

Atrial flutter in an elderly man with dynamic intraventricular conduction disturbances

Case Report

Dr. Paulo Sergio P de Miranda Case report.

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Case report

AHJ, elderly (74 years old) male, born in Bahia/Brazil, with hypertensive heart disease, dyslipidemia, and permanent arrhythmia.

Antecedents: Chronic high blood pressure without appropriate control.

He referred palpitation making the patient seek medical attention, functional Class II (NYHA).

Physical: apex beat can be palpated in the precordium left 7th intercostal space, 1cm outside the hemiclavicular line, BP: 160/100 mmHg

Medication in use: Sodium warfarin, (Marevan®) 5mg daily + Losartan potassium 50mg an angiotensin II receptor antagonist twice daily + Amlodipine besylate 5 mg daily + Simvastatin 20 mg daily, and Metoprolol succinate (SELOZOK®) 100 mg daily.

Transthoracic echocardiogram

Septum: Interventricular and interatrial septum preserved.

Cardiac chambers: Large dilated LA (volume 1:1, 18 ml and volume index: 66.58 ml/m²). Large dilated right atrium (subjective analysis).

Mitral valve: It presents normal aspect and movement of its cusps. Color Doppler mapping shows minimal reflux.

Aortic valve: Presents normal appearance and movement of its valves. Doppler study and color mapping are normal.

Tricuspid valve: It presents normal aspect and movement of its cusps. Doppler study and color mapping shows mild reflux (it was not possible to assess PSAP).

Pulmonary valve: It presents normal appearance and movement of its valves. Doppler study and color mapping are normal.

Ventricles: Left ventricle has diffuse contractile dysfunction at moderate level. Concentric hypertrophy of significant level. Diastolic function by analyzing mitral flow and tissue Doppler with a restrictive pattern. Right ventricle with preserved contractility.

Aorta and pulmonary artery: Six aortic, ascending aorta, aortic arch and pulmonary artery without significant anatomical changes.

Thrombi and masses: Intracavitary thrombi or masses are not feasible.

Pericardium: Pericardium with normal echocardiographic appearance.

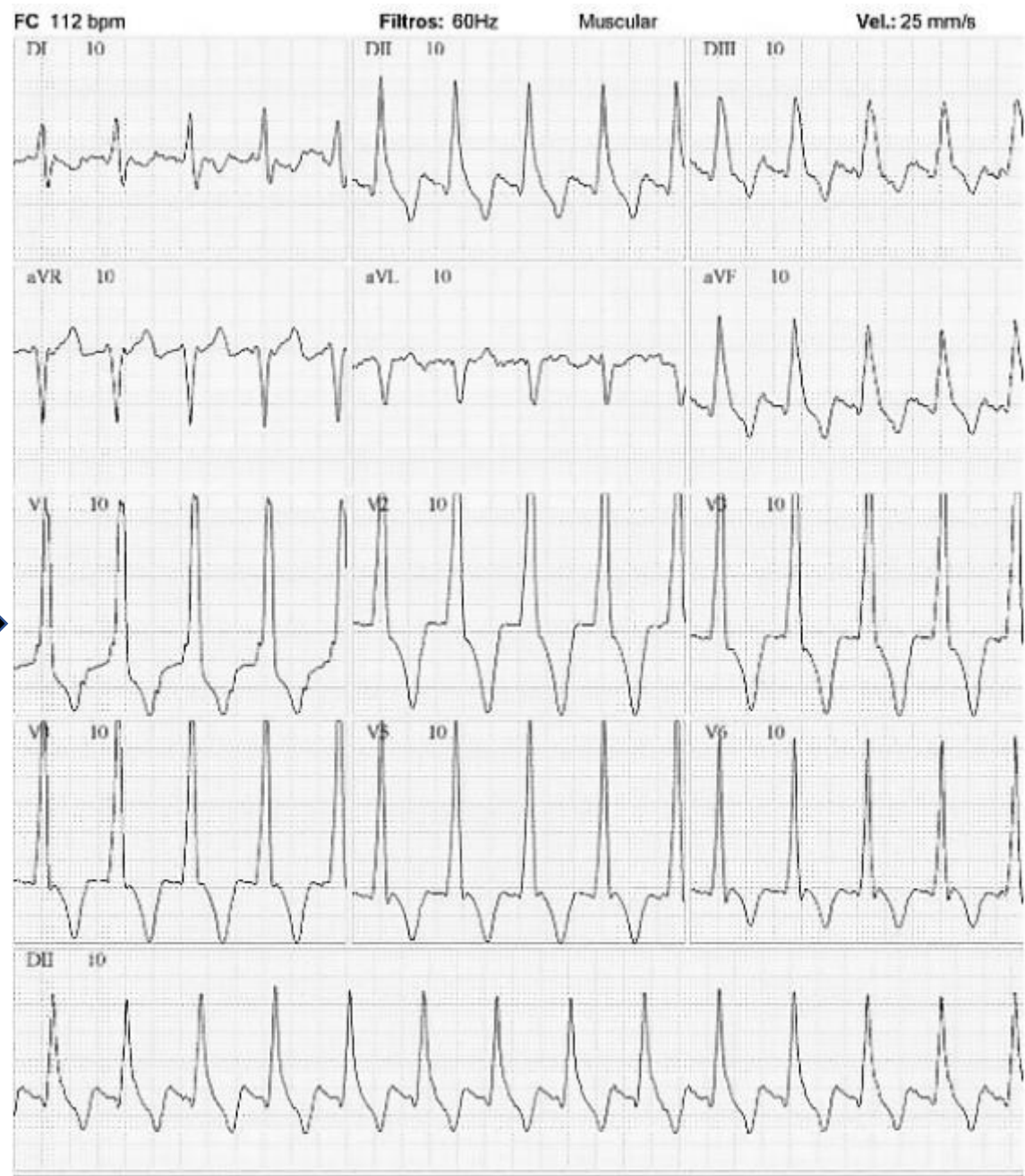
Note: Absence of images suggestive of vegetation on transthoracic echocardiography.

Conclusion: Large dilated atria. Left ventricle with severe concentric hypertrophy, with moderate global systolic dysfunction and restrictive pattern diastolic dysfunction (grade III). Minimal mitral valve insufficiency. Mild grade tricuspid valve insufficiency.

ECG-1 performed on January 27/2020, at 09:00 AM



ECG-2 performed on January 29/2020 at 08:08 AM



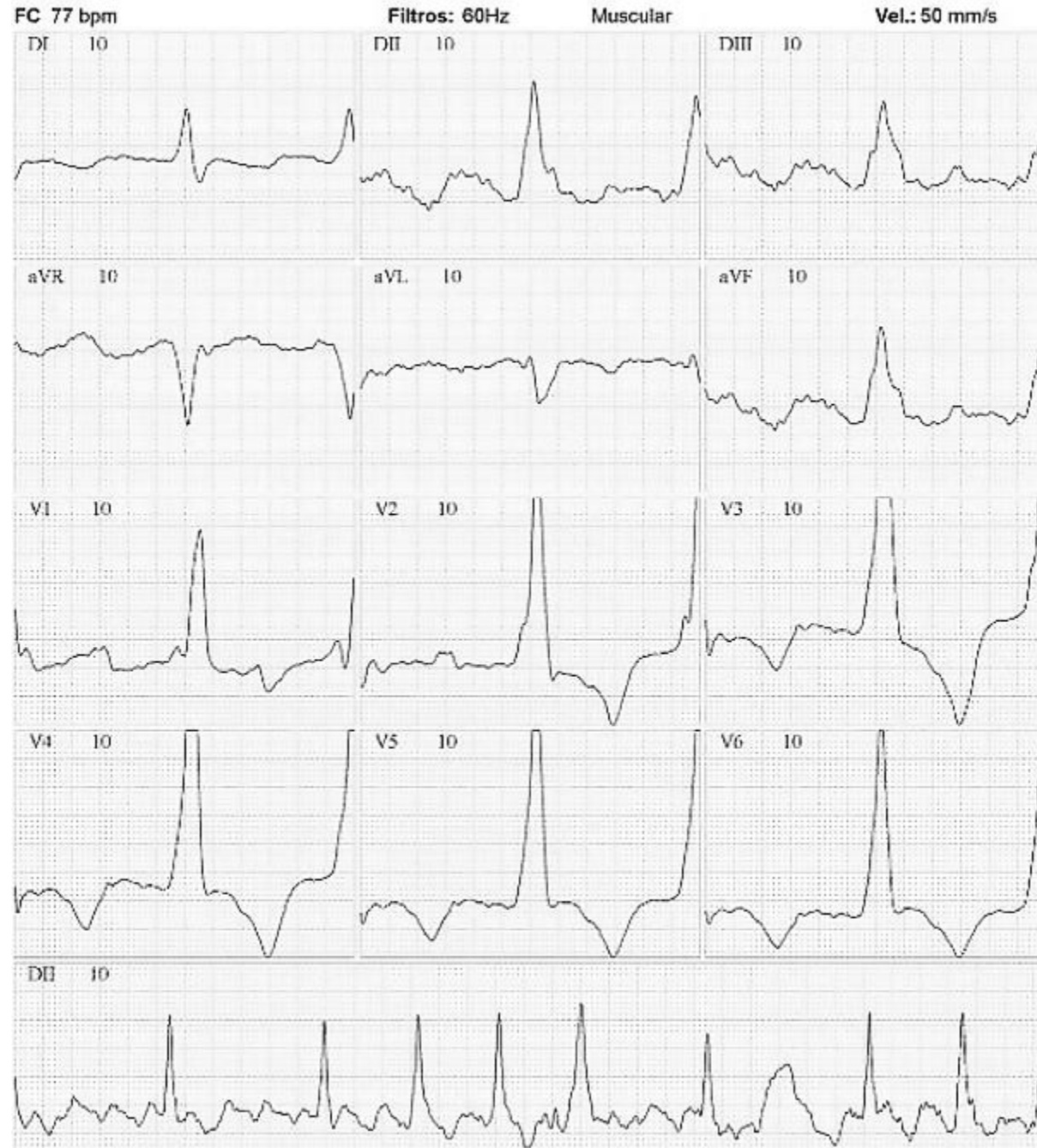
ECG-3 performed on January 29/2020 at 11:07



ECG-4 performed on January 29 at 02:43 PM



ECG-5 performed on January 29 at 03:21 PM



Colleagues' opinions

Buenas tardes estimado Andrés!

Daré mi opinión antes que los Maestros del Foro...

1° ECG aleteo auricular (AA) , eje del QRS cercano a 80°, con pasaje AV irregular, 2:1 y 3:1 con trastornos de conducción de rama derecha.

HVI con strain pattern

2° ECG AA 2:1 , eje entre 80 y 90 ° y FAP. Probable BDAM.

3° ECG AA 2:1 con velocidad de 50 mm/seg, sin variantes con el ECG previo.

4° ECG AA 5:1 con QRS angosto, sin trast de conducción eje 70° con signo de Peñaloza-Tranchesi (dilatación de AD). Hay leve modificación de las ondas del AA, taquicardia auricular?

5° ECG AA similar al 3° trazado a 50 mm/seg, pero parece con FA.

En todos los ECG hay HVI.

Me despido cordialmente.

Juan Manzzardo

Médico Especialista Universitario en Cardiología, Universidad Nacional de Cuyo, Argentina; coordinador de grupos de Telegram-Cardiolatina; médico Cardiólogo del Hospital Ítalo Perrupato, San Martín, Mendoza, Argentina; médico Cardiólogo del Área Sanitaria Junín, Mendoza, Argentina

Good afternoon dear Andres! I will give my opinion before the Forum Masters ...

1st ECG: atrial flutter (AFI), QRS axis near 80°, with irregular AV passage, 2:1 and 3:1, with conduction disorders of the right bundle branch. LVH with strain pattern.

2nd ECG: AFI 2:1, axis between 80 and 90° and PAF. Likely LSFB.

3rd ECG: AFI 2:1 with speed of 50 mm/sec, no variants with the previous ECG.

4th ECG: AFI 5:1, with narrow QRS, without conduction disorder, 70° axis with Peñaloza-Tranchesi sign (RA dilation). Is there slight modification of AFI waves, atrial tachycardia?

5th ECG: AFI similar to the 3rd ECG at 50 mm/sec, but seems to be AF.

In all ECGs there is LVH.

Best regards

Juan Manzzardo MD from Mendoza city Argentina (the best Mabec around the word)



The arrhythmia is atrial tachycardia likely from the LA as well as typical CCW flutter. I agree with Bernard the most interesting part is the QRS configuration with strong monophasic R waves in v1 and a concordant precordial pattern more reminiscent of VT. Appears to have phasic variation in RBBB pattern with very bizarre pattern at slower and faster rates raising the possibility of both phase 3 and 4 block. Look forward to your insight.

We should also mention the possibility of pre excitation from a left free wall pathway in a patient with broad QRS tachycardia.

Melvin Scheinman MD

Section of Cardiac Electrophysiology, University of California San Francisco, San Francisco, California.

Spanish

La arritmia es una taquicardia auricular probablemente de la aurícula izquierda, así como el aleteo típico de CCW. La parte más interesante de este caso es la configuración QRS con prominentes ondas R monofásicas en V1 y un patrón precordial concordante que recuerda más a la TV. Parece tener una variación fásica en el patrón BCRD y otro patrón muy extraño a tasas más lentas y más rápidas, lo que aumenta la posibilidad de bloqueos de fase 3 y 4. Esperamos su interpretación.

También debemos mencionar la posibilidad de preexcitación de una vía de pared libre izquierda por el patrón concordante en una taquicardia de QRS ancho.



Professor Bernard Belhassen opinion

My presumed diagnosis of the 5 ECG tracings is as follows:

First I will only discuss about TRACINGS 1, 3 and 5 obtained at the same paper speed (25mm/sec).

ATRIAL ACTIVITY: presuming that the atrial rhythm did not change throughout the 3 tracings, I think we are dealing with a LEFT ATRIAL FLUTTER (at a regular cycle length of 280msec).

AV CONDUCTION: while tracing 1 shows AFL with 2:1 conduction, tracing 3 shows 2:1 or 3:1 conduction while tracing 5 shows apparently 5:1 conduction.

HEART RATE: ranging from mean 112, 83 and 55/min in tracings 1, 3 and 5 respectively.

QRS duration: similar and wide in the first 2 tracings, narrower in the last tracing.

MORPHOLOGY: obviously different in the 3 tracings:

1. Tracing 1: Prominent R waves in all precordium; m/p CRBBB in V1; amplitude apparently decrescendo from V4 to V5 (difficult to talk about V1-V3); QRS axis + 80; no significant q waves in V1-V3; mini q in V4-V6.
2. Tracing 3: typical RBBB; R wave in V2=12mm; no q in V1-V3; QRS axis more left than in tracing 1
3. Tracing 5: minimal right IVCD; the prominent precordial R in V1-V3 seen in tracings 1 and 3 are no longer present; probable LVH. QRS axis: +60

Let us try to summarize and speculate now:

I have the feeling that the QRS changes are RATE-MEDIATED and therefore we should try to find what kind of IVCD can exist for each of the tracings:

TRACING 5: "baseline QRS" with minimal right IVCD with no additional LAFB or LPFB or LSFB.

TRACING 3: RBBB without apparent LAFB or LPFB or LSFB

TRACING 1: RBBB + LSFB ????????

- in favor of the LSFB: the prominent R in the precordial leads

- against the LSFB: the lack of small R waves in the right derivations (V1-V3).

I have nothing to add

This patient who has many reasons to worry about his cardiac status.

Answer to the last possibility posed by the Professor Melvin Scheinman : Why can't it be WPW?

Because

1. There is no known WPW showing such QRS morphology in PRECORDIAL and STANDARD ECG leads.
2. It is almost impossible that a MAJOR “WPW PATTERN” will appear at high rate while it does not appear at SLOWER RATE (the contrary is however possible when you have rate-dependence block in the accessory pathway)
3. The QRS morphology may suggest VENTRICULAR TACHYCARDIA; however, the obvious 2:1 relationship between the atrial flutter and the WIDE QRS would indicate that we are dealing with SIMULTANEOUS VT (122/min) and ATRIAL FLUTTER (244/min)

I have published on such combination and I feel strong enough to say that this is not the case) see references below I am convinced (99.9%) that the rapid HR – WIDE QRS TACHYCARDIA cannot be explained by VT or WPW.

References

- 1) **Motté G, Sebag C, Belhassen B, Vaysse J, Welti JJ. [Bitachycardia]. Arch Mal Coeur Vaiss. 1980 Apr;73(4):336-48.[Article in French]**
One or several episodes of **bitachycardia** (a simultaneous ventricular tachycardia and atrial tachycardia or fibrillation) were observed in 13 patients. An oesophageal or right atrial endocavitary recording is usually necessary to show the atrioventricular dissociation: even then the diagnosis may be difficult in cases of isorhythmic dissociation or when the ventricular tachycardia is irregular. In 5 cases the double tachycardia appeared to be coincidental. In 7 patients the ventricular tachycardia seemed to be dependant on the atrial tachycardia and could be initiated by a simple spontaneous atrial extrasystole in 3 cases. In one patient the ventricular tachycardia, after a phase of retrograde conduction to the atria, initiated the atrial arrhythmia. The therapeutic indications depend in part on the eventual relationship between the two arrhythmias.

2. Belhassen B, Shapira I, Kauli N, Keren A, Laniado S. Initiation of ventricular tachycardia by supraventricular beats. Cardiology. 1982;69(4):203-13.

9 patients (6 males and 3 females, age 5-69 years) with ventricular tachycardia induced by supraventricular beats are reported. 3 patients had had previous myocardial infarction, 1 patient had mitral valve prolapse and in 5 patients no organic heart disease could be demonstrated. Ventricular tachycardia was initiated by a single atrial premature beat in 4 patients, double atrial premature beats in 3 patients (in 1 of them following exercise), by nonsustained AV nodal tachycardia in 1 patient, by rapid atrial pacing in 3 patients and exercise-related ectopic atrial tachycardia in 1 patient. Programmed ventricular stimulation induced ventricular tachycardia in all patients in whom the tachycardia was induced by atrial stimulation. Verapamil abolished sustained ventricular tachycardia in 1 of the 3 patients in whom this drug was administered. Hypotheses are made on the electrophysiological mechanisms of the arrhythmias and clinical implications are listed,

3. Eldar M1, Belhassen B, Hod H, Schuger CD, Scheinman MM. Exercise-induced double (atrial and ventricular) tachycardia: a report of three cases. J Am Coll Cardiol. 1989 Nov 1;14(5):1376-81.

Exercise-induced double tachycardia, i.e., the simultaneous occurrence of atrial and ventricular tachycardia, is described in three patients: one patient had coronary artery disease; the other two were young and had no apparent heart disease. One of the latter patients later died suddenly. Double tachycardia could not be initiated by programmed atrial or ventricular stimulation. In two patients atrial tachycardia always preceded ventricular tachycardia and, in one patient, ventricular tachycardia was terminated by the administration of adenosine triphosphate. Reentry does not seem to be the underlying mechanism for these arrhythmias; abnormal automaticity or triggered activity may be the mechanism

Warmest regards
Bernard Belhassen
Professor Emeritus of Cardiology,
Cardiologic Institute
Hadassah University Hospital
Jerusalem. ISRAEL



Dear Andrés,

Thank you for sharing this interesting ECG case of a 74 year old man with advanced hypertensive heart disease.

I offer the following ECG interpretations of the 5 ECGs:

ECG-1: The rhythm is atrial flutter (AFL) (~200 bpm, due to enlarged atria) with variable (3:1 and 2:1) AV block. QRS axis $\sim 75^\circ$, RBBB, LVH with strain pattern.

ECG-2: AFL is now with a regular 2:1 conduction. Prominent R waves across the precordial leads probably reflect the combination of RBBB with LVH strain pattern.

ECG-3 recorded at 50mm/s: looks similar to ECG-2 on the rhythm strip.

ECG-4: AFL is now 4:1 block, and RBBB is no longer present (suggesting it is rate-related). Severe LVH with strain also present

ECG-5 recorded at 50mm/s: AFL with variable AV block and intermittent rate-related RBBB.

I await your erudite interpretations and that of our colleagues.

My 80-year old life in semi-retirement continues to be enjoyable especially when I receive the wonderful cases and publications that you share with us. I continue teaching ECG interpretation to our medical residents several hours a week, but I worry that advanced knowledge of ECG is declining overall as medical trainees are increasingly overwhelmed by electronic medical records and keeping “up-to-date”.

Regards,

Frank G. Yanowitz MD Professor of Medicine (Retired) University of Utah School of Medicine



Spanish

Querido Andrés

Gracias por compartir este interesante caso de ECG de un hombre de 74 años con enfermedad cardíaca hipertensiva avanzada. Ofrezco las siguientes interpretaciones de ECG de los 5 ECG:

ECG-1: el ritmo es aleteo auricular (AFL) (~ 200 lpm, debido a las aurículas agrandadas) con bloqueo AV variable (3: 1 y 2: 1). Eje QRS $\approx 75^\circ$, RBBB, LVH con patrón sistólico de repolarización (Cabrera) o “Strain pattern”.

ECG-2: AFL ahora tiene una conducción normal 2: 1. Las ondas R prominentes a través de las derivaciones precordiales probablemente reflejan la combinación de RBBB con el patrón de SVI con patrón de repolarización sistólico de Cabrera “strain pattern”.

ECG-3 registrado a 50 mm / s: se parece a ECG-2.

ECG-4: AFL ahora está con tasa de respuesta ventricular 4: 1, y el RBBB ya no está presente (lo que sugiere que está relacionado con la frecuencia). SVI severa con patrón de repolarización sistólico de Cabrera “strain pattern”.

ECG-5 registrado a 50 mm / s: AFL con bloqueo AV variable y RBBB relacionado con la frecuencia intermitente.

Espero sus interpretaciones eruditas y las de nuestros colegas.

Mi vida a los 80 años en semi-retiro continúa siendo agradable, especialmente cuando recibo los maravillosos casos y publicaciones que compartes con nosotros. Continúo enseñando interpretación de ECG a nuestros residentes médicos varias horas a la semana, pero me preocupa que el conocimiento avanzado de ECG esté disminuyendo en general, ya que los alumnos médicos están cada vez más abrumados por los registros médicos electrónicos y por mantenerse "actualizados".

Saludos,

Frank G. Yanowitz, MD Professor of Medicine (Retired) University of Utah School of Medicine

Atrial flutter at different rates. Did I miss something else?

Adrian Baranchuk

Division of Cardiology, Queen's University, Kingston, Ontario, Canada



Dear Riera: The daily activities of our practice offers occasionally facts that we do not see frequently in the literature. The colleague Paulo and you put to us a dynamic ECG evolution rarely well done like this. Finally a golden opinion by Master Yanowitz put we all ahead.

Congratulations

Adail **Paixão-Almeida** Vitoria da Conquista Brazil

Dear Adail: Frank is one of the most brilliant electrocardiologists around the world.

I met him in person. In addition, he is an outstanding musician in USA.

Andrés



Electrocardiographic final analysis and theoretical features on Atrial Flutter



By Andrés Ricardo **Pérez-Riera**, MD PhD

Laboratório de Metodologia de Pesquisa e Escrita Científica, Centro Universitário Saúde ABC, Santo André, São Paulo, Brazil.

«Todos caminamos hacia el anonimato, sólo que los mediocres llegan un poco antes.»

"We all walk towards anonymity, only that the mediocre arrive a little earlier."

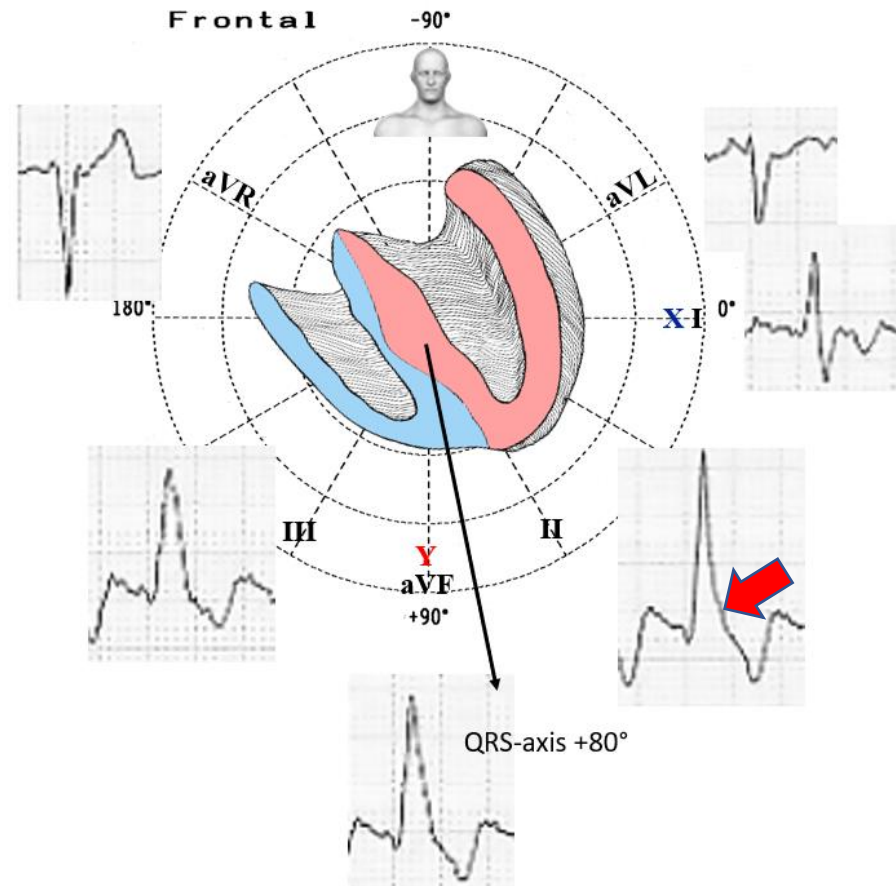
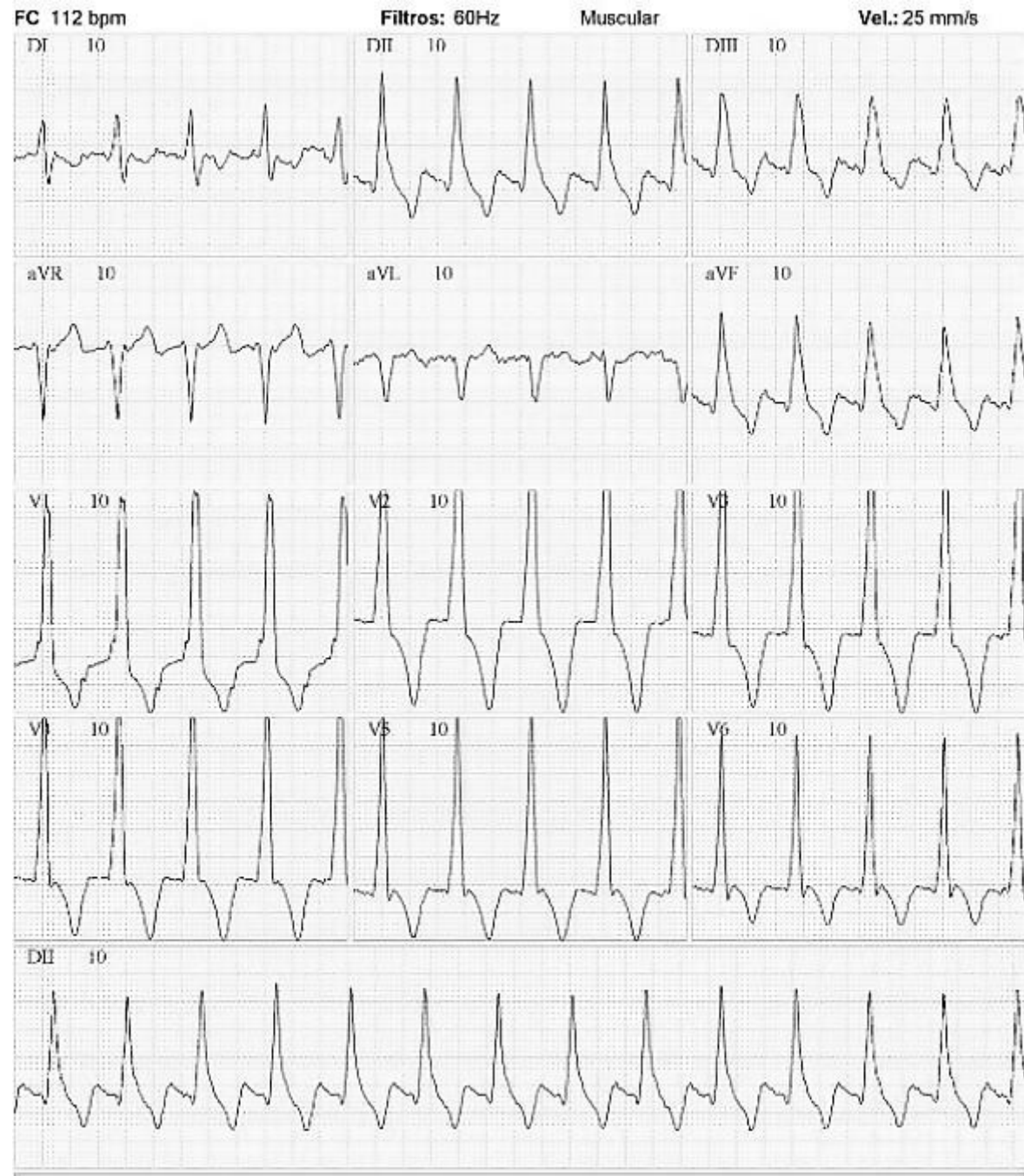
Jorge Luis Borges

ECG-1 performed on January 27/2020, at 09:00 AM



- ❑ Rhythm: Atrial flutter (AFL)
- ❑ HR: mean 85bpm
- ❑ QRS axis $\approx +75^\circ$
- ❑ AV conduction: Irregular or variable 3:1/2:1 AFL appear as an irregular rhythm. The term “AV block” in the context of AFL is something of a misnomer. AV block is a physiological response to rapid atrial rates and implies a normally functioning AV node.
- ❑ Complete Right Bundle Branch Block
- ❑ Prominent anterior QRS forces across all precordial leads probably by CCW heart rotation around the longitudinal axis consequence of the severe concentric LV hypertrophy,(ECHO date) associated with RBBB
- ❑ Negative strain T-waves from V3 to V6 consequence of severe LVH associated with CRBBB. Typical Left ventricular hypertrophy (LVH) produces T-wave inversion in the lateral leads I, aVL, V5-6 (left ventricular “strain” pattern)
- ❑ Artifact in V3 lead.
- ❑ Severe left ventricular hypertrophy with strain pattern

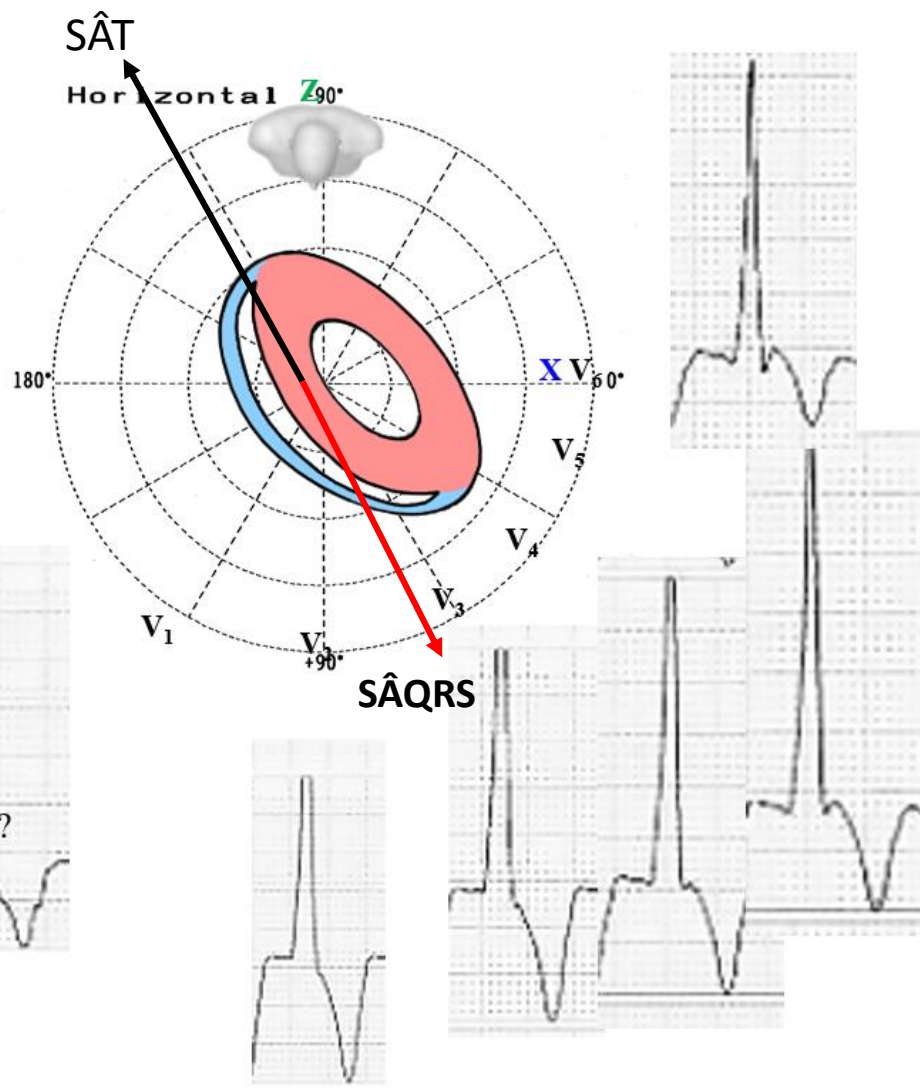
ECG-2 performed on January 29/2020 at 08:08 AM



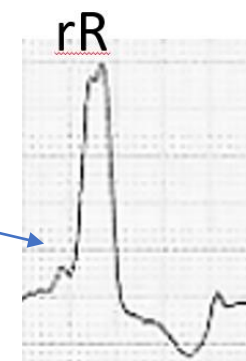
AFL, HR 112bpm, In the frontal plane(FP) ventricular activation suggest atypical LPFB activation: FP axis +80° (between +80° and ±180° in adults); rS pattern in leads aVL, qR pattern in III, aVF and II, Notch in the descending limb of the R wave in inferior leads (middle-final notch or slurring: red arrow); ventricular activation time > 35ms in aVF , with strain pattern across all precordial leads: association of RBBB, LVH .. Prominent R waves across the precordial leads reflect severe LVH(coincident with ECHO data) in combination of RBBB.

ECG-2 precordial leads performed on January 29/2020 at 08:08 AM

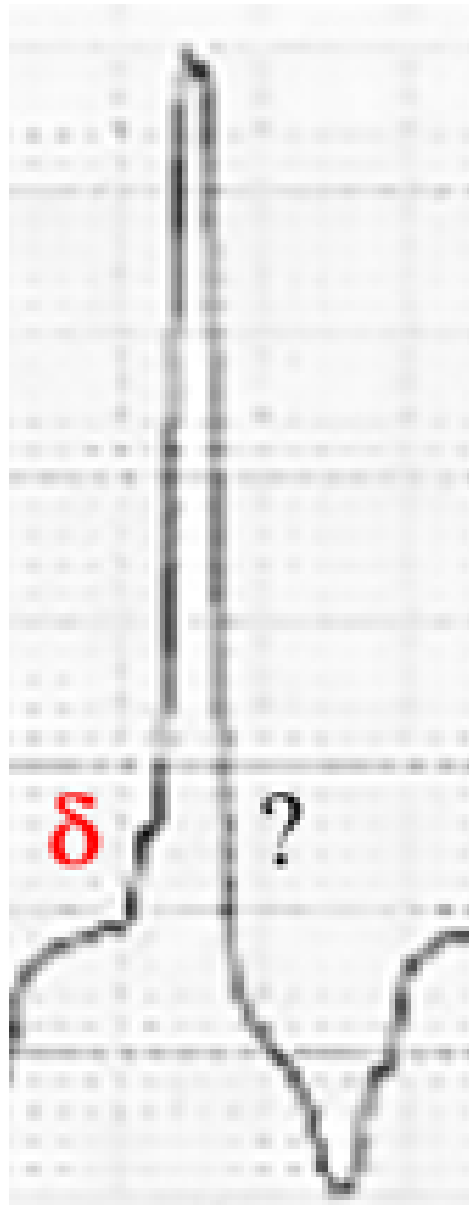
Broad complex tachycardias occur by various mechanisms and may be ventricular or supraventricular in origin. In the emergency setting most broad complex tachycardias have a ventricular origin. However, an arrhythmia arising from the atria or the atrioventricular junction will produce a broad complex if associated with ventricular pre-excitation or bundle branch block. The presence of concordance suggests that the tachycardia has a ventricular origin. Positive concordance probably indicates that the origin of the tachycardia lies on the posterior ventricular wall; the wave of depolarization moves towards all the chest leads and produces positive complexes. When all of the ventricular complexes from leads V1 to V6 are positive (positive concordance), the diagnosis is most likely left posterior ventricular tachycardia or, rarely, **supraventricular tachycardia with atrioventricular conduction over a left posterior accessory pathway**. In the present case a pseudo delta(δ) wave is insinuate in V1 lead. Against this hypothesis is the morphology of the ECG-3 in lead V1 typical of RBBB performed on January 29/2020



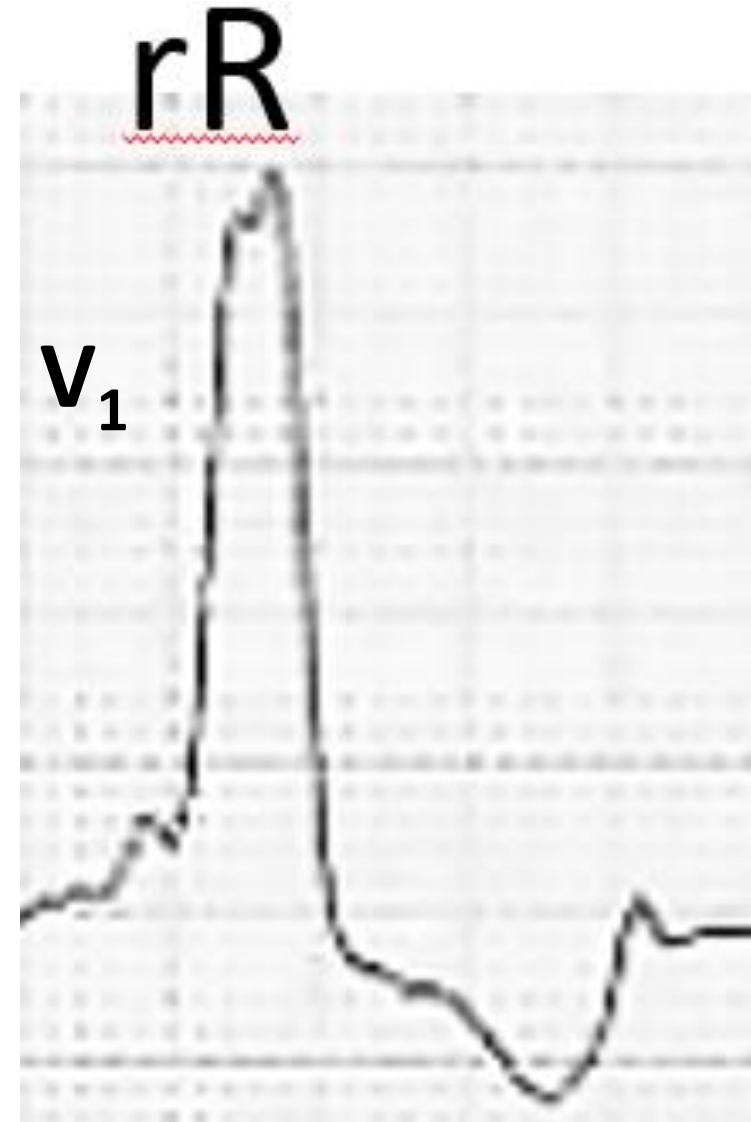
QRS/T angle broad means the T-waves on the ECG are deflected opposite the majority of the QRS complex, which is a normal finding in bundle branch blocks, paced rhythm, and left ventricular hypertrophy with strain. In other words, it's a normal finding with a secondary ST/T-wave abnormality.



ECG-2 V1 Could be confused with delta wave



ECG-3 V1 The V1 pattern rR leaves no doubt that it is a CRBBB



ECG-3 performed on January 29/2020 at 11:07 AM



ECG performed with double speed (50 mm/s) HR 110bpm, broad sustained QRS tachycardia. Ventricular activation in the frontal plane again suggest atypical LPFB activation. In the horizontal plane concordance positive across all precordial leads. Differentiate of ECG-2 V1 clearly shows CRBBB pattern HD AFL with regular 2:1, sustained broad QRS tachycardia showing CRBBB + LPFB

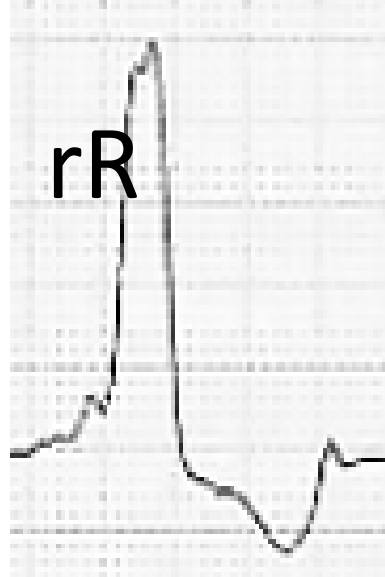
See figure below

Why **atypical** LPFB?

Answer

Because

- 1) RII > RII In typical LPFB RIII > RII
- 2) I lead has not rS only aVL

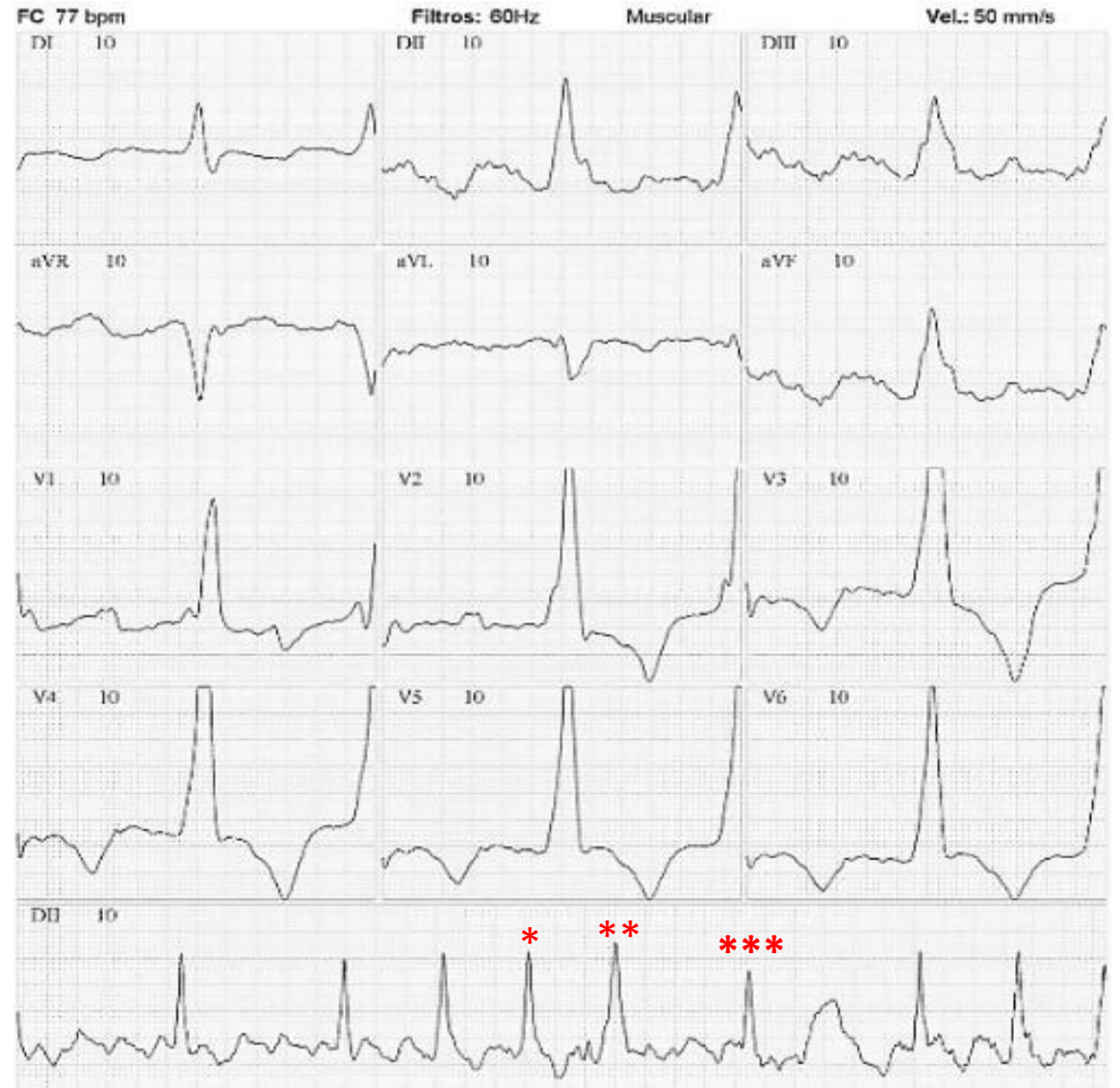


ECG-4 performed on January 29 at 02:43 PM



HR 55bpm, AFL with regular AV conduction 3:1 ($-\frac{1}{3}$ - rate and it means 3 "F" waves per each QRS.) QRS axis $+70^\circ$, narrow QRS complexes, and left ventricular hypertrophy: strain pattern of repolarization in lateral leads).

ECG-5 performed on January 29 at 03:21 PM



12-lead ECG performed with paper speed running at double speed (50mm/s), HR 72bpm, QRS axis in $+80^\circ$, AFL, 3: 1, 2:1 Transient LPFB pattern of variable degree is observed in the third(*), fourth(**) and fifth(***) beat of the lower strip (II lead). AFL, transient LPFB of variable degree+ CRBBB.

Acronyms used in this presentation

1. AADs: antiarrhythmic drugs
2. AF: Atrial Fibrillation
3. AFL: Atrial Flutter
4. APs Action Potentials
5. AV auriculoventricular
6. Beats/min: bpm
7. CA: Catheter Ablation
8. CL: cycle length
9. CW: Clock Wise Rotation
10. CCW: Counter Clock Wise Rotation
11. CS: Coronary Sinus
12. CTI: Cavotricuspid isthmus
13. CTIA: Cavo tricuspid isthmus ablation
14. EAD: Early After Depolarziation
15. ECG: Electrocardiogram
16. EPS: Electrophysiological study
17. HR: Heart Rate
18. IVC: inferior vena cava
19. LA: Left Atrium
20. MRTs: Macro-Re-entrant Tachycardia
21. RA: Right Atrium
22. RFCA: Radiofrequency Catheter ablation
23. TA: Tricuspid Annulus.
24. WPW: Wolff-Parkinson White

Atrial Flutter (AFL) theoretical considerations

Concept: Atrial flutter (AFL) is a type of supraventricular tachycardia caused in most cases by a re-entry circuit within the right atrium (RA). The length of the re-entry circuit corresponds to the size of the right atrium, resulting in a fairly predictable atrial rate of around 300 bpm (range 200-400). Infrequent atrial tachyarrhythmia, nearly always present, accompanied by organic substrate, the electrophysiological mechanism of which in most cases, is a circular circuit of macro-reentry that encompasses all the RA; more rarely by unifocal or multifocal atrial focus with very high shock, or exceptionally by focal micro-reentry in the RA. There are always intraatrial or interatrial dromotropic disturbances, with a minimal extension being necessary in the circular movement, refractoriness dispersion and variations in autonomic tone. ECG is characterized by the typical atrial "F" waves with aspect in "sawtooth" or "picket fence", frequently better observed in II, III, aVF and V₁, with average atrial HR of 250-350 bpm (HR of atypical flutter or type II is 350 to 450 bpm), characteristic absence of isoelectric line between the F waves, variable degrees of AV block or rarely 1:1 conduction. Ventricular HR is usually half of atrial HR (i.e. 150 bpm). A significantly slower ventricular rate in absence of drugs, suggests normal AV conduction. Clinical electrophysiology has made the traditional classification of rapid atrial rhythms into AFL and tachycardia of little clinical use. EPSs have defined multiple mechanisms of tachycardia, both re-entrant and focal, with varying ECG morphologies and rates, authenticated by the results of catheter ablation (CA) of the focal triggers or critical isthmuses of re-entry circuits. In patients without a history of heart disease, cardiac surgery or CA, typical AFL ECG remains predictive of a RA re-entry circuit dependent on the IVC–tricuspid isthmus that can be very effectively treated by CA, although late incidence of AF remains a problem. Secondary prevention, based on the treatment of associated AF risk factors, is emerging as a therapeutic option. In patients subjected to cardiac surgery or CA for the treatment of AF or showing atypical ECG patterns, macro-re-entrant and focal tachycardia mechanisms can be very complex and EPSs are necessary to guide CA treatment in poorly tolerated cases.

The term ‘flutter’ was coined to designate the visual and tactile rapid, regular atrial contraction induced by faradic stimulation in animal hearts, in contrast with irregular, vermiform contraction in AF.^{1,2} On the ECG, AFL was a regular continuous undulation between QRS complexes at a CL of ≤ 250 ms (≥ 240 bpm). Slower tachycardias displaying discrete P waves, separated by isoelectric baselines, were called ‘atrial tachycardia’. Early studies suggested that AFL had a re-entrant mechanism³⁻⁵ but others attributed AFL to focal discharge.^{6,7} Later human studies left the door open for a focal mechanism.⁸ This was not a significant consideration when digitalis and very few antiarrhythmic drugs (AADs) were the only therapeutic armamentarium, but determining the mechanism involved in AFL has become crucial for the design and application of CA and surgical ablation techniques. Modern EPS has confirmed the re-entrant mechanism of typical AFL, and has opened wide the spectrum of mechanisms of MRTs, prompting a new, more open view of clinical ECG-based classification (see *Figure 1A and 1B*).⁹

Epidemiology of atrial flutter

Prevalence: infrequent and less prevalent than AF: 10 to 1 in favor of the latter. Estimated in 0.0006% to 0.004% between 50,000 patients from a General Hospital.

Gender: greater prevalence in males.

Age: 25 to 35 y/o.: 2-3/1000; 55 to 64: 30-90/1000; 62 to 90: 50-90/1000

AFL nearly always presents underlying organic heart disease. Exceptionally described in patients without heart disease, associated to ventricular preexcitation of the WPW type.

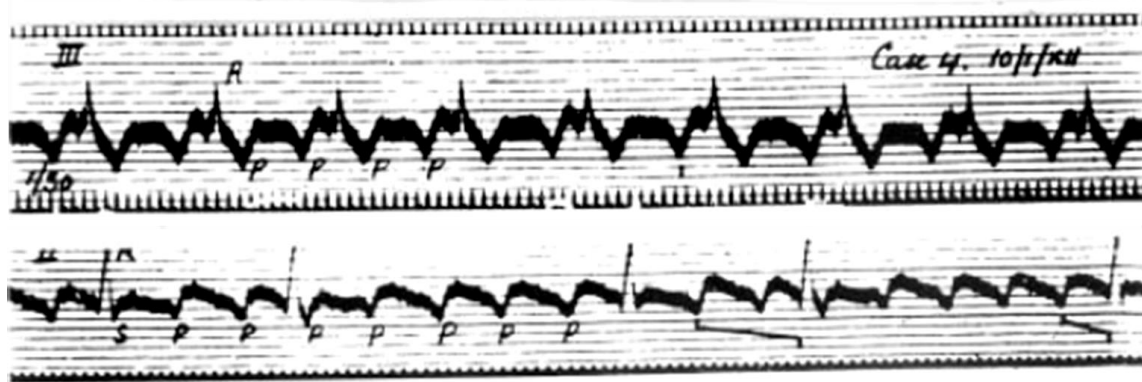
Sex: male predominance.

Atrial Flutter: Historical Perspectives

□ 1886: The first published description of AFL. John A. McWilliam described observing regular, rapid excitations of the atrium in an animal (**McWilliam JA. Fibrillar contraction of the heart. J Physiol 1886;8:296; Waldo AL. Mechanisms of atrial fibrillation, atrial flutter, and ectopic atrial tachycardia—a brief review. Circulation 1987;75:III37-40; Scheinman MM, Yang Y. Atrial flutter: historical notes—Part 1. Pacing Clin Electrophysiol 2004;27:379-81.**). The first published description of AFL dates back to October of 1886 when the Scottish physician John Alexander McWilliam (side photo) Professor of the Institutes of Medicine in the University of Aberdeen described observing regular, rapid excitations of the atrium in an animals (dog, cat, rabbit, rat, mouse, hedgehog and fowl; both in the young animal and in the adult.). His earlier investigations were pursued in the Physiological Laboratory of University College, London, and the more recent ones in the Physiological Laboratory of the University of Aberdeen (**McWilliam JA. Fibrillar contraction of the heart. J Physiol 1887; 8(5):296-310.doi: 10.1113/jphysiol.1887.sp000261**). In summary, the term ‘flutter’ was coined by John A. McWilliam. In this year to designate the visual and tactile rapid, regular atrial contraction induced by faradic stimulation in animal hearts, in contrast with irregular, vermiform contraction in AF. (**Jolly WA, Ritchie WT Auricular flutter and fibrillation. Heart. 1911;2:177–86**).



- 1906 Einthoven made an ECG showing AFL. (**Einthoven W. The telecardiogramme. Arch Int Physiol 1906;4:132-41.**)
- 1911: Description of the sawtooth waves with absence of isoelectric plateau between F waves in the inferior ECG leads were described by Jolly and Ritchie (**Jolly WA, Ritchie TW. Auricular flutter and fibrillation. Heart 1911;3:177-221.**) in 1911.) These authors were the first to distinguish AFL from AF.
- 1913 Lewis (**Lewis T. Observations upon a curious, not uncommon form of extreme acceleration of the auricle. atrial flutter. Heart 1913;4.**) also described the distinctive sawtooth waves. Sir Thomas Lewis announces the AFL criteria



Electrocardiograph used by Lewis at the University College Hospital Medical School built by Cambridge Scientific Instrument Company of London in 1911 (Reprinted from: **BMJ 1950;1:720, British Medical Association, London.**).

- 1920 Lewis et al. were the first to investigate the mechanism of the AFL. (**Lewis T, Feil HS, Stroud WD. Observations upon flutter, fibrillation. Part II. The nature of auricular flutter. Part III: Some effects of rhythmic stimulation of the auricle. Heart 1920;7**)(**Lewis T, Feil HS, Stroud WD. Observations upon flutter, fibrillation. Part II. The nature of auricular flutter. Part III: Some effects of rhythmic stimulation of the auricle. Heart 1920;7**). In this year Lewis suggested that AFL had a re-entrant mechanism (**Lewis T, Feil S, Stroud WD. Observations upon flutter and fibrillation. II. The nature of auricular flutter. Heart. 1920;7:191-233.**) Modern electrophysiology has confirmed the re-entrant mechanism of typical flutter, and has opened wide the spectrum of mechanisms of macro-re-entrant tachycardias (MRTs), prompting a new, more open view of clinical ECG-based classification Using a combination of epicardial maps and ECG recordings

from a canine model of AFL induced by rapid atrial pacing, they showed that constant activation of at least some part of the atrium resulted in the AFL waves seen in the surface ECG. They also showed that the activation sequence was orderly, ie, the wave front circulated in either a cranial-caudal or a caudo-cranial direction in the RA. **(Lewis T, Feil HS, Stroud WD. Observations upon flutter, fibrillation. Part II.**

The nature of auricular flutter. Part III: Some effects of rhythmic stimulation of the auricle. Heart 1920;7.)

□ **1921:** Lewis et al. concluded that AFL was due to intraatrial circus movement around the IVC. **(Lewis T, Drury AN, Ilescu CC. A demonstration of circus movement in clinical flutter of the auricles. Heart 1921;8:341.)**

□ **1947:** Rosenbleuth and Garcia-Ramos postulate that AFL was due to intra-atrial reentry. They who constructed a crush injury model of this arrhythmia by creating a lesion between the vena cavae. **(Rosenbleuth A, Garcia-Ramos J. Studies on flutter and fibrillation II. The influence of artificial obstacles on experimental auricular flutter. Am Heart J 1947;33:677-84.)** Based on the epicardial maps, the authors deduced that the reentry loop circled around the RA crush lesion. They also noted that when the crush lesion was extended from the IVC to the AV groove, the arrhythmia disappeared and could not be induced. This finding suggests that the true circuit may have included the cavotricuspid isthmus. Based on works with aconitine Scherf felt that AFL was due to abnormal automaticity. **(Scherf D. Studies of auricular tachycardia caused by aconitine administration. Proc Exp Biol Med 1947;64:233-9.)** **(Scherf D, Terranova R. Mechanism of auricular flutter and fibrillation. Am J Physiol 1949;159:137-42)**. Rosenbleuth et al. studied the influence of artificial obstacles on experimental AFL. They constructed a crush injury model of the AFL by creating a lesion between the vena cava. Based on the epicardial maps, the authors deduced that the reentry loop circled around the RA crush lesion. They also observed that when the crush lesion was extended from the IVC to the AV groove, the arrhythmia disappeared and could not be induced. This finding suggests that the true circuit may have included the Cavotricuspid isthmus.

- ❑ **1967/68** In this year Goto et al postulate abnormal automaticity in phase 2 (atrial hyperautomaticity mechanism) as mechanism for AF and AFL using aconitine (**Goto M, Sakamoto Y, Imanaga I. Aconitine-induced fibrillation of the different muscle tissues of the heart and the action of acetylcholine. In: Electrophysiology and Ultrastructure of the Heart. New York: Grune & Stratton; 1967:199-201. Edited by Sano Toyomi, Matsuda Kojiro, Mizuhira Vinci, eds. Grune & Stratton, Inc., 381 Park Ave S, New York 10016, 1968.** This mechanism is called also early triggered activity: it is the one that depends on the oscillations of the AP that occur before repolarization is fulfilled at the end of phase 2 and phase 3. EAD are oscillatory potentials that occur during the AP plateau (phase 2 EADs) or during the late repolarization (phase 3 EADs). Both types may appear during similar experimental conditions, but they differ morphologically as well as in the underlying ionic mechanism.
- ❑ **1969** Azuma et al demonstrate that aconitine caused abnormal automaticity at rapid rates in the rabbit atria. (**Azuma K, Iwane H, Ibukiyo C. Experimental studies on aconitine-induced atrial fibrillation with microelectrodes. Isr J Med Sci 1969;5:470-4.**)
- ❑ **1977** Albert Waldo et al verified entrainment and interruption of AFL with atrial pacing: studies in man following open heart surgery. This author demonstrated in humans entrainment and interruption of AFL with atrial pacing. Modern electrophysiology has confirmed the re-entrant mechanism of typical AFL, and has opened wide the spectrum of mechanisms of MRTs, prompting a new, more open view of clinical ECG-based classification Waldo characterized and classified AFL in humans. (**Waldo AL, MacLean WA, Karp RB, Kouchoukos NT, James TN. Entrainment and interruption of atrial flutter with atrial pacing: studies in man following open heart surgery. Circulation 1977;56:737-45.**)

- ❑ **1980** Boineau et al studied AFL in dogs observing circus movement with abnormal atrial pathways, slow conduction, nonuniform refractory period distribution and premature beats (**Boineau JP, Schuessler RB, Mooney CR, Miller CB, Wylds AC, Hudson RD, Borremans JM, Brockus CW. Natural and evoked atrial flutter due to circus movement in dogs. Role of abnormal atrial pathways, slow conduction, nonuniform refractory period distribution and premature beats. Am J Cardiol 1980;45:1167-81.**).
- ❑ **1981** Inoue et al, studied clinical and experimental of the effects of extrastimulation and rapid pacing on AFL: evidence of macroreentry with an excitable gap (**Inoue H, Matsuo H, Takayanagi K, Muraio S. Clinical and experimental studies of the effects of extrastimulation and rapid pacing on atrial flutter: evidence of macroreentry with an excitable gap. Am J Cardiol 1981;48:623-31.**
- ❑ **1982** Allessie et al using a total mapping of atrial excitation during acetylcholine-induced AFL and AF in the isolated canine heart (**Allessie MWL, Smeets J, Bonke F, Hollen J. Total mapping of atrial excitation during acetylcholine-induced atrial flutter and fibrillation in the isolated canine heart. In: Kulbertus HE, Olsson SB, Schlepper M, eds. Atrial Fibrillation. Molndal, Sweden: AB Hassell;1982:44.**)
- ❑ **1983** Frame et al, observed in dogs that RA incision stabilizes the reentry around the tricuspid valve (**Frame LH, Page RL, Boyden PA, Hoffman BF. A right atrial incision that stabilizes reentry around the tricuspid ring in dogs. Circulation 1983;68(Suppl. III):361.**). In this year, Bink et al described several atrial arrhythmias after atrial surgery (Mustard's operation and closure of a secundum atrial septal defect) in children (**Bink-Boelkens MT, Velvis H, van der Heide JJ, Eygelaar A, Hardjowijono RA. Dysrhythmias after atrial surgery in children. Am Heart J 1983;106:125-30.**).

- ❑ **1984** Flinn et al studied AFL after Mustard operation for complete transposition of the great arteries (**Flinn CJ, Wolff GS, Dick M 2nd, Campbell RM, Borkat G, Casta A, Hordof A, Hougen TJ, Kavey RE, Kugler J, et al: Cardiac rhythm after the Mustard operation for complete transposition of the great arteries. N Engl J Med 1984;310:1635-8**). Allessie et al studied the intra-atrial reentry as a mechanism for AFL induced by acetylcholine in rapid pacing in the dog (**Allessie M, Lammers W, Bonke F, Hollen J. Intra-atrial reentry as a mechanism for atrial flutter induced by acetylcholine in rapid pacing in the dog. Circulation 1984;70:123-35**).
- ❑ **1986** Klein et al reported their findings on intra-operative mapping studies of two patients with persistent AFL. They found that the narrowest part of the circuit had relatively slow conduction and was localized to the low RA, between the IVC and tricuspid ring. (**Klein GJ, Guiraudon GM, Sharma AD, Milstein S. Demonstration of macroreentry and feasibility of operative therapy in the common type of atrial flutter. Am J Cardiol 1986;57:587-91**.) Furthermore, cryosurgical ablation of this critical region and its surrounding tissue prevented short-term recurrences of the arrhythmia. (**Frame LH, Page RL, Hoffman BF. Atrial reentry around an anatomic barrier with a partially refractory excitable gap. A canine model of atrial flutter. Circ Res 1986;58:495-511**.)
- ❑ **1987** Frame et al, verified that a Y-shaped lesion in the RA allows induction of AFL in dogs. They recorded the activation sequence during this tachycardia from 96 endocardial bipolar electrodes using intracavitary electrode arrays during 12 separate episodes in three isolated perfused hearts. In each case a reentrant impulse circulated around the tricuspid valve orifice in either a CW or CCW. Cutting the pathway terminated the rhythm and prevented its reinduction. There was no discrete segment of markedly slow conduction in the reentrant circuit. The tachycardia CL was decreased by methacholine and increased by lidocaine. (**Frame LH, Page RL, Boyden PA, Fenoglio JJ Jr, Hoffman BF. Circus movement in the canine atrium around the tricuspid ring during experimental atrial flutter and during reentry in vitro**).

- **Circulation 1987;76:1155-75**). Reentry was also induced in atrial tissue around the tricuspid orifice when this structure was isolated and superfused in vitro. Tachycardia CL, depending on the circumference of the ring and temperature. Induction of tachycardia by premature stimulation depended on differences in the duration of the effective refractory period among parts of the ring. Conduction velocity was relatively uniform and was slower during tachycardias than during pacing at long CL. Analysis of the response to premature stimuli that reset the tachycardia provided evidence for incomplete recovery of excitability between depolarizations during the tachycardia. Fast-response APs were recorded throughout the pathway and up to six to eight cell layers deep. Histologic studies showed the supravascular lamina, a circumferential band of fibers several cell layers below the endocardial surface, to be continuous around the tricuspid orifice. Propagation through this layer best explains the conduction velocities observed in the intact heart during AFL in this preparation.
- **1989** Chauvin et al used fulguration with success for paroxysmal and recurrent AFL. (**Chauvin M, Brechenmacher C. A clinical study of the application of endocardial fulguration in the treatment of recurrent atrial flutter. Pacing Clin Electrophysiol 1989;12:219-24.**).
- **1990** Saoudi et al. observed that patients with type I AFL referred for AV node-His bundle ablation may be successfully managed by delivering the ablative shock directly on the atrial arrhythmia substrate. (**Saoudi N, Atallah G, Kirkorian G, Touboul P. Catheter ablation of the atrial myocardium in human type I atrial flutter. Circulation 1990;81:762-71.**).
- **1992** Fell et al identified a critical zone of reentrant circuit in type I AFL using mapping techniques (**Feld GK, Fleck RP, Chen PS, et al: Radiofrequency catheter ablation for the treatment of human type 1 atrial flutter. Identification of a critical zone in the reentrant circuit by endocardial mapping techniques. Circulation 1992;86:1233-40**)

- ❑ **1993** Francisco G Cosio et al. observed that the CTI is a part of the RA located between the IVC ostium and the tricuspid valve. The CTI is a concept that was first introduced by Cosio which confirmed that the IVC-TV isthmus is an essential part of the AFL circuit and the ablation of this area may be of therapeutic value, but technical improvements are needed. At that time the authors observed that long-term efficacy of the procedure is uncertain. (**Cosio FG, Lopez-Gil M, Goicolea A, Arribas F, Barroso JL. Radiofrequency ablation of the inferior vena cava-tricuspid valve isthmus in common atrial flutter. Am J Cardiol 1993;71:705-9.**). Stevenson et al observed that regions giving rise to reentry after myocardial infarction are complex and can include bystander areas, slow conduction zones, and isthmuses for impulse propagation at which radiofrequency current lesions can interrupt reentry.(**Stevenson WG, Khan H, Sager P, Saxon LA, Middlekauff HR, Natterson PD, Wiener I. Identification of reentry circuit sites during catheter mapping and radiofrequency ablation of ventricular tachycardia late after myocardial infarction. Circulation 1993;88:1647-70.**)
- ❑ **1995** Stevenson et al. Observed that many atrial tachycardias, AFL, and postmyocardial infarction VTs are due to reentry through large "macroreentrant" circuits. These circuits can be difficult to define by catheter mapping of the activation sequence. Entrainment techniques allow the relation of a mapping site to the reentrant circuit to be assessed on a site-by-site basis during catheter mapping. Regions of abnormal conduction that are in the reentrant circuit can be distinguished from bystander sites outside the circuit. A mapping site classification to guide CA is reviewed.(**Stevenson WG, Sager PT, Friedman PL. Entrainment techniques for mapping atrial and ventricular tachycardias. J Cardiovasc Electrophysiol 1995;6:201-16**)

- **1996** Nakagawa et al postulated that the eustachian valve and ridge (EVR) forms a line of conduction block between the IVC and CS ostium and forms a second isthmus (septal isthmus) between the TA and CS ostium. The EVR forms a line of fixed conduction block between the IVC and the CS; (2) the EVR and the TA provide boundaries for the AFL reentrant circuit; and (3) verification of a complete line of block between the TA and the EVR is a more reliable criterion for long-term ablation success. (Nakagawa H1, Lazzara R, Khastgir T, Beckman KJ, McClelland JH, Imai S, Pitha JV, Becker AE, Arruda M, Gonzalez MD, Widman LE, Rome M, Neuhauser J, Wang X, Calame JD, Goudeau MD, Jackman WM. Role of the tricuspid annulus and the eustachian valve/ridge on atrial flutter. Relevance to catheter ablation of the septal isthmus and a new technique for rapid identification of ablation success. *Circulation*. 1996 Aug 1;94(3):407-24.) In this year The Marshfield Epidemiologic Study Area (MESA) database have reported that the overall incidence of AFL is about 88 per 100,000 person-years (DeStefano F, Eaker ED, Broste SK, et al: Epidemiologic research in an integrated regional medical care system: the Marshfield Epidemiologic Study Area. *J Clin Epidemiol* 1996;49:643-52;)
- **1997** Albert Waldo et al. observed that Type I AFL is due to reentrant excitation, principally in the RA. The standard ECG remains the cornerstone for its clinical diagnosis. Acute treatment should be directed at control of the ventricular response rate and, if possible, restoration of sinus rhythm. RFCA therapy provides the best hope of cure, although AF may subsequently occur after this procedure. Alternatively, antiarrhythmic drug therapy to suppress recurrent AFL episodes may be useful. RFCA of the His bundle ablation with placement of an appropriate pacemaker system may be useful in selected patients. (Waldo AL, Mackall JA, Biblo LA. Mechanisms and medical management of patients with atrial flutter. *Cardiol Clin* 1997;15:661-76.)
- **2005** Although linear ablation of the RA isthmus in patients with isthmus-dependent AFL can be highly successful, recurrences and complications occur in some patients. To provides morphological details for a better understanding of the structure of the isthmus is crucial. Cabrera et al. examined the isthmus area in 30 heart specimens by dissection, histology, and scanning electron microscopy. This area was

- bordered anteriorly by the hinge of the tricuspid valve and posteriorly by the orifice of the IVC. With the heart in attitudinal orientation, they identified and measured the lengths of three levels of isthmus: paraseptal (24 +/- 4 mm), central (19 +/- 4 mm), and inferolateral (30 +/- 3 mm). Comparing the three levels, the central isthmus had the thinnest muscular wall and the paraseptal isthmus the thickest wall. At all three levels, the anterior part was consistently muscular whereas the posterior part was composed of mainly fibro-fatty tissue in 63% of hearts. The RCA was less than 4 mm from the endocardial surface of the inferolateral isthmus in 47% of hearts. Inferior extensions of the AVN were present in the paraseptal isthmus in 10% of hearts, at 1-3 mm from the endocardial surface(**Cabrera JA1, Sánchez-Quintana D, Farré J, Rubio JM, Ho SY.The inferior right atrial isthmus: further architectural insights for current and coming ablation technologies.J Cardiovasc Electrophysiol. 2005 Apr;16(4):402-8.**).
- **2009** Meta-analysis, involving 158 studies, established the importance of using irrigated ablation catheters for AFL ablation, and the endpoint of bidirectional conduction block in the isthmus. This reduced AFL recurrence rates to 6e9% post ablation.(**Perez FJ, Schubert CM, Parvez B, Pathak KA, et al. Long-term outcomes after catheter ablation of cavo-tricuspid isthmus dependent atrial flutter: a meta-analysis. Circ, Arrhythm Electrophysiol. 2(4) 2009 393-401. August**)
- **2012** In 126 patients with 3 years follow-up after AFL ablation, Tomson et al. found an AF incidence of 37%, with stroke in 8 (6%) patients, 6 of whom had documented AF occurrence. The decision on stopping anticoagulation must take into account the likelihood of recurrent AFL, new AF, and the risk should these occur - usually estimated by the CHADS2 or CHADs-VASc score, versus the competing risk of bleeding (**T.T. Tomson, S. Kapa, R. Bala, et al., Risk of stroke and atrial fibrillation after radiofrequency catheter ablation of typical atrial flutter, Heart Rhythm. 9 (11) (2012) 1779e1784. November.**)

□ **2019** Giehm-Reese et al. presented a registry study of 2409 patients undergoing AFL ablation in Denmark between 2010 and 2016. Over 4.0 ± 1.7 years of follow up, 801 (33%) patients were hospitalized for either recurrent AFL or AF. This is an underestimate of the incidence, to some degree, as only hospitalizations were captured and not ambulatory clinic presentations. Indeed, 1077 patients had 'either hospitalization or further ablation', and we can infer that a further 276 patients proceeded directly to a second procedure. With regard to these second procedures, 242 of the original 22,409 (10%) patients required a second ablation for recurrent AFL, and 326 (13.5%) underwent ablation for AF. Factors associated with a repeat AFL ablation were both indicative of a difficult or failed first ablation (longer procedure time, unsuccessful first ablation) and also of a lower risk of stroke should AFL recur (younger age, lower CHA2DS2-VASc score). Similarly, patients were more likely to undergo AF ablation if they were younger and had a low CHA2DS2-VASc score. Extrapolation of these results to stroke risk requires some caution, however, as these factors may have been more associated with the decision on whom to offer repeat ablation, than with who actually developed AF or AFL. Ppatients over 75 years of age and with higher CHA2DS2-VASc scores were more likely to be hospitalized for atrial arrhythmias, even though they were not the group more likely to have repeat ablation. (**M. Giehm-Reese, M.B. Kronbork, P. Lukac, et al., Recurrent atrial flutter ablation and incidence of atrial fibrillation ablation after first-time ablation for typical atrial flutter: a nationwide Danish cohort study, Int. J. Cardiol. (2019)**). Giehm-Reese et al. have provided further current evidence, based on reliable registry data, that ablation of AFL cannot be equated with elimination of atrial arrhythmias - and more importantly, does not amount to elimination of stroke risk. Although postablation recurrence of AFL will hopefully continue to diminish with use of irrigated catheters and proof of bidirectional conduction block, the incidence of AF continues to be a reality. Recurrence of AF in those with prior AF history is a virtual certainty, while new AF should also be anticipated. The importance of continuing anticoagulation after AFL ablation should therefore be considered proportional to stroke risk, tempered by bleeding risk, and guided by the consistent finding that 50% of patients will present with AF some time over the

- following 5 years. Novel approaches to this problem, such as primary prevention AF ablation at time of AFL ablation, are being studied but the incremental risk and cost of this approach is an important consideration and further evidence is needed. In the meantime, it may be best to consider AFL as the ‘herald patch’ of an atrial myopathy that is likely to result in further rhythm issues down the road, while remaining vigilant about the associated risk of stroke.
- **2020** Sousa et al. presented a case where, although an eccentric CS activation pattern suggests a LA circuit, suspicion for biatrial AFL should be heightened in the setting of extensive scar in the anteroseptal LA, as this can promote reentry over the Bachmann Bundle(BB) superiorly and the CS inferiorly. By acknowledging the interatrial conduction via the BB and visualizing lines of conduction block displayed with the HD Coloring software, the authors were able to understand the tachycardia mechanism and successfully treat the patient. (**Sousa PA1, Barra S2,3,4, Elvas L1, Gonçalves L1,5.HD Coloring for atypical atrial flutter after mitral valve repair: What is the mechanism? J Cardiovasc Electrophysiol. 2020 Jan;31(1):252-255. doi: 10.1111/jce.14272. Epub 2019 Nov 26**)
- **2020** Mikkel Giehm-Reese et al. from Skejby University Hospital, Aarhus (Denmark) describe incidences of re-ablation for AFL and ablation for AF after first-time Cavo tricuspid isthmus ablation (CTIA) in a nation-wide cohort. CTIA is an effective first-line treatment for typical AFL. However, many patients develop AF after successful CTIA. Knowledge about recurrent arrhythmia after CTIA mainly comes from small cohort studies with limited follow-up. In the Danish National Ablation Registry, the author identified patients undergoing first-time CTIA during 2010-2016. Subsequent CTIA and AF-ablation procedures were identified until March 1st, 2018. They collected information on patient comorbidities in the Danish National Patient Registry. The authors identified 2409 patients undergoing first-time CTIA. Median age was 66 years, 81% were men, and 3% patients had a history of previous ablation for AF. Acute procedural success was achieved in 95% patients. During mean follow-up of 4.0 ± 1.7 years, 242 (10%) patients underwent CTI re-ablation and 326 (13.5%) underwent ablation for AF. Baseline characteristics

□ associated with CTI re-ablation included: Prolonged procedural time, unsuccessful index CTIA, Age <75 years and CHA2DS2-VASc score <2. Hypertension, History of AF-ablation, age <65 years use of a contact force sensing catheter and CHA2DS2-VASc score <2 were associated with later ablation for AF. The authors concluded that in a nation-wide cohort undergoing first-time CTIA for AFL, 10% of patients underwent CTI re-ablation and 13.5% ablation for AF during mean follow-up of 4.0 ± 1.7 years. Probability of a second procedure was higher in younger patients with less comorbidities. (**Giehm-Reese M1, Kronborg MB2, Lukac P2, Kristiansen SB2, Nielsen JM2, Johannessen A3, Jacobsen PK4, Djurhuus MS5, Riahi S6, Hansen PS7, Nielsen JC2. Recurrent atrial flutter ablation and incidence of atrial fibrillation ablation after first-time ablation for typical atrial flutter: A nation-wide Danish cohort study. Int J Cardiol. 2020 Jan 1;298:44-51. doi: 10.1016/j.ijcard.2019.07.077.**)

Etiology

The etiology behind AFL is the presence of a re-entry mechanism for initiation of the tachycardia.

To have this electrical circuit, one must have the following elements:

- 1. Areas with fast and slow velocities of conduction*
- 2. Different refractory periods*
- 3. A functional core where the circuit exists*

These elements are present in a typical AFL in the CTI. The initiation of AFL is due to an ectopic beat that depolarizes one segment of the pathway of the circuits that become refractory and starts the tachycardia from a no-refractory segment.

Epidemiology

AFL is the second most common cardiac arrhythmia after AF. It is commonly associated with AF, but the incidence and the prevalence of the AFL are less known when compared with AF.

AFL is common in patients with underlying diseases such as chronic obstructive pulmonary disease, pulmonary hypertension, and heart failure.

Isolated AFL in the absence of abnormal heart anatomy is rare and usually is present when atrial size abnormalities have developed. AFL is more frequent in males than in females. Aging is a significant risk factor as other associated disorders in patients with AF include systemic hypertension, diabetes mellitus, and history of alcohol abuse. Older age is associated with an increased risk of AF and AFL.

Clinical causes of atrial flutter

- Coronary insufficiency: a) chronic b) AMI: 03% and 5.3% of cases.
- Hypertensive heart disease. 60% of flutters have heart failure or hypertensive heart disease as their cause.
- COPD.
- Rheumatic mitral and/or tricuspid valve disease.
- Severe aortic stenosis.
- Bronchopneumonia.
- Acute pulmonary embolism: transient.
- Bronchogenic carcinoma.
- Thyrotoxicosis: transient. Frequent rate of ventricular response 1:1. Ventricular HR of 300 bpm.
- Congenital heart diseases: E.g.: ASD not operated > 40 years old.
- Post-operative period of cardiac surgery. E.g.: Mustard surgery to correct TGA.
- Digitalis intoxication (exceptional)
- As part of the tachy-brady syndrome.
- Myocarditis and pericarditis.
- Patients that underwent surgical correction of congenital heart diseases.
- As part of the WPW syndrome (frequent 1:1 AV conduction and possible sudden cardiac death)
- Mitral valve prolapse syndrome.
- Alcoholism. 30% of AFLs do not have underlying structural heart disease.

Electrophysiological mechanisms of atrial flutter

A. Dromotropic mechanisms

Macro-reentry around fixed or functional, anatomical or surgical barriers.

Micro-reentry.

B. Automatic mechanisms

Unifocal atrial focus.

Multifocal AFL with very high shock.

Types of atrioventricular conduction in atrial flutter

A) Regular AV conduction:

- ❑ 2:1 – $\frac{1}{2}$ Ventricular rate is determined by the AV conduction ratio (“degree of AV block”). The commonest AV ratio is 2:1, resulting in a ventricular rate of approximately 150 bpm.
- ❑ 1:1 – it suggests ventricular pre-excitation (anomalous accessory pathway). In these cases, regular and wide QRS complexes without apparent atrial activity may lead to the mistaken diagnosis of ventricular tachycardia, with atrial and ventricular rate close to 250 bpm. AFL with 1:1 conduction can occur due to sympathetic stimulation or in the presence of an accessory pathway — especially if AV-nodal blocking agents are administered to a patient with WPW. AFL with 1:1 conduction is associated with severe hemodynamic instability and progression to ventricular fibrillation.
- ❑ 3:1 – $\frac{1}{3}$ – rate and it means 3 F waves per each QRS
- ❑ 4:1 – $\frac{1}{4}$ Higher-degree AV blocks can occur — usually due to medications or underlying heart disease — resulting in lower rates of ventricular conduction, e.g. 3:1 or 4:1 block.
- ❑ 6:1 – observed in cases with marked AV block. The differential diagnosis of conduction with a high rate of ventricular response should be done with complete AV block. A constant ventricular rate with FR intervals is present in the first case with fixed FR, contrary to the third degree or complete block with constant RR intervals accompanied by FR interval variations.

B) Irregular or variable AV conduction

C) **Absent:** with complete AV block – ventricular rate is usually low and independent from atrial rate.

•**Commentaries:** in flutter, ventricular rhythm could be regular or irregular, unlike AF where ventricular rhythm is nearly always irregular. The term “AV block” in the context of AFL is something of a misnomer. AV block is a physiological response to rapid atrial rates and implies a normally functioning AV node.

Another AFL Classification

This is based on the anatomical location and direction of the re-entry circuit. AFL is a macro-reentrant tachycardia and depending on the site of origin can be typical or atypical atrial. Electrocardiographic findings of AFL are "F" waves without an isoelectric line in between QRS complex. Electrical axis of the "F" waves can help to determine the origin of the AFL.

A. Typical or cavotricuspid isthmus(CTI) dependent AFL(Common, or Type I AFL): Involves the IVC & tricuspid isthmus in the reentry circuit. This rhythm originates in the RA at the level of the tricuspid valve annulus. Can be further classified based on the direction of the reentry circuit (Counterclockwise or clockwise):AFL

A. Anticlockwise Reentry: Commonest form of AFL (90% of cases). Retrograde atrial conduction produces:

- A. Inverted flutter waves in leads II,III, aVF
- B. Positive flutter waves in V1 – may resemble upright P waves.

B. Clockwise Reentry. This uncommon variant produces the opposite pattern:

- A. Positive flutter waves in leads II, III, aVF
- B. Broad, inverted flutter waves in V1

B. Atypical AFL(Uncommon, or Type II AFL)

- Does not fulfill criteria for typical AFL.
- Often associated with higher atrial rates and rhythm instability.
- Less amenable to treatment with ablation.

Classifications of atrial flutter (Dr Francisco G. Cossio)

A. From the right atrium

I. Isthmus dependent. HR between 240 to 339 bpm. Subtypes: with CCW and CW rotation.

- Type I AFL with CW rotation: In this case, F waves are positive in II, III and aVF.
- Type I AFL with CCW rotation: intercaval macro-reentry, CCW circular movement descending through the RA free wall, going through the cavo-tricuspid isthmus and ascending by the interatrial septum: mother circus wave. F waves are inverted in II, III and aVF. In both subtypes catheter ablation of the isthmus is the right procedure for treatment. The removal of conduction through the isthmus prevents the perpetuation of the circular motion, preventing AFL recurrence. Intercaval macro-reentry: CCW circular motion descending by the RA free wall going through the cavo-tricuspid isthmus and ascending by the interatrial septum: mother circus wave.
- Double wave reentry.
- Lower loop reentry with single or multiple pauses.

II. Nonisthmus dependent-

- Upper loop reentry.
- Scar reentry.
- Critical flutter circuits.

III. Surgical circuits: isthmus-dependent incisional scar and complex circuits.

IV. Left atrial circuits: they could be of the mitral annulus, related to scar and left membranous circuit.

B. From the LA

Typical Atrial Flutter

The re-entrant Mechanism

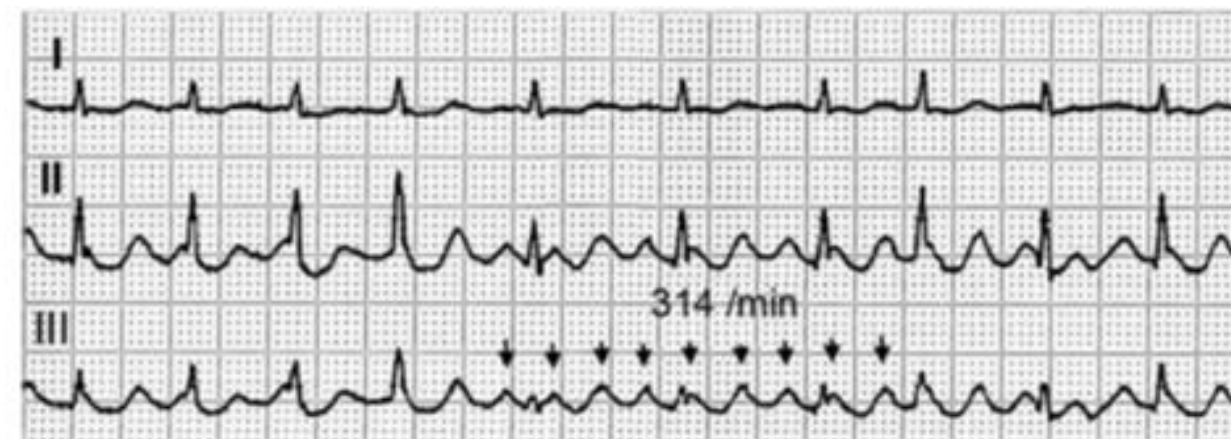
Typical flutter is the type of MRT most frequently found in the clinical setting. The mechanism is a large re-entrant circuit contained in the right atrium (RA) with passive activation of the LA.¹⁰ Activation courses superoinferiorly in the anterior and lateral RA and inferosuperiorly in the septal RA, with a critical inferior turning point between the tricuspid ring and IVC known as the cavotricuspid isthmus (CTI) (see Figure 2). An area of transverse conduction block in the posterior RA related to anisotropic conduction at the terminal crest^{11–14} and other structures¹⁵ forces activation toward the high RA so that the upper turning point can be at the RA roof or high in the posterior RA, depending of the size of the area of block.^{16–18} In either case, the CTI remains an obligatory passage for activation in the inferior RA. Either spontaneously or after programmed stimulation, re-entry may occur in the opposite (clockwise) direction – i.e. superoinferior in the septal wall and inferosuperior in the anterolateral wall – with the same zones of block in the posterior RA and obligatory passage through the CTI (see Figure 3).¹⁹ This reverse typical flutter is much less common clinically than the counter clockwise form, but the clinical manifestations are indistinguishable.

The ECG Patterns

Typical (counter clockwise) flutter is associated with the ‘common’ flutter pattern^{20,21} (see Figure 2): a regular continuous undulation with dominant negative deflections in inferior leads II, III and aVF, often described as a ‘saw tooth pattern’, and flat atrial deflections in leads I and aVL. Atrial deflections in V1 can be positive, biphasic or negative. The CL is usually 250–170 ms (rates 240–350/min). Reverse typical AFL (see Figure 3) usually shows rounded or bimodal positive deflections in inferior leads II, III and aVF, and a very characteristic bimodal negative wave in the shape of a W is seen in lead V1.^{21,22}

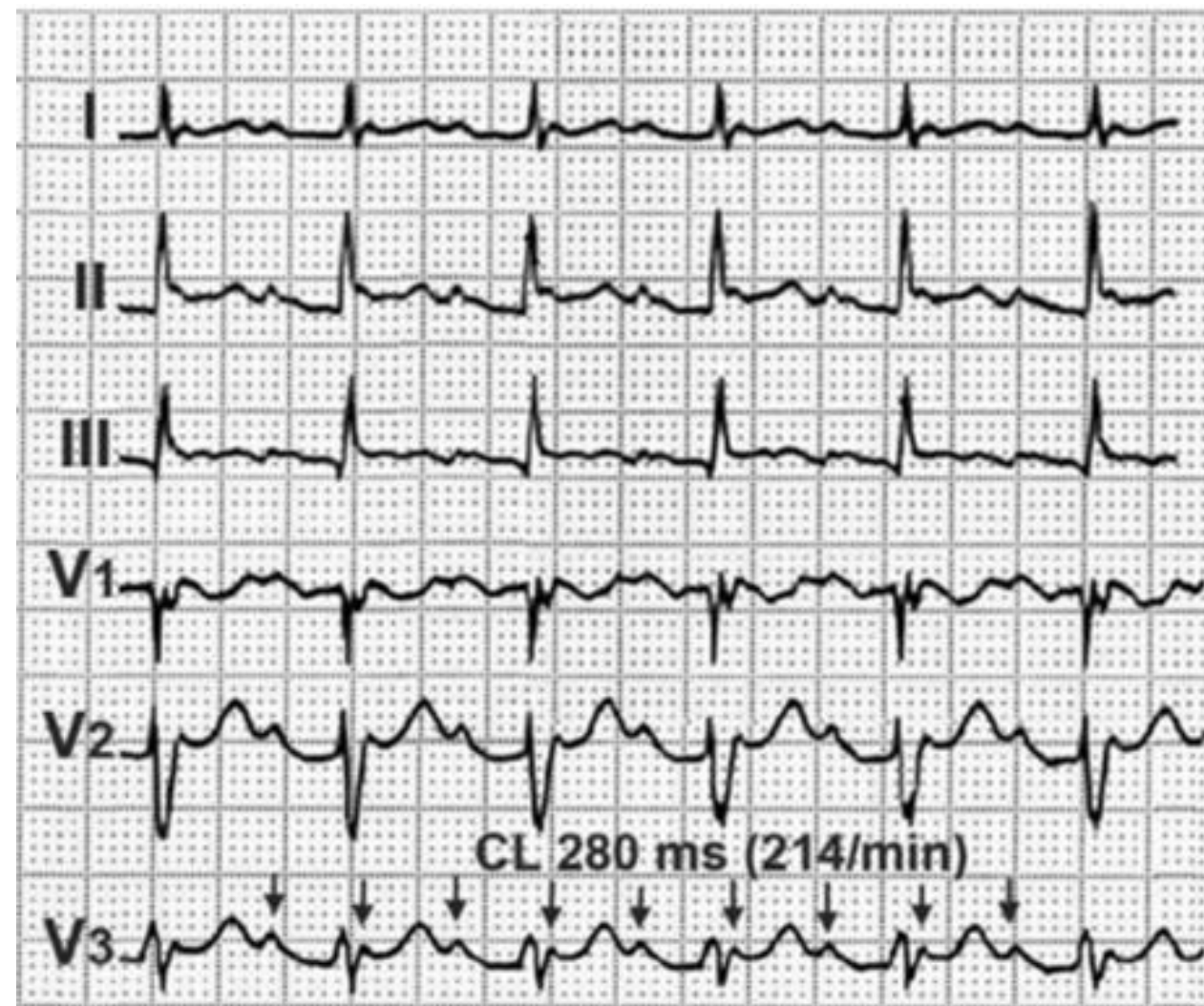
A frequent presentation of AFL is in patients treated with class IC AADs for AF. AFL rate may be slowed by the AAD to ≤ 200 /min, facilitating 1:1 AV conduction that due to the effect of the ADD results in aberrant intraventricular conduction and a wide QRS complex tachycardia (see Figure 4).

Figure 1 : The ECG pattern may not reflect the mechanism



ECG fulfilling classical flutter criteria (rate and lack of isoelectric baseline) in a case of focal tachycardia originating in the right superior pulmonary vein. Note the irregular ventricular rate in the face of regular atrial rate

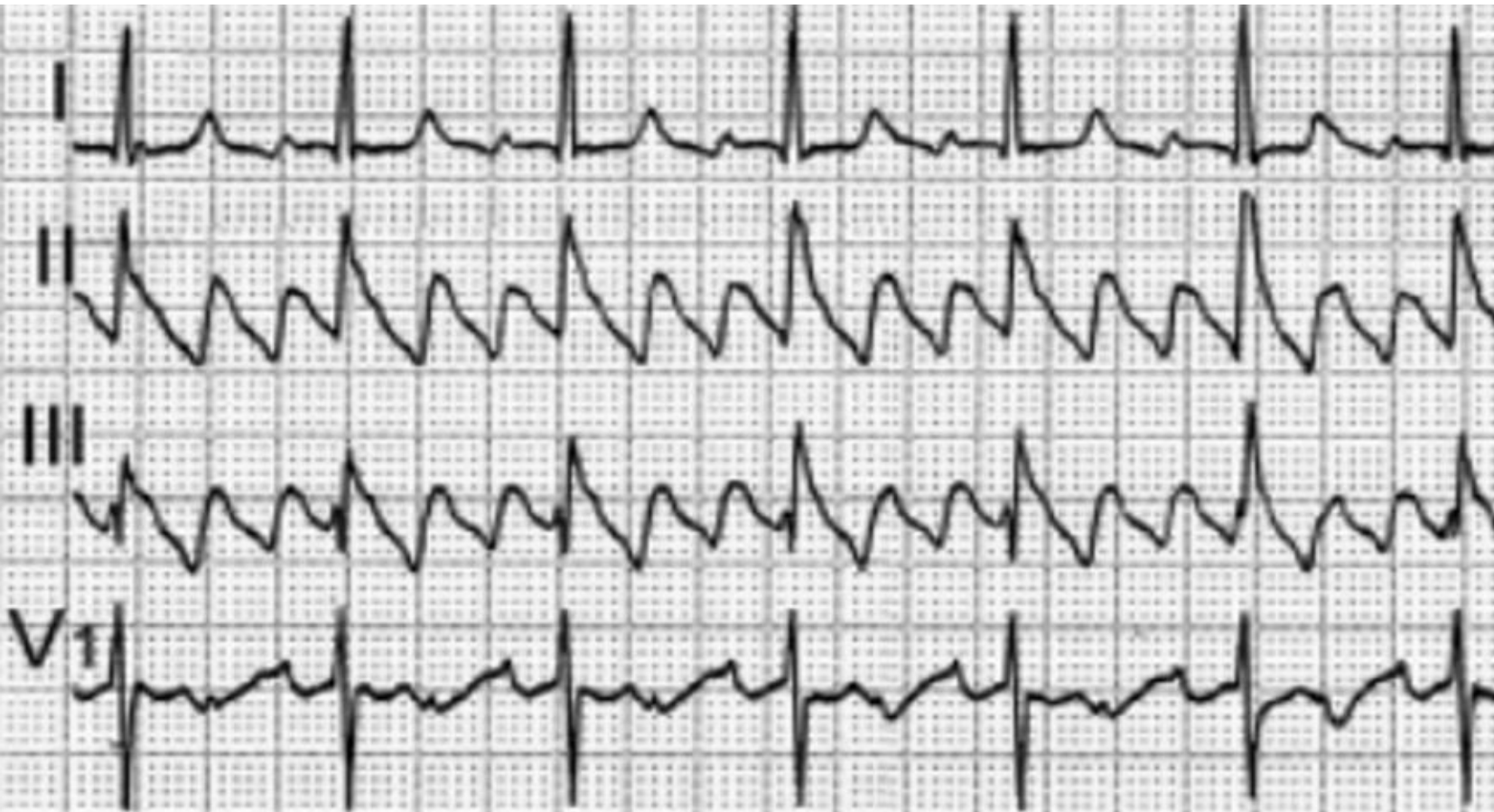
Figures from Francisco G Cossio.



ECG of a case of scar macro-reentrant tachycardia of the right atrium fulfilling the classical atrial tachycardia criteria. Discrete P wave separated by stable baseline are recorded between QRS complexes with 2:1 atrioventricular conduction.

Figure 2: ECG of a typical AFL

Atrial cycle length 220ms(271/min)



Type I CCW rotation, typical, common or classical flutter: intercaval macro-reentry: CCW circular motion descending by the RA free wall going through the cavo-tricuspid isthmus and ascending by the interatrial septum: mother circus wave. Atrial activity in leads II and III is a continuous undulation with a sharp negative deflection (“shadow-tooth pattern”). There is a biphasic deflection in V1, The schema are enlarged in order to show the basal walls. The terminal crest (TC) is shown as a vertically-dashed area reaching form the superior vena cava (SVC) to the inferior vena cava (IVC). The circular arrow shows typical CCW re-entrant activation. CS = Coronary Sinus ostium; CTI = Cavo tricuspid isthmus; PV = left pulmonary veins ostia.

CTI-dependent MRT is also frequent in patients with previous surgical atriectomies or atrial baffle procedures, or after LA ablation for the treatment of AF.^{23,24} In these cases ECG patterns are often atypical. Conversely, a typical flutter ECG may be generated by atypical re-entry circuits, independent of the CTI, including LA circuits.²⁵ Flutter wave morphology can be determined by activation outside the re-entry circuit, which would explain the often-difficult correlation between mechanism and ECG pattern.^{26,27}

It should be emphasized that ECG diagnosis is based on atrial deflections and not on ventricular (QRS) rate and rhythm. An irregular ventricular rhythm may be caused by changing degrees of AV nodal block (see *Figures 1A and 3*), including Wenckebach cycles. In doubtful cases it is essential to document atrial activity dissociated from ventricular activity by increasing AV block by vagal manoeuvres or intravenous adenosine. However adenosine can produce a rebound increase in AV conduction to 1:1^{28,29} and in some cases it can precipitate AF,³⁰ therefore it should only be used if necessary for diagnosis and resuscitation equipment should be readily available.

Pathogenesis of Typical Flutter

About 80 % of flutter patients are male,^{31,32} otherwise flutter occurs in clinical contexts very much like those observed in AF (in old age, hypertension, diabetes, chronic obstructive lung disease, excessive alcohol consumption³³ or during endurance sports practice).³⁴ In many cases AFL episodes alternate with AF episodes.^{32,35} Of those initially presenting with AFL as the only arrhythmia, 50 % develop AF during long-term follow-up.³⁶ This figure is not far from the proportion of patients developing AF in the long term after CTI ablation for the treatment of typical AFL.^{37,38} The thickness of the terminal crest^{39,40} and its capacity to block transverse conduction^{41–44} are increased in cases of AFL compared to AF. EPs have shown areas of low-voltage electrograms⁴⁵ and slow conduction in the RA – particularly at the CTI^{46–48} – to be a sign of arrhythmogenic myocardial remodeling. LA dilatation and abnormalities in its reservoir function have been described as predictors of the incidence of AFL or AF.⁴⁹

Clinical Presentation

Heart palpitations (feeling like your heart is racing, pounding, or fluttering, fast, steady pulse, shortness of breath, trouble with everyday exercises or activities, pain, pressure, tightness, or discomfort in chest, dizziness, lightheadedness, or fainting Flutter can be paroxysmal or persistent. Clinical presentation will depend in large part on the ventricular rate, which is most often around 120–150 due to 2:1 AV conduction, but in some cases 1:1 AV conduction leads to extremely high rates with poor clinical tolerance often requiring immediate intervention (see *Figure 5*). As in AF, loss of effective atrial contraction synchronized to ventricular contraction and rapid ventricular rates may result in hypotension, angina, heart failure, syncope or a feeling of palpitation making the patient seek medical attention.⁵⁰ Occasionally AFL can be asymptomatic for weeks or months and the sustained tachycardia can lead to systolic ventricular dysfunction and HF(tachycardiomyopathy).^{51,52} Ventricular function and atrial dilatation may recover after return to sinus rhythm,⁵³ but arrhythmia recurrence can again precipitate dysfunction with a risk of SCD.⁵⁴ LA appendage thrombi, spontaneous echo contrast and low appendage emptying velocities have been detected in cases of AFL submitted to cardioversion,⁵⁵ although to a lesser extent than in AF,⁵⁶ and normalization can occur days after return to sinus rhythm.⁵⁷ The frequency of systemic embolism in AFL is about one-third that in AF,^{36,58,59} but this difference disappears when both AFL and AF occur in the same patient.

Some medical conditions increase the risk for developing AFL. These medical conditions include:

Previous heart attack	Acquired or congenital valve abnormalities
High blood pressure	Thyroid dysfunction Hyperthyroidism
Recent upper chamber surgery	Alcoholism (especially binge drinking)
Heart failure	Chronic long Disease
Acute (serious) illness	Diabetes
Advanced age	Obesity

Complications of Atrial Flutter

The most common complication of AFL is the increased risk of embolic stroke and disability related to this event. Hemodynamically instability is also possible especially in patients with a rapid ventricular response. Chronicity and poor control of AFL can generate tachycardia induce cardiomyopathy and also can produce hard to control HF. The complications secondary to the use of antiarrhythmic drugs are related to the type of drug and underlying mechanism of the drug. AFL ablation complications also depend on the side of the origin of the AFL. Right-sided AFL is related to fewer complication rates than left-sided AFL ablation, and this is due to the need for creating a transeptal communication during the procedure to reach the LA foci of arrhythmia and perform the ablation. The transeptal puncture produces transient communication between the left and right chambers of the heart. There is also increasing the risk of embolic strokes with left-sided AFL ablation when compared with right side procedures. AFL itself is not life threatening. If left untreated, the side effects of AFL can be potentially life threatening. AFL makes it harder for the heart to pump blood effectively. With the blood moving more slowly, it is more likely to form clots. If the clot is pumped out of the heart, it could travel to the brain and lead to a stroke or heart attack. Without treatment, AFL can also cause a fast pulse rate for long periods of time. This means that the ventricles are beating too fast. When the ventricles beat too fast for long periods of time, the heart muscle can become weak and tired. This condition is called cardiomyopathy. This can lead to HF and long-term disability. Without treatment, AFL can also cause another type of arrhythmia AF. It is the most common type of abnormal heart rhythm. AFL arrhythmias can be dangerous because of complications caused by the heart condition. Some typical and atypical AFL complications include: *Tachycardia or rapid heartbeat (blood may not be pumped adequately resulting in decreased function or failure of various organs, especially the brain and heart muscle), Low blood pressure (hypotension), Thromboembolism, Stroke, Cardiomyopathy and Chronic AF.*

Prognosis

Prognosis of patients with typical AFL undergoing catheter ablation is good with a recurrence rate of less than 5%.

Persistence of AFL can generate tachycardia induce cardiomyopathy that is hard to control causing multiple hospitalizations due to decompensation.

Management of AFL

Rate control should be the first treatment step in symptomatic patients with a rapid ventricular rate. This is often a difficult goal in AFL, and even associations of the AV node blocking drugs (digoxin, β -blockers and calcium antagonists) may fail, making cardioversion to sinus rhythm necessary. Dofetilide and ibutilide, pure class III AADs, are effective for interrupting AFL with a small risk of QT prolongation and TdP. Class IA and IC AADs are relatively ineffective or have no effect^{60–65} and can be problematic if they cause a slow AFL rate ≤ 200 /min with 1:1 AV conduction and QRS widening that mimics VT (see *Figure 4*).^{66,67} Amiodarone may not be very effective at re-establishing sinus rhythm in the acute setting but it does help control ventricular rate.^{68,69}

Rhythm Control: Cardioversion

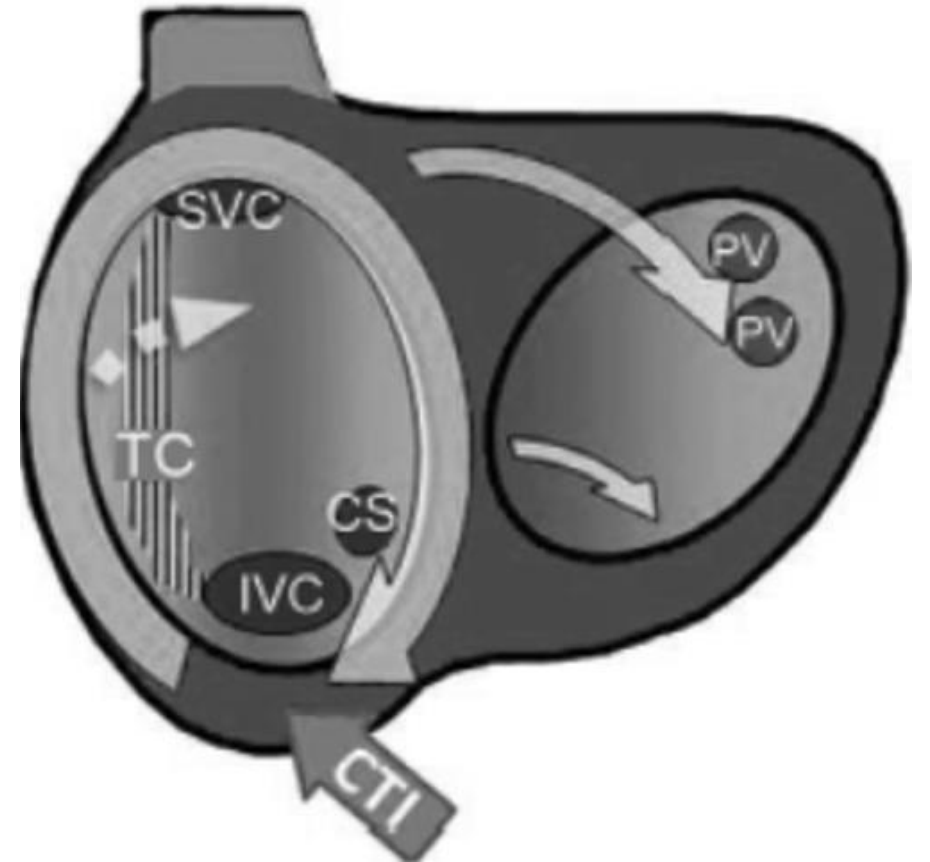
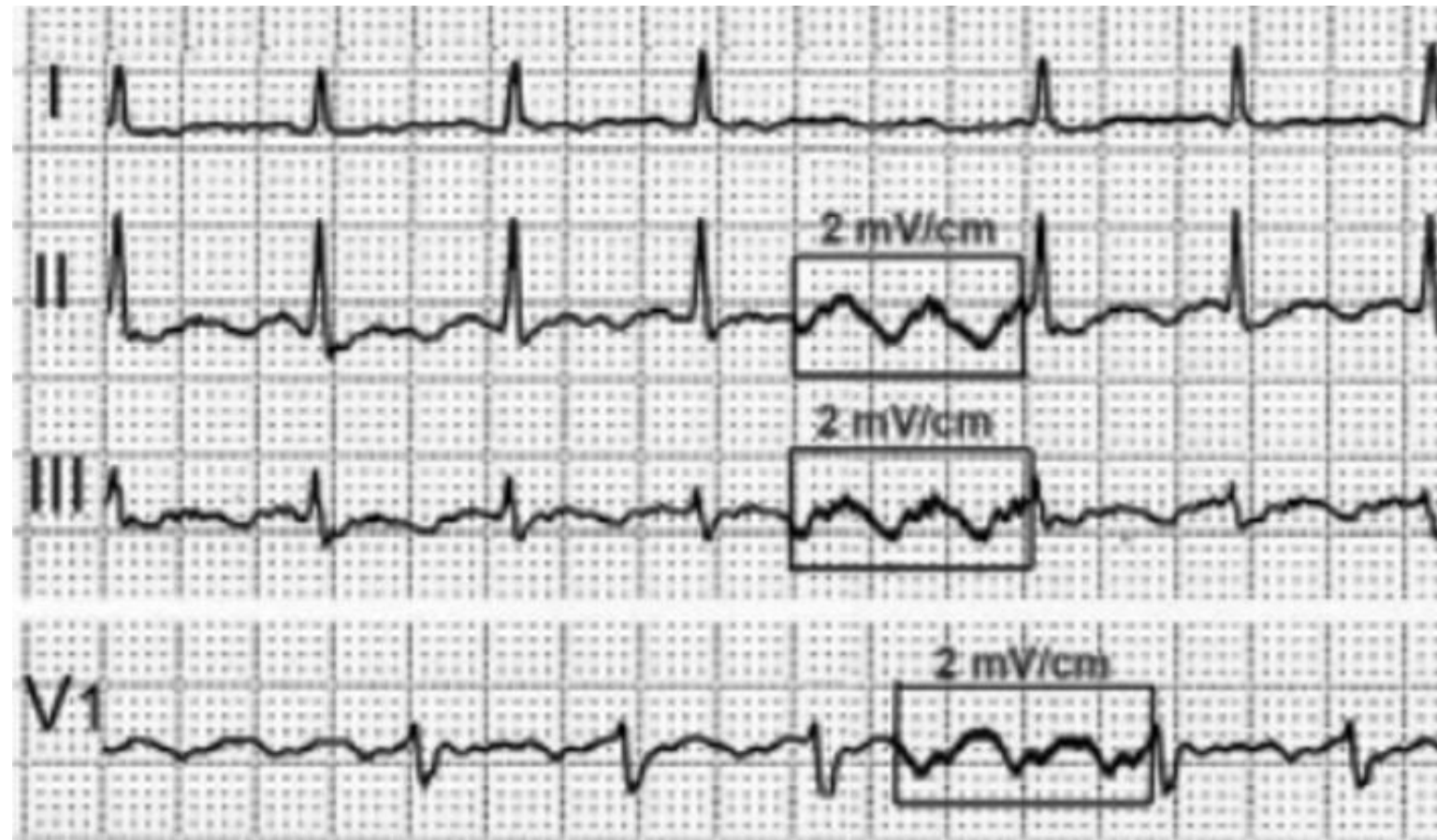
The poor results of rhythm control strategies in AF may not apply in flutter because of a lower recurrence rate after cardioversion in flutter, making a strategy of repeated cardioversions supported with AADs a clinically applicable option.^{70,71} Transthoracic direct-current cardioversion, under short-lasting sedation, is the quickest and most effective method to recover sinus rhythm in patients with flutter, with a lower energy delivery and higher success rate than in AF.^{72,73} In 50–80 % of cases flutter interruption

can be achieved by atrial pacing above the AFL rate through a transvenous catheter, through epicardial electrodes placed during cardiac surgery⁸ or by programming fast atrial rates in patients with atrial or dual-chamber pacemakers.⁷⁴ Pacing runs of 20–30 s are started at a rate 10 bpm higher than AFL, increasing in 10 bpm steps up to 400 bpm or until AFL is interrupted and sinus (or paced) atrial rhythm is established (*Figure 6*). Pacing may induce AF or a faster AFL (type II flutter),⁷⁵ probably as an expression of functional re-entry⁷⁶ that tends to return to baseline AFL or change to AF. AF induced by pacing usually results in a lower ventricular rate and, not infrequently, terminates spontaneously into sinus rhythm. AFL cardioversion by pacing is painless and can be done without sedation or anaesthesia.⁷⁷ It may be more effective in postoperative AFL⁷⁸ and in younger patients without structural heart disease or HF⁷⁹ and it may be facilitated by class I AADs.^{80,81} Atrial pacing can be applied from the oesophagus⁸² but the higher output stimulation necessary may be painful⁸³ and can occasionally induce VT.⁸⁴ The patient should be anticoagulated if cardioversion is planned, be it by direct current shock or pacing, whenever the duration of AFL is >48 h. Patients with AFL of longer duration should be anticoagulated for 3–4 weeks before cardioversion or LA thrombi should be ruled out by transoesophageal echocardiography. Following cardioversion, anticoagulation should be maintained for a minimum of 3–4 weeks in patients with low embolic risk. If high embolic risk is present, anticoagulation should be continued indefinitely, unless prolonged follow-up monitoring demonstrates an absence of recurrence.⁸⁵

Catheter Ablation: RFCA of the CTI is the standard treatment for typical AFL.⁸⁶ The full thickness of the CTI must be ablated along a line reaching from the tricuspid ring (TR) to the IVC. RFCA can be applied point-by-point, keeping the catheter tip stable for 45–60 s at each site or by dragging the catheter tip slowly from the TR to IVC during continuous RFCA delivery.⁸⁷ The endpoint of the procedure is complete, bidirectional CTI conduction block that has to be checked by recordings along the ablation line^{88,89} and differential pacing manoeuvres.⁹⁰ CTI block can be transient, so an observation period of 20–30 min is necessary to confirm success.^{91,92} Only when this endpoint is reached is flutter recurrence post ablation reduced to $\leq 10\%$. At mid-term (months) conduction may still resume in 15 % of cases, even in the absence of AFL recurrence.⁹³

Figure 3: Reverse (Clockwise) Typical Flutter

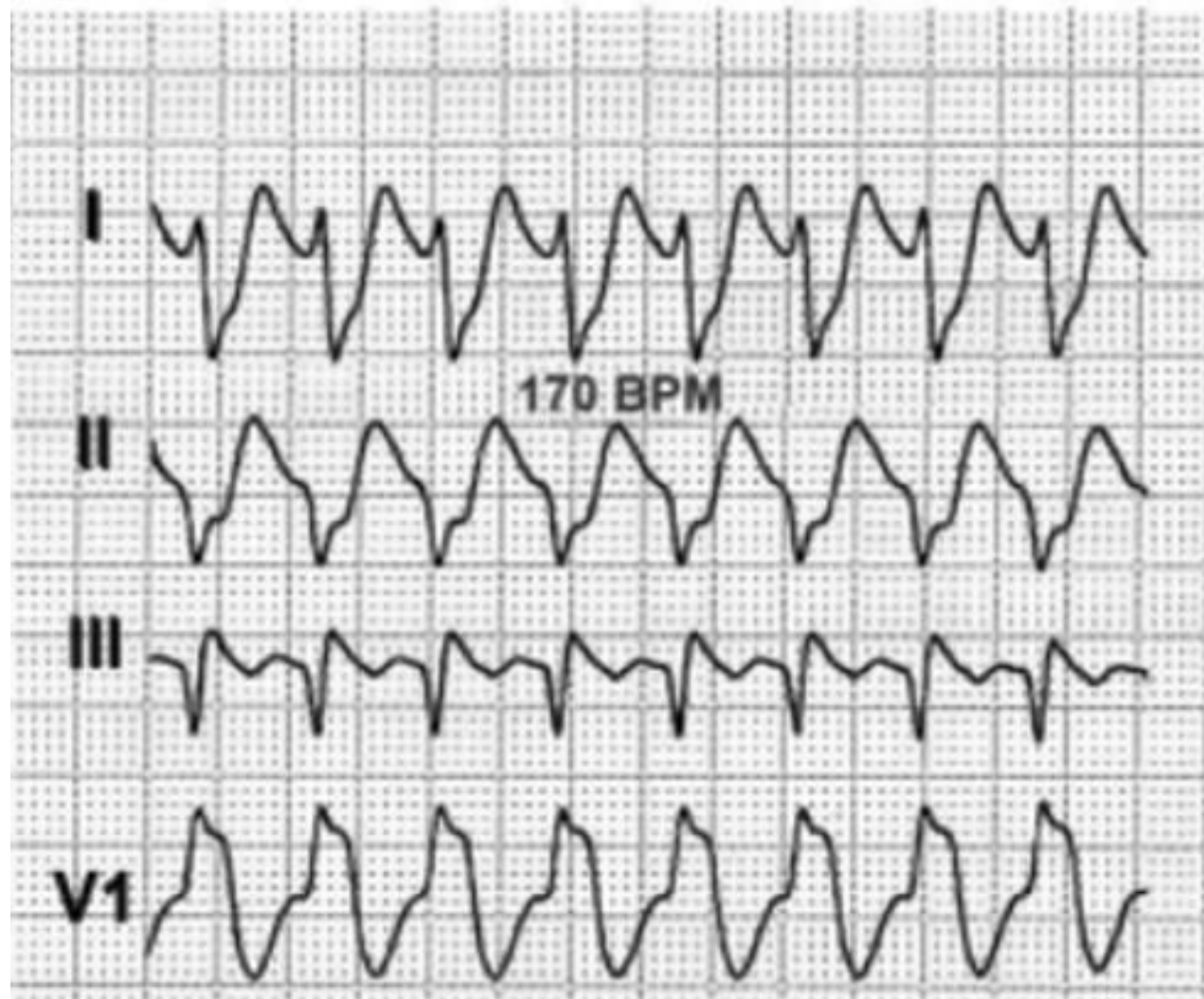
Atrial cycle length 240ms(250/min)



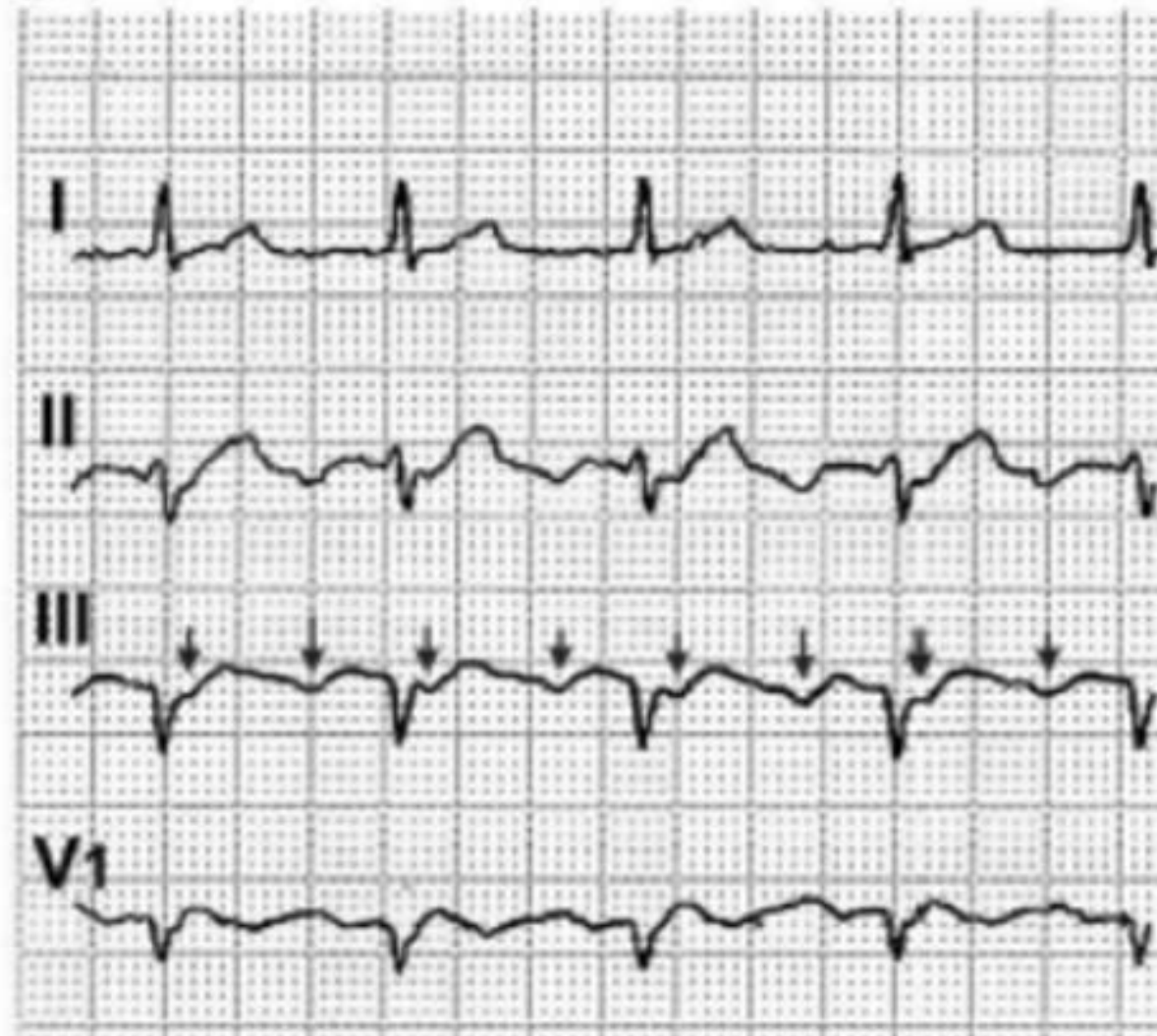
Note the dominant positive deflection in the flutter waves and the W-shaped deflection in V1,

Figure 4: one to one AV conduction in AFL Slowed by flecainide

A



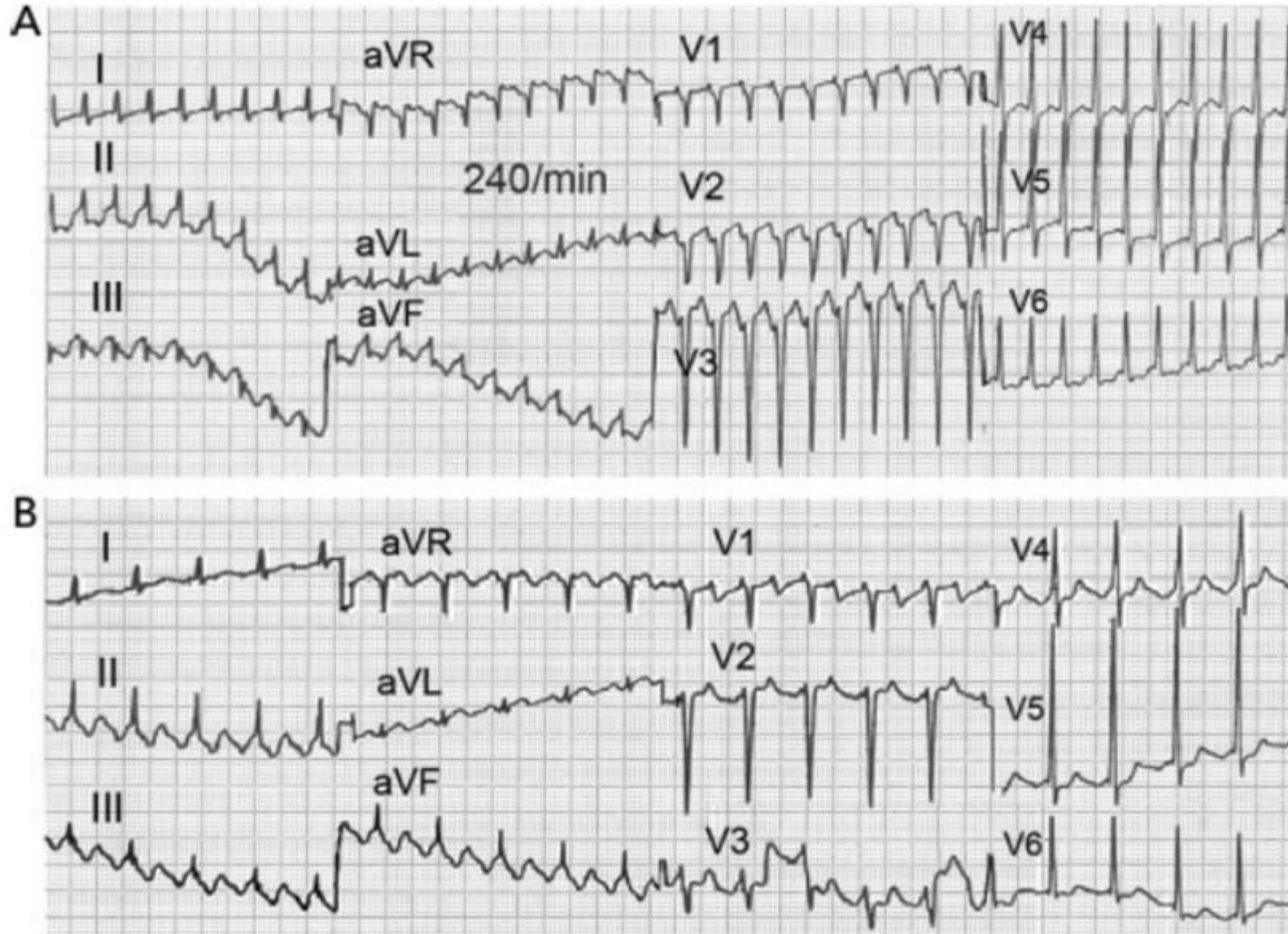
B



(A) Show AFL (170bpm) with 1:1 atrioventricular conduction and wide QRS complex (Right Bundle Branch block and superior axis) in a patient treated with flecainide for paroxysmal AF.

(B) A 2:1 atrioventricular block with slower ventricular rate and narrow QRS allows recognition of slow but typical flutter waves.

Figure 5: Spontaneous 1:1 AV Conduction in Typical Flutter



(A) Typical flutter with 1:1 atrioventricular conduction at 240 bpm spontaneously evolving to 1:1 atrioventricular conduction

(B) Typical flutter waves can be easily identified

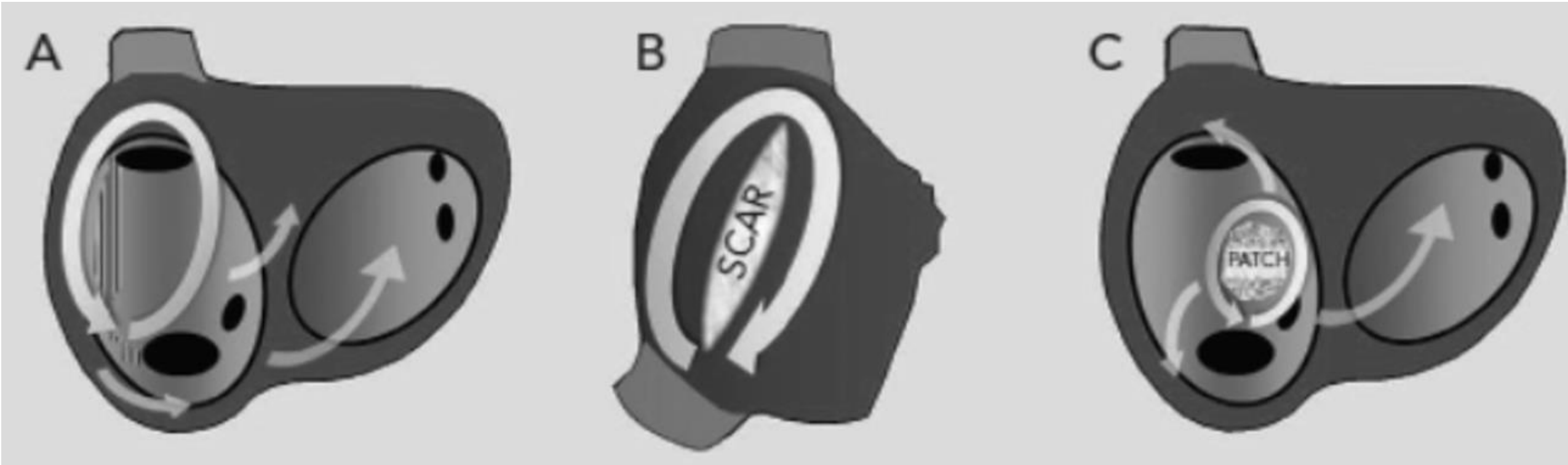
For radiofrequency ablation large tipped (8 mm electrode length)⁹⁴ or irrigated tip catheters⁹⁵ are more effective than standard tip (4 mm electrode length) catheters. Supporting sheaths may be used to obtain good contact force on the CTI. Radiofrequency application to the CTI can be quite painful and moderate sedation is often needed during the procedure. Cryoablation can also be effective for CTI ablation and has the advantage of being painless.⁹⁶ Resumption of CTI conduction at mid-term is more common after cryoablation than after radiofrequency ablation.

Figure 6: Flutter Cardioversion by Rapid Stimulation



ECG leads I, II and III in a patient with an implanted AAI pacemaker. Typical flutter is present at the onset. Rapid atrial asynchronous(AOO) pacing abolishes negative deflection in II and III and a positive P wave appears in I, When pacing stops flutter is not longer present and atrial demand placing resumes.

Figure 7: Atypical Right Atrial Macro-reentrant Circuits



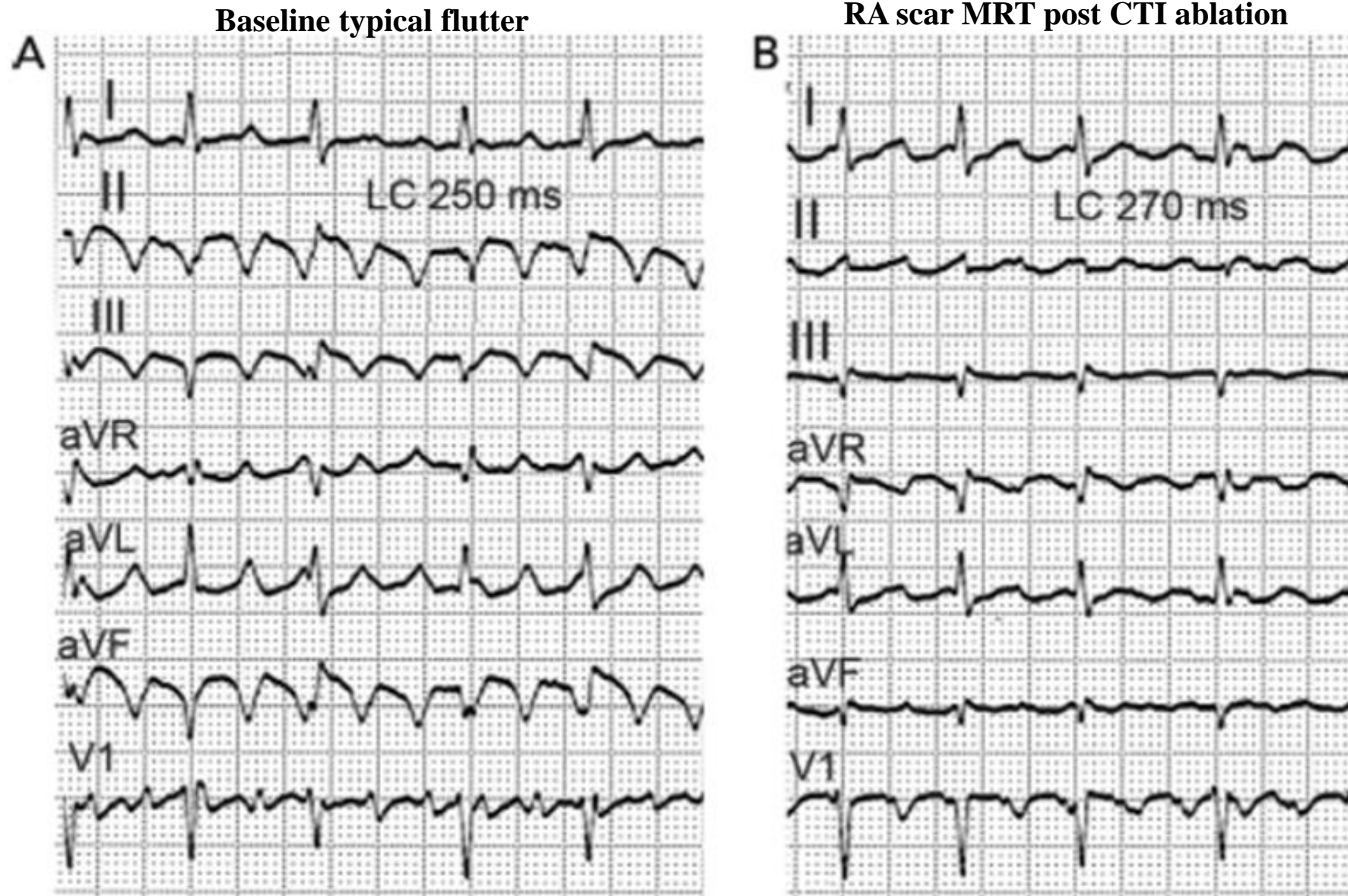
(A) Upper loop reentry(left anterior oblique view). Activation rotates around the superior vena cava (SVC) and the terminal crest(TC) but the cavotricuspid isthmus(CTI) is not part of the circuit

(B) Right lateral view of the right atrium showing slowing reentry around a surgical scar.

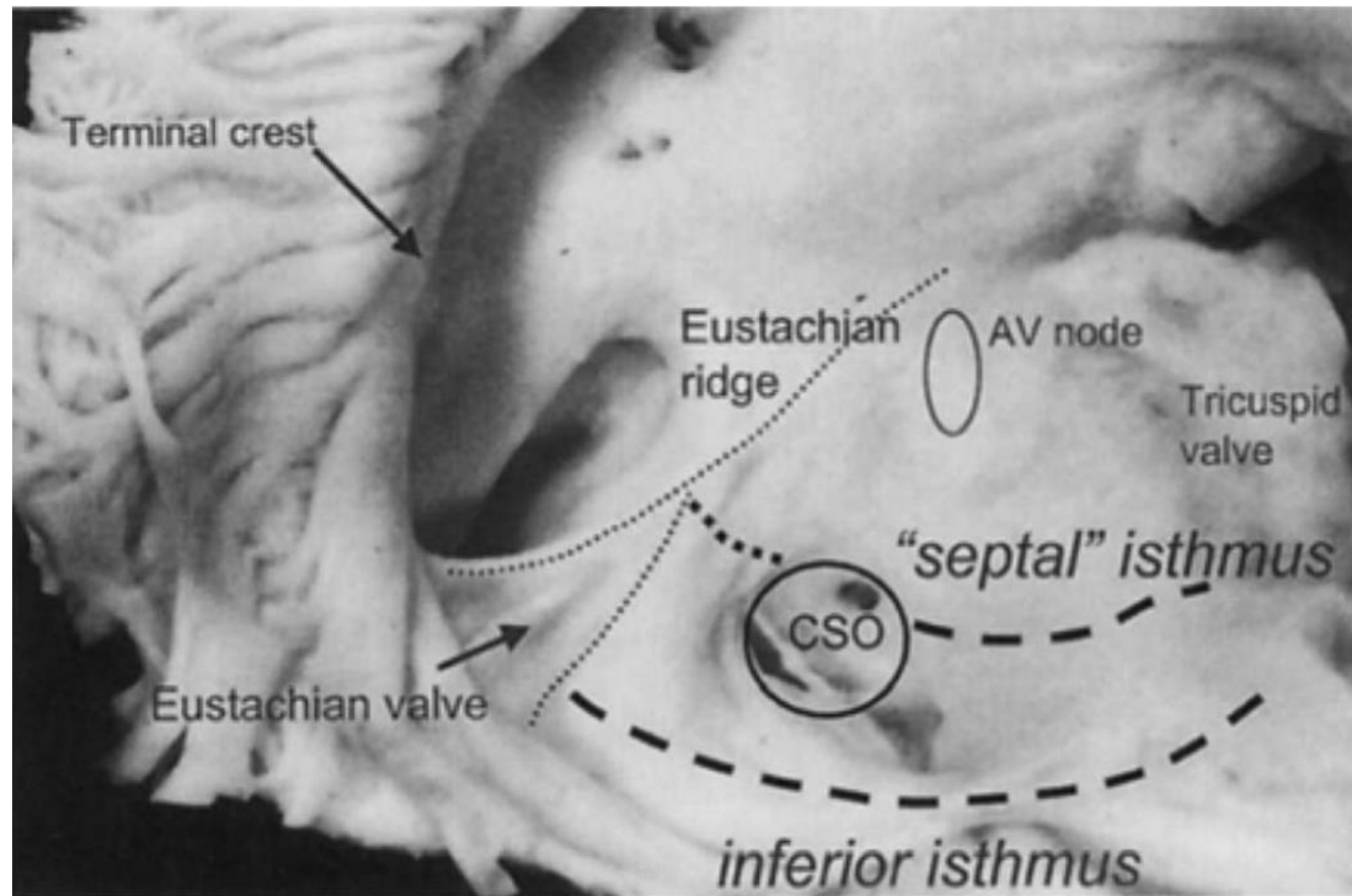
(C) Reentry around and atrial septal defect repair patch,

Modified from Cosio et al 2003 117.

Figure 8: Two Flutter Mechanism, typical and atypical, in the same patient



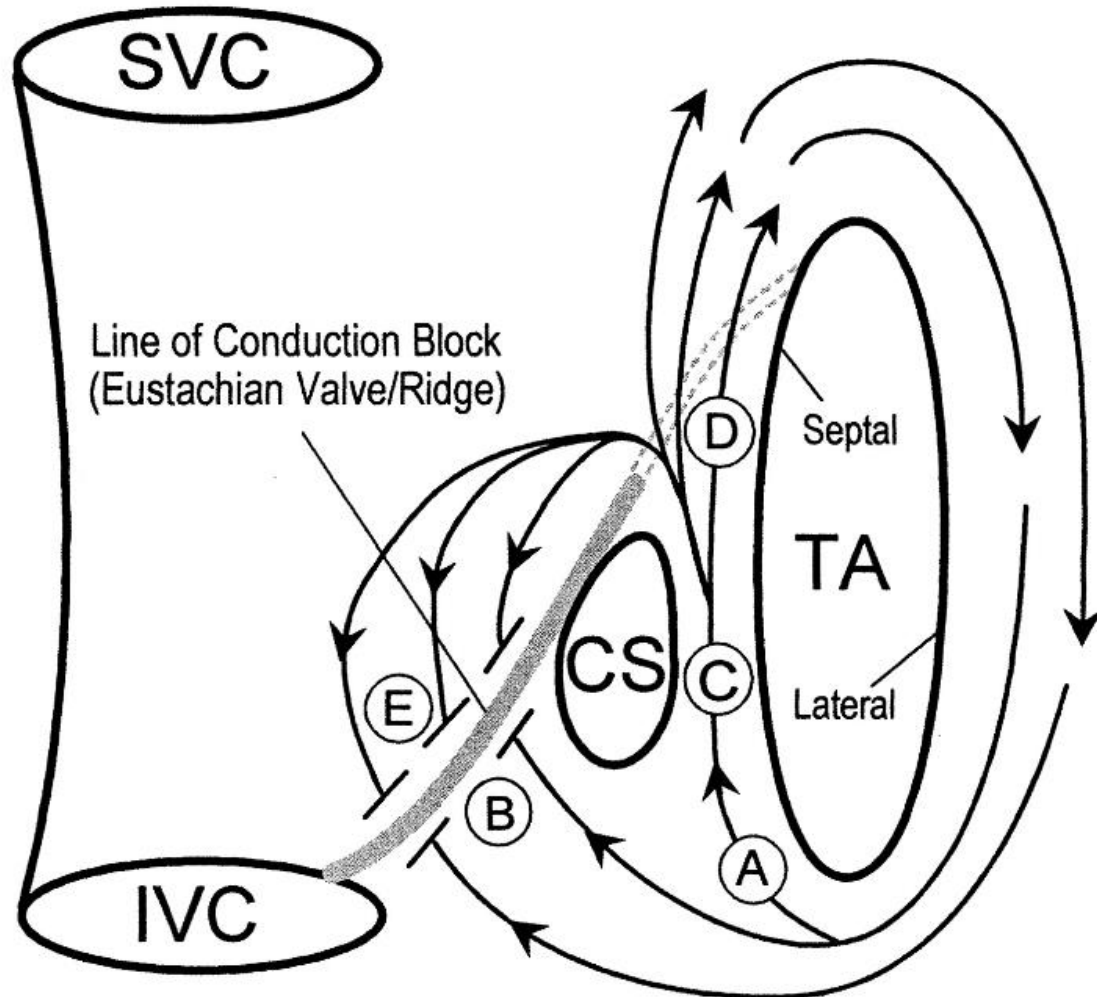
(A) ECG of typical AFL and (B) RA macro-re-entrant tachycardia in the same patient. The scar macro-re-entrant tachycardia was induced after cavotricuspid isthmus ablation. Note the cycle length prolongation and atrial wave morphology resembling clockwise AFL in (B).



RA anatomic structures of interest in cavotricuspid-isthmus-dependent AFL. The inferior isthmus is the target of RFCA in most electrophysiology laboratories. ¹⁴⁶

- ❑ **Terminal crest or “crista terminalis”(TC):** This structure represents the junction between the sinus venosus and the heart in the developing embryo. In the development of the human heart, the right horn and transverse portion of the sinus venosus ultimately become incorporated with and forms a part of the adult RA where it is known as the sinus venarum. The line of union between the RA and the RA appendage is present on the interior of the atrium in the form of a vertical crest, known as the crista terminalis or crista terminalis of His.¹⁴⁷ The crista terminalis is generally a smooth-surfaced, thick portion of heart muscle in a crescent shape at the opening into the RA appendage. On the external aspect of the RA, corresponding to the crista terminalis is a groove, the terminal sulcus or commonly known as sulcus terminalis. The crista terminalis provides the origin for the pectinate muscles.
- ❑ **Eustachian valve(EV):** a crescent-shaped fold of the lining membrane of the heart at the entrance of the inferior vena cava that directs the blood through the foramen ovale to the LA in the fetus but is rudimentary and functionless in the adult. Typical AFL results from RA reentry by propagation through an isthmus between the IVC and tricuspid annulus (TA). Nakagawa et al postulated that the eustachian valve and ridge (EVR) forms a line of conduction block between the IVC and CS ostium and forms a second isthmus (septal isthmus) between the TA and CS ostium. The EVR forms a line of fixed conduction block between the IVC and the CS; the EVR and the TA provide boundaries for the AFL reentrant circuit; and verification of a complete line of block between the TA and the EVR is a more reliable criterion for long-term ablation.

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Schematic of the RA, as viewed in the right anterior oblique projection, illustrates the hypothesized reentrant circuit in typical AFL (arrows) and the role of the eustachian valve and ridge in forming a line of conduction block between the IVC and the CS ostium. The eustachian valve/ridge and the tricuspid annulus (TA) form boundaries of a protected channel within the reentrant circuit, beginning with the posterior isthmus (between the TA and the IVC, site A) and ending with the septal isthmus (between the TA and the CS, site C). Dashed lines represent the anterior end of the tendon of Todaro, which has overlying right atrial myocardium. SVC indicates superior vena cava.

- ❑ **Eustachian ridge(EVR)** Amphibological remnant of the valve of the IVC. In fetal life, the EVR and associated EV direct inferior venal caval blood to the fossa ovalis. The CS and compact atrioventricular node are located between the ER and the tricuspid valve
- ❑ **The atrioventricular node, AV node (AVN)** is contained in the interatrial septum in the triangle of Koch that is defined anteriorly by the septal leaflet of the tricuspid valve, on inferiorly by the orifice of the CS and posteriorly endon of Todaro, a fibrous tendon within the atrial septal wall which extends superiorly from the fibrous Eustachial ridge to the central fibrous body. The compact AVN is located at the apex of the triangle, Many people have an extension of AV nodal tissue inferiorly along the tricuspid annulus that forms a slow AV nodal pathway that is used in atrio-ventricular nodal re-entrant tachycardias(AVNRT), the most common form of paroxysmal supraventricular tachycardia encountered in adults
- ❑ **Tricuspid valve: or right atrioventricular valve**, is on the right dorsal side of the mammalian heart, at the superior portion of the RV. The function of the valve is to prevent back flow (regurgitation) of blood from the RV into the RA during RV contraction: systole. Structure The tricuspid valve usually has three leaflets, named the anterior, posterior, and septal leaflets. Each leaflet is connected via chordae tendineae to the anterior, posterior, and septal papillary muscles of the RV, respectively. Tricuspid valves may also occur with two or four leaflets; the number may change over a lifetime. The tricuspid valve functions as a one-way valve that closes during ventricular systole to prevent regurgitation of blood from the RV back into the RA. It opens during ventricular diastole, allowing blood to flow from the RA into the RV. The back flow of blood is also known as regression or tricuspid regurgitation Tricuspid regurgitation can result in increased ventricular preload because the blood refluxed back into the atrium is added to the volume of blood that must be pumped back into the ventricle during the next cycle of ventricular diastole. Increased RV preload over a prolonged period of time may lead RV enlargement (dilatation),¹⁴⁹

□ which can progress to right HF if left uncorrected. Tricuspid regurgitation is not uncommon. Infected valves can result in endocarditis in intravenous drug users. Patients who inject narcotics or other drugs intravenously may introduce infection, which can travel to the right side of the heart, most often caused by the bacteria *S. aureus*. In patients without a history of intravenous exposure, endocarditis is more frequently left-sided.¹⁵⁰ The tricuspid valve can be affected by rheumatic fever, which can cause tricuspid stenosis or tricuspid regurgitation.¹⁵¹ Some individuals are born with congenital abnormalities of the tricuspid valve. Congenital apical displacement of the tricuspid valve is called Ebstein's anomaly and typically causes significant tricuspid regurgitation. Certain carcinoid syndromes can affect the tricuspid valve by producing fibrosis due to serotonin production by those tumors. The first endovascular tricuspid valve implant was performed by surgeons at the Cleveland Clinic.

□ **Coronary sinus orifice/ ostium(CSO):** The CS is a collection of veins joined together to form a large vessel that collects blood from the myocardium. It delivers less-oxygenated blood to the RA, as do the SVC and IVC. The name comes from the Latin corona, meaning crown, since this vessel forms a partial circle around the heart. The CS drains into the RA, at the CS orifice(CSO), and the blood refluxed back into the atrium is added to the volume of blood that must be pumped back into the ventricle during the next cycle of ventricular diastole. Increased RV preload over a prolonged period of time may lead RV enlargement (dilatation)

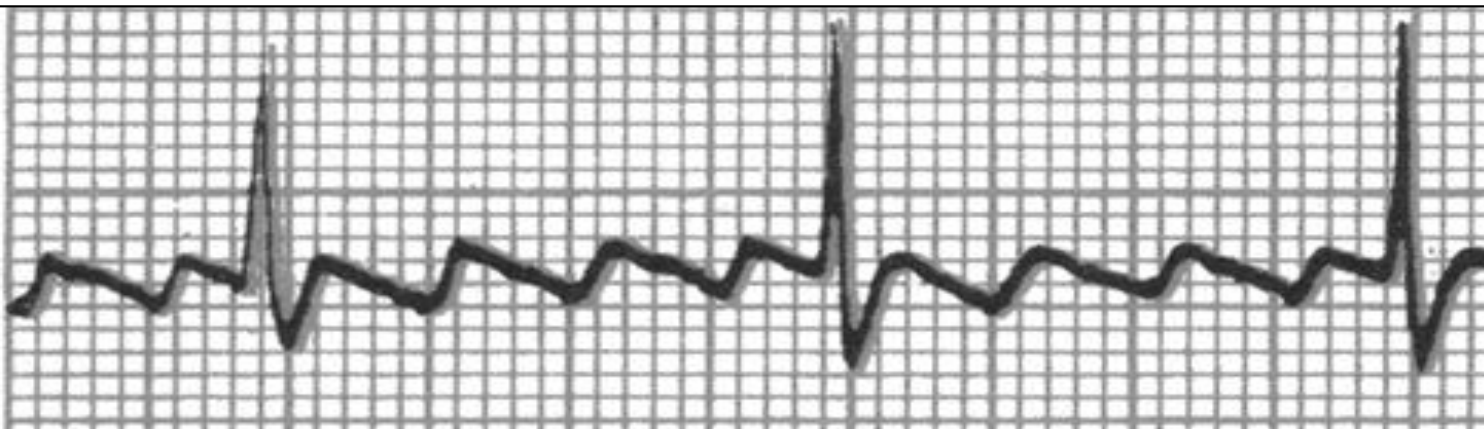
□ opening between the IVC and the right atrioventricular orifice or tricuspid valve. It returns blood from the heart muscle, and is protected by a semicircular fold of the lining membrane of the auricle, the valve of CS (or valve of Thebesius). The sinus, before entering the atrium, is considerably dilated - nearly to the size of the end of the little finger. Its wall is partly muscular, and at its junction with the great cardiac vein is somewhat constricted and furnished with a valve, known as the valve of Vieussens consisting of two unequal segments. The CS starts at the junction of the great cardiac vein and the oblique vein of the LA. The end of the great cardiac vein and the CS is marked by the Vieussens valve. The CS runs transversely in the left atrioventricular groove on the posterior side of the heart. It is the distal portion of the great cardiac vein feeding into the right atrium. The valve of the coronary sinus is on the posterior, inferior surface of the heart, medial to the IVC opening, just superior to the septal leaflet of the tricuspid valve. The CS valve is also known as the Thebesian valve.

□ **“Septal” isthmus:** The cavotricuspid isthmus (CTI) is a part of the RA located between the IVC ostium and the tricuspid valve. The CTI is a concept that was first introduced by Cosio et al;¹⁵² this region of the heart plays an essential role in the AFL circuit. Since then, this small, quadrilateral-shaped area of the RA has served as a target for catheter-directed ablation, which has become the method of choice for treating AFL.¹⁵³ Despite very high success rates and almost no complications,¹⁵⁴ ablation of the CTI can be extremely difficult in some patients with atypical anatomical conditions; the CTI anatomy is complex and associated with a significant inter-individual variability [4–6]. The verification of

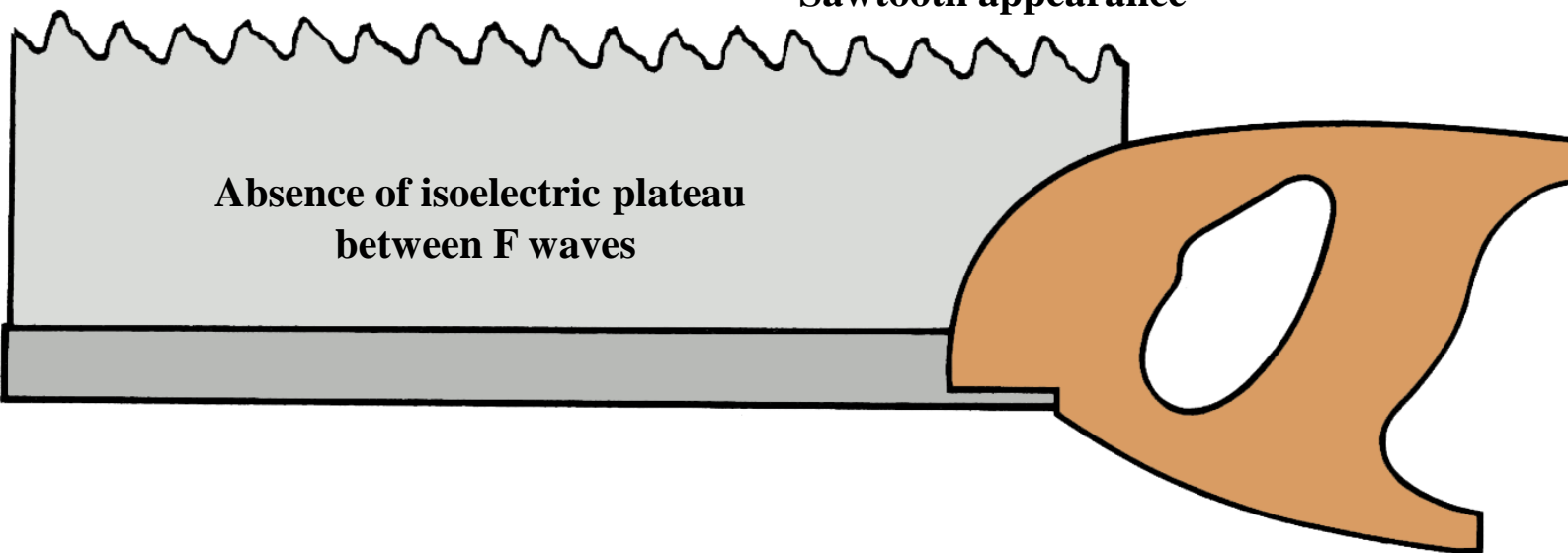
- ❑ complete isthmus conduction block with atrial multipolar mapping is an effective strategy to assess electrophysiological success and absence of late recurrence in common AFL ablation.¹⁵⁵
- ❑ **Inferior isthmus or The inferior right atrial isthmus:** Although linear ablation of the RA isthmus in patients with isthmus-dependent AFL can be highly successful, recurrences and complications occur in some patients. To provides morphological details for a better understanding of the structure of the isthmus is crucial. Cabrera et al. examined the isthmic area in 30 heart specimens by dissection, histology, and scanning electron microscopy. This area was bordered anteriorly by the hinge of the tricuspid valve and posteriorly by the orifice of the IVC. With the heart in attitudinal orientation, they identified and measured the lengths of three levels of isthmus: paraseptal (24 +/- 4 mm), central (19 +/- 4 mm), and inferolateral (30 +/- 3 mm). Comparing the three levels, the central isthmus had the thinnest muscular wall and the paraseptal isthmus the thickest wall. At all three levels, the anterior part was consistently muscular whereas the posterior part was composed of mainly fibro-fatty tissue in 63% of hearts. The RCA was less than 4 mm from the endocardial surface of the inferolateral isthmus in 47% of hearts. Inferior extensions of the AVN were present in the paraseptal isthmus in 10% of hearts, at 1-3 mm from the endocardial surface.¹⁵⁶

Characteristics of atrial activation in atrial flutter

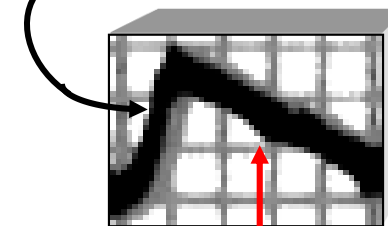
Waves with sawtooth or picket fence appearance called F waves, with rate between 250 and 350 bpm, better observed in the inferior wall and V_1 with slow descending ramp and rapid ascending ramp. These waves seem an inverted P, followed by ascending ramp: Tp waves.



Sawtooth appearance



Atrial depolarization



Atrial repolarization



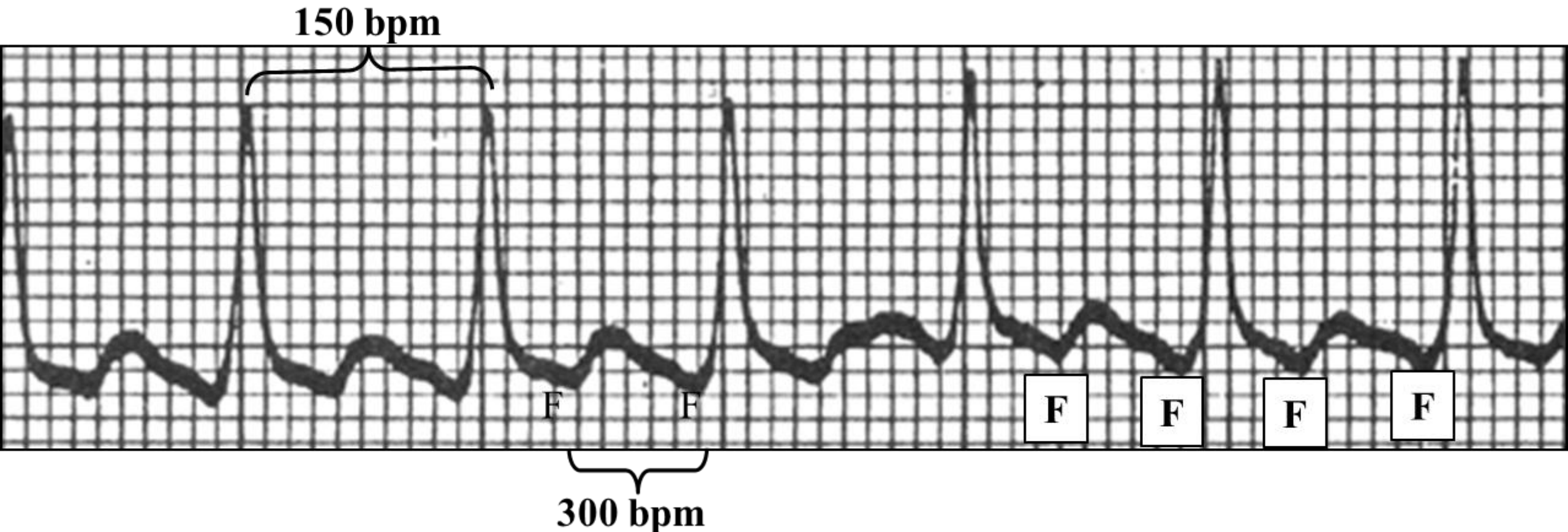
Regular AFL with 1:1 AV conduction



1:1 AV conduction (rare) is a medical emergency. Ventricular rate close to 300 bpm should be treated immediately. 1:1 AV conduction could be found in the following scenarios:

- Preexcitation of the WPW type because the stimulus is conducted in anterograde fashion by the anomalous pathway;
- AFL secondary to hyperthyroidism;
- Pediatric group flutter;
- Subsequent to the initial use of class IA drugs (quinidine, procainamide or disopyramide) by atrial slowing and by vagolytic anticholinergic action in the AV junction that this set of drugs causes, especially if the drugs were used without previously administering digoxin, calcium antagonists or β -blockers with the aim of controlling the rate of ventricular response.

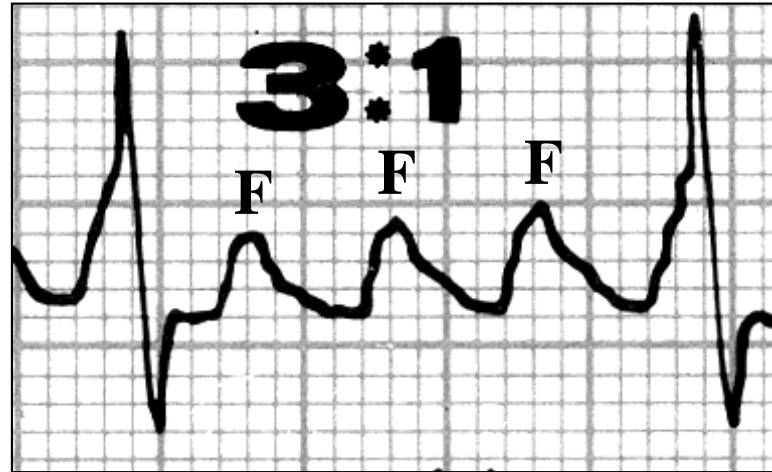
Regular AFL with 2:1 AV conduction



The most frequent ratio in untreated patients is 2:1 with atrial and ventricular rate of 300/150 bpm respectively. This ratio is due to physiological interference in the junction. If the ventricular response rate is regular and constant (E.g. always 2:1) the FR interval will also be so, varying between 260 ms to 460 ms.

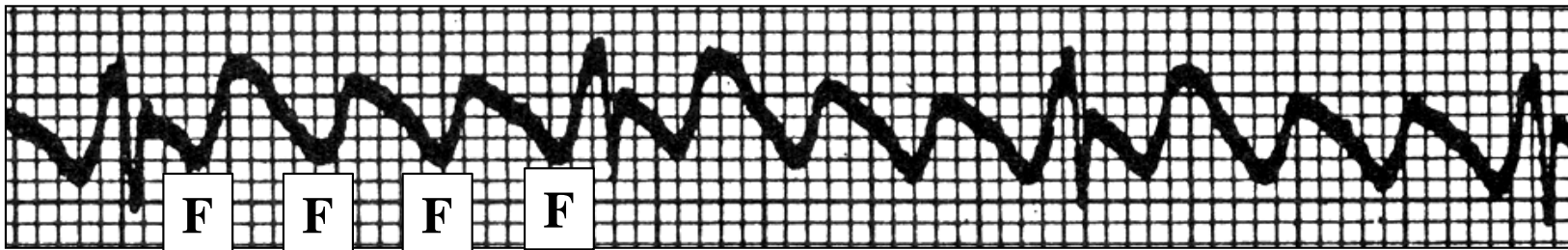
If the rate of F is 240 bpm, in 2:1 flutter, ventricular rate will be 120 ppm in the arterial pulse.

Regular AFL with 3:1 AV conduction



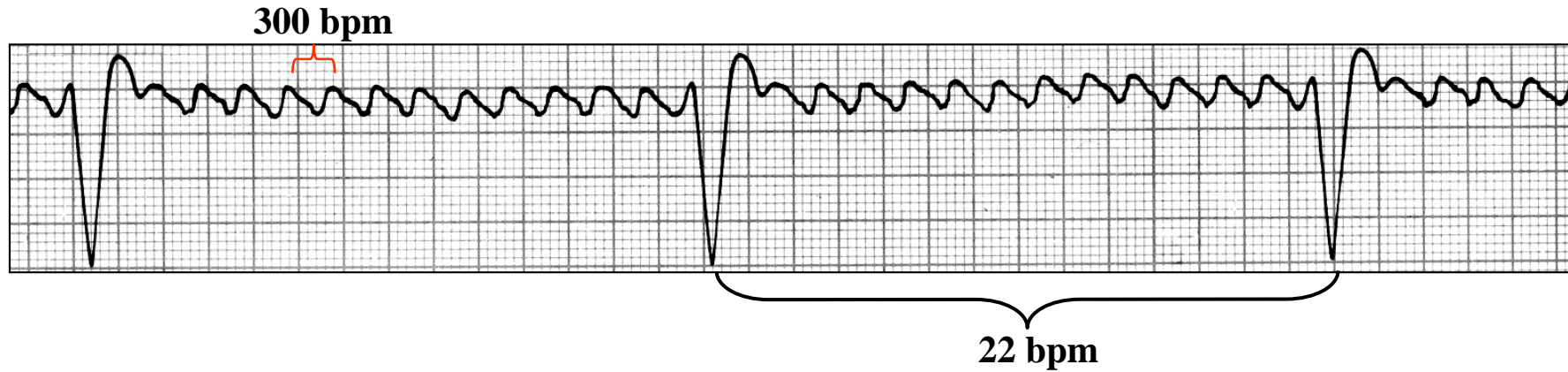
If the rate of F is 240 bpm, in 3:1 flutter, ventricular rate will be 80 ppm in arterial pulse, i.e. within what is considered a normal HR.

Regular AFL with 4:1 AV conduction



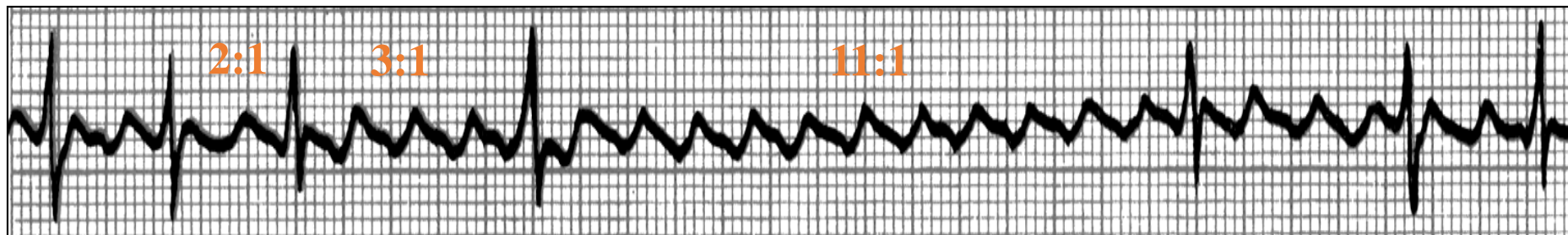
If the rate of F is 240 bpm, in 4:1 flutter, ventricular rate will be 60 ppm in arterial pulse; i.e. within what is considered a normal HR.

AFL with complete AV block

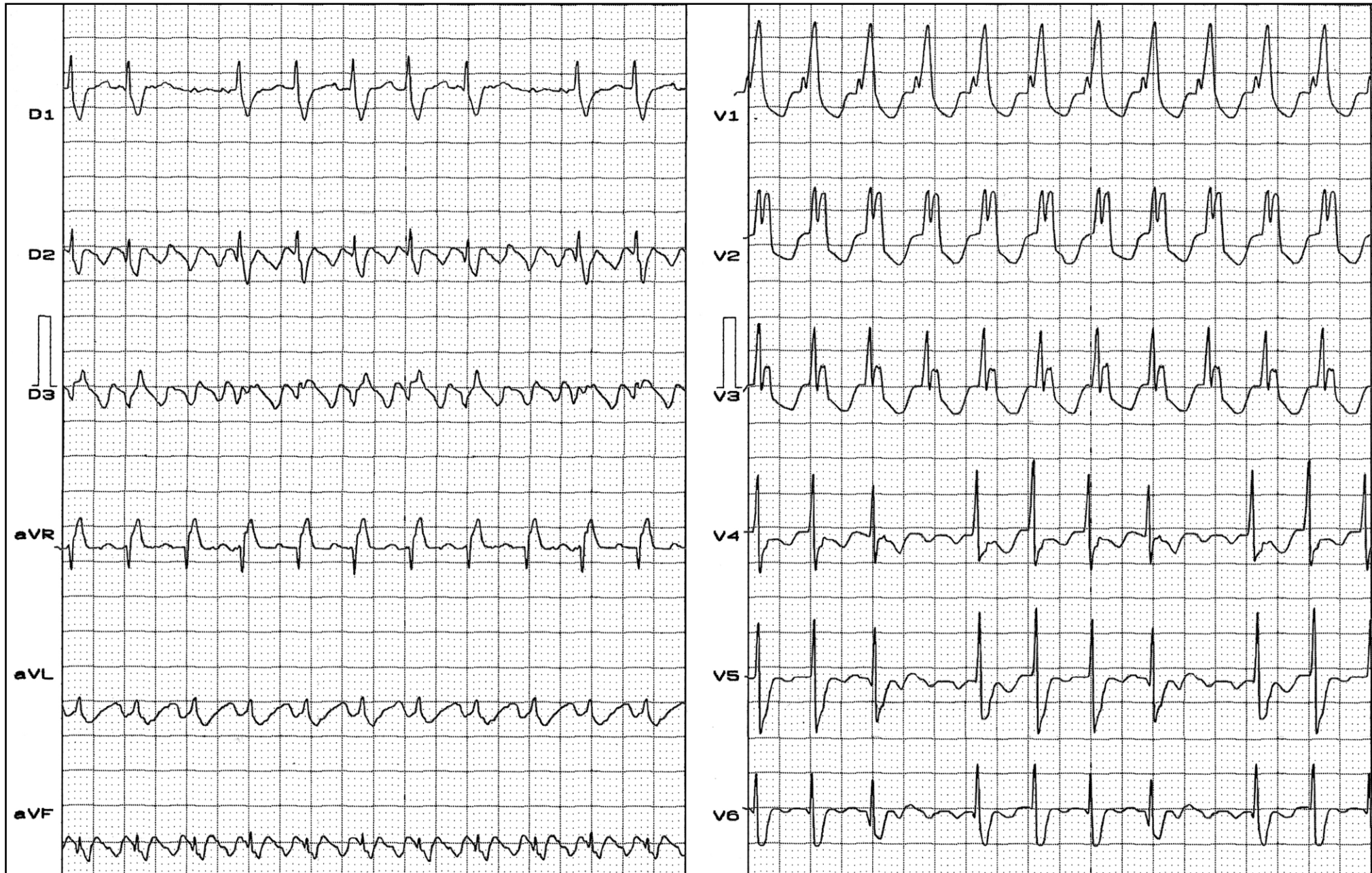


Atrial heart rate of 300 bpm. The stimulus does not conduct to the ventricles. Very low, regular ventricular heart rate, regardless of atrial activity.

AFL with irregular AV conduction



AFL with irregular AV conduction



AFL with 2:1 and 4:1 AV conduction. Atrial rate of 330 bpm. QRS complexes with complete right bundle branch block pattern.

Complications are infrequent (around 1 %)⁹⁷ and are usually limited to vascular access; however, extension of ablation to the septal RA can result in AV block when using radiofrequency^{98,99} and cryoablation.⁹⁶ Damage to the right coronary artery is rare but can result in myocardial infarction in some cases with pre-existing coronary atherosclerotic lesions.^{100,101} Cardiac perforation secondary to tissue disruption by boiling with audible ‘pops’ can occur when high energy is delivered with large-tip catheter-electrodes.^{102,103} A one in 1,000 incidence of cerebrovascular accidents is reported.⁹⁷ The recurrence rate of typical flutter is ≤ 10 % after successful CTI ablation and definitive flutter suppression can be attained by a second procedure in recurrent cases. The main problem is the incidence of AF after ablation, which can be 30–50 % in the long term (>3 years).^{38,104–106} More recent reports have reported even higher incidences of AF.¹⁰⁷ AF is more likely in patients who have had AF episodes before flutter ablation and in those with dilated LA. The efficacies of CTI ablation and AADs have been compared for the treatment of typical flutter in two randomised studies.^{71,108} CTI ablation proved to be advantageous in terms of better quality of life, less hospitalisation and lower flutter recurrence, but the incidence of AF did not improve in both studies. In patients with flutter appearing during AAD treatment of AF, CTI ablation may help stabilise sinus rhythm¹⁰⁹ at the same time allowing the use of class IC AADs without the risk of slow flutter with 1:1 AV conduction. Direct AF ablation has been proposed by some groups as a complement to CTI ablation in patients with both arrhythmias,¹¹⁰ and even in those with only flutter,¹¹¹ to reduce the later incidence of AF. CTI ablation of typical flutter is associated with a favourable prognosis; however, given the higher incidence of severe complications in AF ablation, patients should be carefully selected for this strategy.¹¹²

There have been no randomised studies published on the risk–benefit ratio of anticoagulation after successful ablation of typical flutter with no associated AF. Prolonged monitoring of atrial rhythm under anticoagulation would appear to be indicated in patients with a high embolic risk score before anticoagulation is discontinued.

Summary: Long-term Strategy

A first and well-tolerated episode of flutter terminated spontaneously or by electrical cardioversion or AAD can be followed clinically with or without AAD coverage. A recurrence rate of around 50 % can be expected in these patients. Amiodarone, dronedarone or sotalol are indicated to prevent recurrences after cardioversion, while class IC AADs should be used cautiously or avoided. Catheter ablation is more effective for the prevention of recurrence and is a better alternative than maintenance AAD, especially in patients with depressed systolic ventricular function. A rate control strategy could be adequate for asymptomatic elderly patients with no deterioration of systolic ventricular function; however, cardioversion in active patients without apparent functional limitation will often improve a patient's well-being and functional capacity. Chronic anticoagulation should be considered on the bases of embolic and haemorrhagic risk scores, along the same lines as for AF.⁸⁵

Progression to AF after successful CTI ablation for typical flutter underlines the presence of an atrial arrhythmogenic substrate that can evolve in many cases, even in the absence of flutter recurrence. The diagnosis of flutter should thus be complemented with a clinical profile of AF risk factors that could guide 'upstream therapy'. Recent reports have shown that physical fitness programmes and vigorous treatment of obesity, metabolic syndrome and sleep apnoea can result in a significant reduction in AF recurrence in patients whether or not they undergo AF ablation,^{113–116} and this may be applicable to flutter given the very similar risk factor profiles.

Atrial or AV pacing may be necessary in patients in whom conversion to sinus rhythm reveals sick sinus syndrome. In these cases, a device capable of overdrive atrial pacing should be implanted.

In the absence of direct evidence of the risk–benefit ratio of chronic anticoagulation in flutter, present recommendations for anticoagulation are the same as for AF, carefully balanced against bleeding risk scores.⁸⁵

Atypical Flutter/Macro-re-entrant Tachycardia

The term atypical has been applied to rapid atrial tachycardias with ECG patterns differing from the typical and reverse typical flutter described above, and also to re-entrant tachycardias with circuit configuration different from the typical RA flutter circuit, even if they have an ECG pattern similar to typical flutter. ECG waveform can be determined by activation of the atrial myocardium outside the re-entry circuit^{26,27} and the precise mechanism generating atypical ECG flutter patterns can only be determined by mapping and pacing EP studies.¹¹⁷ Atypical flutter is often associated with structural heart disease, especially in patients that have undergone cardiac surgery or extensive catheter ablation for the treatment of AF. In these cases focal (centrifugal) mechanisms can coexist with MRT with indistinguishable ECG patterns, making EP study the only way to unveil the mechanisms causing the arrhythmia and plan ablation when clinically indicated.^{118,119}

Right Atrial Macro-re-entrant Tachycardias

MRT circuits turning around the superior vena cava and part of the terminal crest, not involving the CTI, can occasionally be found in patients without surgical atriotomy (see *Figure 7*). In patients with RA surgical atriotomy, the scar can become the centre of the MRT, but the small incisions used to cannulate the superior vena cava and IVC are rarely arrhythmogenic by themselves. Lateral wall, superoinferior atriotomy is a frequent cause of atypical (non-CTI-dependent) MRT. ECG pattern may or may not be atypical (see *Figures 1B and 8*) and it is not unusual for two or more ECG patterns to alternate, as CTI-dependent typical flutter often coexists with the scar MRT (see *Figure 8*).²³ A patch closing an interatrial septal defect can also become the centre of a MRT circuit (see *Figure 7*). Atypical flutter or MRT related to surgery often occurs years after the procedure, suggesting that an atrial remodelling process is necessary to make re-entry stable around the surgical obstacles in many cases. In patients not subjected to cardiac surgery or AF ablation, unexcitable areas of low voltage, most often located in the lateral RA,^{120,121} can become the central obstacle sustaining atypical MRT. These areas are probably related to chronic atrial overload or cardiomyopathy and they are often considered to be fibrotic myocardium but there is no direct evidence of their histology. Low-voltage areas are most prevalent in the RA after

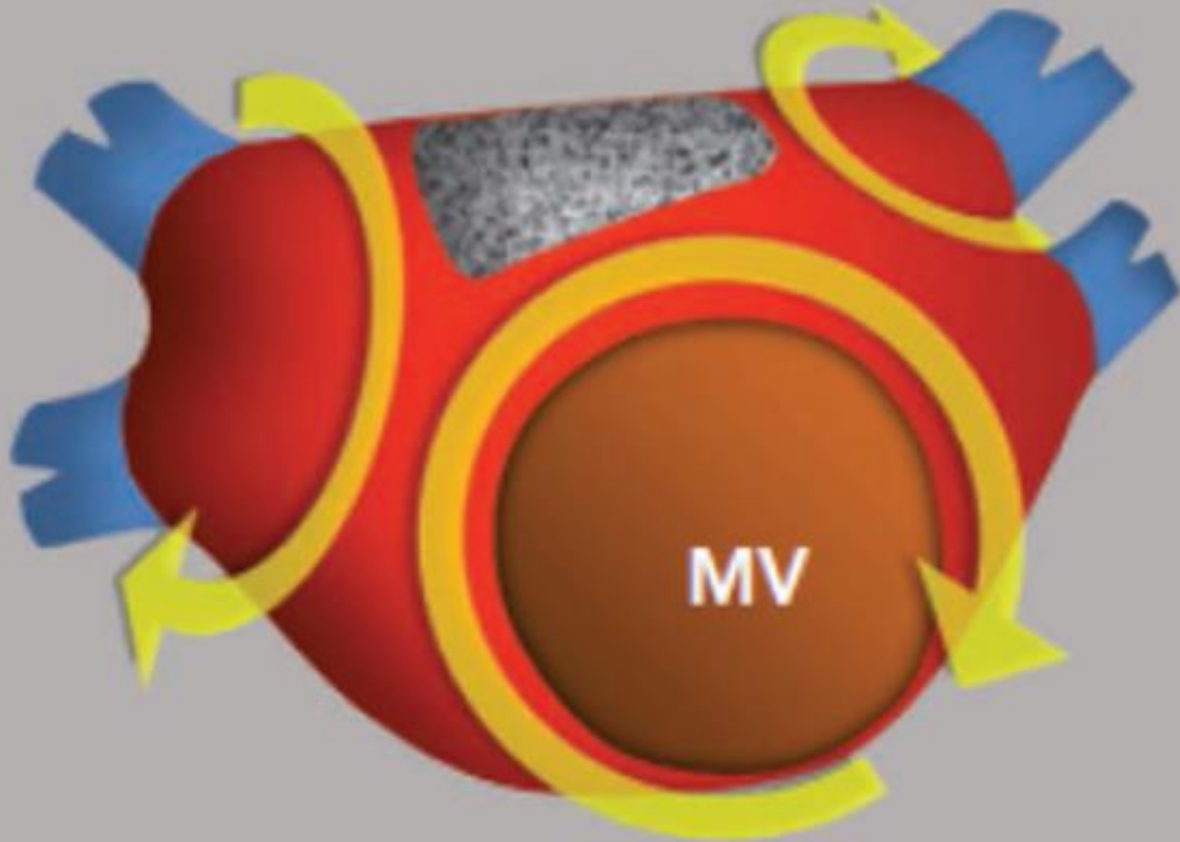
a Fontan procedure,¹¹⁹ leading to the difficult management of recurrent MRTs in these cases.

Left Atrial Macro-re-entrant Tachycardias

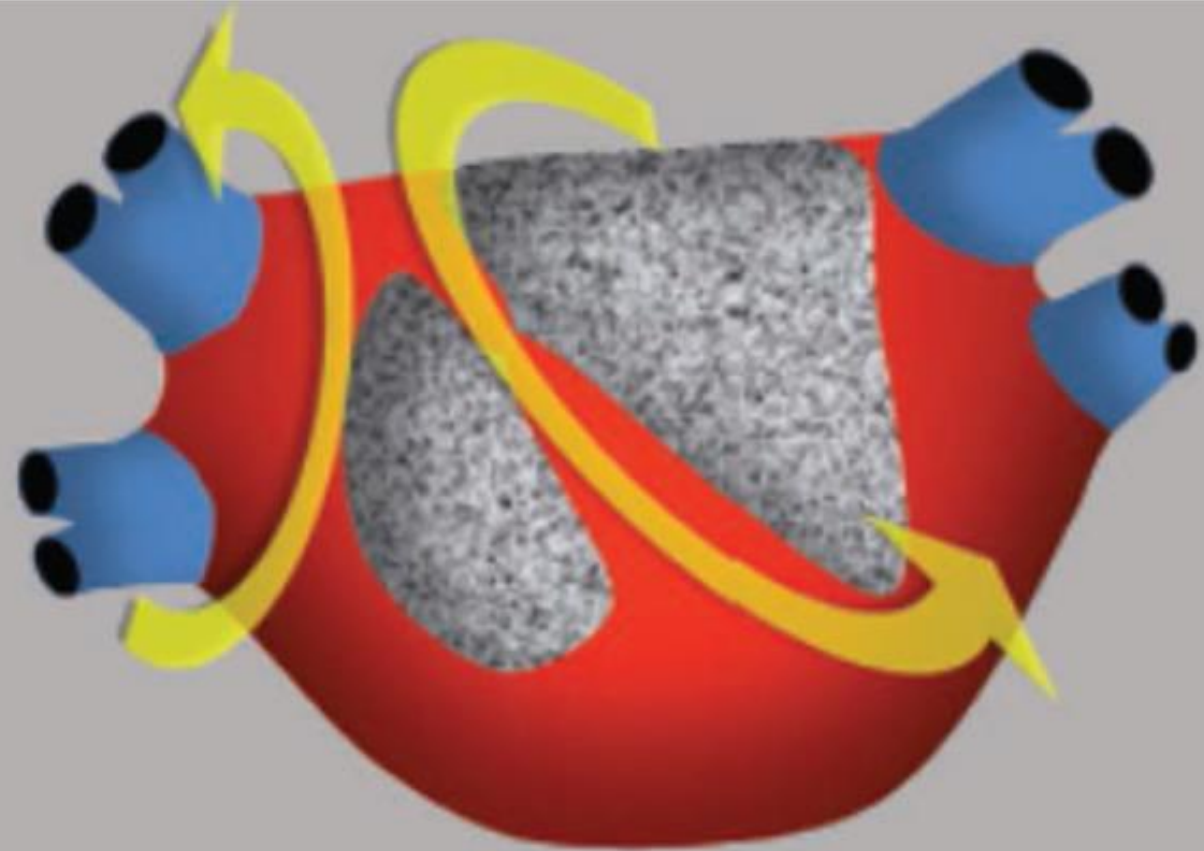
Surgical atriotomy scars are a well-known cause of MRT of the LA^{122–124} often combined with re-entry around low-voltage, inexcitable areas not related to atriotomy. In recent years the incidence of atypical flutter/MRT has become epidemic, with a wide variety of re-entry circuits following extensive LA ‘substrate ablation’ for the treatment of persistent AF (see *Figure 9*). A ‘maturation’ process appears to be necessary to make a MRT circuit stable, as tachycardia inducibility at the end of an AF ablation procedure does not predict later clinical occurrence.^{125,126} Recovery of slow conduction across ablation lines in the mid-term appears to be the arrhythmogenic mechanism in most cases.^{127,128} An ECG pattern of interatrial (Bachmann) block is often associated with atypical flutter/MRT based in the LA.^{129,130} This ECG pattern may be associated too with inexcitable, low-voltage areas in the LA (see *Figure 10*).¹³¹

Figure 9: Schematic representation of macro-re-entrant tachycardia mechanisms in the LA

LA anterior view

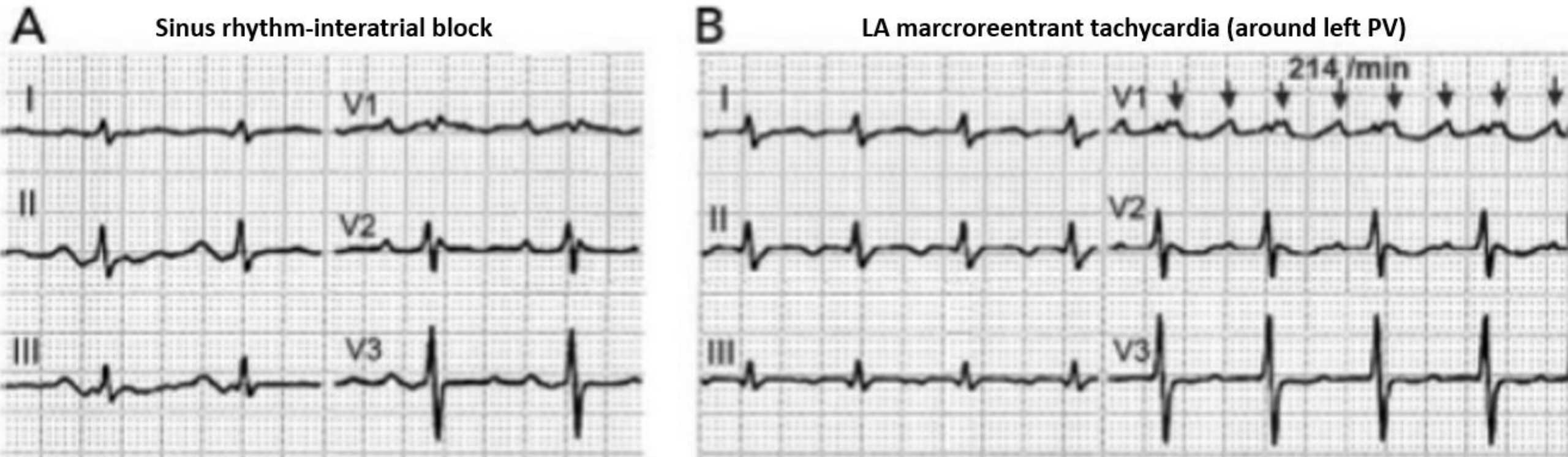


LA posterior view



Stippled, grey areas represent low-voltage, unexcitable “scars”. Yellow curved arrows indicate multiple possible re-entry pathways. The pulmonary veins are represented in blue. MV = mitral valve. Intra-atrial reentrant tachycardia (IART), also called AFL, is a common and potentially lethal complication of surgical correction of congenital heart disease. Main surgical procedures used are Fontan, Mustard/Senning, and biventricular repair (image from Francisco Cosio).

Figure 10: Left atrial macro-reentrant tachycardia in a patient with interatrial block



ECGs of a 63-year-old woman with mild mitral stenosis post-commissurotomy.

(A) in the sinus rhythm note a very wide P wave with terminal negative deflection in II and III, diagnostic of advanced interatrial (Bachmann) block.

(B) (B) ECG during macro-re-entrant tachycardia with very-low-voltage P waves in limb leads and late positive deflection in V₁. Activation is rotated around the left pulmonary veins, supported by a wide area of low voltage in the posterior and superior LA.

The flutter wave morphologies in macro-reentrant ATs are highly variable and there are few invariable features that identify specific reentrant circuits. Atypical flutters from the RA often demonstrate predominantly negative deflections in V₁. However, other RA tachycardias, such as

counterclockwise CTI-dependent AFL, have positive deflections in V_1 , typically preceded by an isoelectric or negative component. Atypical flutters from the LA often show broad positive deflections in V_1 but may show initial negative followed by positive deflections. The limb and precordial leads in LA flutters often show very low-amplitude signals, particularly in patients who had prior ablation. These generalizations are often violated, as the extent and distribution of atrial scar influence the resulting flutter wave morphology. EP studies with RA and LA activation mapping and the response to pacing are necessary to reveal the mechanism in order to guide catheter or surgical ablation. MRT involving the interatrial septum is particularly difficult to treat and success rates are lower than in MRT based on the free atrial walls.^{24,132} Ablation of all inducible tachycardias is the accepted objective; however, the significance of non-clinically inducible tachycardias is not well known. Long-term recurrences can occur despite repeat ablation.^{133,134} Some authors describe better results by targeting areas of focal activity as possible triggers than with ablation of re-entry circuits.¹³⁵ MRT can occur after surgical ‘maze’ procedures for the treatment of AF on the basis of re-established slow conduction across suture lines.^{136,137} Heart transplantation with atrial-to-atrial suture is practically an experimental model of flutter.^{5,138} Knowledge acquired by mapping and ablation-scar-related MRT should help the surgeons and electrophysiologists function as a team to devise non-arrhythmogenic incisions, avoiding surgical approaches that have proved arrhythmogenic, such as the superior transeptal approach to the LA.¹³⁹

Management of Atypical Flutter/Macro-re-entrant Tachycardia

Management of atypical flutter does not differ from that of typical flutter, but the more frequent association with structural heart disease and the multiple possible mechanisms causing an atypical ECG pattern are important factors to consider before making therapeutic decisions. There is very little specific evidence regarding indications for anticoagulation in patients with atypical flutter/MRT and the same indications as in AF are generally recommended.⁸⁵

When atypical flutter/MRT is poorly tolerated and is not controlled with AADs, catheter ablation should be considered. There is no set rule for catheter ablation of atypical MRT tachycardia circuits. Mapping and entrainment studies are necessary to define the focal (centrifugal spread) or MRT mechanism and localise the focal sources or the target isthmus or isthmuses. These procedures may be complicated by the induction of multiple MRT circuits that are not clinically documented. Ablation success is lower than in typical flutter and the recurrence rate is higher, especially in circuits located in the paraseptal areas.^{24,132–134} On the other hand, CTI-dependent flutter is a frequent finding in patients with atrial tachycardia and surgical or ablation scars.²⁴ In cases with multiple MRT circuits, CTI ablation may make ablation success easier by stabilising the atypical MRT circuit and thus making mapping and ablation possible. In cases of atypical MRT of the RA, CTI ablation could be considered even if typical flutter is not documented in order to prevent the later appearance of typical flutter. Prognosis in these complex cases is difficult to predict^{24,128,132–135} but long remissions of tachycardias can be attained in many cases of free wall RA and LA scar. Indications for ablation should be established, taking into account the underlying pathology, quality of life and limitations in functional capacity.

Postoperative Atrial Flutter

The incidence of atrial arrhythmias in the early postoperative period (days) after cardiac surgery is 20–30 %.¹⁴⁰ This high incidence is related to inflammatory changes in the atrial myocardium,¹⁴¹ not unlike the experimental pericarditis animal models,¹⁴² and it may be prevented by anti-inflammatory corticosteroid treatment.^{143,144} AF is the most commonly reported arrhythmia but flutter can also occur in this setting,^{8,35,78} although its frequency in relation to AF is not clear. There are very few data on the long-term follow-up of this postoperative flutter, but the incidence of AF in such cases is reported to be around 30 %.¹⁴⁵ If this incidence is extrapolated to flutter, it would appear reasonable to consider that in the early postoperative period after cardiac surgery flutter is an acute, one-time event in the majority of patients and ablation treatment should not be contemplated unless recurrences are documented.

The CHADS₂ score and its updated version, the CHA₂DS₂-VASc score

The CHADS₂ score and its updated version, the CHA₂DS₂-VASc score, are clinical prediction rules for estimating the risk of stroke in patients with non-rheumatic AF, and typical AFL a common and serious heart arrhythmia associated with thromboembolic stroke. Such a score is used to determine whether or not treatment is required with anticoagulation therapy or antiplatelet therapy,¹⁵⁷ since AF and AFL can cause stasis of blood in the upper heart chambers, leading to the formation of a mural thrombus that can dislodge into the blood flow, reach the brain, cut off supply to the brain, and cause a stroke. A high score corresponds to a greater risk of stroke, while a low score corresponds to a lower risk of stroke. The CHADS₂ score is simple and has been validated by many studies.() In clinical use, the CHADS₂ score (pronounced "chads two") has been superseded by the CHA₂DS₂-VASc score ("chads vasc" (<https://www.stopafib.org/newsitem.cfm/NEWSID/369/Professor%20Gregory%20Y.H.%20Lip/CHA2DS2-VASc%20for%20atrial%20fibrillation%20stroke%20prevention>), which gives a better stratification of low-risk patients.

CHADS₂

The CHADS₂ score does not include some common stroke risk factors, and its various pros/cons have been carefully discussed.¹⁵⁸ Adding together the points that correspond to the conditions that are present results in the CHADS₂ score, that is used to estimate stroke risk.

Annual Stroke Risk¹⁵⁹

CHA ₂ DS ₂ -VASc Score	Stroke Risk %	95% CL
0	0	-
1	1.3	-
2	2.2	-
3	3.2	-
4	4.0	-
5	6.7	-
6	9.8	-
7	9.6	-
8	12.5	-
9	15.2	-

Major guidelines have used the above fixed annual stroke risk as a guideline of starting anticoagulant treatment; where the ischemic stroke risk of more than 1% to 2% should be an indication to start an anticoagulant therapy. However, actual risk of getting stroke varies according to sampling method and geographical regions, as well as use of appropriate study analysis methodology.¹⁶⁰

A meta-analysis of various studies in 2015 shown that annual stroke risk is less than 1% in 13 of the 17 studies for CHA2DS2–VASc score of 1, 6 out of 15 studies reported risk of 1 to 2% and 5 out of 15 studies reported risk of more than 2% for CHA2DS2–VASc score of 2.¹⁶¹ Nevertheless, stroke rates vary by study setting (hospital vs community), population (trial vs general), ethnicity, etc. Some studies included in the metaanalysis include females with score 1 by virtue of gender (who are low risk), into the aggregate rates; others included do not account for followup anticoagulation use (thus lowering rates) and were analysed by excluding all patients ever started on anticoagulants ('conditioning on the future' error).**(Nielsen, P; Lip, G (2017). "Adding Rigor to Stroke Rate Investigations in Patients With Atrial Fibrillation". *Circulation*. 135 (3): 220–223. doi:10.1161/CIRCULATIONAHA.116.025944.).** The CHA2DS2-VASc Score has shown increasing popularity over time while the CHADS2 has shown decreasing popularity, which could "partly be related to introduction of guidelines recommending the use of the CHA2DS2-VASc score for stroke risk stratification".**(Lip, GY; Habboushe, J; Altman, C (2019). "Time trends in use of the CHADS₂ and CHA₂DS₂-VASc scores, and the geographical and specialty uptake of these scores from a popular online clinical decision tool and medical reference". *International Journal of Clinical Practice*. 73 (2): e13280. doi:10.1111/ijcp.13280. PMID 30281876.).**

The CHA2DS2-VASc score has been used in the 2012 European Society of Cardiology guidelines for the management of atrial fibrillation.[15][16][17] The 2014 American College of Cardiology/American Heart Association Task Force on Practice Guidelines and the Heart Rhythm Society guidelines also recommend use of the CHA2DS2-VASc score.[18]

The European Society of Cardiology (ESC),(**Kirchhof, Paulus; Benussi, Stefano; Kotecha, Dipak; Ahlsson, et al. (7 October 2016). "2016 ESC Guidelines for the management of atrial fibrillation developed in collaboration with EACTS". European Heart Journal. 37 (38): 2893–2962. doi:10.1093/eurheartj/ehw210. PMID 27567408. Retrieved 12 February 2017.**) and National Institute for Health and Care Excellence (NICE)(**Atrial fibrillation: management | Guidance and guidelines | NICE". www.nice.org.uk. June 2014. Retrieved 12 February 2017.**) guidelines recommend that if the patient has a CHA2DS2-VASc score of 2 and above, oral anticoagulation therapy (OAC) with a Vitamin K Antagonist (VKA, e.g. warfarin with target INR of 2-3) or one of the non-VKA oral anticoagulant drugs (NOACs, e.g. dabigatran, rivaroxaban, edoxaban, or apixaban) is recommended. If the patient is 'low risk' using the CHA2DS2-VASc score (that is, 0 in males or 1 in females), no anticoagulant therapy is recommended. In males with 1 stroke risk factor (that is, a CHA2DS2-VASc score=1), antithrombotic therapy with OAC may be considered, and people values and preferences should be considered.(**Joundi, RA; Cipriano, LE; Sposato, LA; Saposnik, G; Stroke Outcomes Research Working, Group (May 2016). "Ischemic Stroke Risk in Patients With Atrial Fibrillation and CHA2DS2-VASc Score of 1: Systematic Review and Meta-Analysis". Stroke: A Journal of Cerebral Circulation. 47 (5): 1364–7. doi:10.1161/strokeaha.115.012609. PMID 27026630.**) Even a single stroke risk factor confers excess risk of stroke and mortality, with a positive net clinical benefit for stroke prevention with oral anticoagulation, when compared to no treatment or aspirin(**Fauchier, L; Clementy, N; Bisson, A; Ivanes, F; Angoulvant, D; Babuty, D (2016). "Should Atrial Fibrillation Patients With Only 1 Nongender-Related CHA2DS2-VASc Risk Factor Be Anticoagulated?". Stroke. 47 (7): 1831–6. doi:10.1161/STROKEAHA.116.013253. PMID 27231269.**) Thromboembolic event rates differ according to various guideline treatment thresholds and methodological approaches.(**Nielsen P; Larsen TB; Skjøth F; et al. (2016). "Stroke and thromboembolic event rates in atrial fibrillation according to different guideline treatment thresholds: A nationwide cohort study". Sci Rep. 6: 27410. Bibcode:2016NatSR...627410N. doi:10.1038/srep27410. PMC 4893655. PMID 27265586.**)

Based on the ESC guidelines on AF/AFL, oral anticoagulation is recommended or preferred for patients with one or more stroke risk factors (i.e. a CHA2DS2-VASc score of ≥ 1 in males, or ≥ 2 in females). (Lip GY, Lane DA (2015). "Stroke prevention in atrial fibrillation: a systematic review". *JAMA*. 313 (19): 1950–62. doi:10.1001/jama.2015.4369. PMID 25988464) This is consistent with a recent decision analysis model showing how the 'tipping point' on the decision to anticoagulate has changed with the availability of the 'safer' NOAC drugs, where the threshold for offering stroke prevention (i.e. oral anticoagulation) is a stroke rate of approximately 1%/year. (Eckman MH, Singer DE, Rosand J, Greenberg SM (Jan 2011). "Moving the tipping point: the decision to anticoagulate patients with atrial fibrillation". *Circ Cardiovasc Qual Outcomes*. 4 (1): 14–21. doi:10.1161/circoutcomes.110.958108. PMC 3058150. PMID 21139092.) Those patients recommended for stroke prevention treatment via oral anticoagulation, choice of drug (i.e. between a Vitamin K Antagonist and Non-Vitamin K Antagonist Oral Anticoagulant (NOAC)) can be evaluated using the SAME-TT2R2 score to help decision-making on the most appropriate oral anticoagulant. (Apostolakis S, Sullivan RM, Olshansky B, Lip GY (Nov 2013). "Factors affecting quality of anticoagulation control among patients with atrial fibrillation on warfarin: the SAME-TT₂R₂ score". *Chest*. 144 (5): 1555–63. doi:10.1378/chest.13-0054. PMID 23669885.) (Proietti, Marco; Lip, Gregory Y.H. (July 2015). "Simple decision-making between a vitamin K antagonist and a non-vitamin K antagonist oral anticoagulant: using the SAME-TT2R2 score". *European Heart Journal - Cardiovascular Pharmacotherapy*. 1 (3): 150–152) Stroke risk assessment should always include an assessment of bleeding risk. This can be done using validated bleeding risk scores, such as the HEMORR2HAGES or HAS-BLED scores. The HAS-BLED score is recommended in guidelines, to identify the high risk patient for regular review and followup and to address the reversible risk factors for bleeding (e.g. uncontrolled hypertension, labile INRS, excess alcohol use or concomitant aspirin/NSAID use). (Nielsen P; Larsen TB; Skjøth F; et al. (2016). "Stroke and thromboembolic event rates in atrial fibrillation according to different guideline treatment thresholds: A nationwide cohort study". *Sci Rep*. 6: 27410. Bibcode:2016NatSR...627410N.

doi:10.1038/srep27410. PMC 4893655. PMID 27265586.) If the patient is taking warfarin, then knowledge of INR control is needed to assess the 'labile INR' criterion in HAS-BLED; otherwise for a non-warfarin patient, this criterion scores zero. A high HAS-BLED score is not a reason to withhold anticoagulation. Also, when compared to HAS-BLED, other bleeding risk scores that did not consider 'labile INR' would significantly underperform in predicting bleeding on warfarin, and would often inappropriately categorize many patients who sustained bleeds as 'low risk'.**(Proietti, Marco; Senoo, Keitaro; Lane, Deirdre A.; Lip, Gregory Y. H. (Apr 2016). "Major Bleeding in Patients with Non-Valvular Atrial Fibrillation: Impact of Time in Therapeutic Range on Contemporary Bleeding Risk Scores". *Sci. Rep.* 6: 24376. Bibcode:2016NatSR...624376P. doi:10.1038/srep24376. PMC 4828703. PMID 27067661.)**

Change in Guideline Recommendations (Only major included)

2014	2019
The term "nonvalvular AF" is no longer used	
Section 4.1.1 - Selection of Antithrombotic Regimen	
Oral anticoagulants recommended for high risk patients now include edoxaban.	
Exclusion criteria for CHA ₂ DS ₂ -VASc assessment and use of NOACs now defined as moderate to severe mitral stenosis or a mechanical heart valve.	
For patients with AF and end stage chronic kidney disease, the direct thrombin inhibitor dabigatran or the factor Xa inhibitors rivaroxaban or edoxaban are not recommended	
Section 6.1.1 - Prevention of Thromboembolism	
For patients with AF or atrial flutter of 48 hours' duration or longer, or when the duration of AF is unknown, anticoagulation with warfarin (INR 2.0 to 3.0), a factor Xa inhibitor, or direct thrombin inhibitor is recommended for at least 3 weeks before and at least 4 weeks after cardioversion.	
For patients with AF or atrial flutter of <48 hours' duration with a CHA ₂ DS ₂ -VASc score of ≥2 in men and ≥3 in women, administration of heparin, a factor Xa inhibitor, or a direct thrombin inhibitor is reasonable as soon as possible before cardioversion, followed by long term anticoagulation therapy.	

New Recommendations

Section 4.1.1 - Selection of Antithrombotic Regimen

NOACs are recommended over warfarin where eligible except in those patients with moderate - severe mitral stenosis or a mechanical heart valve.

Section 4.3 - Interruption and Bridging Anticoagulation

Idarucizumab is the reversal agent for dabigatran in the event of life-threatening bleeding or an urgent procedure.

Andexanet Alfa is the reversal agent for apixaban and rivaroxaban.

Section 4.4.1 - Percutaneous Approaches to Occlude the Left Atrial Appendage

Percutaneous LAAO should be considered for those AF patients at an increased risk of stroke who have contraindications to long-term anticoagulation and who are at high risk of thromboembolic events.

Section 6.3.4 - Catheter Ablation in HF

Catheter ablation of AF is reasonable in symptomatic AF patients with HF and reduced LVEF.

Section 7.4 - Complicating Acute Coronary Syndrome

If triple therapy is prescribed post-stent placement, clopidogrel is preferred over prasugrel.

Double therapy with a P2Y₁₂ inhibitor and dose adjusted vitamin K antagonist is reasonable post-stenting.

Double therapy with clopidogrel and low-dose rivaroxaban (15 mg daily) may be reasonable post-stenting.

Double therapy with a P2Y₁₂ inhibitor and dabigatran 150 mg twice daily is reasonable post-stenting.

If triple therapy is prescribed for patients with AF who are at increased risk of stroke and who have undergone PCI with stenting for ACS, a transition to double therapy at 4-6 weeks may be considered.

Section 7.12 - Device Detection of AF and Atrial Flutter

In patients with cardiac implantable electronic devices, atrial high rate episodes (AHREs) should prompt further evaluation.

In patients with cryptogenic stroke in whom long-term external ambulatory monitoring is inconclusive implantation of a cardiac monitor is reasonable to detect silent AF.

Section 7.13 - Weight Loss

Weight loss and risk factor modification is recommended for overweight/obese patients with AF.

Recommendations for Selecting an Anticoagulant Regimen—Balancing Risks

COR	LOE	Recommendations
I	A	<p>1. For patients with AF and an elevated CHA₂DS₂-VASc score of 2 or greater in men or 3 or greater in women, oral anticoagulants are recommended.</p> <p>Options include:</p> <ul style="list-style-type: none"> • Warfarin (LOE: A) • Dabigatran (LOE: B) • Rivaroxaban (LOE: B) • Apixaban (LOE: B) or • Edoxaban (LOE: B-R) <p>MODIFIED: This recommendation has been updated in response to the approval of edoxaban, a new factor Xa inhibitor. More precision in the use of CHA₂DS₂-VASc scores is specified in subsequent recommendations. The LOEs for warfarin, dabigatran, rivaroxaban, and apixaban have not been updated for greater granularity as per the new LOE system. (Section 4.1. in the 2014 AF Guideline) The original text can be found in Section 4.1 of the 2014 AF guideline. Additional information about the comparative effectiveness and bleeding risk of NOACs can be found in Section 4.2.2.2.</p>
	B	
	B	
	B	
	B-R	
I	A	<p>2. NOACs (dabigatran, rivaroxaban, apixaban, and edoxaban) are recommended over warfarin in NOAC-eligible patients with AF (except with moderate-to-severe mitral stenosis or a mechanical heart valve).</p> <p>NEW: Exclusion criteria are now defined as moderate-to-severe mitral stenosis or a mechanical heart valve. When the NOAC trials are considered as a group, the direct thrombin inhibitor and factor Xa inhibitors were at least noninferior and, in some trials, superior to warfarin for preventing stroke and systemic embolism and were associated with lower risks of serious bleeding.</p>

I	A	<p>3. Among patients treated with warfarin, the international normalized ratio (INR) should be determined at least weekly during initiation of anticoagulant therapy and at least monthly when anticoagulation (INR in range) is stable.</p> <p>MODIFIED: "Antithrombotic" was changed to "anticoagulant."</p>
I	B	<p>4. In patients with AF (except with moderate-to-severe mitral stenosis or a mechanical heart valve), the CHA₂DS₂-VASc score is recommended for assessment of stroke risk.</p> <p>MODIFIED: Exclusion criteria are now defined as moderate-to-severe mitral stenosis or a mechanical heart valve. Patients with AF with bioprosthetic heart valves are addressed in the supportive text. (Section 4.1. in the 2014 AF guideline)</p>
I	B	<p>5. For patients with AF who have mechanical heart valves, warfarin is recommended.</p> <p>MODIFIED: New information is included in the supportive text.</p>
I	B	<p>6. Selection of anticoagulant therapy should be based on the risk of thromboembolism, irrespective of whether the AF pattern is paroxysmal, persistent, or permanent.</p> <p>MODIFIED: "Antithrombotic" was changed to "anticoagulant."</p>

I	B-NR	<p>7. Renal function and hepatic function should be evaluated before initiation of a NOAC and should be reevaluated at least annually.</p> <p>MODIFIED: Evaluation of hepatic function was added. LOE was updated from B to B-NR. New evidence was added. (Section 4.1. in the 2014 AF Guideline)</p>
I	C	<p>8. In patients with AF, anticoagulant therapy should be individualized on the basis of shared decision-making after discussion of the absolute risks and relative risks of stroke and bleeding, as well as the patient’s values and preferences.</p> <p>MODIFIED: “Antithrombotic” was changed to “anticoagulant.”</p>
I	C	<p>9. For patients with atrial flutter, anticoagulant therapy is recommended according to the same risk profile used for AF.</p> <p>MODIFIED: “Antithrombotic” was changed to “anticoagulant.”</p>
I	C	<p>10. Reevaluation of the need for and choice of anticoagulant therapy at periodic intervals is recommended to reassess stroke and bleeding risks.</p> <p>MODIFIED: “Antithrombotic” was changed to “anticoagulant.”</p>
I	C-EO	<p>11. For patients with AF (except with moderate-to-severe mitral stenosis or a mechanical heart valve) who are unable to maintain a therapeutic INR level with warfarin, use of a NOAC is recommended.</p> <p>MODIFIED: Exclusion criteria are now defined as moderate-to-severe mitral stenosis or a mechanical heart valve, and this recommendation has been changed in response to the approval of edoxaban. (Section 4.1. in the 2014 AF Guideline)</p>

IIa	B	<p>12. For patients with AF (except with moderate-to-severe mitral stenosis or a mechanical heart valve) and a CHA₂DS₂-VASc score of 0 in men or 1 in women, it is reasonable to omit anticoagulant therapy.</p> <p>MODIFIED: Exclusion criteria are now defined as moderate-to-severe mitral stenosis or a mechanical heart valve. (Section 4.1. in the 2014 AF Guideline)</p>
IIb	B-NR	<p>13. For patients with AF who have a CHA₂DS₂-VASc score of 2 or greater in men or 3 or greater in women and who have end-stage chronic kidney disease (CKD; creatinine clearance [CrCl] <15 mL/min) or are on dialysis, it might be reasonable to prescribe warfarin (INR 2.0 to 3.0) or apixaban for oral anticoagulation.</p> <p>MODIFIED: New evidence has been added. LOE was updated from B to B-NR. (Section 4.1. in the 2014 AF Guideline)</p>

Recommendations for Selecting an Anticoagulant Regimen— Balancing Risks and Benefits (3 of 3)

IIb	B-R	<p>14. For patients with AF (except with moderate-to-severe mitral stenosis or a mechanical heart valve) and moderate-to-severe CKD (serum creatinine ≥ 1.5 mg/dL [apixaban], CrCl 15 to 30 mL/min [dabigatran], CrCl ≤ 50 mL/min [rivaroxaban], or CrCl 15 to 50 mL/min [edoxaban]) with an elevated CHA₂DS₂-VASc score, treatment with reduced doses of direct thrombin or factor Xa inhibitors may be considered (e.g., dabigatran, rivaroxaban, apixaban, or edoxaban).</p> <p>MODIFIED: Exclusion criteria are now defined as moderate-to-severe mitral stenosis or a mechanical heart valve, and this recommendation has been changed in response to the approval of edoxaban. LOE was updated from C to B-R. (Section 4.1. in the 2014 AF Guideline)</p>
IIb	C- LD	<p>15. For patients with AF (except with moderate-to-severe mitral stenosis or a mechanical heart valve) and a CHA₂DS₂-VASc score of 1 in men and 2 in women, prescribing an oral anticoagulant to reduce thromboembolic stroke risk may be considered.</p> <p>MODIFIED: Exclusion criteria are now defined as moderate-to-severe mitral stenosis or a mechanical heart valve, and evidence was added to support separate risk scores by sex. LOE was updated from C to C-LD. (Section 4.1. in the 2014 AF Guideline)</p>
III: No Benefit	C-EO	<p>16. In patients with AF and end-stage CKD or on dialysis, the direct thrombin inhibitor dabigatran or the factor Xa inhibitors rivaroxaban or edoxaban are not recommended because of the lack of evidence from clinical trials that benefit exceeds risk.</p> <p>MODIFIED: New data have been included. Edoxaban received FDA approval and has been added to the recommendation. LOE was updated from C to C-EO. (Section 4.1. in the 2014 AF Guideline)</p>
III: Harm	B-R	<p>17. The direct thrombin inhibitor dabigatran should not be used in patients with AF and a mechanical heart valve.</p> <p>MODIFIED: Evidence was added. LOE was updated from B to B-R. Other NOACs are addressed in the supportive text. (Section 4.1. in the 2014 AF Guideline)</p>

Recommendations for Interruption and Bridging Anticoagulation

COR	LOE	Recommendations
I	C	<p>1. Bridging therapy with unfractionated heparin or low-molecular-weight heparin is recommended for patients with AF and a mechanical heart valve undergoing procedures that require interruption of warfarin. Decisions on bridging therapy should balance the risks of stroke and bleeding.</p>
I	B-R	<p>2. For patients with AF without mechanical heart valves who require interruption of warfarin for procedures, decisions about bridging therapy (unfractionated heparin or low-molecular-weight heparin) should balance the risks of stroke and bleeding and the duration of time a patient will not be anticoagulated.</p> <p>MODIFIED: LOE was updated from C to B-R because of new evidence. (Section 4.1. in the 2014 AF Guideline)</p>
I	B-NR	<p>3. Idarucizumab is recommended for the reversal of dabigatran in the event of life-threatening bleeding or an urgent procedure.</p> <p>NEW: New evidence has been published about idarucizumab to support LOE B-NR.</p>
IIa	B-NR	<p>4. Andexanet alfa can be useful for the reversal of rivaroxaban and apixaban in the event of life-threatening or uncontrolled bleeding.</p> <p>NEW: New evidence has been published about andexanet alfa to support LOE B-NR.</p>

Recommendation for Percutaneous Approaches to Occlude the LAA

COR	LOE	Recommendation
IIb	B-NR	<p>1. Percutaneous LAA occlusion may be considered in patients with AF at increased risk of stroke who have contraindications to long-term anticoagulation.</p> <p>NEW: Clinical trial data and FDA approval of the Watchman device necessitated this recommendation.</p>

Recommendation for Cardiac Surgery—LAA Occlusion/Excision

COR	LOE	Recommendation
IIb	B-NR	<p>1. Surgical occlusion of the LAA may be considered in patients with AF undergoing cardiac surgery, as a component of an overall heart team approach to the management of AF.</p> <p>MODIFIED: LOE was updated from C to B-NR because of new evidence.</p>

Recommendations for Prevention of Thromboembolism Rec

COR	LOE	Recommendations
I	B-R	<p>1. For patients with AF or atrial flutter of 48 hours' duration or longer, or when the duration of AF is unknown, anticoagulation with warfarin (INR 2.0 to 3.0), a factor Xa inhibitor, or direct thrombin inhibitor is recommended for at least 3 weeks before and at least 4 weeks after cardioversion, regardless of the CHA₂DS₂-VASc score or the method (electrical or pharmacological) used to restore sinus rhythm.</p> <p>MODIFIED: The 2014 AF Guideline recommendation for use of warfarin around the time of cardioversion was combined with the 2014 AF Guideline recommendation for NOACs to create a single recommendation. This combined recommendation was updated to COR I/LOE B-R from COR IIa/LOE C for NOACs in the 2014 AF Guideline on the basis of additional trials that have evaluated the use of NOACs with cardioversion.</p>
I	C	<p>2. For patients with AF or atrial flutter of more than 48 hours' duration or unknown duration that requires immediate cardioversion for hemodynamic instability, anticoagulation should be initiated as soon as possible and continued for at least 4 weeks after cardioversion unless contraindicated.</p>
I	C-EO	<p>3. After cardioversion for AF of any duration, the decision about long-term anticoagulation therapy should be based on the thromboembolic risk profile and bleeding risk profile.</p> <p>MODIFIED: The 2014 AF Guideline recommendation was strengthened with the addition of bleeding risk profile to the long-term anticoagulation decision-making process.</p>

IIa	B-NR	<p>4. For patients with AF or atrial flutter of less than 48 hours' duration with a CHA₂DS₂-VASc score of 2 or greater in men and 3 or greater in women, administration of heparin, a factor Xa inhibitor, or a direct thrombin inhibitor is reasonable as soon as possible before cardioversion, followed by long-term anticoagulation therapy.</p> <p>MODIFIED: Recommendation COR was changed from I in the 2014 AF Guideline to IIa, and LOE was changed from C in the 2014 AF Guideline to B-NR. In addition, a specific CHA₂DS₂-VASc score is now specified.</p>
IIa	B	<p>5. For patients with AF or atrial flutter of 48 hours' duration or longer or of unknown duration who have not been anticoagulated for the preceding 3 weeks, it is reasonable to perform transesophageal echocardiography before cardioversion and proceed with cardioversion if no left atrial thrombus is identified, including in the LAA, provided that anticoagulation is achieved before transesophageal echocardiography and maintained after cardioversion for at least 4 weeks.</p>
IIb	B-NR	<p>6. For patients with AF or atrial flutter of less than 48 hours' duration with a CHA₂DS₂-VASc score of 0 in men or 1 in women, administration of heparin, a factor Xa inhibitor, or a direct thrombin inhibitor, versus no anticoagulant therapy, may be considered before cardioversion, without the need for postcardioversion oral anticoagulation.</p> <p>MODIFIED: Recommendation LOE was changed from C in the 2014 AF Guideline to B-NR to reflect evidence from 2 registry studies and to include specific CHA₂DS₂-VASc scores derived from study results.</p>

Recommendation for Catheter Ablation in HF

COR	LOE	Recommendation
IIb	B-R	<p>1. AF catheter ablation may be reasonable in selected patients with symptomatic AF and HF with reduced left ventricular (LV) ejection fraction (HFrEF) to potentially lower mortality rate and reduce hospitalization for HF.</p> <p>NEW: New evidence, including data on improved mortality rate, have been published for AF catheter ablation compared with medical therapy in patients with HF.</p>

Recommendations for Prevention of Thromboembolism

COR	LOE	Recommendations
I	B-R	<p>1. For patients with AF or atrial flutter of 48 hours' duration or longer, or when the duration of AF is unknown, anticoagulation with warfarin (INR 2.0 to 3.0), a factor Xa inhibitor, or direct thrombin inhibitor is recommended for at least 3 weeks before and at least 4 weeks after cardioversion, regardless of the CHA₂DS₂-VASc score or the method (electrical or pharmacological) used to restore sinus rhythm.</p> <p>MODIFIED: The 2014 AF Guideline recommendation for use of warfarin around the time of cardioversion was combined with the 2014 AF Guideline recommendation for NOACs to create a single recommendation. This combined recommendation was updated to COR I/LOE B-R from COR IIa/LOE C for NOACs in the 2014 AF Guideline on the basis of additional trials that have evaluated the use of NOACs with cardioversion.</p>

I	C	<p>2. For patients with AF or atrial flutter of more than 48 hours' duration or unknown duration that requires immediate cardioversion for hemodynamic instability, anticoagulation should be initiated as soon as possible and continued for at least 4 weeks after cardioversion unless contraindicated.</p>
I	C-EO	<p>3. After cardioversion for AF of any duration, the decision about long-term anticoagulation therapy should be based on the thromboembolic risk profile and bleeding risk profile.</p> <p>MODIFIED: The 2014 AF Guideline recommendation was strengthened with the addition of bleeding risk profile to the long-term anticoagulation decision-making process.</p>
IIa	B-NR	<p>4. For patients with AF or atrial flutter of less than 48 hours' duration with a CHA₂DS₂-VASc score of 2 or greater in men and 3 or greater in women, administration of heparin, a factor Xa inhibitor, or a direct thrombin inhibitor is reasonable as soon as possible before cardioversion, followed by long-term anticoagulation therapy.</p> <p>MODIFIED: Recommendation COR was changed from I in the 2014 AF Guideline to IIa, and LOE was changed from C in the 2014 AF Guideline to B-NR. In addition, a specific CHA₂DS₂-VASc score is now specified.</p>
IIa	B	<p>5. For patients with AF or atrial flutter of 48 hours' duration or longer or of unknown duration who have not been anticoagulated for the preceding 3 weeks, it is reasonable to perform transesophageal echocardiography before cardioversion and proceed with cardioversion if no left atrial thrombus is identified, including in the LAA, provided that anticoagulation is achieved before transesophageal echocardiography and maintained after cardioversion for at least 4 weeks.</p>
IIb	B-NR	<p>6. For patients with AF or atrial flutter of less than 48 hours' duration with a CHA₂DS₂-VASc score of 0 in men or 1 in women, administration of heparin, a factor Xa inhibitor, or a direct thrombin inhibitor, versus no anticoagulant therapy, may be considered before cardioversion, without the need for postcardioversion oral anticoagulation.</p> <p>MODIFIED: Recommendation LOE was changed from C in the 2014 AF Guideline to B-NR to reflect evidence from 2 registry studies and to include specific CHA₂DS₂-VASc scores derived from study results.</p>

Recommendation for Catheter Ablation in HF

COR	LOE	Recommendation
IIb	B-R	<p>1. AF catheter ablation may be reasonable in selected patients with symptomatic AF and HF with reduced left ventricular (LV) ejection fraction (HFrEF) to potentially lower mortality rate and reduce hospitalization for HF.</p> <p>NEW: New evidence, including data on improved mortality rate, have been published for AF catheter ablation compared with medical therapy in patients with HF.</p>

COR	LOE	Recommendations for AF Complicating ACS
I	B-R	<p>1. For patients with ACS and AF at increased risk of systemic thromboembolism (based on CHA₂DS₂-VASc risk score of 2 or greater), anticoagulation is recommended unless the bleeding risk exceeds the expected benefit.</p> <p>MODIFIED: New published data are available. LOE was updated from C in the 2014 AF Guideline to B-R. Anticoagulation options are described in supportive text.</p>
I	C	<p>2. Urgent direct-current cardioversion of new-onset AF in the setting of ACS is recommended for patients with hemodynamic compromise, ongoing ischemia, or inadequate rate control.</p>
I	C	<p>3. Intravenous beta blockers are recommended to slow a rapid ventricular response to AF in patients with ACS who do not display HF, hemodynamic instability, or bronchospasm.</p>

Ila	B-NR	<p>4. If triple therapy (oral anticoagulant, aspirin, and P2Y₁₂ inhibitor) is prescribed for patients with AF at increased risk of stroke (based on CHA₂DS₂-VASc risk score of 2 or greater) who have undergone percutaneous coronary intervention (PCI) with stenting for ACS, it is reasonable to choose clopidogrel in preference to prasugrel.</p> <p>NEW: New published data are available.</p>
Ila	B-R	<p>5. In patients with AF at increased risk of stroke (based on CHA₂DS₂-VASc risk score of 2 or greater) who have undergone PCI with stenting for ACS, double therapy with a P2Y₁₂ inhibitor (clopidogrel or ticagrelor) and dose-adjusted vitamin K antagonist is reasonable to reduce the risk of bleeding as compared with triple therapy.</p> <p>NEW: New RCT data and data from 2 registries and a retrospective cohort study are available.</p>
Ila	B-R	<p>6. In patients with AF at increased risk of stroke (based on CHA₂DS₂-VASc risk score of 2 or greater) who have undergone PCI with stenting for ACS, double therapy with P2Y₁₂ inhibitors (clopidogrel) and low-dose rivaroxaban (15 mg daily) is reasonable to reduce the risk of bleeding as compared with triple therapy.</p> <p>NEW: New published data are available.</p>
Ila	B-R	<p>7. In patients with AF at increased risk of stroke (based on CHA₂DS₂-VASc risk score of 2 or greater) who have undergone PCI with stenting for ACS, double therapy with a P2Y₁₂ inhibitor (clopidogrel) and dabigatran 150 mg twice daily is reasonable to reduce the risk of bleeding as compared with triple therapy.</p> <p>NEW: New published data are available.</p>
Iib	B-R	<p>8. If triple therapy (oral anticoagulant, aspirin, and P2Y₁₂ inhibitor) is prescribed for patients with AF who are at increased risk of stroke (based on CHA₂DS₂-VASc risk score of 2 or greater) and who have undergone PCI with stenting (drug eluting or bare metal) for ACS, a transition to double therapy (oral anticoagulant and P2Y₁₂ inhibitor) at 4 to 6 weeks may be considered.</p> <p>NEW: New published data are available.</p>
Iib	C	<p>9. Administration of amiodarone or digoxin may be considered to slow a rapid ventricular response in patients with ACS and AF associated with severe LV dysfunction and HF or hemodynamic instability.</p>
Iib	C	<p>10. Administration of nondihydropyridine calcium antagonists may be considered to slow a rapid ventricular response in patients with ACS and AF only in the absence of significant HF or hemodynamic instability.</p>

COR	LOE	Recommendations for Device Detection of AF and Atrial Flutter
I	B-NR	1. In patients with cardiac implantable electronic devices (pacemakers or implanted cardioverter-defibrilators), the presence of recorded atrial high-rate episodes (AHREs) should prompt further evaluation to document clinically relevant AF to guide treatment decisions.
Ia	B-R	2. In patients with cryptogenic stroke (i.e., stroke of unknown cause) in whom external ambulatory monitoring is inconclusive, implantation of a cardiac monitor (loop recorder) is reasonable to optimize detection of silent AF.

COR	LOE	Recommendation for Weight Reduction in Patients with AF
I	B-R	1. For overweight and obese patients with AF, weight loss, combined with risk factor modification, is recommended. NEW: New data demonstrate the beneficial effects of weight loss and risk factor modification on controlling AF.

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