Intermittent episodes of paced tachycardia: what is the cause?

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Introduction

A hospital in-patient with a dual chamber pacemaker in situ (Boston Scientific Essentio, Ingevity leads) was noted to be having intermittent episodes of rapid ventricular pacing. Figure 1 is a six lead ECG (V1-V6) showing dysrhythmia onset. Figure 2 is a baseline 12 lead ECG and Figure 3 shows intracardiac signals during tachycardia. Lead parameters are all normal and the pacemaker settings are displayed below.

Mode	*DDD*	*Rate smoothing*	
Lower rate limit	*50 / min*	*- Up*	*9%*
Maximum tracking rate	*130 / min*	*- Down*	*12%*
Paced AV delay	*80-180ms*	*Rate Hysteresis*	
Sensed AV delay	*55-150ms*	*- Offset*	*-10 /min*
A-Refractory (PVARP)	*240-280ms*	*Rate Adaptive Pacing*	
V-Refractory (VRP)	*230-250ms*	*- Minute ventilation*	*passive*
AV search	*Off*	*- Accelerometer*	*passive*

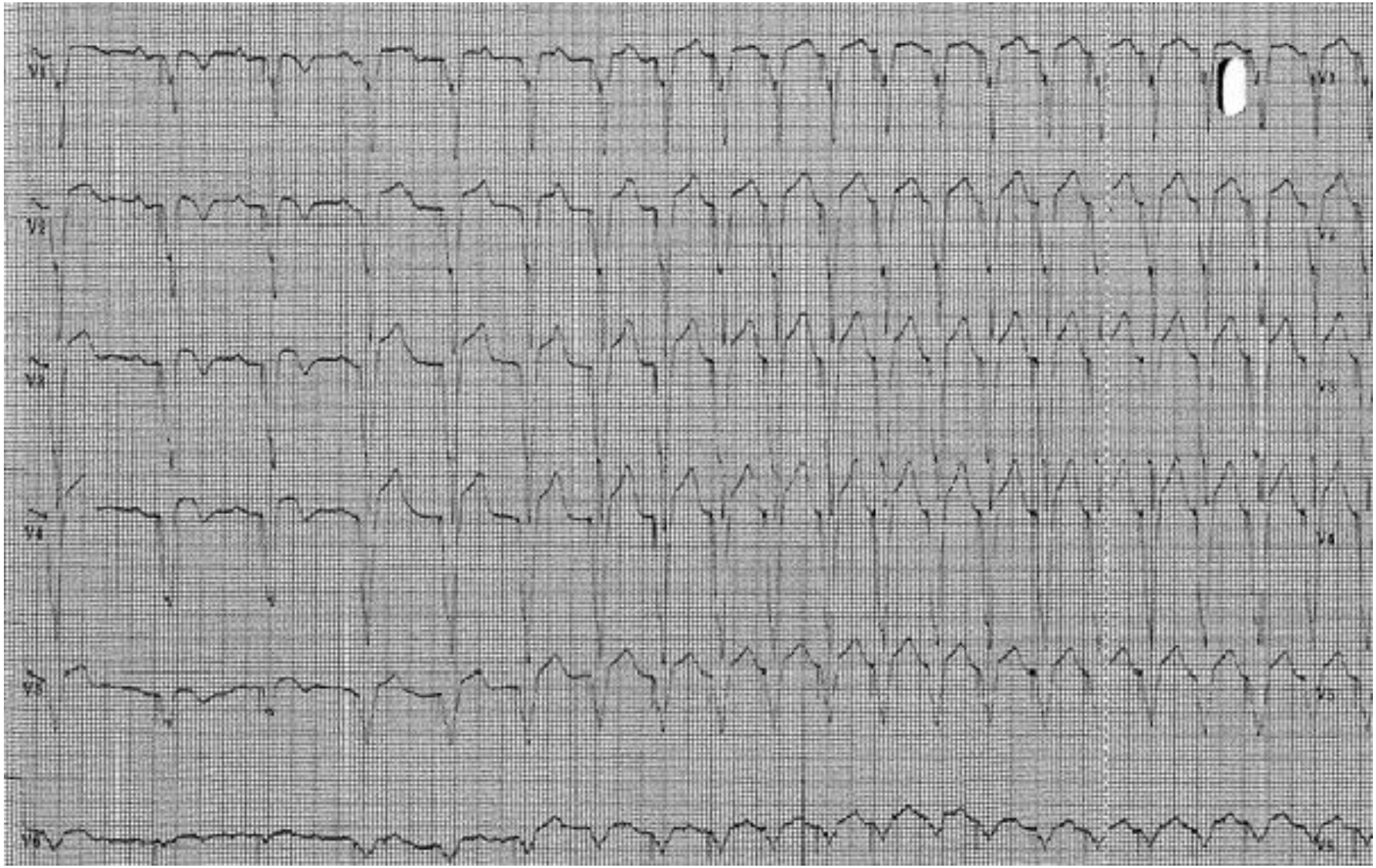

Figure 1

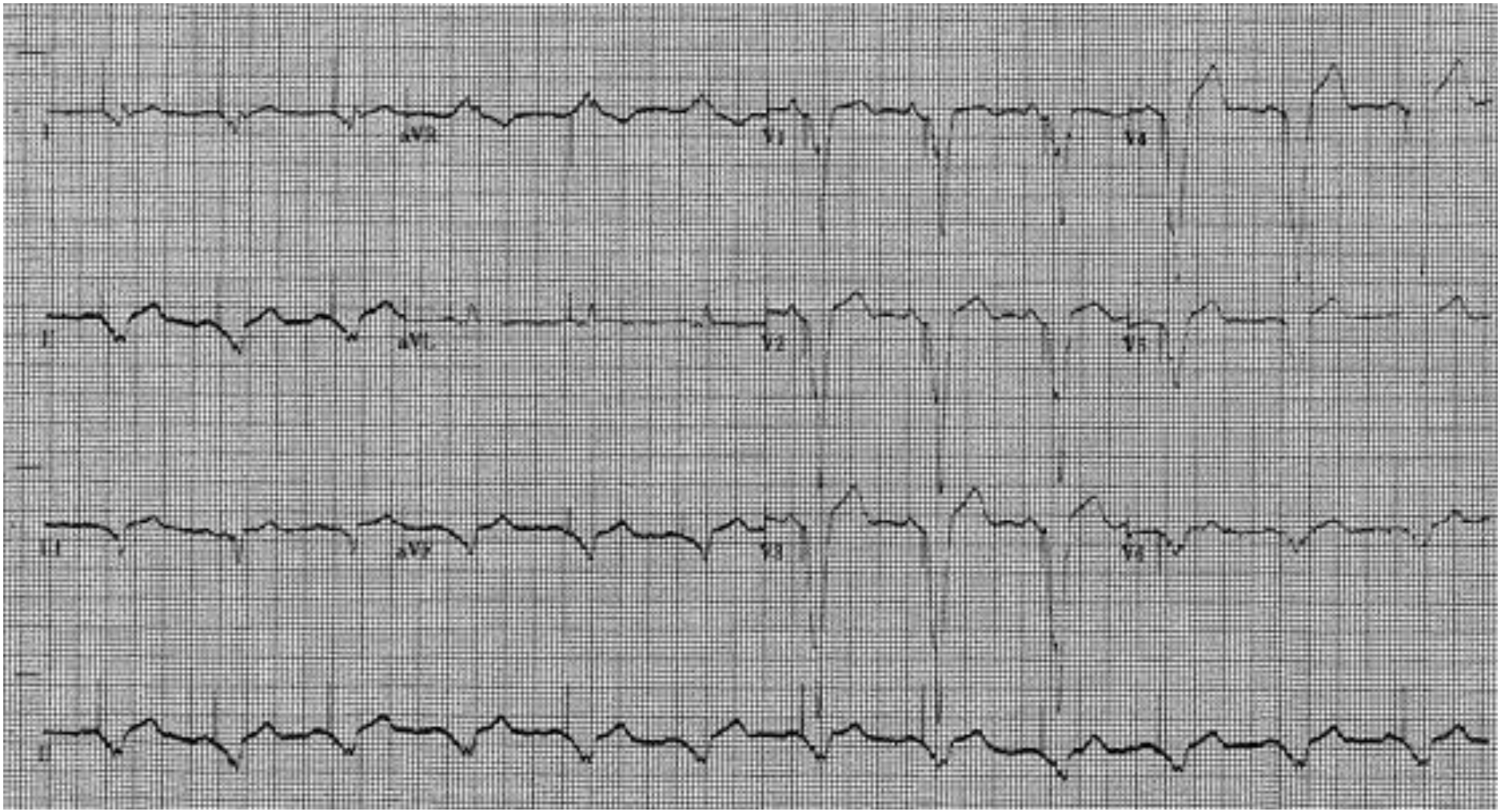

Figure 2

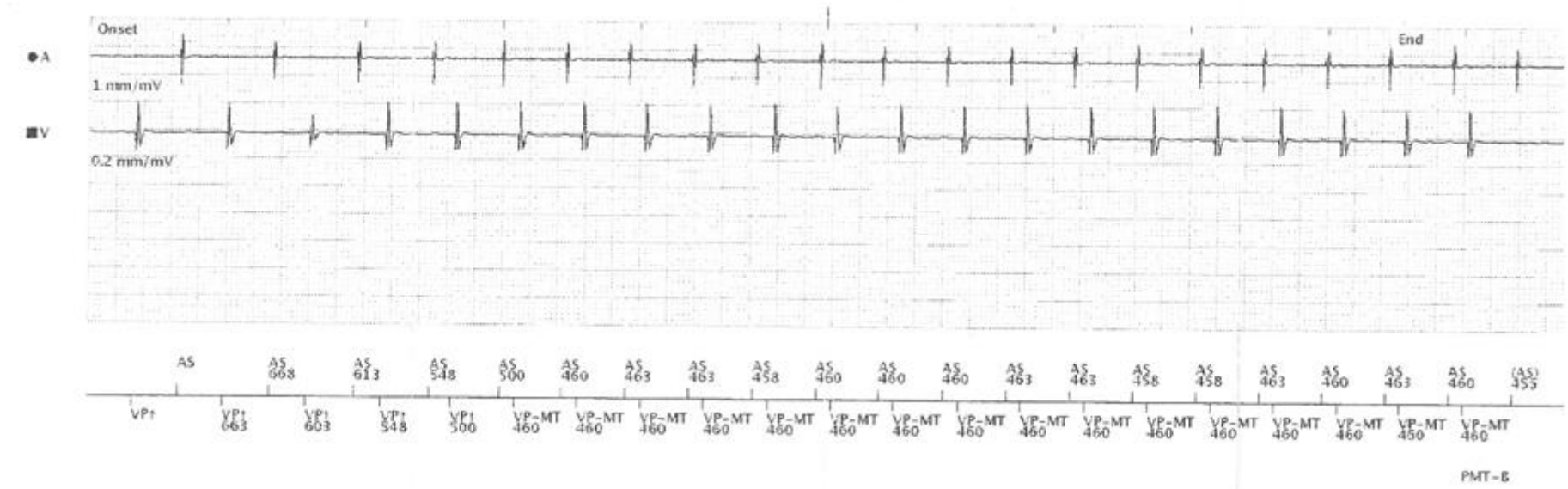

Figure 3

Questions

1. What type of dysrhythmia is this?

2. What is the cause of the tachycardia in this particular case?

3. What can be done to prevent this from happening?

Discussion

1) This is an example of a Pacemaker Mediated Tachycardia (PMT), a form of endless loop re-entry tachycardia associated with dual chamber pacemakers. In a typical PMT ventricular stimulation, which is programmed to follow a sensed atrial event, creates an anterograde limb of a re-entry circuit when it occurs in the presence of preserved VA (ventricular to atrial) conduction. This allows retrograde atrial depolarisation to occur, which is sensed on the atrial channel, initiating an AV delay. A ventricular pacing stimulus is then delivered at the maximum tracking interval of the pacemaker resulting in in further retrograde AV nodal conduction and a re-entry circuit is established. This repeated cycle of sensing and tracking retrograde conduction can continue until retrograde conduction is lost or the atria become refractory. The usual circumstances which may result in a PMT are: atrial tachyarrhythmia, AV block, premature ventricular contractions, atrial oversensing and loss of atrial capture.

2) Our initial impression, without reviewing programmed parameter, was that the PMT was most likely caused by the programmable AV search algorithm, as lengthening of the PR interval prior to the event can be seen. The AV search algorithm is used to promote intrinsic ventricular conduction by temporarily allowing the lengthening the programmed AV delay to allow time for an intrinsic R wave to occur before ventricular pacing occurs. However this was discounted as a cause as the programmed settings revealed that this feature was not programmed on.

   The patient was not known to have atrial tachyarrhythmias and the ECG does not substantiate this as a cause as discrete P waves are visible throughout the PMT. There were also no premature ventricular contractions preceding the PMT, so this could also be excluded. Device interrogation was performed to assess lead function and test results revealed good sensing and threshold measurements therefore atrial oversensing and loss of atrial capture were quickly discounted, there was also no evidence of this on the ECG.

The cause of the PMT in this case was in fact the rate smoothing algorithm. The rate smoothing algorithm is used to control the pacemaker's response to atrial and/or ventricular rate variations that cause sudden changes in pacing intervals, for example; sino atrial disease (sinus pause, SA block, brady-tachy syndrome), premature atrial and ventricular contractions, upper rate behaviour (Wenckebach), paroxysmal atrial fibrillation/flutter, retrograde P waves, myopotentials, EMI and crosstalk. Rate smoothing is therefore used to control these sudden changes in rate.

Rate smoothing can be independently programmed for both rate smoothing up and rate smoothing down, therefore controlling the largest change allowed in the pacing rate when the rate is either increased or decreased. This is done by calculating the preceding R – R intervals (either sensed or paced), which then allows two synchronisation windows to be set-up for the next cycle, one for the atrium and one for the ventricle. Therefore rate smoothing redefines a beat to beat temporary lower rate limit and maximum tracking rate based on the rate smoothing up and down percentages.

In this case rate smoothing up was programmed at 9% and rate smoothing down at 12%. The PMT occurs due to premature atrial contractions, whereby rate smoothing prevents the tracking of the 'quick' premature atrial contractions. The AV delay is lengthened to limit the maximum tracking rate, as defined by the rate smoothing up percentage therefore only allowing the ventricular rate to increase 9% each cycle. This in turn results in loss of AV synchrony and the subsequent pacemaker mediated tachycardia.

This can be clearly seen in intracardiac ECG (Figure 3), where the pacing interval is only allowed to increase by 9% (663 ms, 603 ms, 548 ms, 500 ms, 460 ms). This is achieved by extending the AV delay which in turn results in the loss of AV synchrony and the initiation of the pacemaker mediated tachycardia. The PMT is at 460 msec or 130 bpm which is the programmed upper rate of the pacemaker.

3) There were 3 programming options:
    a. Turn rate smoothing off, particularly rate smoothing up in this case as this was the cause of the observed PMT.
    b. Reverse the rate smoothing up and down percentages, rate smoothing up 12% and rate smoothing down 9%. Therefore allowing a greater variation in heart rate and minimise the incidence of loss of AV synchrony.
    c. Maintain rate smoothing down at 12% but program rate smoothing up to a larger percentage.

We opted to turn the rate smoothing algorithm off, so that we could be confident that this algorithm would no longer be a contributing factor to the incidence of pacemaker mediated tachycardias in this patient.

Conclusion

This case clearly demonstrates the complexity of cardiac device trouble shooting and highlights the need for careful consideration when performing pacemaker programming. An in-depth knowledge of pacemaker function, the numerous programmable features/algorithms and specific manufacturer nuances is also essential when assessing the cause of a PMT.

References

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