Atypical flutter following lung transplantation involving recipient-to-donor tissue connections

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Introduction
Atrial arrhythmias commonly occur following lung transplantation. Atrial fibrillation is the most common arrhythmia in the first weeks and months following transplantation, while atrial tachycardia (AT) or atrial flutter (AFL) is the most common atrial arrhythmia in the late follow-up period.1–3 Right atrial circuits, including cavotricuspid isthmus–dependent flutter, are reported to be the most common mechanism of postoperative AT/AFL, while tachycardia originating within the donor cuff of atrial tissue and late establishment of a single donor-to-recipient electrical connection across the graft anastomosis remains an unusual mechanism of atrial arrhythmias following lung transplantation. We describe an adult lung transplant recipient who presented with a left-sided AFL that involved 2 discrete electrical connections between the donor pulmonary vein (PV) graft and recipient left atrium (LA).

Case report
A 53-year-old woman with a history of alpha-1 antitrypsin deficiency–related emphysema underwent bilateral lung transplantation 7 years prior to arrhythmia presentation. At transplant, the donor PV cuffs were anastomosed to separate recipient atriotomies for the right and left PVs. She presented with symptomatic atypical AFL that recurred despite cardioversion and antiarrhythmic medication trials, and she was referred for a catheter ablation. The 12-lead electrocardiogram during tachycardia demonstrated flutter waves with a right inferior axis, consistent with a left atrial origin. In the electrophysiology lab, the patient arrived in tachycardia, which had an atrial cycle length of 220–240 ms. A decapolar catheter was introduced into the coronary sinus (CS), with the earliest activation in the distal electrodes, demonstrating an eccentric LA activation pattern. A preprocedure cardiac computed tomography scan had been performed and was imported to merge with 3-dimensional electroanatomic maps (Figure 1A). Following double transseptal access, a 10-electrode circular mapping catheter was positioned just inside the circumferential atrial anastomosis between the recipient LA and the donor PV cuff of the transplanted left lung. An ablation catheter was used to perform point-by-point entrainment and left atrial mapping with the electroanatomic mapping system (Carto, Biosense Webster, Diamond Bar, CA). Entrainment from the CS showed that the postspacing interval (PPI) was longer than the tachycardia cycle length (TCL), with a smaller difference seen in the distal CS (electrodes 1,2). Entrainment from the ablation catheter at sites around the mitral annulus, as well as the LA roof and LA septum, showed manifest fusion and PPI greater than TCL, ruling out mitral

KEY TEACHING POINTS

- Atrial fibrillation is the most common arrhythmia in the first weeks and months following lung transplantation, while atrial tachycardia or flutter (AT/AFL) is the most common atrial arrhythmia in the late follow-up period.
- Right atrial circuits, including cavotricuspid isthmus–dependent flutter, are reported to be the most common mechanism of postoperative AT/AFL, while tachycardia originating from the graft anastomosis between the pulmonary veins and the atrium remains an unusual mechanism of atrial arrhythmias following lung transplant.
- Although a surgical anastomosis between the donor pulmonary vein cuff and recipient left atrium should represent the ultimate form of antral pulmonary vein isolation, late-appearing electrical conduction across the donor-to-recipient anastomosis, between tissues from different hosts, occurs rarely and can result in a reentrant mechanism of AT.

KEYWORDS
Atrial tachycardia; Atrial flutter; Catheter ablation; Lung transplantation; Donor-to-recipient conduction; Entrainment; Figure-of-8

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annular flutter, roof flutter, and septal flutter circuits. Entrainment just outside the posterior aspect of the left PV cuff showed a PPI that was identical to the TCL, demonstrating that this site was in the reentry circuit (Figure 2). Entrainment maneuvers performed around the full circumference outside the left PV anastomosis (which was identified by a slight “waist” on the computed tomography image) all showed PPI equal to TCL. The circular mapping catheter, being positioned just inside the left PV cuff, recorded near-field fractionated electrograms around the circumference of the donor tissue, and also far-field signals from around the circumference of the nearby recipient left atrial tissue. Virtually the entire cycle length of the atypical AFL was encompassed by the circular mapping catheter. The electrical wavefront entered from recipient LA into the donor PV cuff via a posterior electrical connection; it then traveled forward both superiorly and inferiorly inside the donor cuff, exited from the donor PV cuff back into the recipient LA at a second anterior electrical connection, and then traveled backward both superiorly and inferiorly toward the first connection (Figure 1B–D). Entrainment showed that all these aforementioned sites were “in” the circuit, which therefore was demonstrated to be a double-loop or “figure-of-8” circuit, critically involving 2 distinct connections that spanned the donor–recipient suture line.

Radiofrequency ablation was performed at the posterior donor–recipient connection site, which terminated the AFL to sinus rhythm (Figure 3). In sinus rhythm, there was now a reversal of the near-field electrogram activation sequence in the Lasso catheter, corresponding to the wavefront now entering the PV cuff at the remaining anterior
donor–recipient connection site (Figure 3C). Radiofrequency application at this anterior connection site then achieved complete electrical isolation of the donor PV cuff, and isolated, dissociated ectopy was now seen inside the PV cuff. The patient remained symptom-free, off all antiarhythmic drugs, with no recurrence of left AFL.

Discussion
In the literature, there are limited data on unique mechanisms of AT in lung transplant recipients. Donor-to-recipient graft anastomosis conduction represents a rare AT mechanism in lung transplant recipients, with 3 cases reported previously presented. See and colleagues' reported a single case of the 4 lung transplant recipients who underwent electrophysiology study at their center, and Nazmul and colleagues' and Sacher and colleagues' reported a similar case of donor cuff AT that exited across a single donor-to-recipient connection. Electrical connectivity between recipient and donor transplant tissues supporting an atrial arrhythmia mechanism has also been reported to occur after cardiac transplant. Chaikriangkrai and colleagues' disputed this mechanism in their series of 25 patients who underwent electrophysiology study for atrial arrhythmias, instead concluding that all PV antral arrhythmias actually arose from the recipient’s PV antrum, without any connections across the PV anastomosis sites; their conclusions were supported by 2 other cases with similar mechanisms published recently. Other reports of graft anastomosis site ATs exist with less clear mechanisms.

To our knowledge, this is the first report of a unique AFL mechanism in a lung transplant recipient, critically involving 2 separate donor-to-recipient connections across the anastomosis line. The fortuitous positioning of a circular mapping catheter parallel to the circular anastomosis line allowed for simultaneous recording of anteriorly directed wavefronts in donor tissue and posteriorly directed wavefronts in nearby recipient tissue, eliminating any doubt that the anastomosis served as a circumferential electrical barrier except for 2 discrete connections on the anterior and posterior aspects of the suture line. The reversal of wavefront activation within the donor PV cuff after posterior connection ablation and flutter termination further confirmed...
this observation. Entrainment at all sites just outside and inside the suture line demonstrated a PPI that was equal to the TCL, proving the figure-of-8 flutter mechanism.

Although a surgical anastomosis between the donor PV cuff and recipient LA should represent the ultimate form of antral PV isolation, late-appearing electrical conduction across the donor-to-recipient anastomosis, between tissues from different hosts, occurs rarely and raises interesting questions regarding the mechanisms underlying the establishment of new cell-to-cell conduction.

Limitations
The version of Carto that was used for this case did not have the FAM mapping option, and therefore a detailed voltage map was not created of the left atrium.

Conclusion
Surgical anastomoses between donor and recipient left atrial tissue during lung transplantation usually represent long-term electrical barriers, but late-appearing electrical conduction across these anastomoses may rarely occur. When recipient-to-donor conduction occurs in one or more locations, such connections can play a critical role in arrhythmogenesis. Ablation on the suture line can be curative for atrial arrhythmias that originate within and exit the donor cuff, or reentrant arrhythmias that critically depend on recipient-donor tissue conduction.

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