Electrical Heart Disease in Aircrew: Evaluation and Risk Assessment

NATO Aviation Cardiology Working Group (RTG HFM-251)

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I have no financial relationships to disclose.

I will not discuss off-label use and / or investigational use in my presentation.

Electrical Abnormalities: Overview

Syncope

Bradyarrhythmia and conduction disturbances:

– Sinus node dysfunction

– Atrioventricular conduction disturbance

– Bundle branch blocks (left bundle branch block, right bundle branch block, left anterior and left posterior fascicular block)

Ectopy:

– Atrial ectopy

– Ventricular ectopy / premature ventricular complexes (PVC)

Electrical Abnormalities: Overview

Tachyarrhythmia and asymptomatic pre-excitation:

– Supraventricular tachycardia (AV nodal reentrant tachycardia, AV reentrant tachycardia caused by an accessory pathway, atrial tachycardia)

– Asymptomatic pre-excitation

– Atrial fibrillation

– Atrial flutter

– Accelerated idioventricular rhythm

– Non sustained and sustained ventricular tachycardia

Inherited arrhythmogenic conditions

(e.g. Brugada syndrome, long QT syndrome)

Screening for Electrical Abnormalities

Luftwaffe
Wir. Dienen. Deutschland.

First level investigation:

– Medical history including familiy history
– Physical examination
– 12-lead resting ECG

Second level investigation:

– Holter monitoring (24 hours to 7 days)
– Echocardiography
– Exercise ECG
– Laboratory investigations (blood count, electrolytes, thyroid hormones etc.)
– Telemetric ECG
– External / implantable loop recorders
– 24 hours ambulatory blood pressure monitoring (in case of suspected hypertension)

Screening for Electrical Abnormalities

Third level investigation / treatment:

– Specialist pharmacological testing
– Invasive electrophysiological (EP) testing and/or treatment
– Genetic testing
– Human centrifuge testing

In case of suspected underlying structural or coronary artery disease:

– Stress echocardiography
– Cardiovascular CT
– Cardiac MRI
– Invasive coronary angiography

Risk Assessment

	Level 1 Medical Event	Level 2 Medical Event	Level 3 Medical Event	Level 4 Medical Event
	Minimal impact on mission	May result in a mission abort or compromised effectiveness	Likely to result in a flight safety hazard or compromise	Likely to result in a flight safety critical event
	May result in a deleterious effect on the health of the individual aircrew but minimal effect on performance	Aircrew able to continue duties with minor to moderate performance compromise.	Major decrement in performance	Total acute incapacitation (may include sudden death)
	Requires routine periodic medical follow-up	Requires medical attention	May require immediate medical attention	Requires immediate advanced medical care
PILOTS, COPILOTS				
Likely >2%/yr				
Possible 1-2%/yr				
Unlikely 0.5-1%/yr				
Highly unlikely <0.5%/yr				
NAVIGATORS, FLIGHT ENGINEER, FLIGHT CONTROLLERS				
Likely >2%/yr				
Possible 1-2%/yr				
Unlikely 0.5-1%/yr				
Highly unlikely <0.5%/yr				
FLIGHT ATTENDANTS LOADMASTERS				
Likely >2%/yr				
Possible 1-2%/yr				
Unlikely 0.5-1%/yr				
Highly unlikely <0.5%/yr				

Risk assessment with the aeromedical risk matrix used by the Royal Canadian Air Force as an example.

Risk Assessment

Luftwaffe
Wir. Dienen. Deutschland.

- Low risk – acceptable
- Moderate risk – aeromedical board-level discussion required
- High risk – not acceptable

Increasing severity of outcome →

	Level 1 Medical Event	Level 2 Medical Event	Level 3 Medical Event	Level 4 Medical Event
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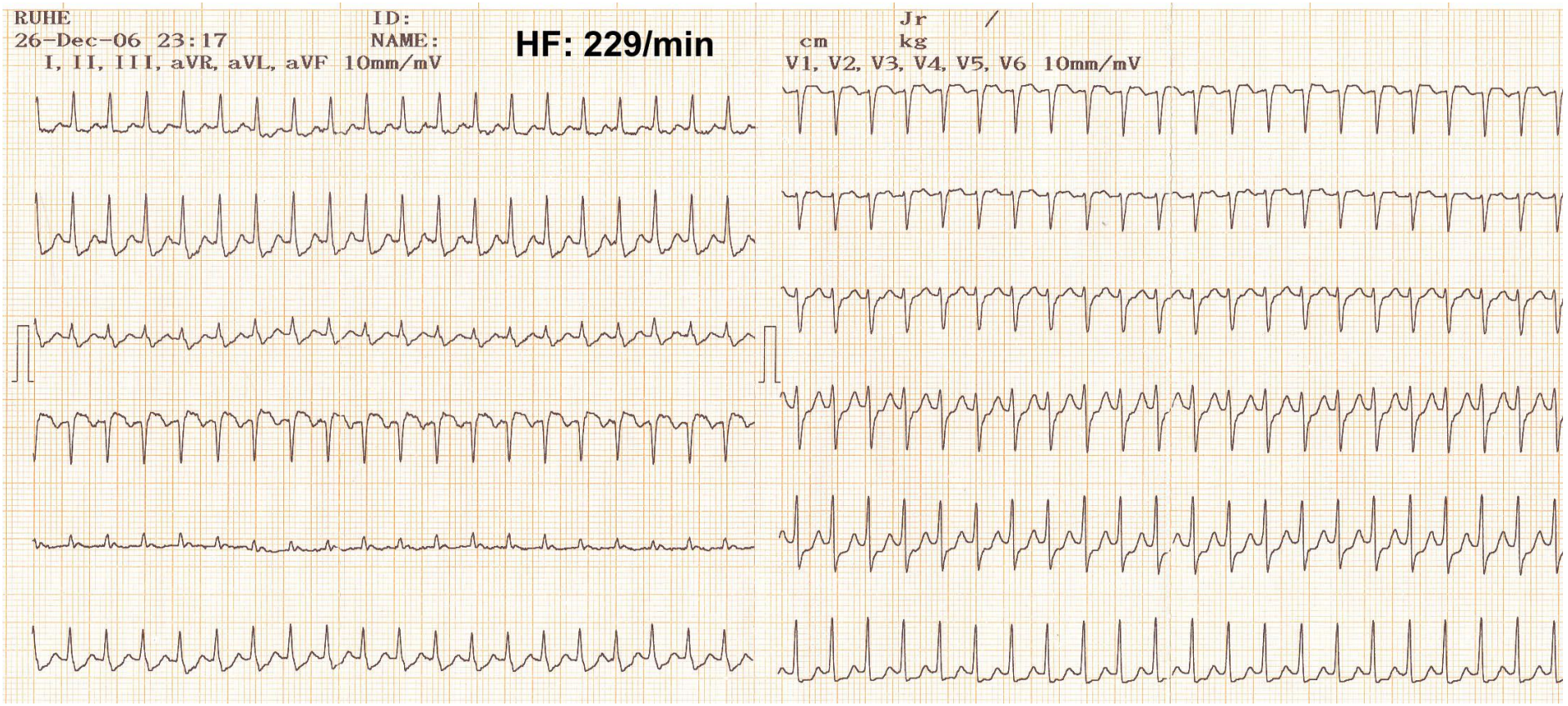
PILOTS, COPILOTS				
Likely >2%/yr				
Possible 1-2%/yr				
Unlikely 0.5-1%/yr				
Highly unlikely <0.5%/yr				

Increasing likelihood of occurrence ↑

Case 1

- 28 year old fighter pilot
- 4 episodes of regular tachycardia with narrow QRS complexes within the last two years
- Sudden onset, sudden termination, 3 of them spontaneously, the last episode had to be treated in the emergency room (i.v. medication)
- Heart rate above 200 bpm
- One syncope and one presyncope during tachycardia, felt weak and dizzy during the other episodes
- Duration between 15 minutes and 3 hours
- No signs for structural heart disease (echocardiogram and stress testing normal)
- Normal resting ECG
- Normal thyroid hormons
- Normal family history

Case 1



AV nodal reentrant tachycardia, heart rate 229 bpm

Case 1

- Low risk – acceptable
- Moderate risk – aeromedical board-level discussion required
- High risk – not acceptable

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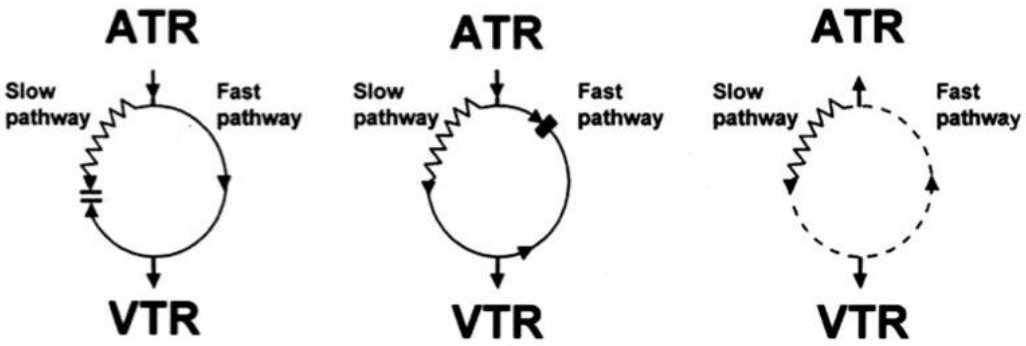
PILOTS, COPILOTS				
Likely >2%/yr				AVNRT
Possible 1-2%/yr				
Unlikely 0.5-1%/yr				
Highly unlikely <0.5%/yr				

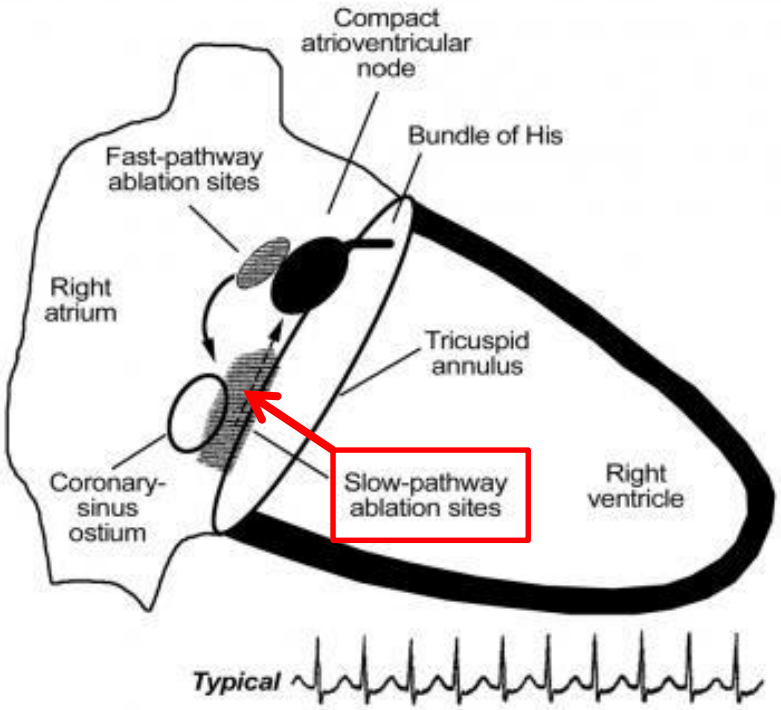
Tachycardia must be regarded as a class 4 medical event, the likelihood of occurence is defined by the patient´s history. This Pilot is unfit for flying.

Case 1



Sinus rhythm PAC AVNRT

AV nodal reentrant tachycardia (AVNRT)



Therapy:

Ablation or modification of the slow pathway

Success rate > 95%

Case 1

- Low risk – acceptable
- Moderate risk – aeromedical board-level discussion required
- High risk – not acceptable

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PILOTS, COPILOTS				
Likely >2%/yr				
Possible 1-2%/yr				
Unlikely 0.5-1%/yr				
Highly unlikely <0.5%/yr				AVNRT

After successful AVNRT ablation the likelyhood of occurence is <0.5%/yr, so that the fighter pilot can be assessed fit for flying.

Case 2

- 48 year old transport pilot
- 3 episodes of paroxysmal atrial fibrillation within the last 5 years
- Palpitations, slight nausea and dizziness, reduced exercise tolerance
- No major performance decrement, still able to fly
- Resting heart rate 110 to 120 bpm
- All episodes converted to sinus rhythm spontaneously after less than 24 hours
- No signs for structural heart disease (echocardiogram and stress testing normal)
- CHA_2DS_2Vasc Score 0
- Normal resting ECG
- Normal thyroid hormons

Case 2

- Low risk – acceptable
- Moderate risk – aeromedical board-level discussion required
- High risk – not acceptable

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PILOTS, COPILOTS				
Likely >2%/yr		AFib Recurrence		
Possible 1-2%/yr				
Unlikely 0.5-1%/yr				
Highly unlikely <0.5%/yr				

Restricted flying (no high performance, second qualified pilot), betablocker treatment in case of tachyarrhythmia. Catheter ablation can be discussed.

Case 2

- Low risk – acceptable
- Moderate risk – aeromedical board-level discussion required
- High risk – not acceptable

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PILOTS, COPILOTS				
Likely >2%/yr				
Possible 1-2%/yr		AFib Recurrence		
Unlikely 0.5-1%/yr				
Highly unlikely <0.5%/yr				

After AFib ablation the likelyhood of occurence changes to 1 - 2%/yr, but there is still a risk of recurrence. The individual has to fly with a second qualified pilot, which usually does not cause any problems for a transport pilot.

Case 3

- 33 year old helicopter pilot
- Monomorphic PVCs, 3 to 5% of all QRS complexes in Holter
- He often notices palpitation, no hemodynamic symptoms
- Morphology: inferiorly directed axis + left bundle branch block, origin probably right ventricular outflow tract (RVOT)
- No signs for structural heart disease (echocardiogram and stress testing normal, less PCVs during stress testing)

Case 3

- Low risk – acceptable
- Moderate risk – aeromedical board-level discussion required
- High risk – not acceptable

	Level 1 Medical Event	Level 2 Medical Event	Level 3 Medical Event	Level 4 Medical Event
	Minimal impact on mission	May result in a mission abort or compromised effectiveness	Likely to result in a flight safety hazard or compromise	Likely to result in a flight safety critical event
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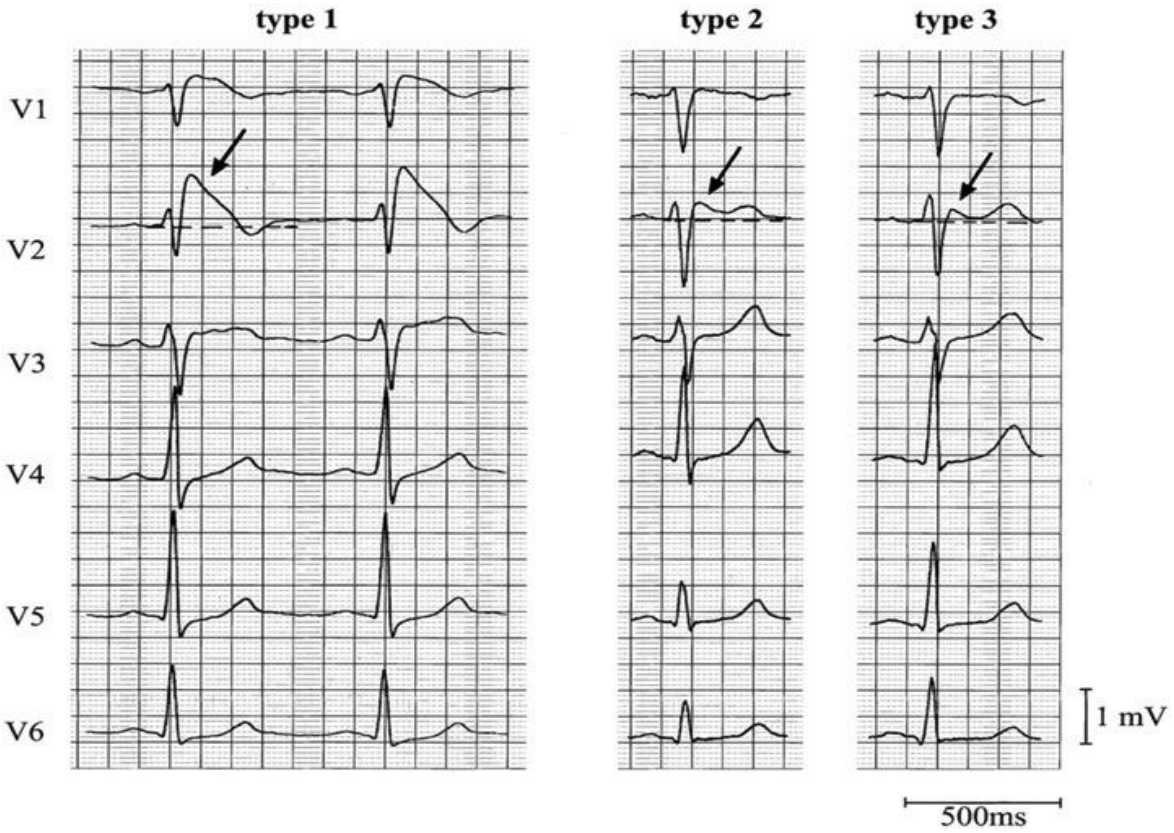
PILOTS, COPILOTS				
Likely >2%/yr	PVCs			
Possible 1-2%/yr				
Unlikely 0.5-1%/yr				
Highly unlikely <0.5%/yr				

If number of PVCs should exceed 15,000 to 20,000 in a 24 hour Holter, he should receive close follow-ups by echocardiography for left ventricular ejection fraction.

Case 4

- 30 year old transport pilot
- Brugada type 1 pattern
- No symptoms so far
- Negative family history concerning sudden cardiac death, syncope, or ventricular tachycardia
- No signs for structural heart disease (echocardiogram and stress testing normal)

Case 4



Brugada ECG types. Type 1 (Coved ST segment elevation >2mm in >1 of V_1-V_3 followed by a negative T wave) is the only ECG abnormality that is potentially diagnostic. This has been referred to as Brugada sign.

Case 4

- Low risk – acceptable
- Moderate risk – aeromedical board-level discussion required
- High risk – not acceptable

	Level 1 Medical Event	Level 2 Medical Event	Level 3 Medical Event	Level 4 Medical Event
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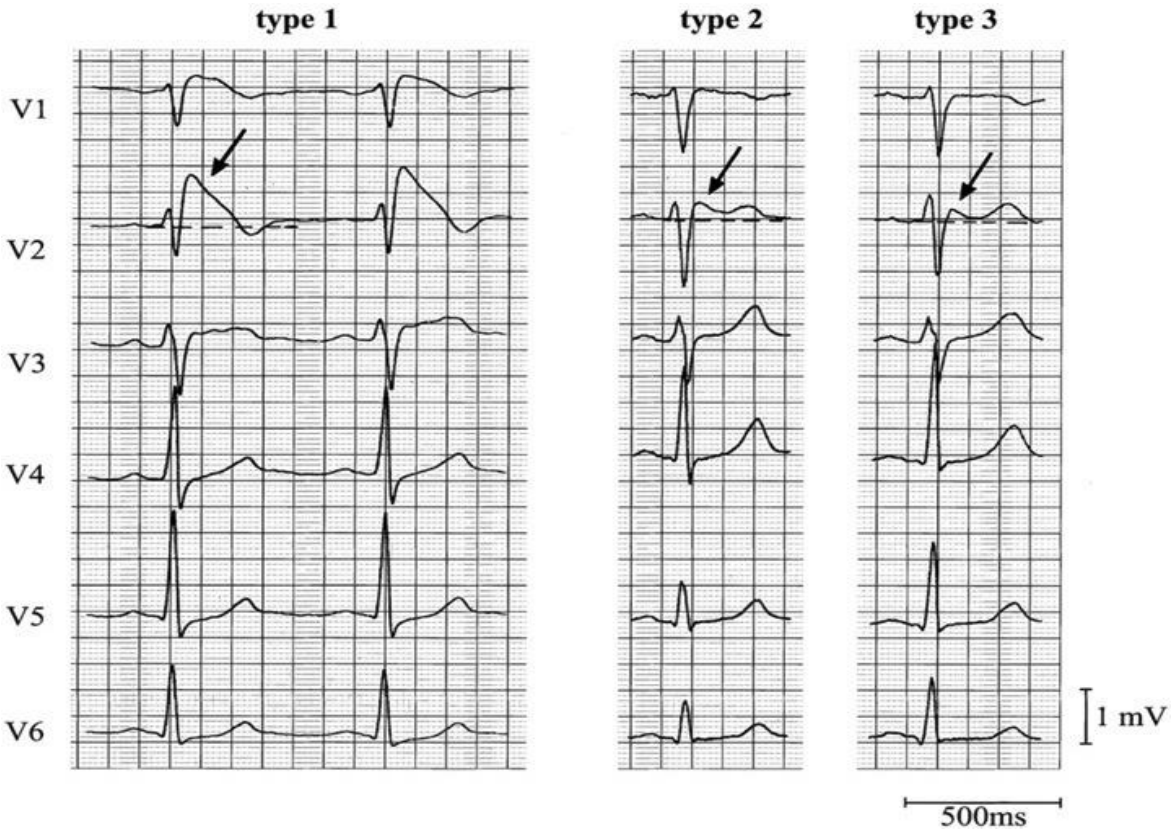
PILOTS, COPILOTS				
Likely >2%/yr				Ventr. Arrhythmias
Possible 1-2%/yr				
Unlikely 0.5-1%/yr				
Highly unlikely <0.5%/yr				

Literature review: Calculated event rate of ventricular arrhythmia in patients with Brugada type 1 pattern 2.3%/y (Probst et al. 2010).

Case 5

- 30 year old transport pilot
- Brugada type 2 pattern, no type 1 pattern after challenge with sodium channel blockers
- No symptoms so far
- Negative family history concerning sudden cardiac death, syncope, or ventricular tachycardia
- No signs for structural heart disease (echocardiogram and stress testing normal)

Case 5



Brugada ECG types. Type 1 (Coved ST segment elevation >2mm in >1 of V_1-V_3 followed by a negative T wave) is the only ECG abnormality that is potentially diagnostic. This has been referred to as Brugada sign.

Case 5

- Low risk – acceptable
- Moderate risk – aeromedical board-level discussion required
- High risk – not acceptable

	Level 1 Medical Event	Level 2 Medical Event	Level 3 Medical Event	Level 4 Medical Event
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PILOTS, COPILOTS				
Likely >2%/yr				
Possible 1-2%/yr				
Unlikely 0.5-1%/yr				
Highly unlikely <0.5%/yr				Ventr. Arrhythmias

Literature review: Calculated event rate of ventricular arrhythmias in patients with Brugada type 2 pattern < 0.5%/y (Dobler et al. 2010), time-limited medical certificate can be issued (follow-ups necessary).

Treatment Options

Antiarrhythmic Drug Treatment:

Mainly antiarrhythmic drugs Vaughan-Williams class 1c and 3 are used. Most of them are not compatible with flying because of possible side effects.

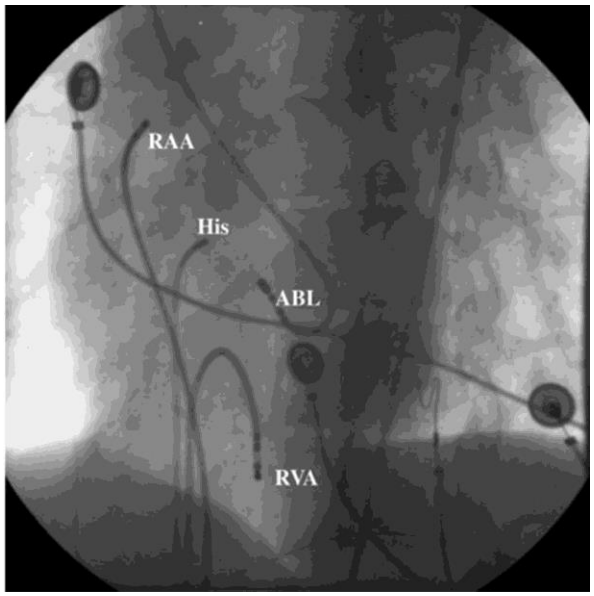
Pacemaker:

Restricted flying may be possible, if:

– Implanted bipolar lead system and bipolar programming
– No complete pacemaker dependency
– Regular follow-ups
– Multi-pilot limitation

Aircrew with implanted cardioverter-defibrillator (ICD) are usually unfit for flying.

Treatment Options

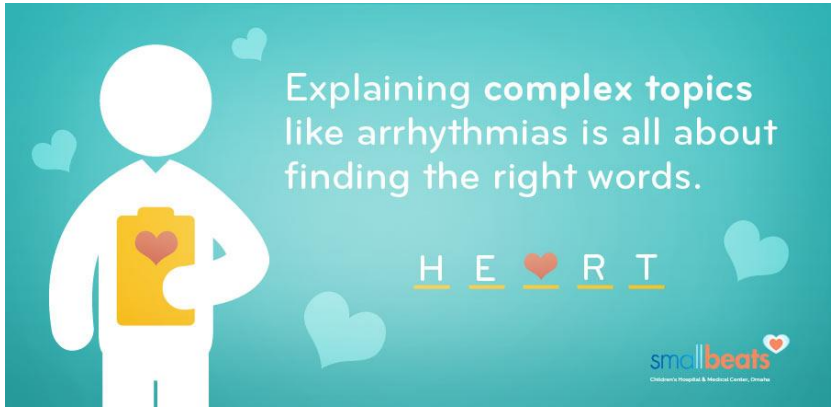


Catheter ablation:

Good option for many aeromedically relevant arrhythmia.

Success, recurrence, and complication rate depend on the treated arrhythmia.

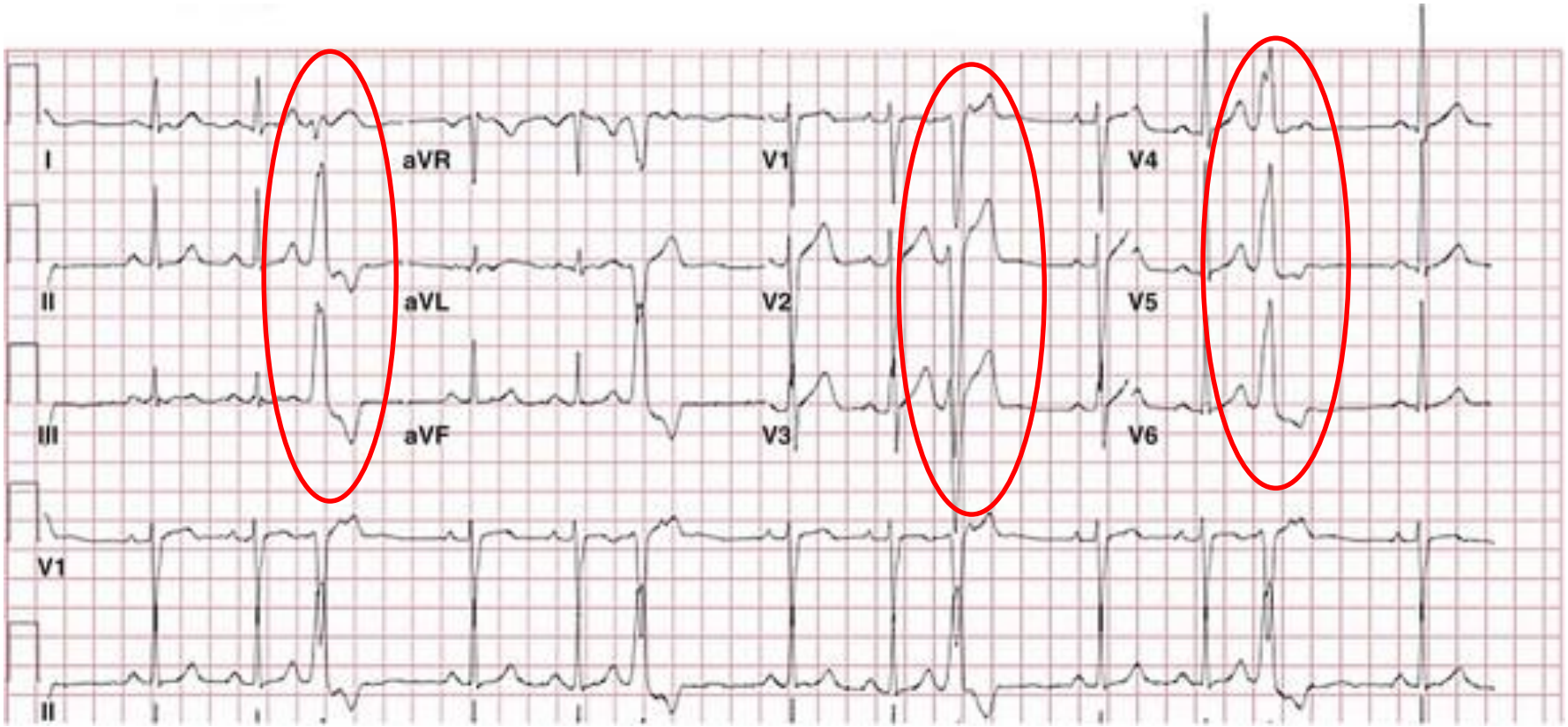
Restricted or unrestricted flying is possible after a certain observation period ensuring sustained ablation success.



Thank you for your attention!

Questions?

Case 3



Premature ventricular complexes (PVC) from the right ventricular outflow tract (RVOT): inferiorly directed axis plus left bundle branch block morphology

Case 3

Effect of ablation of frequent premature ventricular complexes on left ventricular function in patients with nonischemic cardiomyopathy

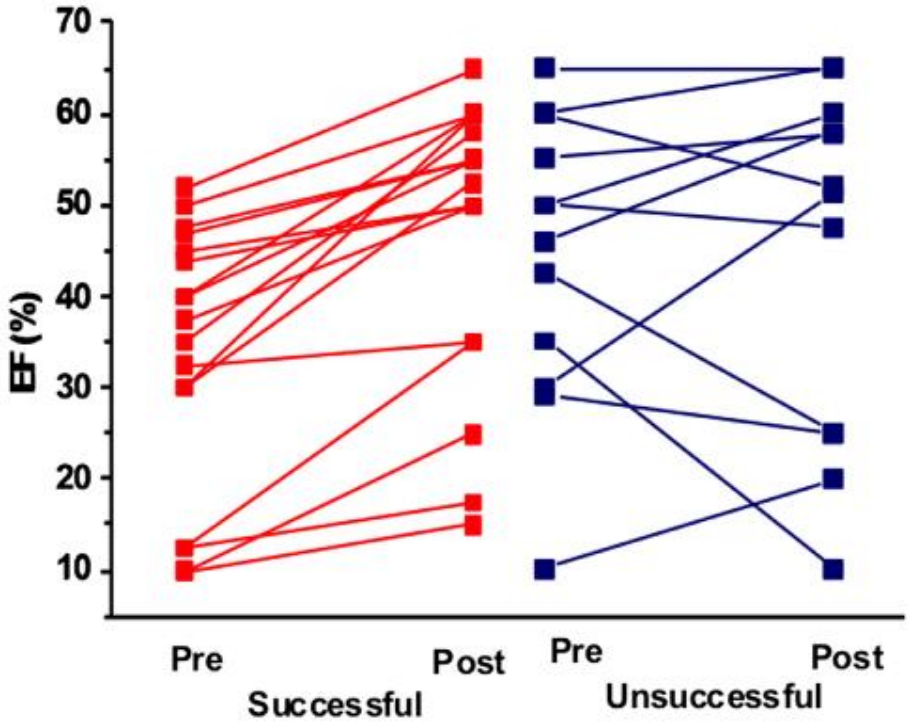


Figure 3 **Left:** Change of ejection fraction (EF) in patients with successful ablation. **Right:** Change of EF in patients with unsuccessful ablation.

El Kadri et al., Heart Rhythm 2015