Successful ablation of cavotricuspid isthmus–dependent flutter through a mechanical tricuspid valve

Gareth J. Padfield, BMSc, MBChB, PhD, MRCP, Gary A. Wright, BMSc, MBChB, MD, MRCP, Gruschen R. Veldtman, MBChB, FRCP, Niki L. Walker, MBChB, PhD, FRCP, Mark H.D. Danton, MBBCH, MD, FRCS, Derek T. Connelly, MBChB, MD, FRCP

From the Golden Jubilee National Hospital, Glasgow, Scotland.

Introduction

The cavotricuspid isthmus (CTI) is an exceptionally arrhythmogenic structure due to a combination of particular anatomic and electrophysiological characteristics. It is a relatively narrow corridor of myocardium, bounded by anatomic conduction block at the ventricular aspect by the tricuspid annulus, and atrially by electrically inert portions of the inferior vena cava. Electrical wavefronts may propagate into the CTI via septal and lateral inputs, which are characterized by myocyte anisotropy and relatively slow conduction velocity. The crista terminalis, which lies adjacent to the CTI on the anterolateral right atrium, forms a line of functional block to perpendicular wavefront propagation, but allows very rapid conduction of wavefronts propagating parallel to the crista's longitudinal orientation. These properties may serve to funnel a rapidly propagating wavefront inferiorly toward the slowly conducting CTI, facilitating macro entry around the tricuspid annulus, and hence the reason for a counterclockwise direction of activation. Relatively minor degrees of right atrial enlargement and fibrotic change can predispose to CTI flutter, and this arrhythmia is therefore very common in patients with heart disease in general, and especially so in those with operated congenital heart disease. Fortunately, the discrete nature of the arrhythmogenic substrate and its relatively accessible location, makes it most amenable to catheter ablation, which is frequently curative. However, in Ebstein disease the CTI can be elongated and thickened, and can be quite resistant to ablation. Furthermore, prosthetic material, such as a valve ring, can block access to the CTI, preventing radiofrequency delivery to tissue deep to it. Further ablation on the ventricular aspect of the valve may be necessary to achieve conduction block. This has been described previously in the setting of a bioprosthetic valve, where the risk to damaging the valve leaflets is relatively low, but mechanical valve leaflets would generally be considered a contraindication to this approach. An ablation catheter could damage the valve struts or become wedged within the valve, and this could lead to potentially lethal acute or chronic valve dysfunction and necessitate high-risk redo surgery. However, atrial flutter can be highly symptomatic and lead to cardiac decompensation and, as with all treatments to a greater or lesser extent, there is a balance to be struck between risk and reward, even though this can be difficult to quantify in absolute terms.

KEY TEACHING POINTS

- Prosthetic valves may complicate ablation of arrhythmias by preventing access to a critical isthmus.
- An ablation catheter may be passed safely through a mechanical prosthetic valve in the tricuspid position to perform ablation of the cavotrucuspid isthmus, however, consideration must be given to the aperture of the valve, and whether there are factors that might limit control of the catheter and directing sheath.
- This approach would most likely not be safe to facilitate ablation of a more complex substrate within the right ventricle, where there would be a need for more catheter manipulation.
- A robust patient consent process is very important when risks of treatments are hard to define.

Case report

The patient was a 45-year-old woman with Ebstein anomaly who had undergone a Carpentier-Edwards tricuspid valve

KEYWORDS Ablation; Cavotricuspid-dependent flutter; Ebstein disease; Mechanical tricuspid valve; Operated congenital heart disease
(Heart Rhythm Case Reports 2025;11:133–137)

Address reprint requests and correspondence: Dr Gareth J. Padfield, Cardiac Pacing and Electrophysiology Service, Golden Jubilee National Hospital, Glasgow, Scotland G81 4DY. E-mail address: Gareth.Padfield@gjnh.scot.nhs.uk.

https://doi.org/10.1016/j.hrcr.2024.10.024

replacement in 1988 due to severe tricuspid regurgitation and right heart dysfunction. In 1997, a redo tricuspid valve replacement was required, and this was performed with a 33-mm ATS bileaflet mechanical prosthesis (ATS Medical). In 2014, the valve function was compromised due to acute thrombosis in the context of pregnancy. This was successfully treated with thrombolysis, which restored normal prosthetic valve function. Her presentation at that time was complicated by typical atrial flutter, which continued to be problematic in the years following that. In 2017, a CTI ablation was performed for typical atrial flutter (Figure 1). During this ablation, the catheter transiently and harmlessly passed through the inferior component of the valve aperture, allowing some ablation to be performed, which terminated tachycardia with apparent evidence of bidirectional block. Unfortunately, tachycardia with the same surface morphology recurred and, due to severe symptoms of tachycardia, effort intolerance, and lethargy, was considered for repeat ablation. Cardiac computed tomography had previously demonstrated that the position of the mechanical prosthesis was offset to the valvular plane, with the coronary sinus ostium and paraseptal components of the CTI positioned on the ventricular side of the valve (Figure 2). It was considered unlikely that CTI block could be achieved with ablation purely on the atrial side of the valve. An in-depth discussion was had with the patient and her close family regarding the potential risks associated with ablation of the CTI. From the fluoroscopic appearance of the valve, it was evident that an ablation catheter could be passed between either leaflet and the annulus. Given the previous experience, the likelihood of valve disruption during catheter ablation was thought to be low, but it was recognized that an absolute risk was difficult to define. However, it was clear that should a complication arise, such as valve disruption or catheter entrapment, it could potentially be very serious, potentially requiring a third sternotomy and redo-redo surgery, or chronic valve dysfunction and right heart failure. This risk would be in addition to the usual risks associated with an ablation procedure. The procedure might also be met with failure. After due consideration and discussion, the patient decided to proceed with catheter ablation on account of severe reduction in quality of life.

Electrophysiological procedure

The patient was in atrial flutter at baseline. The case was performed on therapeutic anticoagulation with warfarin and assisted by the Precision electroanatomic mapping system (Abbott). Femoral venous access was achieved in duplicate under ultrasound guidance and a decapolar catheter (Inquiry M; Abbott) was placed on the lateral right atrium adjacent to the tricuspid annulus. Using a DF-TactiCath (Abbott), activation mapping of the tachycardia was performed, which demonstrated CTI dependence (Figure 3), and this was confirmed by entrainment mapping. Attempts to terminate the tachycardia by ablation on the atrial aspect of the prosthesis did not affect the tachycardia cycle length. Using an m-curl Agilis sheath (Abbott), the ablation catheter was advanced through the superior aperture of the valve, and the Agilis sheath abutted against the superior aspect of the annulus for stability. The ablation catheter was retro-flexed to the CTI, just medial to the ostium of the coronary sinus (Figure 4 and Supplemental Video). Entrainment at this site confirmed participation in the circuit. Ablation at 50 W irrigated radiofrequency caused termination of tachycardia back to sinus rhythm (Figure 5). It was difficult to accurately determine the presence of bidirectional block due to limited catheter maneuverability. Unidirectional block in the lateral to medial direction was present. Tachycardia remained noninducible at 30 minutes using extrastimulus testing. Sheaths were removed and hemostasis achieved.

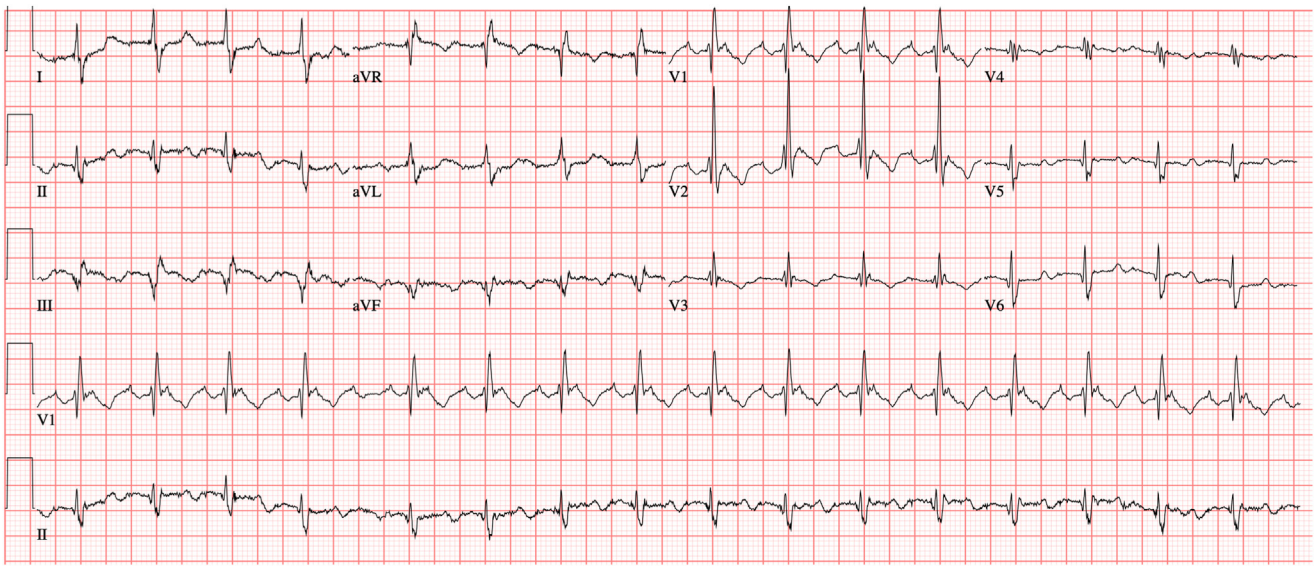

Figure 1 12-lead electrocardiogram demonstrating typical atrial flutter with 2:1 atrioventricular conduction.

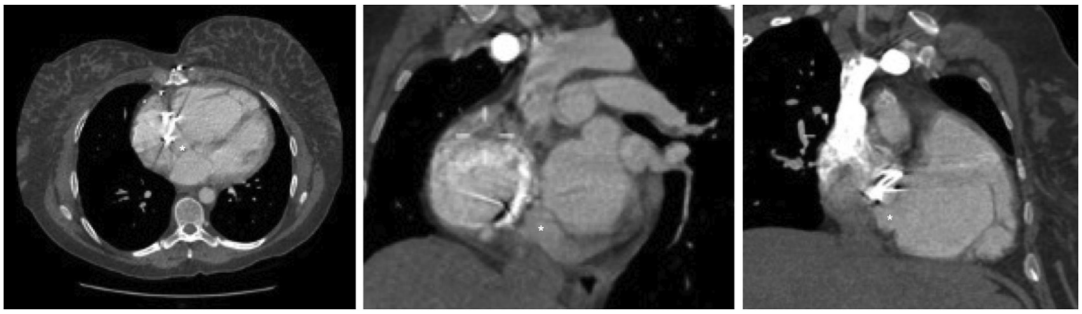

Figure 2 Computed tomography chest demonstrating the attitude of the tricuspid prosthesis relative to the valvular plane and coronary sinus (CS) ostium. Proximal CS annotated with asterisk (*).

Fluoroscopic inspection of the valve postoperatively demonstrated normal valve movement (Supplemental Video) and serial echo assessment has shown normal valve function.

The patient has presented approximately 2 years post ablation with nonsustained and non–CTI-dependent atrial arrhythmia in the context of a urinary tract infection, which resolved spontaneously. She has otherwise remained free of arrhythmia with no recurrence of CTI-dependent flutter over follow-up approaching 4 years.

Discussion

The incidence of atrial arrhythmias is high in operated congenital heart disease, occurring at some point in more than 50% of patients who survive to adulthood.[1] The combination of surgical incisions, sutures, and progressive fibrosis provide the perfect environment for the development of re-entrant arrhythmias; however, despite the multiple potential flutter circuits that can occur, CTI-dependent flutter remains the most commonly encountered atrial arrhythmia across a spectrum of congenital malformations.[2] Ablation of the CTI is normally straight forward; however a number of factors may make ablation difficult in congenital heart disease. These include structural remodeling with enlargement and displacement of the CTI and, importantly, the presence of structural barriers that guard components of the CTI from access via the conventional inferior caval approach, such as those encountered in patients after Fontan and atrial switch procedures. Ebstein anomaly is associated with both significant chamber dilatation and loss of definition of the atrioventricular groove, and although acute success is good, recurrence of typical atrial flutter is probably high, judging from the limited data available.[3] The presence of a prosthetic valve can complicate matters further by protecting myocardium that is a critical component of the flutter circuit, located underneath the valve ring itself or on its ventricular aspect. If one were to cross the valve, impaired catheter maneuverability would be anticipated, along with the potential hazard of prosthetic leaflet damage and valvular dysfunction. Indeed, in the case of a mechanical prosthesis, crossing the valve with an ablation catheter is generally not performed for this reason. Ablation of CTI-dependent flutter in a patient with a bioprosthetic tricuspid valve has been previously described by Traykov et al.[4] They encountered a situation very similar to our case, with the septal aspect of the tricuspid valve being attached posterior to the ostium of the coronary sinus, thereby misaligning the prosthesis with the annular plane, and leaving the paraseptal component of the CTI anterior and ventricular to the valve prosthesis. Durable termination of flutter

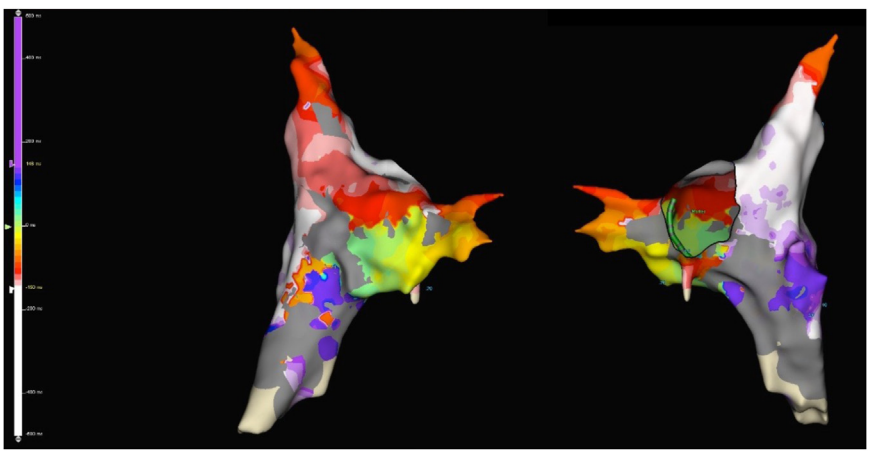

Figure 3 Activation map during tachycardia demonstrating clockwise flutter. A small portion of the tachycardia cycle length has not been accounted for in association with the heavily scarred cavotricuspid isthmus.

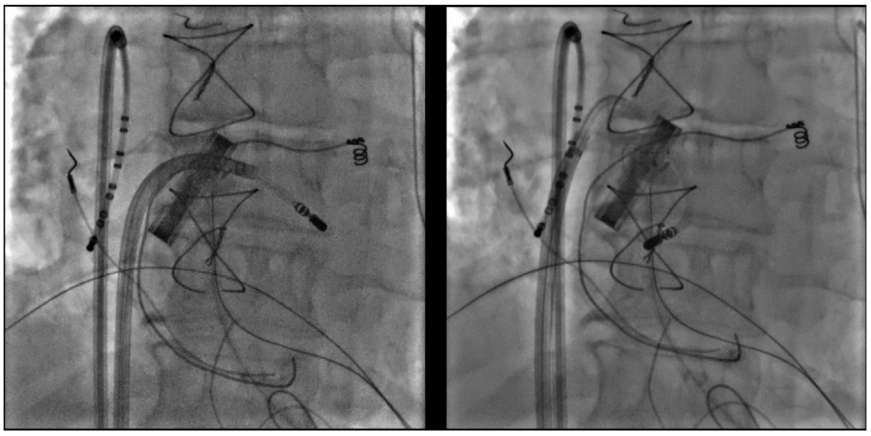

Figure 4 A fluoroscopic right anterior oblique view of the ablation catheter guided across the mechanical prosthesis with an Agilis sheath (Abbott), and retroflexed to the cavotricuspid isthmus.

was only achieved by ablation on the ventricular aspect of the valve. Our case was made more challenging by the presence of mechanical leaflets, which could easily become disrupted by the ablation catheter or sheath. Safe right-heart catheterization in the presence of a mechanical valve has been described,[5] however, an ablation catheter and steerable sheath are considerably heavier and pose an increased risk of disrupting valve leaflets, although conceivably may be less likely to become entrapped.

The risk associated with the procedure was the most important consideration relating to this case, but this was very difficult to quantify for the consenting process. The fluoroscopic appearance of the valve demonstrated that the catheter could pass through the superior and inferior aspects of the valve orifice. There was a concern that inadvertent force might be applied to the leaflets during catheter manipulation, or that the catheter might wedge against a valve leaflet preventing retraction of the catheter. The use of a steerable sheath was used to mitigate against the first concern and, by holding the steerable sheath firmly against the annulus in a static position while manipulating the catheter toward the CTI, contact with the leaflets could be avoided. As it transpired to manipulate the catheter to the site of successful termination, the sheath did need to be retracted into the right atrium, although catheter displacement against the leaflets did not occur.

Figure 5 Termination of atrial flutter during ablation of the cavotricuspid isthmus.

We had extensive preoperative discussions on multiple occasions with the patient and her family regarding the wisdom of proceeding with the ablation. We felt that an acutely successful ablation was likely, but that recurrence of an alternative non–CTI-dependent arrhythmia could easily occur, potentially dissolving any benefit provided by the CTI flutter. However, this development might be several years in the future, and significant symptomatic benefit might be achieved during this period. The fact that there was no proven prognostic benefit was also discussed. Importantly, the potential for a life-threatening outcome was possible, including the need for redo surgery and cardiopulmonary bypass, and all the associated sequelae that might follow. This decision had to be made in the context of significant symptoms and diminution of her quality of life. After these discussions and a joint electrophysiologist/adult congenital multidisciplinary meeting, a process of shared decision making with the patient and her family allowed the patient to reach the conclusion that the risk, although imprecisely defined, was worth taking.

Conclusion

This case demonstrated that successful catheter ablation of CTI flutter can be performed without complication by crossing a mechanical tricuspid valve, and with good long-term results. Importantly, we highlight the considerations relating to patient consent when undergoing potentially hazardous procedures when the risks and benefits are difficult to quantify. Although this proved to be a successful course of action in this case, it would be inappropriate to generalize this approach to all such cases. The risk remains difficult to quantify and even given similar anatomic parameters and symptom burden, it may not be appropriate for every person. Risk tolerance will vary markedly between patients and, of course, their treating physicians.

Funding Sources: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Disclosures: The authors have no conflicts of interest to disclose.

Appendix

Supplementary data

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.hrcr.2024.10.024.

References

1. Bouchardy J, Therrien J, Pilote L, et al. Atrial arrhythmias in adults with congenital heart disease. Circulation 2009;120:1679–1686.
2. Lukac P, Pedersen AK, Mortensen PT, Jensen HK, Hjortdal V, Hansen PS. Ablation of atrial tachycardia after surgery for congenital and acquired heart disease using an electroanatomic mapping system: which circuits to expect in which substrate? Heart Rhythm 2005;2:64–72.
3. Hassan A, Tan NY, Aung H, et al. Outcomes of atrial arrhythmia radiofrequency catheter ablation in patients with Ebstein's anomaly. Europace 2018;20:535–540.
4. Traykov VB, Pap R, Bencsik G, Makai A, Forster T, Saghy L. Ventricular location of a part of the right atrial isthmus after tricuspid valve replacement for Ebstein's anomaly: a challenge for atrial flutter ablation. J Interv Card Electrophysiol 2009;25:199–201.
5. Pettit S, Tsui S, Parameshwar J. Right heart catheterisation may be cautiously performed through a mechanical valve prosthesis in the tricuspid position. BMJ Case Rep 2016;2016:10 1136/bcr-2016-215326. doi:10.1136/bcr-2016-215326.