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CME Article

Electrocardiographical case. Narrow complex tachycardia provoked by the Valsalva manoeuvre

Koh C H, Foo D, Ng K S, Chong C H

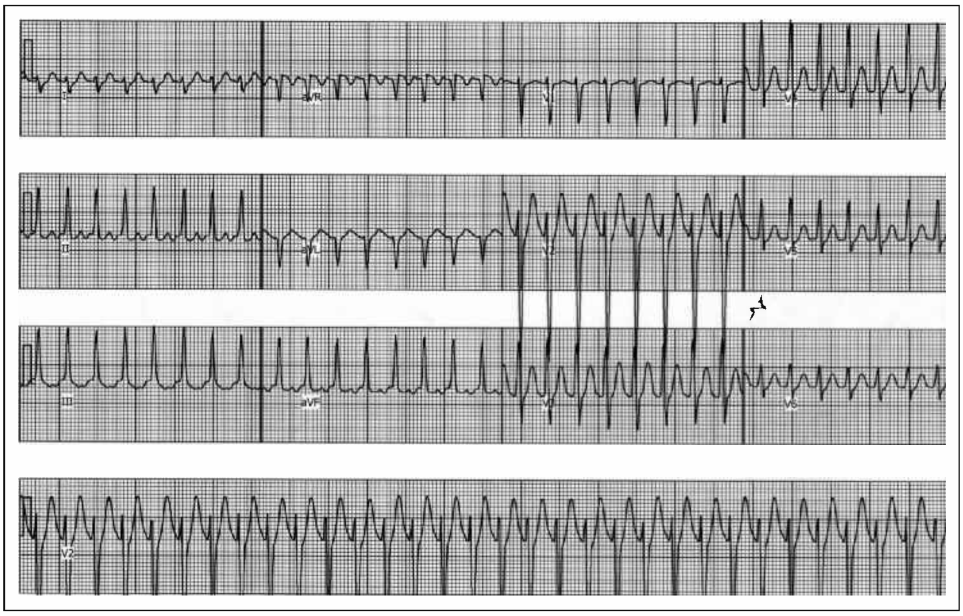

Fig. 1 12-lead ECG.

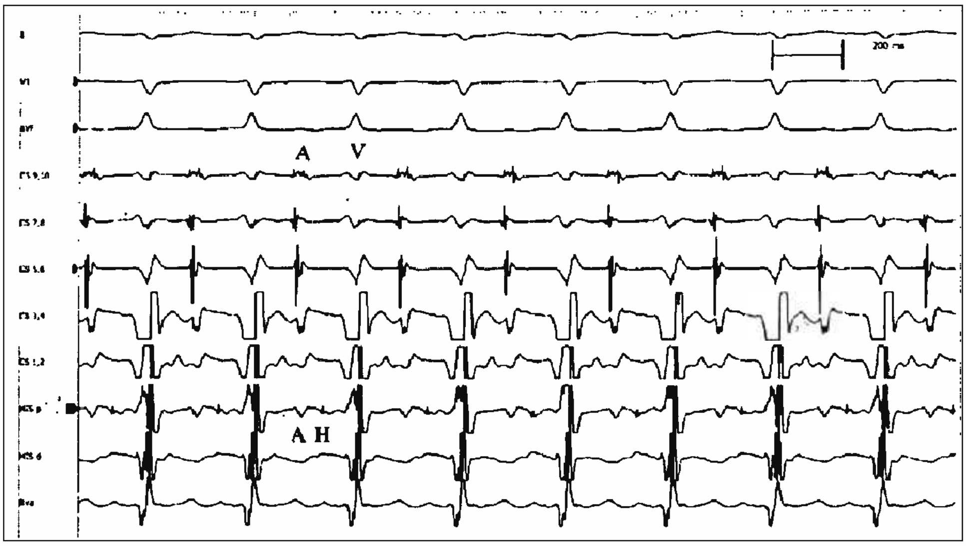

Fig. 2 ICEG.

CLINICAL PRESENTATION

A 19-year-old male air force pilot cadet presented with narrow complex long R-P' tachycardia (Fig. 1) during a human centrifuge session while performing a practice Valsalva manoeuvre at near normal (+1.4 Gz) centripetal forces. The event took place 30 secs after a 30-second exposure to 6 Gs and lasted three mins before abating spontaneously (after cessation of the centrifuge machine). Baseline 12-lead electrocardiography (ECG) was normal with no pre-excitation pattern. From an aeromedical perspective, the associated heart disease could be significant enough to affect performance during flight training. He was therefore referred for an electrophysiology study. A decapolar catheter was placed in the coronary sinus with the distal and proximal pair of electrodes configured as CS 1-2 and CS 9-10, respectively. Quadripolar catheters were positioned in the high right atrium, His-bundle region and right ventricular apex. During straight atrial pacing with a drive-cycle length of 300 ms, a narrow complex tachycardia was reproduced with the intracardiac electrogram (ICEG) (Fig. 2). What is the diagnosis?

Republic of Singapore Air Force Medical Service, Aeromedical Centre, 492 Airport Road, Singapore 539945

Koh CH, MBBS, DAvMed
Aviation Medical Officer

Chong CH, MMed, DAvMed
Senior Project Officer

Department of Cardiology, The Heart Institute, 11 Jalan Tan Tock Seng, Singapore 308433

Foo D, MRCP
Associate Consultant

Ng KS, FRCP
Senior Consultant

Correspondence to: Dr Koh Choong Hou
Tel: (65) 6381 4424
Fax: (65) 6285 3032
Email: xjunhao@gmail.com

ECG INTERPRETATION

The 12-lead ECG (Fig.1) showed a narrow complex tachycardia with visible P-waves after the QRS complexes consistent with a long R-P' tachycardia. The differential diagnosis of a long R-P' tachycardia included atypical atrioventricular nodal reentry tachycardia (AVNRT) with fast-slow pathway, atrial tachycardia and atrioventricular reciprocating tachycardia with a slowly conducting accessory pathway. The ICEG (Fig. 2) demonstrated a concentric retrograde atrial activation during narrow complex tachycardia. The V-A interval was 150 ms which was much longer than in a typical AVNRT, which is usually less than 70 ms. The A-H interval was short and the H-A interval was long, indicating that antegrade activation was over the fast pathway and retrograde activation was over the slow pathway.

DIAGNOSIS

Atypical atrioventricular nodal reentry tachycardia.

CLINICAL COURSE

The diagnosis of atypical AVNRT was made. Radiofrequency ablation was successfully applied to the slow AV nodal pathway. There was no recurrence even with isoproterenol infusion.

DISCUSSION

Centrifugal forces generated in a human centrifuge machine can be as high as 9 Gs (9 times the gravitational force on the earth's surface). Pilots of high performance aircraft, such as fighter jets, train in the centrifuge machine to increase their tolerance to G forces. Exposure to high acceleration forces may induce dysrhythmia by causing autonomic imbalance, with a sympathetic predominance before and during the high G-force load, followed by a parasympathetic response during recovery.[1] During sustained accelerations in a cephalad direction, blood tends to pool in the venous capacitance vessels of the lower limbs, and together with the hydrostatic pressure gradient generated by the increased gravitational force, a drop in the transmural pressure across the baroreceptors in the carotid sinus occurs. Baroreceptor reflexes are activated and increase sympathetic discharge to raise the heart rate and cause vasoconstriction.[2] Upon cessation of acceleration, both the venous pooling effect and hydrostatic pressure gradient are removed and the reverse autonomic response takes place with a parasympathetic dominance characterised by a slowing of the heart rate. The elevated gravitational force also distorts the shape of the heart by lengthening its longitudinal axis. Presumably this will have an effect on cardiac conduction as well.

The anti-G straining manoeuvre is employed by fighter pilots to counter the undesirable effects of high gravitational forces on cerebral perfusion (cerebral hypoperfusion occurs with venous pooling at high +Gz forces). It involves the Valsalva manoeuvre and lower body isometric muscle tensing. The Valsalva manoeuvre improves G tolerance to centrifugal forces by increasing intrathoracic pressure which, when transmitted directly to the heart and great vessels, raise systemic arterial blood pressure and maintain cerebral perfusion.[2,3] In the usual setting, it also increases the vagal tone of the autonomic system, which then exerts a greater parasympathetic influence on the cardiac conduction circuit (increased vagal inhibition resulting in the slowing of AV nodal conduction). This may result in the slowing or termination of exercise-induced tachycardias.

However, in our case, we postulate that this length distortion coupled with huge swings in the autonomic drive of the cardiovascular system lower the threshold for dysrhythmias. The increased vagal tone secondary to the Valsalva manoeuvre, by decreasing the excitability of the AV junctional fibres between the atrial musculature and AV node, may have allowed the opportunity for the re-entry phenomenon via the (now) comparably more excitable accessory pathway. The dynamic and rapid fluctuations of the autonomic nervous system while experiencing centrifugal forces also likely alter the refractoriness of the cardiac conduction system and give rise to re-entry type tachyarrhythmias. Supraventricular and ventricular arrhythmias during peak accelerations of centrifuge trainings are not uncommon.[4-6] Similar case series have illustrated dysrhythmias being induced during high G runs and almost always resolve spontaneously upon return to a 1 G environment. It is a rare observation that an abnormal tachyarrhythmia be triggered post G exposure, that is, at idling speeds as in this case. Abnormal tachyarrhythmias like this can compromise cardiac output and cause a sudden loss of consciousness.

With the advent of agile high performance aircrafts and the accompanying strenuous G tolerance training, dysrhythmias will be picked up during recorded centrifuge trainings. The aeromedical challenge is determining which of the dysrhythmias may be clinically significant, and which ones represent normal responses to G.[5] This case has shown that a person with a normal resting and stress ECG can manifest re-entry type tachyarrhythmia under high physiological stresses during exposure to high G. Therefore, the continued use of ECG monitoring during such training is beneficial and important, as the heart rhythm has been considered to be an appropriate surrogate marker of cardiovascular stress and fatigue.[7,8] More research needs to be conducted to look into the effects of a high G environment on the susceptible cardiac conduction system to elicit the mechanism of tachyarrhythmias in individuals with intrinsic conduction abnormalities, especially in the context of pilots flying high performance jets.

ABSTRACT

A 19-year-old Chinese man presented with tachyarrhythmia during a human centrifuge session while performing a Valsalva manoeuvre at near normal (+1.4 Gz) centripetal forces. It was likely that the hydrostatic effects of sustained centrifugal forces, the distortion of the heart's shape, as well as swings in the autonomic dominance pre- and post-Valsalva manoeuvre, contributed to the tachyarrhythmia. The 12-lead ECG showed a narrow complex tachycardia with visible P-waves after the QRS complexes consistent with a long R-P' tachycardia. The intracardiac electrogram demonstrated a concentric retrograde atrial activation during narrow complex tachycardia. The V-A interval was 150 ms which was much longer than in typical atrioventricular nodal reentry tachycardia, which is usually less than 70 ms. The A-H interval was short and the H-A interval was long, indicating that antegrade activation was over the fast pathway and retrograde activation was over the slow pathway. The diagnosis was atypical atrioventricular nodal reentry tachycardia, and radiofrequency ablation was successfully applied to the slow AV nodal pathway.

Keywords: atrioventricular nodal reentry tachycardia, centrifugal forces, narrow complex tachycardia, tachyarrythymia, Valsalva manoeuvre.

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SINGAPORE MEDICAL COUNCIL CATEGORY 3B CME PROGRAMME
Multiple Choice Questions (Code SMJ 200904B)

	True	False
Question 1. The differential diagnosis of a long R-P' tachycardia includes:		
(a) Atypical atrioventricular nodal reentry tachycardia (AVNRT) with fast-slow pathway.	☐	☐
(b) Atrial tachycardia.	☐	☐
(c) Atrioventricular reciprocating tachycardia with a slowly conducting accessory pathway.	☐	☐
(d) Ventricular fibrillation.	☐	☐
Question 2. Dysrhythmias may be induced during exposure to high accelerative forces:		
(a) Due to swings in the autonomic nervous systems.	☐	☐
(b) Can be contributed by distortion of the cardiac conduction system.	☐	☐
(c) Are more common with an underlying conduction defect or accessory pathway.	☐	☐
(d) Is more frequent during G-exposure than after G-exposure.	☐	☐
Question 3. The uses of the centrifuge include:		
(a) Building up G-tolerance in pilots and pilot trainees.	☐	☐
(b) Exposure to positive acceleration forces.	☐	☐
(c) Deliberately inducing loss of consciousness.	☐	☐
(d) Diagnostic tool for cardiac arrhythmias.	☐	☐
Question 4. During sustained acceleration in a cephalad direction:		
(a) Blood tends to pool intracranially.	☐	☐
(b) Can cause a drop in the transmural pressure across the baroreceptors in the carotid sinus.	☐	☐
(c) Results in an increase in sympathetic discharge to raise the heart rate and cause vasoconstriction.	☐	☐
(d) Upon cessation, will lead to a transient sustained vasoconstriction due to a prolonged sympathetic response.	☐	☐
Question 5. The anti-G straining manoeuvre:		
(a) Involves the tensing of specific muscle groups coupled with the Valsalva manoeuvre.	☐	☐
(b) Is employed by fighter pilots to counter the undesirable effects of high gravitational forces on cerebral perfusion.	☐	☐
(c) Improves G tolerance to centrifugal forces by decreasing intrathoracic pressure.	☐	☐
(d) Can exacerbate exercise-induced tachycardias.	☐	☐

Doctor's particulars:

Name in full: ______________________________

MCR number: ____________________ Specialty: ____________________

Email address: ______________________________

SUBMISSION INSTRUCTIONS:
(1) Log on at the SMJ website: http://www.sma.org.sg/cme/smj and select the appropriate set of questions. (2) Select your answers and provide your name, email address and MCR number. Click on "Submit answers" to submit.

RESULTS:
(1) Answers will be published in the SMJ June 2009 issue. (2) The MCR numbers of successful candidates will be posted online at www.sma.org.sg/cme/smj by 20 June 2009. (3) All online submissions will receive an automatic email acknowledgment. (4) Passing mark is 60%. No mark will be deducted for incorrect answers. (5) The SMJ editorial office will submit the list of successful candidates to the Singapore Medical Council.

Deadline for submission: (April 2009 SMJ 3B CME programme): 12 noon, 15 June 2009.