

Transhepatic Access to the Atrioventricular Ring for Delivery of Radiofrequency Energy

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Transhepatic Ablation. *Introduction:* Transcatheter radiofrequency ablation is an effective, safe treatment of arrhythmias in children. However, despite technical advances, patients with obstructed venous access to the heart have not been candidates for this treatment.

Methods and Results: Two children (8.2 and 10.9 kg) with complex congenital heart disease, supraventricular tachycardia, and obstructed venous access underwent successful radiofrequency ablation of either a right (one patient) or left (one patient) accessory pathway using the transhepatic route to the heart.

Conclusion: This experience underscores the usefulness of the transhepatic approach in small patients, in patients with limited venous access, and in patients with complex congenital heart disease. (*J Cardiovasc Electrophysiol*, Vol. 8, pp. 512-516, May 1997)

arrhythmia, cardiac catheterization, children, congenital heart disease, radiofrequency ablation, supraventricular tachycardia, transhepatic catheterization

Introduction

Radiofrequency ablation (RFA) has proved to be an effective and safe treatment of many different arrhythmias in pediatric patients. The expanding use of special techniques such as transseptal entry to the left atrium, single catheters serving two functions, thinner caliber catheters, and long vascular sheaths has led to the successful application of radiofrequency current to complex arrhythmias occurring in children of all sizes with either structurally normal hearts or complex congenital heart disease.¹⁻⁵ Despite these technical advances, patients with venous obstruction and thus absence of venous access to the heart may be denied RFA. Two forms of complex congenital heart defects especially subject to arrhythmias are Ebstein's anomaly of the tricuspid valve and

congenitally corrected transposition of the great arteries. Both of these cardiac malformations are associated with accessory pathways supporting AV reentry tachycardia.⁶⁻⁸ In this report, we present two patients with complex congenital heart disease, supraventricular tachycardia (SVT), and obstructed vascular access to the heart who were successfully treated for SVT by RFA of their accessory pathway using transhepatic cardiac catheterization.⁹

Patient 1

A 26-month-old girl (10.9 kg) with situs solitus, dextrocardia, congenitally corrected transposition of the great arteries, a ventricular septal defect (VSD), pulmonary atresia, a normal left-sided tricuspid valve, and recurrent SVT received a Blalock-Taussig shunt on the 19th day of life. Digoxin and propranolol were administered to control her SVT, with only partial success. Electrophysiologic study, limited by known bilateral femoral venous occlusion, was completed through the right subclavian vein. This study demonstrated

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a concealed posterior septal accessory pathway supporting her SVT. However, because neither the left atrium nor the coronary sinus could be entered, the exact location of the accessory pathway could not be determined. Surgical repair of the VSD and placement of a left ventricular to pulmonary artery conduit was performed, but planned mapping and ablation of the accessory pathway was not attempted because access to the AV ring was limited by the dextrocardia and the conduit. Early after surgery, the SVT (230 beats/min) recurred. On postoperative day 7, an electrophysiologic study through surgically placed transthoracic epicardial atrial and ventricular leads was performed. The technique of transhepatic venous access to the heart has been described in detail previously.⁹ Briefly, a 22-gauge Chiba needle with stylet (Cook, Inc., Bloomington, IN, USA) was introduced percutaneously into the liver in the mid-axillary line half way between the diaphragm and the lower margin of the liver. The needle was advanced under fluoroscopic guidance to the mid-clavicular line. The stylet was then removed, and the needle was withdrawn slowly as a small volume of iohexol was gently and continuously instilled. When the contrast filled a hepatic venous radical and flowed cephalad toward the right atrium, a 0.018-inch mandril guidewire (Cook, Inc.) was then advanced through the needle into the hepatic vein and the right atrium. A 4-French coaxial dilator was then advanced over the wire and positioned in the low right atrium. A 0.035-inch J-wire was

exchanged for the inner dilator, and the mandril wire and the outer dilator were removed. A 6-French curved transhepatic sheath was then advanced over the 0.035-inch J-wire into the right atrium. A 6-French steerable quadripolar electrode catheter was then advanced through the sheath. Mapping demonstrated that the shortest right-sided retrograde activation time, measured during SVT when the catheter was positioned in the right posteroseptal area, was 81 msec. Application of radiofrequency current at this site was unsuccessful. Access to the left AV ring was accomplished by exchanging the transhepatic 6-French sheath for a 6-French pediatric transseptal sheath, which was advanced to the left atrium (Fig. 1). Mapping of retrograde left atrial activation during SVT revealed that the shortest VA interval was 60 msec at the left posteroseptal ring. RFA at this site terminated SVT 2.5 seconds after initiation of the fifth application (Fig. 2). Postablation electrophysiologic study failed to induce SVT. The patient was discharged home the next day; she has remained free of SVT during the 3 months of follow-up.

Patient 2

A 20-month-old boy (8.2 kg) with complex Ebstein's anomaly including pulmonary atresia, pre-excitation, and SVT had received a bidirectional Glenn shunt at 6 months of age. His SVT had been partially controlled with amiodarone. Due to the Glenn shunt and the known bilateral femoral

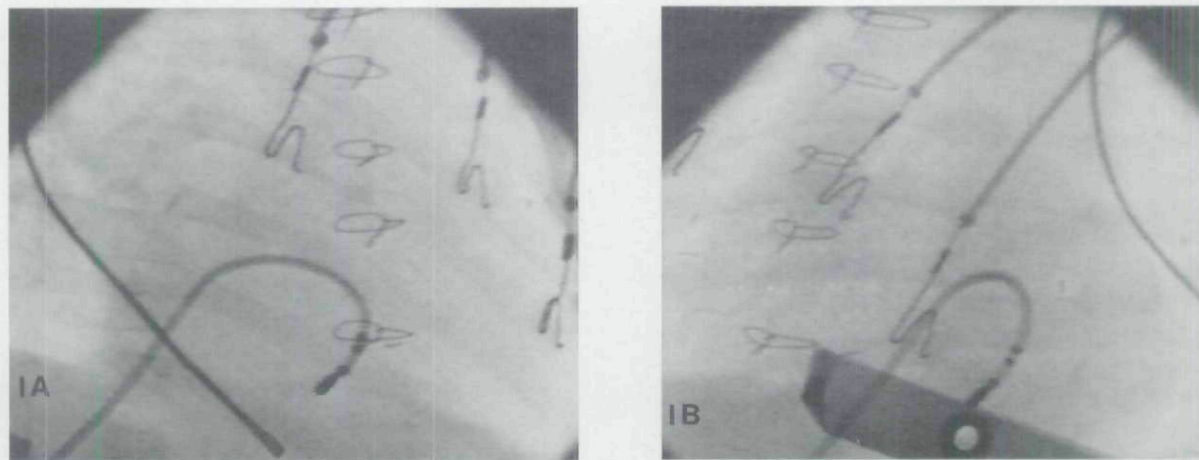


Figure 1. Radiographs from patient 1 displaying the transhepatic, transseptal sheath deployed through the liver, into the right atrium, and across the atrial septum into the left atrium. Note the diagonal course directed from the patient's right side rather than from her leg. The steerable electrode catheter is passed through the sheath so that the oversized electrode tip (4 mm) is positioned at the left posterior AV ring. Note that the right-sided morphologic left ventricle is directed to the right and posteriorly toward the vertebral bodies. (A) Right anterior oblique projection; (B) left anterior oblique projection.

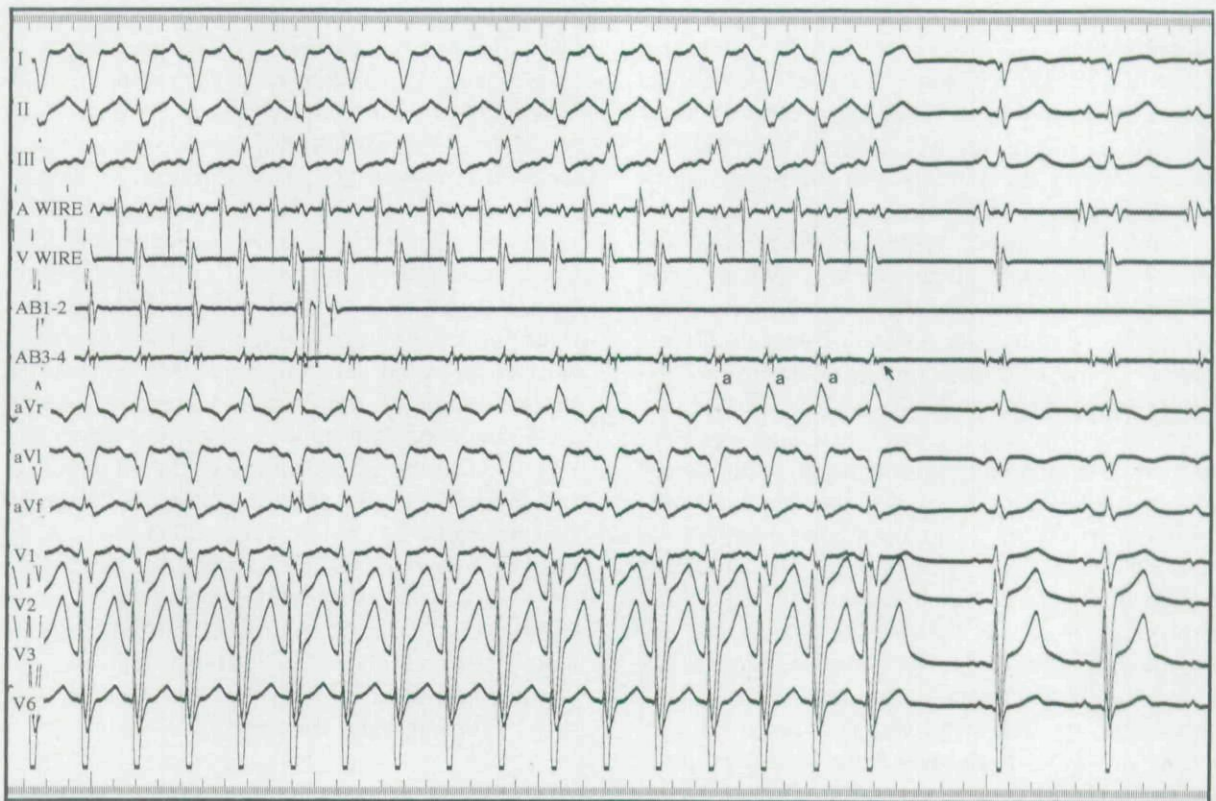


Figure 2. ECG and electrophysiologic tracings during delivery of radiofrequency current in patient 1. Note the absence of a retrograde "a" wave (arrow, recorded through electrodes 3 and 4 [AB3-4] on the mapping/ablation catheter) 2.5 seconds after initiation of radiofrequency current terminating the tachycardia. Paper speed = 50 mm/sec. a = atrial electrogram; AB1-2 = electrodes 1-2 on the mapping/ablation catheter; AB3-4 = electrodes 3-4 on the mapping/ablation catheter; A WIRE = bipolar atrial electrogram recorded through transthoracic epicardial atrial wires; V WIRE = bipolar ventricular electrogram recorded through transthoracic epicardial ventricular wires.

vein occlusion following prior cardiac catheterizations, all standard access to the right atrium was blocked. Therefore, using the transhepatic approach similar to that described for patient 1, a 7-French sheath was advanced into the right atrium. A transesophageal 4-French bipolar electrode catheter was used for atrial recording and pacing. Mapping of the right-sided AV ring was performed anterogradely during preexcited sinus rhythm and retrogradely during SVT. With the steerable quadripolar electrode catheter passing through the hepatic veins into the right atrium toward the atrial septum, a 135° anterior deflection was delivered to the steerable tip. Traction was then applied to the catheter and sheath as a unit, bringing the electrode tip firmly in contact with the right AV groove (Fig. 3). Flexion and extension of the catheter tip moved the catheter tip along the lateral AV groove, whereas counterclockwise and clockwise rotation of the catheter and curved sheath as a unit moved

the tip into the atrium or ventricle, respectively. Using this technique, the patient was found to have a right lateral accessory pathway. Radiofrequency energy delivered during the seventh application at the site with maximal preexcitation during sinus rhythm and the shortest retrograde conduction time during SVT¹⁰ along the right AV groove terminated both the preexcitation and SVT. Recurrence of the SVT and preexcitation 10 minutes later required an additional four applications to achieve permanent ablation of the accessory pathway. The patient was discharged home the next day; he has remained free of preexcitation and SVT at 3 months of follow-up.

Discussion

Application of RFA requires the operator to maneuver specifically designed electrode catheters to the potential ablation site. This report is the first

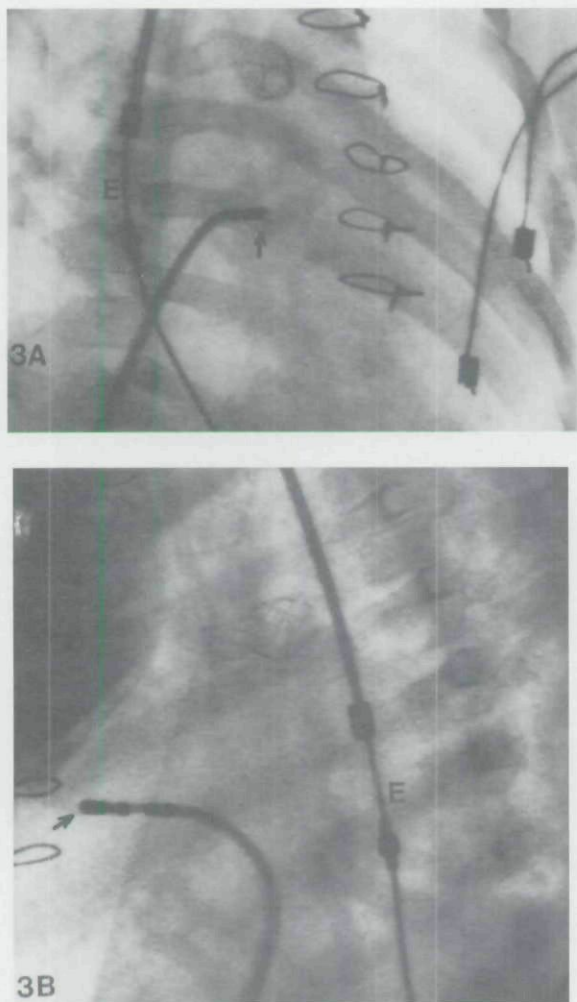


Figure 3. Radiographs from patient 2 displaying the transhepatic sheath and steerable electrode catheter deployed through the liver into the right atrium and then flexed and rotated anteriorly and to the right so that the oversized electrode tip (4 mm, arrow) abuts the right lateral free wall along the AV groove. The bipolar electrode transesophageal catheter (E) can be seen. There is a stent in the left pulmonary artery. (A) Right anterior oblique projection; (B) left anterior oblique projection.

to describe RFA using the transhepatic catheterization approach and highlights the difficulties that may be encountered when performing RFA in small patients with complex congenital heart disease and limited venous access. Even among patients with normal structural hearts and right free-wall pathways, a stable catheter position against the right AV groove is often difficult to achieve, and ablation at this site is less successful.³ Prior cardiac catheterization may result in vein or artery occlusion or injury.^{9,11,12} Surgical procedures such as the Glenn, Mustard, Senning, and modified Fontan

(lateral tunnel) operations, as well as deep vein thrombotic disease in the lower extremities and pelvis, may exclude portions of the right atrium, which is often the site of the RFA target.

Recently, Shim and associates⁹ reported a series of infants and children with limited vascular access who underwent diagnostic and interventional catheterizations using the transhepatic approach and 5- to 8-French sheaths with no significant adverse effects. Interventions in this series included balloon valvuloplasty and angioplasty and device closure of an atrial septal defect. Access to the right atrium was quickly, reliably, and safely achieved in this cohort of patients with no other venous access.

The experience with these two patients demonstrates several advantages of transhepatic cardiac catheterization for RFA. The first is that the technique allows the introduction of electrode catheters to both the right and left sides of the heart as well as to the region of the AV ring on both sides when standard access is unavailable. Retrograde arterial access to the left heart with large-gauge catheters has not proved to be an attractive technique in small children. In a report of children undergoing aortic valvuloplasty using the retrograde approach from the femoral artery(ies), 12% of all patients developed femoral arterial thrombi or damage noted at the time of the valvuloplasty; in patients < 1 year of age, 32% developed femoral arterial thrombi or damage.¹¹ This same group noted femoral artery injury in 3 of 5 patients < 12 months of age at aortic valvuloplasty at intermediate follow-up.¹² In addition, Doppler-detected aortic regurgitation has been noted in children who underwent ablation of left-sided pathways using the retrograde route to the left AV ring.¹³ Finally, similar success for ablation of left-sided accessory pathways using either the transseptal or retrograde approaches has been reported.¹⁴ Thus, this combined transhepatic transseptal technique not only preserves a good outcome, but also avoids passing a large-caliber ablation catheter through the femoral artery placing both the artery and aortic valve at risk.^{9,11-14}

The second patient also demonstrated an unexpected, but important, benefit of the transhepatic catheter procedure. The course of the catheter, as it passed through the hepatic vein and the inferior vena cava into the right atrium toward the atrial septum and was deflected and curved anteriorly, afforded an excellent angle of attack to the right lateral AV ring providing an optimal position for RF energy delivery at that site. Furthermore, the

shorter distance between target site at the right AV ring and the entry point in the liver, compared to that in the groin, may provide greater torque control of the catheter tip. The Ebstein's anomaly or a dilated right atrium often confound efforts to achieve a stable ablation catheter position at the right lateral AV ring.

In conclusion, this experience demonstrates that transhepatic catheterization in the hands of an experienced operator is a rapid and safe route to both the right and left AV ring for delivery of radiofrequency energy. Furthermore, this experience underscores the usefulness of the technique in small patients, in patients with limited venous access, and in patients with complex congenital heart disease. The technique may be of special value not only when access is limited but also when precise, stable catheter placement along the right lateral AV groove is required.

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