velocity ratio was calculated in all pts by the same physician without knowledge of cardiac catheterization results. The sensitivity of this simpler method was found 94 % and the specificity 90%.

This study shows that the fractional shortening-velocity ratio is a simple Doppler echocardiographic method that reliably identifies pts with clinically significant aortic stenosis, especially when aortic stenosis is difficult to assess by conventional methods. A fractional shortening-velocity ratio <.0.8 allows detection of aortic stenosis (<0.53 cm^2/m^2) with good sensitivity and specificity.

Key Words: Aortic stenosis, Fractional shortening-velocity ratio, Echocardiography

T Klin Kardiyoloj 1995, 8:203-206

ÖZET

Devamlılık denkleminin kullanıldığı Doppler-ekokardiyografi metodları ile, anlamlı derecede aort stenozu bulunan hastaların aort kapak alanı doğru bir şekilde hesaplanmaktadır; buna karşılık, bu denklemde kullanılan sol ventrikül çıkış yolunun ölçülmesi, teknik nedenlere bağlı olarak her hastada mümkün olmamaktadır. Bu çalışmanın amacı, anlamlı derecede aort stenozu (kalp kateterizasyonunda Gorlin formülü ile hesaplanmış aort kapak alanı Hem² veya $0.53 cm^2/m^2) bulunan hastaların saptanmasında kullanılan basit ve non invazit bir metodun prospektif olarak değerlendirilmesidir. 45 hasta (9 kadın, 36 erkek, ortalama yaş 59+74) *bu çalışmaya dahil edilmiştir. Fraksiyonel kısalma-hız oranı adı verilen bu metod, sol ventrikülen anteroposteriyor kısalma fraksiyonu yüzdesinin $4V^2$'ye (V: Doppler-ekokardiyografi ile elde edilen maksimal aort kapak akım hızı) bölünmesi şeklinde uygulanmıştır. Şiddetli derecede aort veya mitral regürjitasyonu bulunan veya kalp kateterizasyonu sırasında aort kapağı geçilemeyen hastalar çalışmadan çıkarılmıştır. Fraksiyonel kısalma-hız oranı her hastada, kalp kateterizasyonu sonucundan haberdar olmayan aynı kişi tarafından hesaplanmıştır. Bu basit yöntemin duyarlılığı %94, özgüllüğü ise % 90 olarak bulunmuştur.*

Sonuç olarak bu çalışma, özellikle konvansiyonel yöntemler ile aort stenozu şiddetinin değerlendirilmesinin zor olduğu durumlarda, basit bir metod olan fraksiyonel kısalma-hız oranı hesaplanmasının anlamlı derecede aort stenozu olan hastaları saptayabileceğini göstermiştir. Bu oran 0.8'in altında takdirde, 0.53 cm^2/m nin altındaki aort kapak alanı saptanmasında iyi bir duyarlılığa ve özgüllüğe sahiptir.

Anahtar Kelimeler: Aort stenozu, Fraksiyonel kısalma-hız oranı, Ekokardiyografi

T Klin J Cardiol 1995, 8:203-206

Geliş Tarihi: 14.4.1995

Yazışma Adresi: Hakan KARPUZ
Division of Cardiology, Centre Hospitalier
Universitaire Vaudois, Lausanne, Switzerland

Bu ***çalışma Ağustos 1995Amsterdam'da yapılacak olan "European Society of Cardology" kongresinde sözlü bildiri olarak kabul edilmiştir.***

The high mortality rate associated with symptomatic aortic stenosis makes the accurate clinical assessment of this lesion essential. However, the classic clinical descriptors of significant aortic stenosis are less accurate in patients with hypertension, aortic insufficiency and coronary heart disease. Doppler echocardiographic techniques are now accepted as clinical methods for evaluation of the severity of aortic stenosis (1-3). Transaortic pressure gradients, calculated from flow velocities using the Bernoulli equation, and valve areas, determined by the continuity equation, have been validated (compared with cardiac catheterization) in patients with a wide range of stenosis severity (3-9).

Despite the current widespread acceptance of the continuity equation for determining aortic valve area (AVA), this method has some limitations. For example, the requisite measurements are time-consuming and can be technically difficult in certain subsets of patients (10). In this equation, the outflow tract diameter is the most difficult variable to measure and shows the greatest intra and interobserver measurement variability (11). Thus, methods based on this equation may not be accurate or applicable in all clinical settings.

The purpose of this study was to evaluate a simple method, proposed first by Mann (12), for evaluating aortic stenosis: "fractional shortening-velocity ratio (FSVR)". With this method, we tried to eliminate the difficulties and errors involving in measuring blood flow across a valve, to remain sensitive and accurate in low cardiac flow states and to apply easily in a general clinical setting.

MATERIAL AND METHOD

Patient population

This study is consisted of a prospective series of 45 patients (9 women, 38 men, mean age 59+14). Exclusion criteria included evidence of regional left ventricular dysfunction and more than mild aortic and/or mitral regurgitation.

Echocardiography

The echocardiographic data were recorded with a Hewlett-Packard Sonos 1000 color echocardiography and continuous/pulsed-wave Doppler équipement

Doppler echocardiography: The systolic velocity porfiie across the aortic valve was recorded from the apical, suprasternal and right parasternal views using continuous wave Doppler ultrasound. The maximal flow velocity across the aortic valve was determined from the outer envelope of the continuous wave Doppler spectral tracing, in all patients, the pressure fall across the aortic valve was calculated using the $4xV^2$ approximation of the Bernoulli equation (peak velocity under the aortic valve was <1.2 m/sec in all patients), where V was the peak Instantaneous Doppier-derived flow velocity across the aortic valve.

M-mode echocardiography: All M-mode studies were performed with the patients in the left lateral decubitus position using two-dimensional echocardiographic guidance and a parasternal long-axis view. The extent of left ventricular fractional anteroposterior shortening was measured at the midpapillary muscle level from the end-diastolic (EDD) and endsystolic (ESD) dimensions, using the leading edge to leading edge convention according to American Society of Echocardiography guidelines (13). Percent fractional shortening was calculated as (EDD-ESD)/EDDx100.

FSVR is obtained by dividing the extent of left ventricular fractional shortening (FS%) at the midventricular level by where V is the peak instantenous Doppier-derived flow velocity across the aortic level; where FSVR: $FS\%/4xV^2$.

Cardiac catheterization

Cardiac catheterization was performed via femoral access and the stenotic aortic valve was crossed with of a soft guide wire. Right sided pressures were measured with a balloon-tiped flow-directed catheter and the cardiac output was estimated by means of the thermodilutlon method. Simultaneous left ventricular pressures and femoral artery pressures were registred and a slow pull-back from the left ventricle to the ascending aorta was performed at the end of the procedure. The orifice area of the narrowed aortic valve was calculated automatically by means of the Gorlin formula that is incorporated in the software of the Micor (Siemens-Elema, Solna, Sweden) haemodynamics systems.

Data analysis

Doppler and M-mode tracings were analysed by the same physician who was unaware of the catheterization results. For patients In sinus rhythm three consecutive beats, in atrial fibrillation six consecutive beats were analysed.

Statistical analysis

Data were expressed as mean valueststandart deviation. The correlation between FSVR and AVA determined at cardiac catheterization was assessed using linear regression analysis. Sensitivity and specificity were determined using standart formulas (14).

RESULTS

Figure 1 summarizes the relation between FSVR and the AVA calculated from the data obtained during cardiac catheterization. There was a linear relation (r-0.81) between two parameters. FSVR ratio <1.15 identified all patients in this serie with significant aortic stenosis (defined as an AVA <1 cm^2 or <0.53 cm^2/m^2). FSVR <0.8 had the best combined sensitivity (94%) and specificity (90%) as seen in Table 1. When FSVR <1.15 was used to identify patients with a significant aortic stenosis, sensitivity was 100% but specificity was FSVR £0.6 had the best specificity (100%) but poor sensitivity.

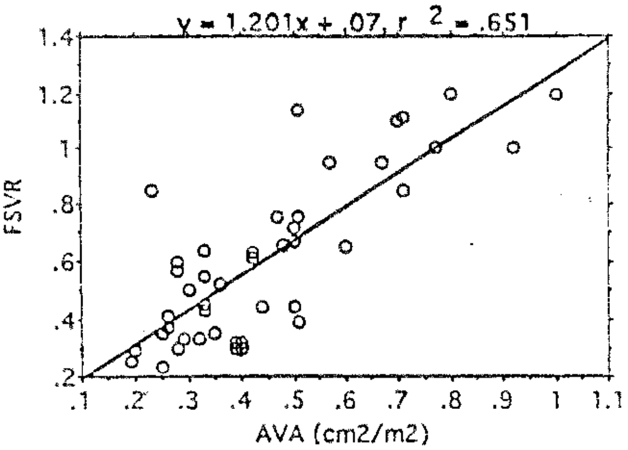

Figure 1. **Relation between the fractional shortening-velocity ratio** (FSVR) **and** aortic valve **area** (AVA) in 45 prospectively studied **patients.**

Table 1. Distribution of the patients according to fractional shortening-velocity ratio (FSVR) and aortic valve area (AVA) values

	AVAS0.53 **cm^2/m^2**	AVA>0.53 cm^2/m^2
FSVR<0.8	33	1
FSVR>0.8	2	9

DISCUSSION

FSVR, although **derived empirically,** was based on the Gorlin formula: it incorporates an index of transvalvular valve flow in the numerator and an index of the transvalvular pressure gradient in the denominator. In this study this ratio was prospectively tested against the current invasive gold standart method cardiac catheterization and **the** Gorlin formula. Additional strenghts of this calculation:

1) It indexes gradient to a left ventricular function variable, 2) the Doppler gradients is the continuous wave gradient already in use and 3) fractional shortening is an accepted variable of left ventricular function that requires minimal computation and no mathematic assumptions.

In our study we observed **a** significant linear relation (r-0.81) between FSVR and AVA determined by the Gorlin formula at cardiac catheterization. This ratio appears to perform well: FSVR < 0.8 had **a** sensitivity of 94% and a specificity 90% for identifying patients with significant aortic stenosis (AVA < 1 cm^2 or < 0.53 cm^2/m). Mann (12) had found same relation (r-0.88) in twenty-five patients studied retrospectively (patients with regional left ventricular dysfunction and more than mild aortic insufficiency were excluded). In his prospective series (no patients were systemically excluded from the analysis) with 29 patients (12), when FSVR < 1.1 was used to identify patients with an AVA < 1 cm^2, the sensitivity was **96%,** and the specificity 50%. In the same study, when **FSVR** < 0.8 was used to identify patients with an AVA < 0.7 cm^2, the sensitivity was 100%, and the specificity 62%. if FSVR *i* 0.8 was choosen for identifying patients with an AVA £ 1 cm^2, **the** sensitivity was **67%** and the specificity 100%. In the **study** Otto (15) FSVR < 0 8 identified 239 of 307 patients with AVA < 0.7 cm^2 (sensitivity 78%) **and** FSVR > 0.8 identified 38 of the 75 patients with AVA > 0.7 cm^2 (specificity **51** %). **In** the study of Peter et al (16), this ratio was applied as **an** estimate of effective, available aortic valve area in patients with aortic valve **prosthesis.**

However several **issues** remain problematic: 1) The continuous wave measurement retains pitfalls, 2) Although the fractional shortening is a good to excellent indicator of left ventricular function, it is not equivalent to flow as such. This becomes apparent in patients with mitral regurgitation, **for** whom this method may be severely limited. Finally, more patients need to be studied with intermediate valve areas to determine the **performance of** this **technique** in borderline situations.

In conclusion, this study shows that the "fractional **shortening**-velocity ratio" is a sensitive and specific non-invasive method for identifying patients with clinically significant aortic stenosis. It is simpler to apply and may be useful in clinical decision-making as continuity equation valve **areas.**

We gratefully acknowledge the assitance of C. Wing in the preparation of this article,

REFERENCES

1. Bansal RC, Shah PM. Usefulness of echo Doppler in management of patients with valvular heart disease. Curr Probl Cardioll989; 14:285-350.
2. Judge KW, Otto CM. Doppler echocardiography evaluation of aortic **stenosis.** Cardiol Clinic 1990; 8:203-16.
3. Rahimtoola SH. Perspective on valvular heart disease: an **update. J** Am Coll Cardiol 1989; 14:1-23.
4. Currie PJ, **Seward JB,** Reeder GS et al. Continuous **wave** Doppler echocardiographic assessement of severity of calcific aortic stenosis: a simultaneous Doppier-catheter correlative study in 100 adult patients. Circulation 1985; 71:1162-69.
5. **Hatle** L, Angelson BA, Tromsdal A. Non-invasive assessement of aortic stenosis by Doppler ultrasound. Br Heart J 1980;43:284-92.
6. Oh JK, Taliercio CP, Holmes **Jr** DR et al. Prediction of the severity of aortic stenosis **by** Doppler aortic valve **area determination:** prospective Doppler-catheterization correlation in 100 patients. **J** Am Coil Cardiol 1988; 11,1227-34.
7. Otto CM, Pearlman AS, Comess KA et al. Determination of the stenotic aortic **valve area** in adults using Doppler-echocardiography. J Am Coll Cardiol 1986; 7:509-17.

8. Teirstein P, Yeager M, Yock PG et al. Doppler echocardiographlc measurement of aortic valve area in aortic stenosis; a non-invasive application of the Gorlin formula. J Am Coll Cardiol 1986; 5:1059-65.

9. Zoghbi WA, Farmer KL, Soto JG et al. Accurate noninvasive quatifiaction of stenotic aortic valve area by Doppler-echocardiography. Circulation 1986; 73:452-9.

10. Skjaerpe T, Hegrenaes L, Hatle I. Noninvasive estimation of valve area in patients with aortic stenosis by Doppler ultrasound and two-dimensional echocardiography. Circulation 1985;72:810-8.

11. Otto CM, Pearlman AS, Gardner CL. Hemodynamic progression of aortic stenosis in adults assessed by Doppler echocardiography. J Am Coll Cardiol 1989; 13:545-50.

12. Mann DL, Usher BW, Hammerman S et al. The fractional shortening-velocity ratio: Validation of a new echocardiographic Doppler method for identifying patients with significant aortic stenosis. J Am Coil Cardiol 1990; 15:1578-84.

13. Gardin JM, Henry WL, Savage DD et al. Echocardiographic measurements in normal subjects: evaluation of an adult population without clinically apparent heart disease. J Clin Ultrasound 1979; 7:439-45.

14. Steingart RM, Scheuer J. Assessement of myocardial ischemia. In: Hurst JW, Louge RB, Schlant RC, Sonnenblick EH, Wallace AG, Wenger NK eds. The Heart. Newyork: McGraw Hill, 1986:305.

15. Otto CM, Nishimura RA, Davis KB et al. Doppler echocardiographic findings in adults with severe symptomatic valvular aortic stenosis. Am J Cardiol 1991; 68:1477-84.

16. Peter M, Weiss P, Jenzer HR et al. The Omnicarbon tilting-dlsc heart valve prosthesis: A clinical and Doppler echocardiographic follow-up. J Thorac Cardiovasc Surg 1993; 106:599-608.