Case report

Tricuspid annular disjunction can be isolated and even arrhythmogenic. A cardiac magnetic resonance study

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Abstract

Mitral annular disjunction is related to increased arrhythmogenic risk; in a certain percentage of cases, mitral annular disjunction is associated with tricuspid annular disjunction. While the prognostic implications of mitral annular disjunction have been well established, there is still little data to define this aspect regarding the tricuspid annular disjunction. We present a case of a patient admitted for life-threatening ventricular arrhythmias that occurred during endurance sporting activity, who was found to have isolated tricuspid annular disjunction, not associated with mitral annular disjunction. Based on several factors, including the morphology and axis of QRS of the ventricular arrhythmic activity, and its behavior, including the response to antiarrhythmic treatment, and in keeping with the finding of edema and late gadolinium enhancement at the basal segment of the right ventricle free wall on cardiac magnetic resonance imaging, a direct relation between tricuspid annular disjunction and ventricular arrhythmias was highly conceivable. Control after three months showed almost complete remission of the previously described and persistence of LGE at the level of the basal segment of the free wall of the right ventricle, so giving strength to the hypothesis of an event related to increased acute RV free wall stress, secondary to high-intensity physical activity, established on a framework of chronic wall stress, as represented by LGE, similarly to what happens for mitral valve prolapse. To the best of our knowledge, this is the first case of a legitimately conceivable direct relation between tricuspid annular disjunction and ventricular arrhythmias.

Keywords: *tricuspid valve prolapse; tricuspid annular disjunction; mitral valve prolapse; mitral annular disjunction; ventricular arrhythmias; endurance exercise activity; cardiac magnetic resonance imaging*

Introduction

Mitral valve prolapse (MVP) is a condition associated with increased arrhythmic risk and increased mortality; among the arrhythmic risk factors associated with MVP is the mitral annular disjunction (MAD); MAD, in a percentage of cases, is associated with a tricuspid annular disjunction (TAD). While the prognostic implications of MAD have been well established, there is still little data to define this aspect regarding TAD. We present a case of TAD which appeared to be isolated from MAD and turned out to be arrhythmogenic in a specific hemodynamic context.

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Case report

A 53-year-old Caucasian male patient, with no history of cardiovascular disease nor previous cardiovascular examinations, was admitted to ER for sustained palpitations and rapidly repetitive episodes of fainting, occurred during endurance biking activity; on access to ER, heart rate was 72 bpm and blood pressure 130/70 mmHg; electrocardiography (ECG) showed sinus rhythm interrupted by frequent isolated and repetitive premature ventricular contractions (PVC's), rapidly evolved into sustained high-frequency pulseless ventricular tachycardia, treated with external defibrillation, fortunately resulting to be effective in restoring cardiovascular activity. The morphology and axis of PVC's QRS on 12 lead ECG was characterized by an R-wave transition beyond V3 lead in precordial leads with wide and notched QRS in the right precordial leads and inferior axis on limb leads (Figure 1).

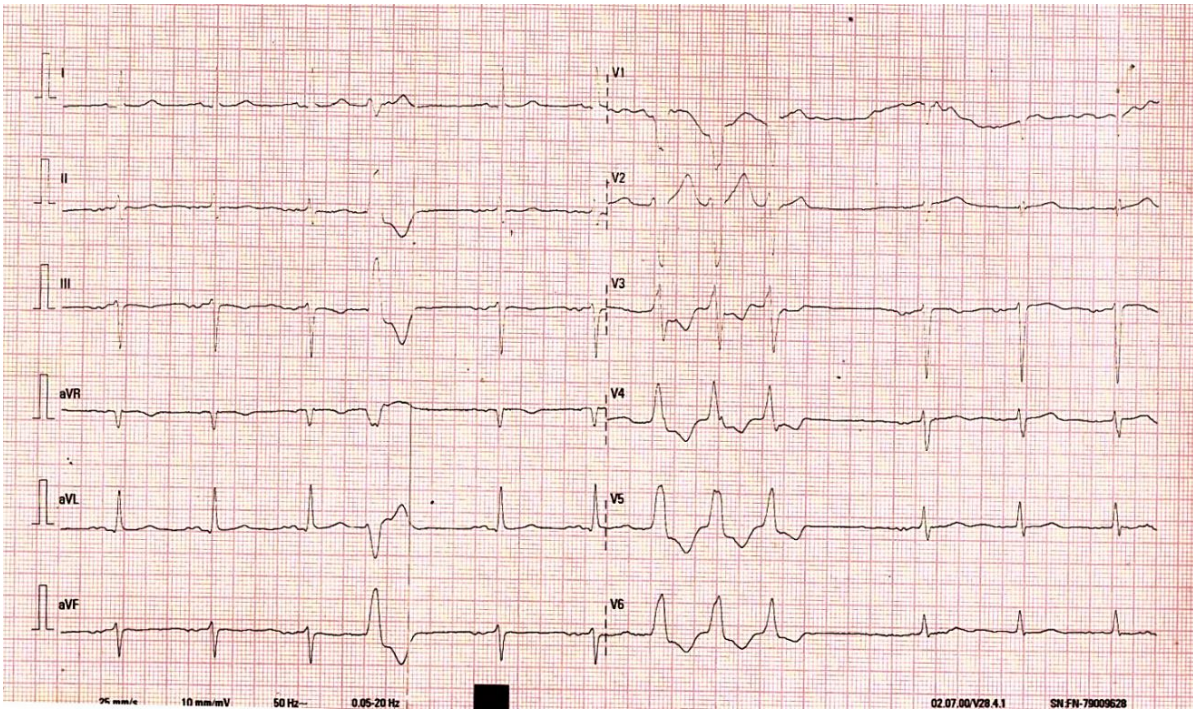

Fig. 1. Twelve leads Electrocardiography. The morphology and axis of PVC's QRS was characterized by an R-wave transition beyond V3 lead in precordial leads with wide and notched QRS in the right precordial leads and inferior axis on limb lead.

Transthoracic echocardiography (TTE), performed in the acute phase, showed normal left ventricle (LV) cavity size, defined by an end-diastolic diameter (EDD) of 52 mm and end-diastolic volume index (EDVI) of 70 ml/m2 and systolic function, defined by a Simpson biplane ejection fraction (EF) of 59%, increased right ventricle (RV) cavity size defined by a basal EDD of 42 mm and normal RV global systolic function of the right ventricle defined by a TAPSE of 21 mm, left atrial enlargement defined by an end systolic volume index (ESVI) of 48 ml/m2, right atrial enlargement defined by an end-systolic area (ESA) of 19 cm^2, right ventricular systolic pressure (RVSP) of 30 mmHg; the same examination also showed the presence of mitral valve prolapse, most evident at the scallops A3, P1, P2 and tricuspid valve prolapse, mostly involving the body of the anterior leaflet; no MAD nor TAD was detected on TTE (Figure 2).

On telemetric monitoring, there was evidence of frequent repetitive PVCs with the aforementioned morphological characteristics, for which the patient was put on antiarrhythmic therapy, with amiodarone as a first instance, without substantial benefit, and then with low doses of atenolol after which, a rapid decrease in ventricular ectopic activity was seen. The

second day after the admission, the complete disappearance of ventricular ectopic activity was observed and clinical stabilization was obtained. Then, the patient was evaluated by cardiac magnetic resonance imaging (CMRi).

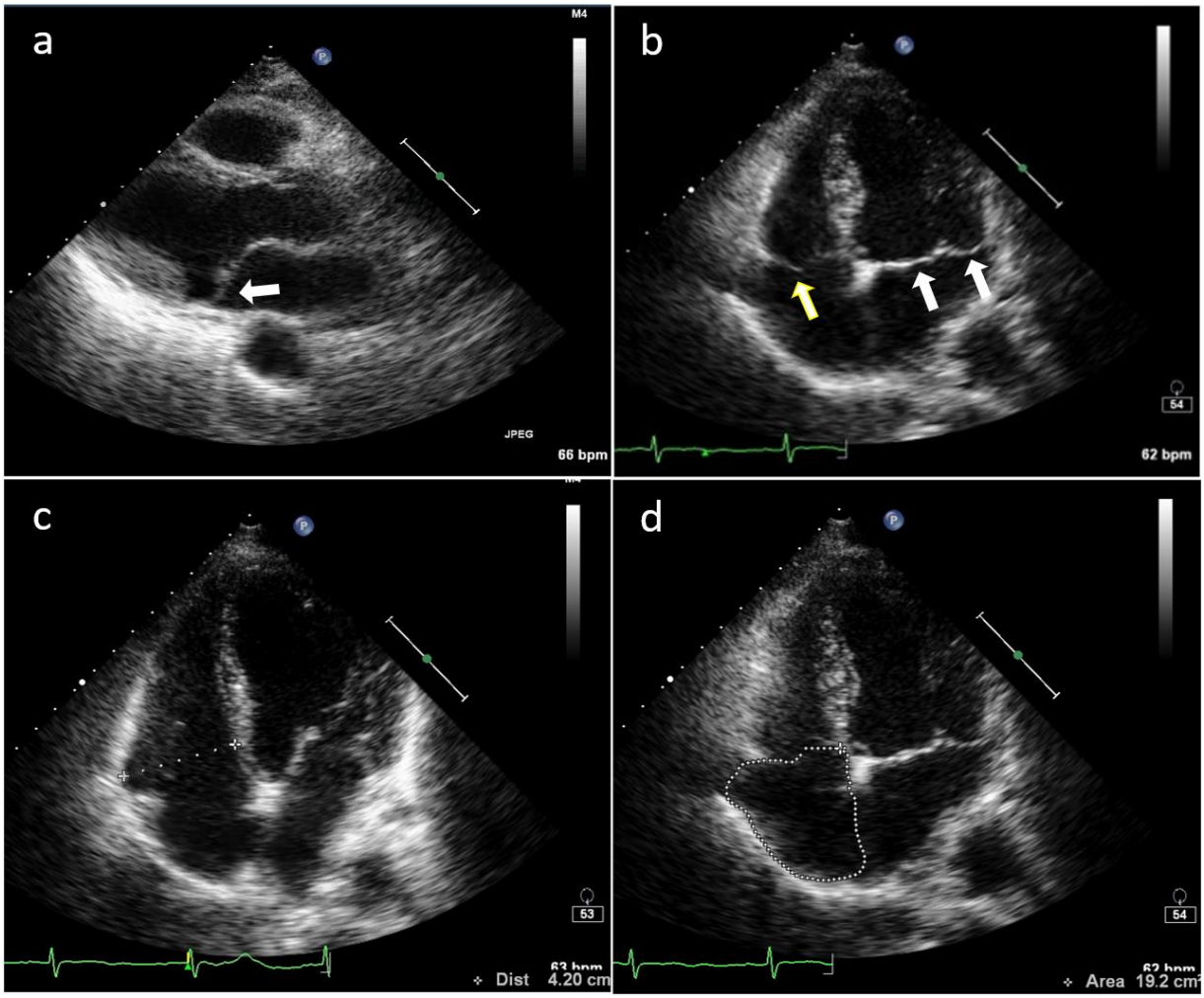

Fig. 2. Transthoracic echocardiography, performed in the acute phase, showed the presence of mitral valve prolapse, most evident at the scallops P2 (a, white arrow), A3, P1 (b, white arrows), and tricuspid valve prolapse, most evident at the scallop of the anterior leaflet (b, yellow arrow); no mitral annular disjunction nor tricuspid annular disjunction was detected (a, b). Furthermore, the exam showed increased right ventricle cavity size defined by a basal end diastolic diameter of 42 mm (c) and right atrial enlargement defined by an end-systolic area of 19 cm^2 (d).

The examination also confirmed normal cavity dimensions and systolic function of the left and right ventricles, defined by EDVI and EF for both ventricles, left atrial enlargement and normal cavitary dimensions of the right atrium defined by ESA index (Table I). However, on SSFp sequences, the examination confirmed the presence of mitral valve prolapse, showing the same features of those seen on TTE including the absence of annular disjunction. Furthermore, tricuspid valve prolapse was also confirmed, mostly involving the anterior leaflet; CMRi allowed to detect an associated significant tricuspid annular junction, with maximum separation between the right atrial wall/tricuspid valve and the free wall of the right ventricle of 6 mm, seen at the level of the portion of the ring adjacent to the anterior leaflet (Figure 3). Lastly, increased signal in TIR/T2w sequences as per edema was observed at the level of the basal segments of the free wall of the right ventricle with corresponding late gadolinium enhancement (LGE) (Figures 4a and 4b). The

patient was discharged in good general condition after observation of 7 days, on therapy with atenolol. The patient was reassessed at 3 months by CMRi. The examination showed almost complete remission of the previously described edema and persistence of LGE at the level of the basal segment of the free wall of the right ventricle (Figure 4 c and d). In the meantime, a complete genetic test for mutations correlating with cardiomyopathy was performed, which was negative for all the genes analyzed. The patient has been scheduled for an exercise stress echocardiography which will be performed in some months in order to reassess the arrhythmic response during exercise under beta-blockers therapy be away from the acute phase. On that occasion, hemodynamic variations in the tricuspid regurgitation entity and RVSP values will also be evaluated.

Discussion

MVP is a condition affecting 2-3% of general population [1]. Although generally considered a benign condition for a long time, it is associated with increased arrhythmic risk and sudden cardiac death, according to growing evidence [2]. Among the arrhythmic risk factors associated with MVP are MAD [3] and LGE with typical localization and distribution [4]. However, in up to 43% of patients with MVP, an associated tricuspid valve prolapse (TVP) occurs [5]; similarly, in nearly 50% of patients with MAD, the presence of associated TAD has been observed [6]. While the prognostic implications of MAD have been well established, including regarding the arrhythmogenic risk related to exercise [7], the evidence so far available in the literature are not unequivocal in confirming that TVP with or without TAD may be

Table I. Transthoracic echocardiography and cardiac magnetic resonance main quantitative parameters

	TTE	CMRi
LV EDD	52 mm	51 mm
LV EDVI	70 ml/m^2	94 ml/m^2
LV EF	59%	61%
RV EDD	42 mm	43 mm
RV EDVI		92 ml/m^2
RV EF		54%
TAPSE	21 mm	
RVSP	30 mmHg	
LA ESVI biplane	48 ml/m^2	
LA area in 4 chambers view		15 cm^2/m^2
RA area in in 4 chambers view	19 cm^2	14 cm^2/m^2

Abbreviations: TTE: Transthoracic echocardiography, CMRi: cardiac magnetic resonance imaging, LV: left ventricle, EDD: end diastolic diameter, EDVI: end diastolic volume index, EF: ejection fraction, RV: right ventricle, RVSP: right ventricular systolic pressure, LA: left atrium, ESVI: end diastolic volume index, RA: right atrium.

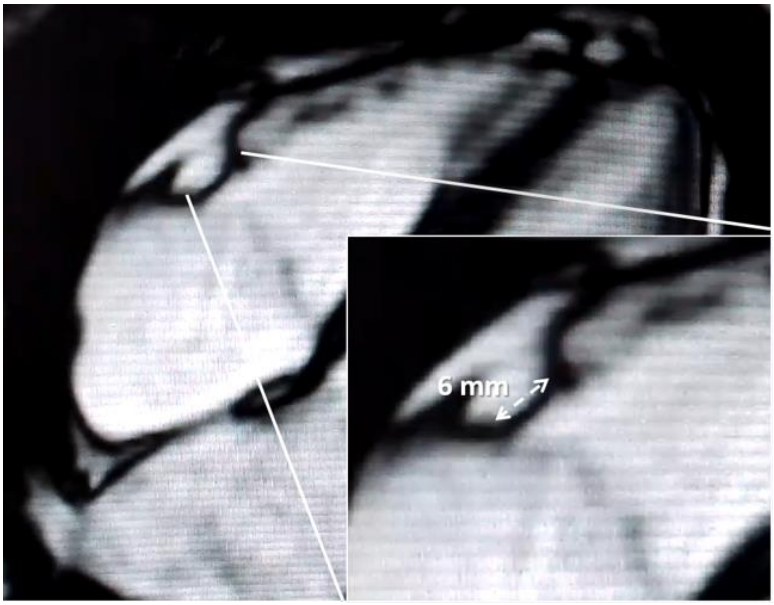

Fig. 3. Cardiac magnetic resonance imaging, SSFP sequences. the examination confirmed the presence of mitral valve prolapse, showing the same features of those seen on transthoracic echocardiography including the absence of annular disjunction; furthermore, tricuspid valve prolapse was also confirmed, mostly involving the anterior leaflet; CMRi allowed to detect an associated significant tricuspid annular junction, with maximum separation between the right atrial wall/tricuspid valve and the free wall of the right ventricle of 6 mm, seen at the level of the portion of the ring adjacent to the anterior leaflet. Abbreviations: SSFP: steady state free precession, CMRi: cardiac magnetic resonance imaging.

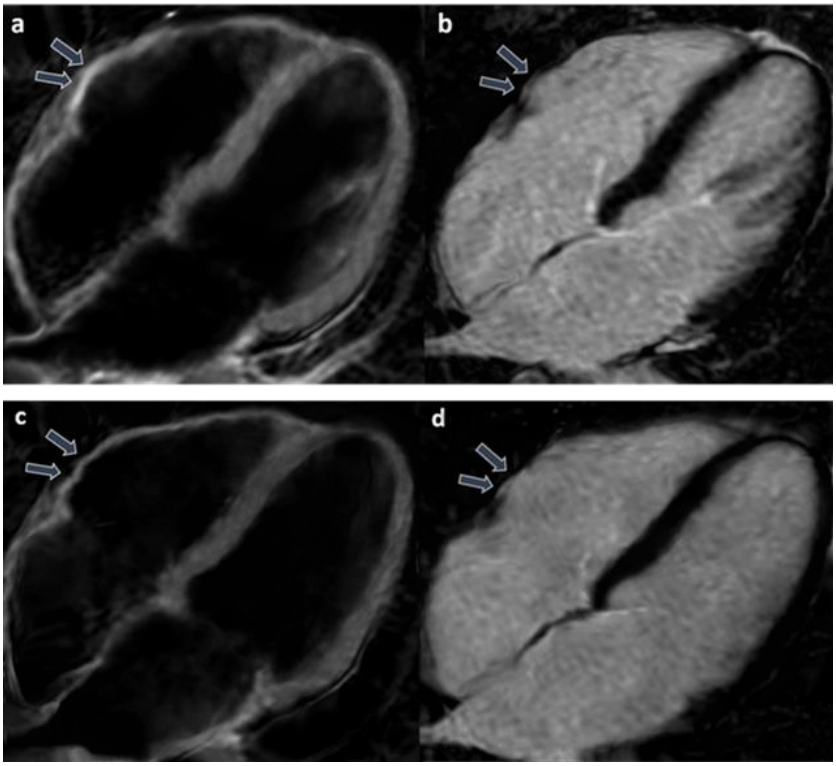

Fig. 4. Cardiac magnetic resonance imaging, TIR/T2w and LGE sequences. In the acute setting, increased signal in TIR/T2w sequences as per edema was observed at the level of the basal segments of the free wall of the right ventricle (a, arrows) with corresponding LGE (b, arrows). Control after 3 months shows almost complete remission of the previously described edema (c, arrows) and persistence of LGE at the level of the basal segment of the free wall of the right ventricle (d, arrows). Abbreviations: TIR/T2w: triple inversion recovery/T2 weighted, LGE: late gadolinium enhancement

associated with increased arrhythmic risk or mortality [8]; moreover, most studies have considered patients with TAD associated with MAD rather than isolated TAD (as in our case), the latter being a very rare occurrence in the general population, basically not reported in the literature.

The prognostic implications of tricuspid annular disjunction have not been well defined. However, it is conceivable that it is associated with increased arrhythmic risk according to some evidence [9], likely by the same mechanisms that characterize the same pathology at the mitral level, such as increased wall stress. However, other evidence suggests that TAD is not associated with an increased risk of arrhythmic events [6]. TAD is an under-reported condition in echocardiography, most likely because the method does not allow exploring all tricuspid ring districts. CMRi, which has a higher spatial resolution than echocardiography and is characterized by the possibility of exploring all anatomical districts ideally, certainly represents the most accurate method for this field of evaluation [6, 10]. Our patient presented an initial picture characterized by palpitations as a leading symptom, with evidence of repetitive ventricular arrhythmias degenerated into cardiocirculatory arrest as mentioned before, occurred during endurance sporting activity, which represents an element associated with an increased wall stress and, more specifically, RV wall stress [11]. The type of ventricular arrhythmias presented by the patient imposes a differential diagnosis, which includes, in particular, outflow tract ventricular arrhythmias; the morphology and axis in peripheral leads are, in fact, compatible with the latter, more likely with RV rather than the LV outflow tract based on the transition that occurs beyond V3 lead into precordial leads [12]. However, the same aspects are also compatible with the origin of the ectopy localized at the level of the tricuspid annulus, specifically at the anteroseptal portion of it [13], an element further supported by the presence of a notch within the QRS which, related to the latter localization [13], not typical of outflow tract arrhythmias. Another key element is represented by the presence of edema at the level of the basal segments of RV free wall with corresponding LGE detected on CMRi; these findings, in fact, suggests an injury induced by chronic wall stress related to tricuspid valve prolapse, defined by LGE, with superimposed corresponding edema related to the additional load and wall stress related the endurance exercise activity, the latter already supported by evidence [14]. The behavior of extrasystoles represents another element suggesting a relationship between ventricular arrhythmias and tricuspid valve disease. In fact, limited response to amiodarone was observed in comparison with an excellent response to beta-blocker therapy since the latter is typically characterized by a greater beneficial action on wall stress than it is for amiodarone [15]. The finding of normalization of the right ventricle and atrium dimensions on CMRi performed a few days after the acute phase are in keeping with the evidence of the fact that there may be a reversible increase in cavity size of the right ventricle and right atrium, evident immediately after endurance activity, no longer evident at a distance when there is remission of the right overload endurance-related [16]. Finally, the finding of remission of edema with persistence of LGE at control after 3 months, correlates with the hypothesis of an event related to increased acute RV free wall stress, secondary to high-intensity physical activity, established on a framework of chronic wall stress in the same site, as represented by LGE, similarly to what happens for mitral valve prolapse [17]. Taken together, all those aspects suggest an at least justifiably conceivable relationship between ventricular arrhythmias and tricuspid valve prolapse, especially in the presence of annular disjunction. Therefore, if on the one hand, it is true that an associated increased arrhythmic risk has not been defined yet for TAD, on the other hand, it is conceivable that in specific hemodynamic conditions, such as those associated with increased wall stress, such as endurance sporting activity, TAD could also contribute, like MAD, to the genesis of ventricular arrhythmias. Moreover, just as imagers are gradually becoming accustomed to looking for MAD as an arrhythmogenic substrate, a myopic focus may result in missed TAD. Further, if the arrhythmogenic focus of MAD, now generally accepted, has any

extrapolation for TAD, it would be reasonable to assume that it is an additive arrhythmogenic phenotype. This consideration, if confirmed, would assume its importance both in pathological contexts, such as pulmonary embolism or other diseases associated with acute right-sided overload, and also in particular but very frequent physiological contexts, typically associated with increased wall stress such as endurance exercise (as in our case) [18] and pregnancy [19]. In general, based on the evidence available so far, the prognosis of patients with TVP with or without TAD is still uncertain; therefore, the prognosis of this patient should be considered mainly dependent on the presence of MVP. Although still not completely established, the prognosis of patients with MVP is generally benign [20] and depends above all on the entity of the associated regurgitation and the presence of associated MVD, complex ventricular arrhythmias, and LGE involving the left ventricular myocardium with typical distribution [17,21,22]. Given the absence of the above elements and the negligible extent of associated mitral regurgitation, a good prognosis could theoretically be assumed in this specific patient. This consideration should be reformulated if the association between ventricular arrhythmias and the presence of TAD is definitively confirmed, especially in the context of high-intensity physical activity that the patient habitually performs. In this case, planned stress echocardiography could certainly provide valuable elements for a better prognostic definition for this patient. The role of exercise stress echocardiography is now well established in the evaluation of mitral and aortic valvulopathies [23], generally, to assess changes in the degree of valvulopathy and to evaluate the possible onset of pulmonary hypertension or the increase of the same if already present [24]. However, the role of this examination in the evaluation of tricuspid valvulopathy is less well defined. In this specific patient, it was felt that this examination could be helpful both to assess any hemodynamic variations in the extent of tricuspid regurgitation and pulmonary pressure values and evaluate the arrhythmic response to beta-blocker therapy during exercise. However, evidence-based targets to reduce the risk of arrhythmic risk and sudden death, in patient with MVP or TVP (or both) with or without annular disjunction, have not been defined yet. Similarly, the factors which influence the progression of mitral and tricuspid regurgitation are in fact still today unclear; therefore, if it is true that no defined therapeutic targets have been identified and, still today, many dilemmas affect the management of MVP [25], this is even more true for TAD.

Conclusions

Tricuspid annular disjunction is an underdiagnosed condition, most often associated with mitral annular disjunction, that may have clinical relevance and potentially a negative prognostic impact due to increased risk of ventricular arrhythmias, especially under specific hemodynamic conditions, such as endurance exercise activity. To the best of our knowledge, this is the first case of isolated tricuspid annular disjunction and the first case of a legitimately conceivable direct relation between tricuspid annular disjunction and ventricular arrhythmias. Further studies are needed to better define the prognostic impact of this condition, even apart from specific hemodynamic conditions and to define the role of additional tests, such as exercise stress echocardiography.

Abbreviations

MVP = mitral valve prolapse
MAD = mitral annular disjunction
TAD = tricuspid annular disjunction
ECG = electrocardiogram
PVC's = premature ventricular contractions
TTE = transthoracic echocardiography
LV = left ventricle
EDD = end diastolic diameter
EDVI = end diastolic volume index
EF = ejection fraction
RV = right ventricle
ESVI: end systolic volume index
ESA = end systolic area
RVSP = right ventricular systolic pressure
CMRi = cardiac magnetic resonance imaging
SSFp = steady state free precession
TIR/T2w = triple inversion recovery/T2 weighted
DIR/T1w = double inversion recovery/T1 weighted
LGE = late gadolinium enhancement
TVP = tricuspid valve prolapse

Consent
Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal

Declarations of interest
None for each of the authors.
Founding
Not founded.

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