Atrial Tachycardia Arising From the Right Atrial Inferoseptum Masquerading as Common Atrial Flutter

Sachiko Ito, MD; Hiroshi Tada, MD; Akihiko Nogami, MD*; Shigeto Naito, MD; Shigeru Oshima, MD; Koichi Taniguchi, MD

Radiofrequency catheter ablation was performed in 2 patients with atrial tachycardia (AT). In both cases the AT originated from the inferoseptal portion of the right atrium, and the cycle length was 210 ms. The surface ECG demonstrated common counterclockwise atrial flutter, probably caused by functional block in the clockwise direction at the cavo-tricuspid isthmus and posterior right atrium with rapid activation of the origin. Although rare (2%), AT originating from the inferoseptal portion of the right atrium should be considered when the surface ECG exhibits common atrial flutter. (Circ J 2007; 71: 160–165)

Key Words: Atrial flutter; Atrial tachycardia; Catheter ablation; Eustachian ridge; Functional block

Most focal atrial tachycardias (ATs) originate from the right atrium (RA), the orifice of the pulmonary veins or the mitral annulus in the left atrium1–8 and radiofrequency (RF) catheter ablation has become an effective curative therapy.1–9 In the RA, AT often originates along the crista terminalis, para-Hisian region, or from the inferoseptum, including the ostium of the coronary sinus (CS).1–3 We describe 2 cases of AT arising from the RA inferoseptum. The remarkable characteristics of the tachycardia were that it masqueraded as isthmus-dependent, common atrial flutter (AFL).

Case Reports

Patient 1
A 34-year-old woman with a 1-year history of incessant, exercise-induced palpitation attacks was admitted for evaluation of the tachycardia. A “saw-tooth” pattern in the inferior leads, and negative P-wave polarity in lead V6 and positive in lead V1 during the tachycardia with a cycle length of 210 ms mimicked common AFL (Fig 1A). After informed consent was obtained, catheter ablation was performed. At the beginning of the procedure, the patient had a normal sinus rhythm. The activation sequence across the cavo-tricuspid isthmus was in a clockwise direction during pacing from the CS ostium with a cycle length of 600 ms. The tachycardia could not be induced by programmed atrial stimuli. However, it could be induced by isoproterenol infusion, with a warm-up and cool-down phenomena, suggesting that the mechanism of this AT was automaticity. Activation mapping demonstrated a counterclockwise activation sequence around the tricuspid annulus during the tachycardia (Fig 1B). The earliest atrial activation was found at a site near the CS ostium. The ablation catheter became stabilized at that site after clockwise torquing the catheter against the RA inferoseptum, away from the CS ostium. The local electrograms at that site exhibited double potentials, and a small, first potential preceded the atrial energy at that site. In the right anterior oblique view, the successful ablation site was posterior to the superior rim of the CS ostium, and corresponded to the Eustachian ridge (ER) (Fig 2B). The P-wave morphology and polarity during pacing from the successful ablation site were almost identical to those of the clinical tachycardia. During the tachycardia, a counterclockwise activation sequence was observed around the tricuspid annulus. However, during pacing from the ablation site with a longer cycle length of 600 ms after the ablation, the activation sequence across the isthmus was in the clockwise direction (Fig 2C). The patient was discharged without the need for medications and has done well with no AT recurrence during a 2-year follow-up period.

Patient 2
A 75-year-old man presented with a 2-year history of recurrent episodes of palpitation attacks. From the electrocardiographic findings recorded during the palpitations, he was diagnosed with common AFL. An intravenous bolus of adenosine triphosphate (10–20 mg) neither terminated nor suppressed the tachycardia. Because it was also not terminated by linear ablation of the cavo-tricuspid isthmus at the 6 o’clock position, when the tricuspid annulus was viewed as a clock face in the left anterior oblique view, and with programmed atrial extrastimuli, he underwent external cardioversion. Complete isthmus block was assessed during pacing from a site just medial to the ablation line (between the ablation line and CS ostium) at a cycle length of 400 ms and resulted in an appropriate atrial activation sequence recorded with a Halo™ catheter and the presence of double-potentials along the entire ablation line (double potential...
interval: 100 ms). Although no tachycardia was induced after the ablation procedure, the tachycardia recurred 2 weeks after the procedure. He was transferred for re-evaluation of the tachycardia. The recurrent tachycardia was paroxysmal, and the P-wave morphology during the tachycardia was identical to that recorded at the other hospital (Fig 3A). Bidirectional block at the cavo-tricuspid isthmus, which had been created at the other hospital, was confirmed by pacing from both sides of the isthmus during sinus rhythm and the presence of double-potentials along the
entire ablation line. The tachycardia could be reproducibly induced and terminated by rapid atrial pacing from the CS ostium, and the tachycardia cycle length was 210 ms. During the tachycardia, counterclockwise activation along the RA free wall and clockwise activation along the septal aspect of the RA near the CS ostium around the tricuspid annulus were both blocked at the isthmus (Fig 3B). During entrainment from the infero-anterior RA, the post-pacing interval was greater than the tachycardia cycle length and had a different atrial activation sequence. Concealed entrainment was obtained during pacing from the RA near the CS ostium: The interval from the stimulus to the P-wave onset was 30 ms, which was less than 30% of the AT cycle length, indicating that this was an exit site of the reentrant circuit (Fig 4). The post pacing interval was 210 ms, which was the same as the AT cycle length. During the tachycardia, the local electrogram at this site, which consisted of a large, sharp first potential and small second potential, preceded the atrial potential at the CS ostium by 25 ms (Fig 5A). RF energy application at this site using a maximum power of 35 W and maximum temperature of 55°C eliminated the tachycardia and it could not be induced after this application. During activation mapping of the tachycardia, the ablation catheter became stabilized at that site after clockwise torquing the catheter to lie along a ridged structure that corresponded to the posterior portion of the ER. The successful ablation site was clearly different from the site at which the linear ablation was performed at the isthmus in the former hospital (Halo 4), and was apparently posterior to the CS ostium where the most proximal electrode of a
2-Fr octapolar catheter (CS 8) was positioned (Figs 5B, C).
The P-wave morphology during pacing from the successful ablation site with a cycle length of 210 ms was identical to that of the clinical tachycardia. Changes in the intra-atrial activation pattern around the tricuspid annulus during pacing from the successful ablation site with different cycle lengths are shown in Fig 6. Pacing with a relatively longer cycle length of 400 ms resulted in a clockwise activation sequence around the tricuspid annulus (Left panel). However, during pacing with a shorter cycle length of 210 ms (Right panel), the same as the tachycardia cycle length, exhibited a counterclockwise activation around the tricuspid annulus, which might indicate functional block in the posterior portion of the right atrium (sinus venosa region or crista terminalis). Abbreviations as in Figs 2, 4.
same as the AT cycle length, resulted in a counterclockwise activation around the annulus (Fig 6, Right panel). The patient was discharged without the need for medications and has done well with no recurrence of the tachycardia during a 3-year follow-up period.

Discussion

This report demonstrates that (1) functional block in the clockwise direction at the isthmus and posterior RA due to rapid activation of the AT origin within the RA inferoseptum may create an ECG masquerading as common AFL, (2) RF catheter ablation is effective in curing this type of AT, and (3) the ER might be the origin of a focal AT. Of 115 patients with focal AT in whom the AT origin was identified and RF ablation was attempted over the past 10 years in our center (56 men, 64 women; 58±17 years), these 2 ATs (2%) were masquerading as isthmus-dependent AFL. Therefore, although rare, AT originating from the RA inferoseptum should be considered when the surface ECG shows common AFL.

In the present cases, the P-wave morphologies and atrial activation sequences around the tricuspid annulus during the AT were the same as those for common AFL. However, during pacing from the successful ablation site with a long cycle length after the ablation, no conduction block at the isthmus (case 1) or postero-medial RA (both cases) was observed. Recent studies demonstrated that functional conduction block can occur at the cavo-tricuspid isthmus and postero-medial RA (sinus venosa region or crista terminalis) during pacing from the CS with short cycle lengths, and those rate-dependent conduction characteristics may play an important role in initiating and maintaining AFL.11–14 Because the mean cycle length of focal AT is usually about 350 ms (range 250–500 ms),7,8 an isoelectric line between the P waves usually can be found during the tachycardia. The P wave polarity of an AT with an exit zone at the RA inferoseptum is very similar to that of common AFL, with its exit zone also at the RA inferoseptum. In the present cases, the cycle length of the ATs was 210 ms, which was clearly shorter than that reported previously.3–5,7,8 Therefore, both rapid activation of the AT origin and the anatomic and conduction properties of the isthmus and posterior RA might result in functional block and counterclockwise activation around the tricuspid annulus during the AT, resulting in distinctive sawtooth waves in the inferior leads, thus mimicking common AFL. A fixed anatomical block between the inferior vena cava and CS ostium formed by the ER may also have played an important role in the counterclockwise activation around the tricuspid annulus in these 2 cases.

The ATs presented here both originated from the RA inferoseptum, which is a preferential site of origin for an AT. Recently, AT originating from the CS ostium (within 1 cm of the CS ostium) has been reported.19 In that type of AT, the RA inferoseptum is the exit zone. Therefore, when the AT has a short cycle length with functional block at the posterior RA and crista terminalis, as in the present cases,1–14 the surface ECG of the tachycardia can masquerade as isthmus-dependent AFL. Therefore, in this setting, it may be difficult to differentiate the ATs originating from the ER from those arising from the CS ostium.20 However, in the cases presented here, by the sensation felt when the catheter was positioned at the successful ablation site and by fluoroscopic guidance with multidirectional views and CS angiography, we confirmed that the successful ablation sites were not at the CS ostium but at a site compatible with the ER. An experimental study demonstrated that normal sinus pacemaker cells exist within the ER and cells with spontaneous automaticity can be found in that region.13 Those cells with abnormal automaticity might be related to the genesis of the AT originating from that region. The reentrant mechanism of the AT could be explained by the non-uniform anisotropic conduction properties around the ER.16 For these reasons mentioned, we believe that the AT origin in the 2 current cases was the ER. However, to support and enhance our idea, we would need to have performed an intracardiac echocardiography to confirm that the successful ablation site in both cases was the ER.

As we did not perform an extensive examination with programmed electrical stimulation, the precise mechanism underlying these ATs was not determined in either case. However, in case 1, the AT could not be induced by programmed electrical stimulation. Instead, it occurred spontaneously or during isoproterenol infusion, which suggested a nonreentrant mechanism for the AT, most likely involving triggered activity or automaticity. On the other hand, in case 2, the AT was reproducibly induced or terminated by programmed electrical stimulation and the entrainment phenomenon was confirmed. The AT was eliminated by a single application of RF energy. Therefore, microreentry at and/or near the ER might be the most likely mechanism of the AT. In these 2 cases, lower loop reentry could be excluded because the cavo-tricuspid isthmus was not a critical component of the tachycardia.17 However, intra-isthmus reentry, which has been reported recently, was possibly the mechanism of those ATs.18 This AT masqueraded as isthmus-dependent AFL under a relatively long cycle length of the tachycardia and a varied RA activation pattern with an identical AT cycle length have been reported as its characteristics.18 Although these characteristics were not found in each of the present patients, the tachycardia circuit might have been confined to the septal portion of the cavo-tricuspid isthmus and CS ostium, and a linear ablation at the isthmus might have resulted in failure because of that special circumstance in case 2.18

Conclusion

Functional block in a clockwise direction at the isthmus and posterior RA caused by rapid activation of the origin in the RA inferoseptum may create an ECG recording that masquerades as common AFL. Therefore, although rare, AT originating from the RA inferoseptum should be considered when the surface ECG shows common AFL and it is important to perform entrainment maneuvers at the cavo-tricuspid isthmus and detailed mapping around the area between the isthmus and the CS ostium.

Acknowledgements

This work was supported by a Research Grant for Cardiovascular Diseases (14C-2) from the Ministry of Health, Labor and Welfare, Japan and by a grant from the Gunma Prefecture Government.

References


