Tachycardia-induced heart failure - Does it exist?

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Rapid atrial fibrillation is a common cause of heart failure.

**Symptoms**
- Light-headedness
- Palpitations
- Syncope
- Dyspnea
- Fatigue
- Chest pain

AF may also be asymptomatic.

**Thromboembolism & stroke**

**Heart failure**

**Hospitalisation**

**Disability**

**Death**
4 patients with AF, discussion: ....

been a consequence and not a cause of the auricular fibrillation. In an inquiry into the conditions associated with fibrillation of the auricles (Lea, in this Journal, iv, 1911, p. 423), dilatation of the heart is noted as a possible cause in about 23 per cent. of the cases. In the present Case IV there was towards the end marked dilatation and hypertrophy of the left ventricle, but when first seen within a few hours of the onset the dilatation was very slight and a progressive increase was noted during his illness. It seems, therefore, justifiable to conclude that this dilatation was a consequence of the auricular fibrillation, or, at any rate, that it had nothing to do with its causation; and in

[Q. J. M., July, 1913.]
Heart failure model induced by rapid pacing


Heart failure induced by rapid pacing

The aim was to reproduce the human condition of tachycardia-induced cardiomyopathy, but it has been used to evaluate broader questions in CHF.

Atrial pacing at 330 beats/min induces symptoms and physical signs of CHF in the dog:

- Biventricular failure with cardiomegaly, hypoperfusion, pulmonary congestion, cachexia and ascites
- HF is reversible after cessation of pacing

72 y.o. patient, congestive heart failure, LVEF 20%
Atrial flutter with 2:1 AV conduction
LVEF normalized 2 months after electrical cardioversion
Reversibility of TIC Catheter ablation of AF in congestive heart failure

Shu, Haïssaguerre, NEJM 2004
Impairment of left ventricular systolic function secondary to chronic uncontrolled tachycardia, which is partially or completely reversible after normalization of heart rate (and/or rhythm irregularity)
Arrhythmias associated with TIC

Supraventricular causes
Atrial tachycardia
Atrial flutter
Atrial fibrillation
Atrioventricular nodal reentry tachycardia
Atrioventricular tachycardia
Permanent junctional reciprocating tachycardia
Arrhythmia associated with TIC

Repetitive monomorphic VT
## Arrhythmias associated with TIC

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Frequent VPBs
Idiopathic VPBs

- 70% originate from the RVOT
- Multiple other origins
  - LVOT
  - valve annuli
  - epicardium
  - PA
  - aortic sinuses of Valsalva *
  - near the bundle of His
  - coronary sinus and cardiac veins
3D activation map of LVOT focus
PVC burden and LV dysfunction: Cut off value?

Patients with decreased LVEF had a higher mean PVC burden than their counterparts with normal LV function (29%–37% versus 8%–13%).

The lowest PVC burden resulting in cardiomyopathy was 10%.

Other risk factors:

- Male gender
- Absence of symptoms
- Persistence of PVCs throughout the day
- Longer PVC duration
- Presence of non-sustained ventricular tachycardia
- Multiform PVCs
- RV PVCs

Bogun F, Heart Rhythm 2007
Baman TS, Heart Rhythm 2010
Hasdemir C, J Cardiovasc Electrophysiol 2011
Arrhythmias associated with TIC

Supraventricular causes
Atrial tachycardia
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Atrioventricular tachycardia
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Ventricular causes
Premature ventricular complexes
VT : Right ventricular outflow tachycardia
Ventricular pacing at high rates (pacemaker mediated tach)
Asynchrony: LBBB, chronic RV pacing
Arrhythmia-induced cardiomyopathy

Rapid heart rate
- Rapid Afib, prolonged or repetitive SVT / VT

Myocardial dysfunction

Asynchrony
- LBBB
- chronic RV pacing
- VPB/VT

Irregular rhythm
- AF
- VPB
Update of the definition
Arrhythmia-induced cardiomyopathy

Ventricular or atrial dysfunction secondary to rapid and/or asynchronous*/irregular myocardial contraction, partially or completely reversible after treatment of the causative arrhythmia

*PVCs or right apical ventricular pacing

Not only cases without primary structural disease patients with ventricular dysfunction of another origin are also prone to develop TIC
Pathophysiology of TIC: Rapid ventricular rates

Primary mechanisms

- Myocardial energy depletion
- Myocardial ischaemia
- Oxidative stress

Microscopic changes

- Myocytes:
  - Loss of contractility
  - Basement membrane dysfunction
  - Increased resting length

- Neurohumoral activation:
  - Elevated atrial natriuretic peptide
  - Elevated catecholamine levels
  - Elevated plasma renin activity
  - Elevated plasma aldosterone levels

- Down-regulation of b-receptors
  - Decreased sensitivity to b-stimulation
  - Decreased adenylate cyclase activity
  - Abnormal calcium handling

Gross changes

- Morphological:
  - Cardiac chambers dilatation (more pronounced for end-systolic than end-diastolic volumes)
  - Isolated RV dysfunction (rare)
  - Spheroid left ventricular geometry
  - Decreased LV wall thickness

- Functional:
  - Reduced cardiac output and LVEF
  - Elevated systemic vascular resistance
  - Elevated filling pressures
  - Diastolic dysfunction
  - Mitral regurgitation

Simantirakis, Europace 2011
Time progression and recovery

TIC develops within weeks, also depends on
- Heart rate
- Arrhythmia burden
- Underlying heart disease
- Unknown factors

Recovery of symptoms and LV contractility is expected within 3 months after rhythm or rate control of the tachyarrhythmia
Atrial TIC

Atrial remodelling resulting from incessant tachycardia, « Afib begets Afib »

The mechanisms contributing to atrial remodelling—atrial dilatation and systolic dysfunction—differ substantially from those for ventricular myocardium.

Alterations of calcium handling, driven from down-regulation or altered function of the L-type Ca(2+)-channel and an increased Ca(2+) extrusion via the Na(+)/Ca(2+)-exchanger have been proposed as primary ionic changes.

Schotten, Cardiovasc Research 2002
Treatment

Pharmacological treatment
  rate control or rhythm control of AF
  anti-arrhythmic treatment of AT, SVT, VPBs

Electrical cardioversion (AF/Aflu)

Catheter ablation
  AF, AFlu, AT, SVT,
  VPB, VT

Cardiac resynchronisation therapy
Conclusion

Tachycardia/arrhythmia -induced cardiomyopathy:

- is a reversible cause of heart failure and dilated cardiomyopathy

- should be considered in all patients with a dilated cardiomyopathy and who have tachycardia or atrial fibrillation with a fast ventricular rate

- Abolishing tachycardia with drugs or catheter ablation often results in clinical improvement and ventricular function recovery