British Journal of Medicine & Medical Research
2(4): 575-586, 2012

SCIENCEDOMAIN ***international***
www.sciencedomain.org

SCIENCEDOMAIN

Left Ventricle Twisting in Athletes: A Comparison between Subjects with Bicuspid Aortic Valve and Tricuspid Ones

Laura Stefani[1*], Gianni Pedrizzetti[2], Alessio De Luca[1], Loira Toncelli[1], Maria Concetta Robertina Vono[1], Roberto Mercuri[1], Gabriele Innocenti[1], Stefano Pedri[3], N. Maffulli[4] and Giorgio Galanti[1]

[1]Sports Medicine Center, University of Florence, Italy.
[2]DICAr, University of Trieste, Italy.
[3]ESAOTE- Italy.
[4]Queen Mary University of London, Barts and The London School of Medicine and Dentistry, Institute of Health Sciences Education, Centre for Sports and Exercise, UK.

Authors' contributions

This work was carried out in collaboration between all authors. LS and GG designed the study, wrote the protocol, and wrote the first draft of the manuscript. GP, SP and ADL performed the statistical analysis and managed the analyses of the study. LT, MCRV, RM and GI managed the literature searches. Authors GG and NM revised the final draft of the manuscript. All authors read and approved the final manuscript.

Research Article

Received 8th March, 2012
Accepted 8th June, 2012
Published 26th September, 2012

ABSTRACT

Aim: In athletes with Bicuspid Aortic Valve (BAV) a slight but progressive left ventricle (LV) enlargement with a reduction of longitudinal strain values at basal segments of the same chamber, have been previously demonstrated. The aim of the study is to verify by deformation parameters any possible asymptomatic myocardial dysfunction in BAV athletes.
Study Design: Cross-sectional study.
Place and Duration of Study: Department of Sports Medicine (Emergency Unit) between June 2009 and July 2010.
Methodology: The study protocol included all athletes investigated for a prime evaluation to enter the criteria for this particular study. 30 BAV athletes (aged 25± 3)

**Corresponding author: Email: laura.stefani@aouc.unifi.it;*

and 30 Tricuspid Aortic Valve (TAV) athletes, regularly trained were submitted to an echocardiographic exam. From the short axis LV view images, the circumferential strain, rotation, twist, distinguished in the endocardial and epicardial component at the basal and apical level, were calculated by the speckle tracking (ST) multi-layer approach. This is a special assisted mode (AHSTM, Aided Heart Segmentation) to track the LV Endo/Epi myocardial points.
Results: In BAV only the epicardial (*5.74±1.4*) and endocardial (*8.64±4.0)* apical rotation are significantly higher than in TAV ($p<0.01$) while the LV basal segments are at the lower limits. The endo/epi twist exams carried out in both BAV & TAV result normal.
Conclusion: ST multi-layer approach improves the assessment of LV myocardial function in asymptomatic trained BAV athletes, where the major apical LV rotation values found seem to compensate for basal dysfunction in them. This confirms the persistence of a normal heart performance despite the mild LV chamber enlargement.

Keywords: Bicuspid aortic valve; twisting; athletes.

1. INTRODUCTION

Myocardial rotation and twist have been recently used in the assessment of cardiac function in healthy individuals (Zhang et al., 2011), in patients affected by heart valve dysfunction (Nagel et al., 2000; Sandstade et al., 2002) and also in trained athletes (Stefani et al., 2008; Neilan et al., 2006). Speckle Tracking (ST) is a method commonly used in calculating these parameters with a high reproducibility and low variability of the results (Mor-Avi et al., 2011; Kim et al., 2009). The term left ventricular (LV) rotation refers to myocardial rotation around the long axis of the left ventricle. It is rotational displacement and is expressed in degrees. Normally, the base and apex of the ventricle rotate in opposite directions. The absolute apex-to-base difference in LV rotation is referred to as the net LV twist angle (also expressed in degrees). LV rotation or twisting motion has an important role in LV systolic and diastolic function and it has been noted that several aspects, such as, sex differences, preload and after load can influence these parameters (Mor-Avi et al., 2011; Notomi et al., 2008).

Authors have recently provided the range of normal value in normal subjects (Zang et al., 2011) adopting the multi-layer approach to measure myocardial deformation by two-dimensional (2D) speckle tracking method. Studies carried out in adult and young athletes have investigated the effects of endurance exercise on Left Ventricle (LV) twist, demonstrating a modification of the values of this parameter (Weiner et al., 2010; Nottin et al., 2008; De Luca et al., 2011). In case of regularly trained athletes affected by asymptomatic Bicuspid Aortic Valve (BAV), a slight but progressive enlargement of LV chamber unlike healthy patients has been demonstrated during an echo- follow-up study (Galanti et al., 2010). In addition to this, the longitudinal strain parameter, calculated at the basal segments of LV chamber, in a smaller sample of the same group, resulted to be at the lower limits of the normal range (Stefani et al., 2009). It can be supposed that a possible different LV twist behaviour in BAV athletes, can be shown when a mild enlargement of the LV chamber is present and in addition an eventual implication of the regular exercise on the different deformation pattern can be hypotized. The present investigation aims to complete the study previously mentioned and to evaluate the LV performance in a group of asymptomatic BAV athletes, using additional deformation parameters that may be more intimately related to the change of heart function in presence of this anomaly. To highlight the eventual peculiar behaviour of LV chamber in BAV athletes, the results obtained are compared to athletes with normal Tricuspid Aortic Valve (TAV).

2. MATERIALS AND METHODS

A group of 30 BAV male athletes (20 soccer players, 5 basket players, 5 swimmers), aged 25 ± 3 years with small up to mild aortic regurgitation were enrolled in the study. These athletes trained regularly for at least 10 months a year, on a two hour basis three times a week. The training regimes for soccer and basketball players consisted on 12 ± 1.2 hours/week for 8.7 ± 2.5 years vs. 14.5 ± 0.5 hours/week for 8.9 ± 2.3 years respectively. For swimmers it was about 15.5 ± 0.5 hours/week for 7.4 ± 0.5 years. The BAV athletes were selected among a large cohort of 120 BAV athletes followed up at Sports Medicine University Center in Florence (Italy). Almost all of them were from the same group of athletes previously analyzed for the LV longitudinal strain assessment (Sefani et al., 2009). They were submitted to a conventional color Doppler echocardiographic exam following the corresponding guidelines (Douglas et al., 2011). The selection of the participants was based also the high quality of the echocardiographic images visually evaluated. For this reason the images of 10 BAV soccer players were not accepted for this study and new BAV athletes, analogous for their general characteristics, were enrolled. Despite the fact that the BAV athletes practiced different sports they have been considered similar for the dynamic sport work-load component and therefore classified as mild-high class (Mitchell et al., 2005). They were matched with a control group composed of 30 athletes with a normal TAV (22 soccer players, 8 basket players), recruited from the athletic population and who were all followed up yearly at our sports medicine center and had all undergone the same training regime. Both groups were submitted to an examination to exclude the presence of additional metabolic diseases (as diabetes), hypertension, or other extra cardiovascular diseases as in case of cardiomyopathies or pathological LV hypertrophy. From parasternal view the standard M-mode echocardiographic systolic and diastolic LV chamber parameters were obtained. From apical view the pulse wave Doppler data, at the mitral valve level, were measured to study the diastolic function. From short axis view, at different level of the LV chamber (as expressed below) the advanced deformation ones were measured. The main deformation parameters calculated were rotation, distinguished in endocardial (Endo) and epicardial (Epi) component, and twist values. The calculation of radial strain, circumferential strain, including the eventual differences between the values found at the Endo/Epi components of myocardial layers was also possible. The Ethics Committee approved all the procedures described in the present study and all the participants gave their oral consent.

2.1 Echocardiographic Examination

All the echocardiographic exams were performed by two experienced board-certified cardiologists. The two cardiologists had worked together for more than 5 years, and no formal reliability of the studies (inter- or intra-tester) was done. However, in order to verify the substantial overlapping of the measurement performed, 5 participants among the cases studied were randomly selected and blindly re-analyzed for the main 2D and deformation parameters considered. From the long axis view at rest condition and following the AHA guidelines the standard LV M-Mode measurements were obtained (Lang et al., 2005). From the long axis parasternal view, the aortic root and the left atrium dimensions were obtained. In case of the upper limits left atrium dimensions, the 2D measurement by four chamber view was acquired to confirm the first value. Basal systolic, diastolic and Doppler measures, including inter ventricular septum (IVS) posterior wall (PW) thickness, left ventricle end-diastolic diameter (LVEDd), left ventricle end-systolic diameter (LVESd), left atrium (LA) and aortic root (Ao) dimensions, pulse wave Doppler transmitral flow E-wave, A-wave (E/A ratio), deceleration time (DT), isovolumic relaxation time (IVRT) were calculated. The diastolic function assessment was completed analyzing the E/E' ratio result by the Tissue Doppler Imaging (TDI) method (Galderisi et al., 2004). The evaluation of left ventricular Cardiac Mass Index g/m2 (CMI) was obtained from Devereux procedure (Devereux et al., 1987). Considering the regular shape of the myocardial chamber the Ejection Fraction (EF %) was calculated by left ventricular end-diastolic diameter, left ventricular end-systolic diameter following the formula (LVEDd–LVESd)/LVESd. The degree of the valve insufficiency was described in first line as a visual assessment determining the extension of the regurgitating jet on a 0 to 4+ scale by the colour-flow mapping method from the four-chamber view and according to the guidelines (Douglas et al., 2011). In addition a more quantitative approach to identify the subjects with mild AR jet was performed by the vena contracta value calculated from parsternal-long axis view (Lancellotti et al., 2010), just to exclude subject with a severe aortic regurgitation.

2.2 Image Acquisition

Images were obtained in the left lateral decubitus position, after a 15 minute rest using the echocardiograph My Lab 50 (Esaote, Florence, Italy) equipped with a 2.5 MHz probe. The two-dimensional grey scale images were obtained at a frame rate between 60 and 70 Hz. The images were acquired in a cine loops triggered to the QRS complex, in a resting condition and at a heart rate (HR) of approximately 70 bps to avoid the effects of a large HR variability on the rotation and the twist. High quality images were acquired with excellent visualization of the endocardial and epicardial borders. The apical plane was obtained from a lower point of view (at least 2 intercostal spaces) respect to the basal one, in order to improve the alignment of ultrasound beam perpendicular to the LV major axis. Acquisitions of the apical and basal segments were stored digitally for subsequent off-line analysis with dedicated ST software included in the echocardiographas shown in the Fig. 1.

2.3 LV Circumferential Strain, Rotation and Twist by Speckle Tracking Method

For each subject studied, two echocardiographic images of the LV chamber from the short-axis view at the mitral and apex levels were captured. The short axis images were obtained taking care to ensure that the 4 basal plane contained the mitral valve and that the apical plane was acquired distally to the papillary muscle. Particular attention has been taken in acquiring these views as it has been demonstrated that the measurement of LV apical rotation, and in exacting rotation in the anterior segments, critically depends on transducer position (Teske et al., 2007). Therefore, as literature reports (van Dalen et al., 2008), the standard parasternal long-axis position has been defined as the position in which the LV and aorta were most inline, with the mitral valve tips in the middle of the sector. From that window an as-circular-as-possible short-axis image of the LV apex, just proximal to the level with end-systolic LV luminal obliteration, was obtained by angulation of the transducer. The short-axis views, captured at the mitral valve plane and apex level, were later on processed by the speckle tracking X-Strain software. The software asks the operator to provide the initial position of the tracking points. The system used provides two different ways for the initial tracking points insertion: free-hand mode where there's no limits to the number and location of the tracking points or assisted mode (AHSTM, Aided Heart Segmentation). The later mode assists the operator in inserting well equi-spaced tracking points over the 2D images and it is based on ASE 18 segments segmentation of the heart. AHSTM methods have been used in our protocol to reduce measurement variability among operators. Following AHSTM, 12 tracking points were superimposed at the end of the diastole on the echocardiographic image at basal level of the LV chamber and 8 tracking points were positioned in apex. The tracking of each point over time is then performed with a 2D technique. A square window of 16 pixels on each side of the current position of the point is extracted from all B-Mode frames, then frame by frame displacement is computed both in horizontal and in vertical directions to minimize total brightness convention error. Considering the regular LV geometry and also for the complete absence of the myocardial synergic dissimilarities of the population studied, the results were accepted in averaged values, with indication of the standard deviation. The parameters evaluated were Circumferential Strain (ε-circum %), Radial Strain, Endocardial and Epicardial Rotation (Mor-Avi et al., 2011.). Twist has been therefore calculated from a post processing analysis as the net difference of LV mean rotation between basal and apical short-axis plane for each subject. This is more properly a differential rotation, although the homogeneity of the population, and the small variability in the LV size, make results equivalent to those evaluable from actual twist.

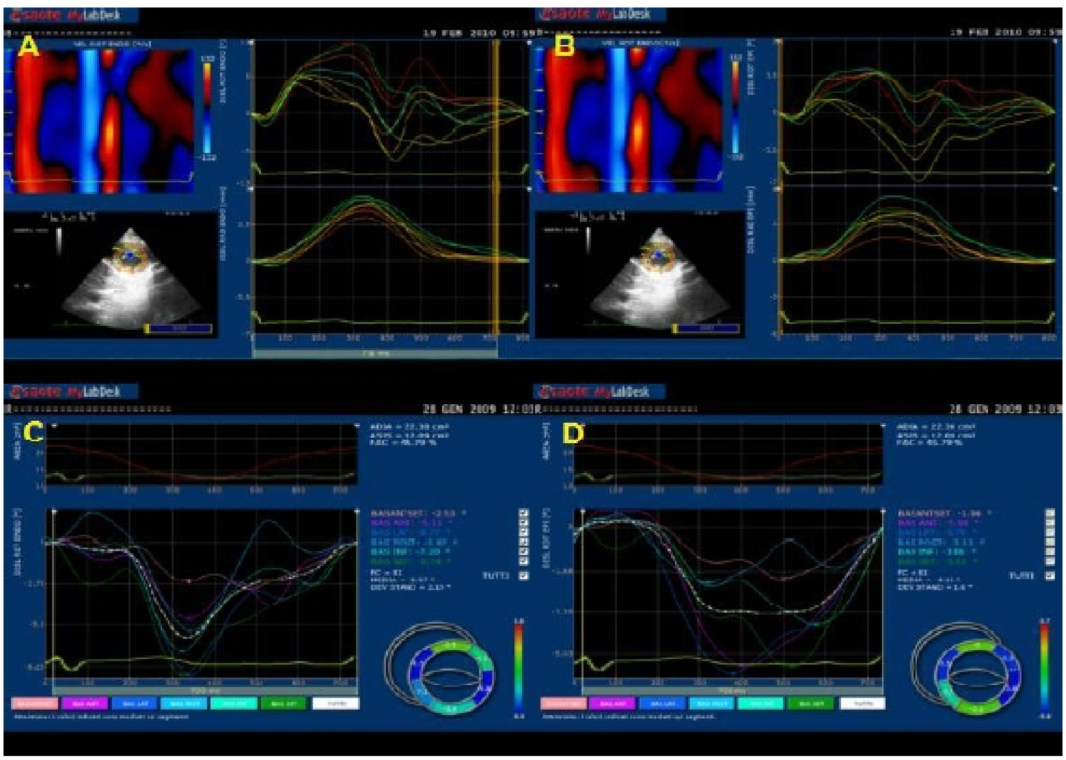

Fig. 1. Apical endocardial (A), apical epicardial (B), basal endocardial (C) and basal epicardial (D) left ventricle rotation assessed by X-Strain® (ESAOTE) software

2.4 Statistical Analysis

Statistical analysis was performed using the SPSS 13.0 package for Windows XP. All data are expressed as mean ± standard deviation (SD). The groups were compared using Student's unpaired *t*-test probability. The (p) value <0.05 was considered statistically significant. The relationship between two parameters was performed by correlation coefficient, (r). The inter-observer variability was calculated as the SD of differences in ST strain measurements by two independent observers for 5 randomly-selected echocardiographic examinations

3. RESULTS AND DISCUSSION

3.1 2D-Echo Parameters

All the participants enrolled are comparable for general characteristics and body surface area (BSA) without any significant variation of the values. The echocardiographic standard parameters and the LV dimensions are normal in both BAV and TAV groups, as shown in Table 1. Particularly the LVEDd of BAV athletes are higher than TAV one even if not significantly. The degree of the aortic valve insufficiency estimated by both, color and vena contracta parameters resulted to be compatible within a small to mild insufficiency. The vena contracta values of the jet resulted to be, where calculated, lower than 3 mm for all.

Table 1. BAV and TAV athletes' hemodynamic and echocardiographic basal values

Hemodynamic	**BAV**	**TAV**	**P**
	30	30	
Heart rate (beats/min)	65±4	67±5	NS
Systolic BP(mmHg)	110±9	112±4	NS
Diastolic BP(mmHg)	80±3	76±6	NS
2-dimensional echocardiography			
IVS(mm)	9.6±0.9	9.7±0.4	NS
PW (mm)	9.6±1.6	9.8±0.4	NS
LVESd (mm)	32.6±2.6	30.4±1.5	NS
LVEDd (mm)	51.5 ±4.4	49±4.3	NS
EF %	67.2 ±5.2	64.6 ±4.7	NS
CMI (g/m2)	115.9±20.2	118.8±22.9	NS
RV (mm)	22.4±5.0	22.2± 1.9	NS
Pulsed-wave Doppler			
E/A ratio	2.02±1.0	1.7±0.1	NS
IVRT (ms)	80.55±9.0	69.4±7.26	<0.01
DTC (ms)	173.33±17.7	170.0±19.0	NS
E/E'	6.17±2.0	6.2±3.6	NS
Ao Root	31.11±1.8	26.22±2.3	<0.05
Left Atrium	33.22±2.3	29.66±1.8	<0.05

**2D and Doppler echo-parameters of the two groups of athletes*
IVS: Inter Ventricular Septum; PW: Posterior Wall; LVESd: Left Ventricle End Systolic diameter; LVEDd: Left Ventricle End Diastolicdiameter; CMI: Cardiac Mass Index; RV: Right Ventricle; Ao Root: Aortic Root; DCT: Deceleration Time; IVRT: Isovolumic Relaxation Time; E/A: E wave /A wave ratio.

The left atrium antero-posterior dimension and the measure of the IVRT parameter are significantly higher in BAV than in TAV. According to the literature, the aortic root dimensions appear significantly higher in BAV respect of TAV. In agreement with the inclusion criteria none of the BAV athletes show a severe aortic dysfunction: the aortic valve insufficiency is globally estimated as mild and no aortic valve gradient, compatible with a stenosis, has been found among the athletes investigated.

3.2 Rotation and Twisting

The results confirm that base and apex of the LV chamber rotate in opposite directions. The apex shows a brief clockwise rotation, reversing rapidly and becoming anti-clockwise during LV ejection. On the contrary the basal LV segments rotate briefly in an anti-clockwise sense, followed by a clockwise rotation during the remaining part of the ejection. All the rotation values, measured either at the endocardial or epicardial layers level are within the normal range in the two groups for the basal and apical segments of the LV chamber (Table 2).

Despite this, some differences between the two groups are evident. The LV apical epicardial and the endocardial rotation values are significantly higher in BAV than in the TAV group while no significant difference has been found at the basal segments of the same chamber (Table 2).

3.3 Circumferential and Radial Strain

The circumferential strain, again calculated at the epicardial and endocardial layers at the basal and apical levels of the LV chamber, shows values within the normal and validated range without any significant variation between the two groups (Table 2).

Table 2. Apical and basal rotation, twist, circumferential and radial strain of the left ventricle in both groups

Parameter	BAV	TAV	P
Apical Rotation (degree)			
❖ Endo	8.64±4.0	5.89±1.8	<0.05
❖ Epi	5.74±1.4	3.40±1.6	<0.01
Basal Rotation (degree)			
❖ Endo	-4.46±2.4	-5.95±2.7	NS
❖ Epi	-4.00±1.2	-3.93±2.5	NS
LV Twist (degree)			
❖ Endo	13.51±5.0	11.80±2.4	NS
❖ Epi	9.45±2.5	7.31±3.4	NS
Circumferential Strain (%)			
❖ Apex Endo	-22.29±7.2	-26.10±6.9	NS
❖ Apex Epi	-13.96±4.3	-14.05±4.2	NS
❖ Base Endo	-19.5±4.0	-21.60±5.8	NS
❖ Base Epi	-13.11±4.2	-13.67±3.5	NS
p	*<0.01*	*<0.01*	
Radial Strain (%)			
❖ Apex	22.97±7.2	38.22±8.4	NS
❖ Base	20.90±12.9	29.68±16.7	NS

**LV: Left Ventricle; Endo: endocardium; Epi: epicardium.*

A trans-mural difference of the circumferential strain values between the sub-endocardial and the subepicardial layers has been demonstrated in both groups. This trans-mural Endo/Epi difference, considered an expression of a normal LV function, is equally significant (as expressed by P in horizontal line) at both the basal and apical levels, and in BAV and TAV groups (Table 3).

Table 3. Comparison of circumferential strain (ε–circum) between subendocardial (endo %) and subepicardial (epi %) myocardium layers within the two groups

Parameter	ε -circum- endo %	ε -circum-epi %	P
	Basal		
BAV	-19.54.0	-13.11±4.2	<0.01
TAV	-21.60±5.8	-13.67±3.5	<0.01
	Apical		
BAV	-22.29±7.2	-13.96±4.3	<0.01
TAV	-26.10±6.04	-14.05±4.2	<0.01

ε -circum- endo %: Endocardial Circumferential Strain; ε -circum-epi %: Epicardial Circumferential Strain.

The peak systolic radial strains are normal in BAV and TAV, despite it being near the lower limits in the former group, principally at the basal level**.** In particular the results of the deformation parameters obtained in 5 exams performed by two different cardiologists, are substantially overlapped and in agreement with low (5.8% p=NS) inter- intra observer variability of the data.

None relationship between twist and LVEDd parameters either in BAV or in TAV (r=0.17; r=0.18 respectively) are found.

4. DISCUSSION

Rotation and twist play a relevant role in the characterization of the heart performance in adaptive (Akagawa et al., 2007; Tischler et al., 2003) and maladaptive pathological hypertrophy (Richand et al., 2007). It is known that the LV muscle fibers are arranged with a different direction across the myocardium: from a right7 handed helix at the endocardium (Endo) to a left-handed helix at the epicardium (Epi) with most intermediate myofibers in approximately circumferential orientation (Streeter et al., 1969); this geometrical arrangement contributes to a base-to-apex rotational movement whose net difference generates the LV twist. The LV twist measurement found in BAV and TAV athletes present similar values, despite the fact that in the BAV group such a conclusion results from a higher apical rotation associated to a reduction at the basal level. This aspect, in agreement with the literature (Weiner et al., 2010) where it has been demonstrated as the exercise can lead to augmentation of LV twist by enhancing apical rotation , can be particularly in this context considered as a special mechanism induced by the exercise in protecting the myocardial function and also in compensate the basal dysfunction in BAV. The present investigation demonstrates in fact as the opposite sign differences of the values obtained, compensate each other and therefore they do not produce a significant augmentation of the LV systolic Endo/Epi twisting values in BAV group vs TAV. In addition, the calculation of the transmyocardial Endo/Epi difference existing in apical rotation, twist, and in circumferential strain parameters of the BAV athletes, confirms the normality of the LV performance in this group. The relevance of the transmural gradient as marker of preserved systolic function has been, in fact specifically described either in normal subjects (Zhang et al., 2011; Chen et al., 2011) or in athletes (Sandstade et al., 2002; Mor-Avi et al., 2011; Weiner et al., 2010).

As literature has previously reported, the strong relationship of these deformation parameters with LVEDd dimension (Dong et al., 1999) suggests that such factors are potentially relevant to evaluate the athlete's heart performance. However, due to the absence in this investigation of a positive relationship between twist and LVEDd parameters either in BAV or in TAV (r=0.17; r=0.18 respectively), can be justified by the LV chamber dimension here, which is almost within the normal range. The peculiar aspect, characterized by an enhancement of apical LV rotation parameter in combination with a slight reduction of basal rotation of BAV athletes in whom the EF is normal can be consequently considered in agreement with the LV longitudinal strain values behaviour previously found in the same group where the existence of normal LV function has been proved (Stefani et al., 2009). All the data heads towards the same direction supporting a possible peculiar motion of the LV basal segments in BAV athletes. Considering the normal values of the LV twist found, it is therefore rational to think that sport activity does not have any negative impact on the LV function of asymptomatic BAV athletes despite their LV chamber being slightly larger than TAV athletes similarly trained. The reduction of basal rotation and the compensatory apical rotation, apparently seem to be the mechanisms able to maintain normal torsion in them and that a possible protective effect on the myocardial function might be presumed. ST multi-layer method can be consequently proposed as an additional and helpful method not only limited to an isolate quantification of myocardial function, but also to follow-up the LV performance in this kind of athletes, mainly when they discontinue their sport activity.

A minor comment has to be considered for the 2D echo-Doppler results. Two main differences between BAV and TAV have been shown. The diastolic function and also the left atria dimensions are slightly altered in BAV rather than in the TAV group. Although this study was not focused on such data, these preliminary finding suggests the need to further investigate the diastolic properties, such as the untwisting phase.

4.1 Comparison with Previous Studies

The relatively high values of apical rotation degree in BAV group, associated with a small reduction of the basal one, and therefore an eventual normal twist are the most relevant aspects found in the present study. Previous investigations have approached the evaluation of the myocardial twist by a ST multilayer method, in normal participants (Zhang et al., 2011), in hypertensive people (Dong et al., 1999) and also in patients after dobutamine infusion (Akagawa et al., 2007). A study carried out in a group of cyclists, demonstrated a reduction of the shear strain values in the LV apex (Mor-Avi et al., 2011). The authors have underlined that the mechanisms involved are still not fully understood even though it is possible to hypothesize that this phenomenon could represent a greater reserve for this type of athletes. These results are in quantitative agreement with the data in literature, with figures in the expected range. Instead there is some dissimilarity with the mentioned studies performed in athletes. Nevertheless, it is expected that such actual results can vary when changing the type of sport activity or focusing on a specific discipline. Indeed, the relative CMI low values of the athletes enrolled in the present study could play a relevant role in the quantitative results. Moreover, the BAV athletes population studied, with a mild aortic valve insufficiency, can nevertheless be considered a special group where several else intrinsic myocardial components of the heart fibers can modify the morphology and the function of the LV chamber.

4.2 Limitations of the Study

Despite the peculiar aspect of the LV function demonstrated by deformation parameters in BAV group of athletes, this study presents several limitations, particularly due to the small sample analyzed that could partially reduce the reproducibility of the absolute single media value of the data obtained that cannot find a counterpart in other contexts. Another limit is related to the difficulty to enhance an eventual different behaviour of the deformation parameters in case of diverse kinds of sport practiced, especially when the volume load is more evident than pressure one. The present investigation has to be moreover completed by a longer follow–up in order to better evaluated the possible beneficial effect of the regular sport activity in maintaining the normal LV function in them.

5. CONCLUSION

The data obtained in young BAV athletes, with mild aortic valve dysfunction strongly support the hypothesis that deformation parameter, particularly LV rotation and twist, follow the functional adaptation of the heart to a regular exercise. This special aspect can also be related to a beneficial effect of the regular exercise that seems to work in maintaining the normal contractility in them. The special recurrent behaviour of the basal segments of the LV camber found only in BAV group highlights the attention on these LV chamber segments. On the other hand any possible specific clinical significance of these results, need anyway a longer follow-up. In conclusion potential predictive role of these parameters to discover an initial myocardial dysfunction can be at present supposed.

CONSENT

All authors declare that written informed consent was obtained from the patient (or other approved parties) for publication of this case report and accompanying images.

ACKNOWLEDGEMENTS

LS designed and conceived the study; LS and ADL performed all the measurements and the statistical analysis; GP supervised the technical aspects of measurements. LS, ADL, GP, SP and GG wrote the manuscript; the others authors contributed to wrote the single section approving the final version of the manuscript

COMPETING INTERESTS

SP is employed for ESAOTE S.p.A. (Florence, Italy). No fund has been received.

REFERENCES

Akagawa, E., Murata, K., Tanaka, N., Yamada, H., Miura, T., Kunichicka, H, Yasuadki, W., Yasuyuki, H., Takeo, T., Yoshio, N., Kyonori, Y., Masateru, K., Masunori, M. (2011). Augmentation of left ventricular apical endocardial with inotropic stimulation contributes to increased left ventricular torsion radial strain in normal subjects. Circulation, 71, 661-668.

Chen, X., Nakatani, S. (2007). Transmural myocardial strain gradient: a new and robust quantitativeindex of left ventricular wall motion based on myocardial strain imaging. Echocardiography, 28, 181-187.

De Luca, A., Stefani, L., Pedrizzetti, G., Pedri, S., Galanti, G. (2011). The effect of Exercise Training on Left Ventricular Function in young elite athletes. Card Ultras, 12, 9(1), 27.

Devereux, R.B. (1987). Detection of left ventricular hypertrophy by M-mode echocardiography. Anatomic validation, standardization and comparison to other methods. Hypertension, 20, 1251-60.

Dong, S.J., Hees, P.S., Huang, W.M., Buffer, S.A., Weiss, J.L., Shapiro, E.P. (1999). Independent effects of preload, afterload and contractility on left ventricular torsion. Am J Physiol, 277, 1053-1060.

Douglas, P.S., Garcia, M.J., Haines, D.E., Lai, W.W., Manning, W.J., Patel, A.R., Picard, M.H., Polk, D.M., Ragosta, M., Ward, R.P., Weiner, R.B. (2011). ACCF/ASE/AHA/ASNC/HFSA/HRS/SCAI/SCCM/.

Galanti, G., Stefani, L., Toncelli, L., Vono, M.C., Mercuri, R., Maffulli, N. (2008). Effects of sport activity in athletes with bicuspid aortic valve and mild aortic regurgitation**.** B J Sports Med, 44, 275-27.

Galderisi, M., Dini, F.L., Temporelli, P.L., Colonna, P., de simone, G. (2004). Doppler echocardiography for the assessment of the left ventricular diastolic function: methodology, clinical and prognostic value. Ital Heart J Suppl, 5, 86-97.

Kim, W.J., Lee, B.H., Kim, Y.J., Kang, J.H. (2009). Apical rotation assessed by speckle tracking echocardiography as an index of global left ventricular contractility. Circ Cardiovasc Imaging, 2, 123-131.

Mitchell, J.H., Haskell, C.W., Snell, P. (2005). Task Force 8: classification of sports. J Am Coll Cardio, 45, 1364–1367.

Mor-Avi, V., Lang, R.M., Badano, L.P., Belohlavek, M., Cardim, N.M., Derumeaux, G., Galderisi, M., Marwick, T., Nagueh, S.F., Sengupta, P.P., Sicari, R., Smiseth, O.A., Smulevitz, B., Takeuchi, M., Thomas, J.D., Vannan, M., Voigt, J.U., Zamorano, J.L. (2011). Current and Evolving Echocardiographic Techniques for the Quantitative Evaluation of Cardiac Mechanics: ASE/EAE Consensus Statement on Methodology and Indications. J Am Soc Echocardiogr, 24, 277-313.

Nagel, E., Stuber, M., Burkhard, B., Fisher, S.E., Sheidegger, M.B., Boesiger, P., Hesse, O.M. (2000). Cardiac rotation and relaxation in patients with aortic valve stenosis. Europ Heart J 2000, 21, 582-589.

Neilan, T.G., Ton–Nu, T.T., Jassal, D.S., Popovic, Z.B., Douglas, P.S., Halpern, E.F., Marshall, J.E., Thomas, J.D., Picard, M.H., Yoerger, D.M., Wood, M.J. (2006). Myocardial adaptation to short-term high-intensity exercise in highly trained athletes. J Am Soc Echocardiogr, 19, 1280-1285.

Notomi, Y., Popovic, Z.B., Setser, R.M. (2008). Ventricular untwisting: a temporal link between left ventricular relaxation and suction. Am J Physiol Heart Circ Physiol, 294, H505–H513.

Nottin, S., Doucende, G., Schster-Beck, I., Dauzat, M., Obert, P. (2008). Alteration in left ventricular normal and shear strains valuated by 2D-strain echocardiography in the athlete's heart. J Physiol, 586, 4721-4733.

Richand, V, Lafitte, S, Reant, P., Serri, K. (2007). An ultrasound speckle tracking (two dimensional strain) analysis of myocardial deformation in professional soccer players compared with healthy subjects and hypertrophic cardiomyopathy. J Am Cardiol, 100, 128-132.

Sandstade, J.J.W., Harre, T.J.K., Beer, M., Hofmann, S., Pabst, T., Kenn, W., Voelker, W., Neubauer, S., Hahn, D. (2002). Cardiac systolic rotation and contraction before and after valve replacement for aortic stenosis. Am J Roentgeneology, 178, 953-958.

SCCT/SCMR. (2011). Appropriate use criteria for echocardiography. J Am Soc Echocardiography, 24, 229-267.

Stefani, L., De Luca, A., Maffulli, N., Mercuri, R., Innocenti G., Suliman I. (2009). Speckle tracking for left ventricle performance in young athletes with bicuspid aortic valve and mild aortic regurgitation. Eur J Echocardiogr, 10, 527-531.

Stefani, L., Toncelli, L., Di Tante, V., Vono, M.C.R., Gianassi, M., Galanti, G. (2008). Supernormal functional reserve of apical segments in elite soccer players: an ultrasound speckle tracking handgrip stress study. Cardiov Ultras, 6, 14.

Streeter, D.D., Spotnitz, H.M., Patel, D.P., Ross, J., Sonnenblick, E.H. (1969). Fiber orientation in the canine left ventricle during diastole and systole. Circ Res, 24, 339-347.

Teske, A.J., De Boeck, B.W.L., Melman, P.G., Sieswerda, G.T., Doevendans, P.A., Cramer, J.M. (2007). Echocardiographic quantification of myocardial function using tissue deformation imaging, a guide to image acquisition and analysis using tissue Doppler and speckle tracking. Cardiov Ultras, 5, 27.

Tischler, M., Niggel, J. (2003). Left ventricular systolic torsion and exercise in normal hearts**.** J Am Soc Echocardiogr, 16, 670-674.

van Dalen, V.B.M., Vletter, W.B., Soliman, O.I., ten Cate, F.J., Geleijnse, M.L. (2008). Importance of transducer position in the assessment of apical rotation by speckle tracking echocardiography. J Am Soc Echocardiography, 21, 895-898.

Weiner, R.B., Hutter, A.M., Wang, F., Kim, J., Weyman, A.E., Wood, M.J., Picard, M.H., Baggish, A.L. (2010). The impact of endurance exercise training on left ventricular torsion. Cardiov Imaging, 3, 1001-1009.

Zhang, Q., Fan, F., Yu-Jia Liang Jun-Min Xie. Wen, Y.Y., Wai-Kwok Yip, G., Lam, A.Y.Y., Chan, J.Y., Fung, J.W., Yu, C.M. (2011). A novel multi-layer approach of measuring myocardial strain and torsion by 2D speckle tracking imaging in normal subjects and patients with heart diseases. International J Cardio, 147, 32-37.
