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Equipment and Technology

Balloon Atrial Septostomy in End-Stage Pulmonary Hypertension Guided by a Novel Intracardiac Echocardiographic Transducer

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Blade and balloon atrial septostomy has been used to reduce cardiopulmonary symptoms and as a bridge to lung or heart lung transplant in primary pulmonary hypertension. Due to severe right atrial dilatation and resultant loss of anatomical landmarks, the procedure is technically difficult, and the reported postprocedure mortality rate varies between 5% and 50%. Among others, marked systemic desaturation and systemic hypotension presumably secondary to an excessively large atrial septal defect have been reported as causes of postprocedure death. We report a case where a novel intracardiac catheter-based phased-array 5.5–10 MHz transducer with spectral and color-flow Doppler capabilities was used to assist a balloon atrial septostomy and to obtain hemodynamic data in a patient with end-stage pulmonary hypertension. *Cathet Cardiovasc Intervent 2001;52:530–534.*

Key words: atrial septostomy; transseptal catheterization; intracardiac echocardiography; pulmonary hypertension; phased-array catheters

INTRODUCTION

Blade and balloon atrial septostomy has been used to reduce cardiopulmonary symptoms and as a bridge to lung or heart lung transplant in primary pulmonary hypertension (PPH) [1–5]. Due to severe right atrial dilatation and resultant loss of anatomical landmarks, the procedure is technically difficult, and the reported postprocedure mortality rate varies between 5% and 50% [1,2]. Among others, marked systemic desaturation and systemic hypotension presumably secondary to an excessively large atrial septal defect have been reported as causes of postprocedure death [2].

Recent studies have demonstrated the utility of intracardiac echocardiography (ICE) during cardiac interventions, including electrophysiologic procedures and transseptal catheterizations [6–10]. We report the use of a novel catheter-based ICE with full Doppler capability to assist balloon atrial septostomy and to obtain Doppler-derived continuous hemodynamic data in end-stage pulmonary hypertension.

MATERIALS AND METHODS

Patient

A 46-year-old woman with NYHA class IV dyspnea and right heart failure attributable to PPH was refractory to therapy, including epoprostenol, diuretics, and digoxin, and trials of intravenous dobutamine, dopamine, and phenylephrine. Her heart rate ranged from 100 to 115, blood pressure of 78–84/40–50, and respiratory rate of 20–22.

Right heart catheterization demonstrated a mean right atrial pressure of 20 mm Hg, pulmonary artery pressure of 84/40 mm Hg, decreased cardiac output at 3.5 l/m, and markedly elevated pulmonary vascular resistance at 10.5 Wood units

A balloon atrial septostomy was suggested as a palliative procedure. Due to her poor clinical status and the potential risks of the procedure, the possibility of transesophageal echocardiographic (TEE) guidance was considered. However, it was felt that the patient would not have been able to tolerate the sedation needed for TEE

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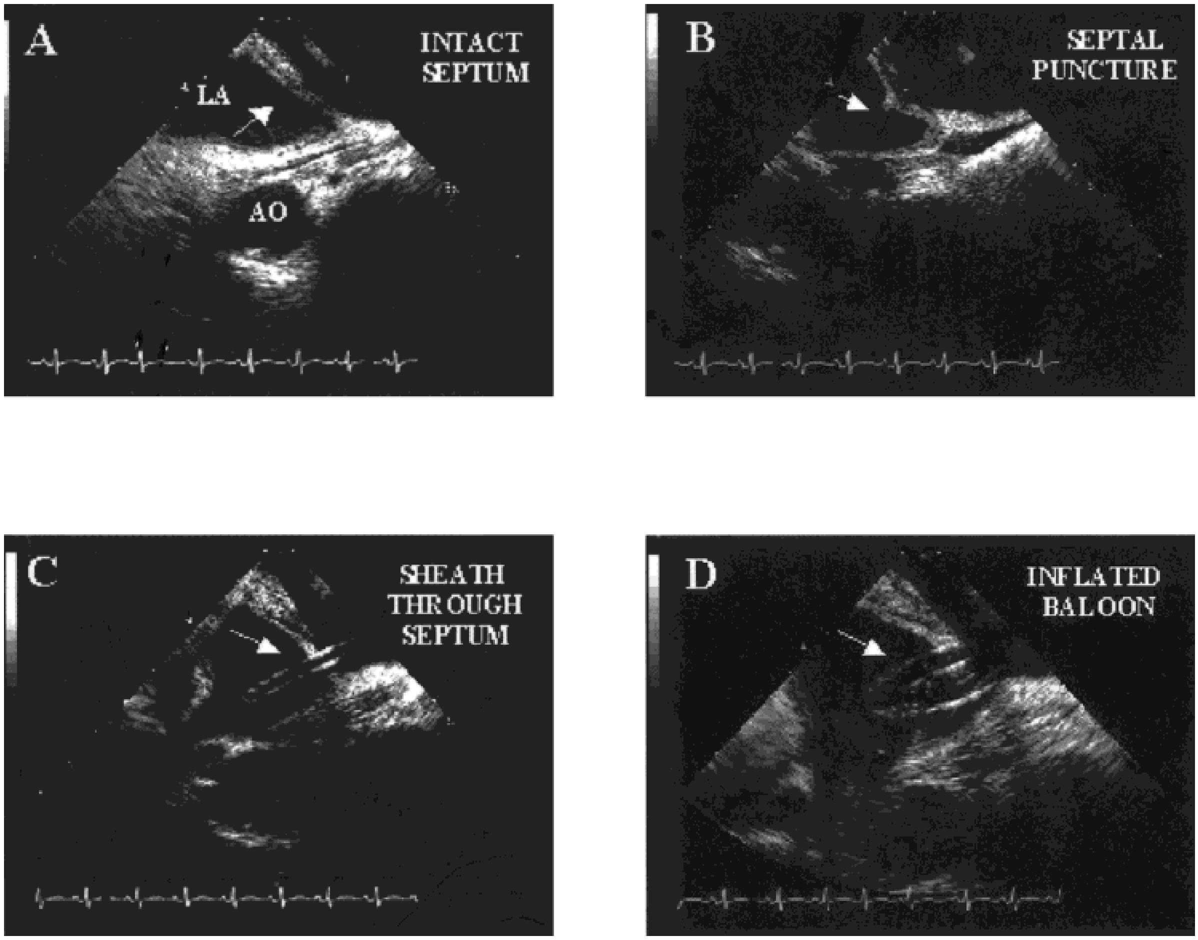

Fig. 1. A: Images of the left atrium (LA), right atrium (RA), the interatrial septum (IAS, white arrow), and the aorta (AO). B: Typical tenting of the IAS by the Mullins sheath and the transseptal needle during advancement of the system (white arrow). This appearance is indicative of appropriate positioning of the Brockenbrough needle against the IAS. C: The Mullins sheath is advanced through the septum (white arrow). D: Inflation of the balloon (white arrow).

guidance. It was therefore decided to perform the procedure using a novel intracardiac ultrasound catheter.

Procedure

After obtaining informed consent and under a compassionate Institutional Review Board approval, a 10 Fr catheter with a phased-array 5.5–10 MHz transducer with spectral and color-flow Doppler capabilities (AcuNav, Acuson, Mountainview, CA) was inserted via the left femoral vein and advanced under ultrasound imaging and fluoroscopic guidance into the right atrium. The catheter was connected to a standard Sequoia (Acuson) ultrasound platform. Images of the left atrium (LA), right atrium (RA), and the atrial septum (IAS, white arrow in Fig. 1) were obtained. Utilizing a Mullins sheath, a Brockenbrough needle was inserted and after appropriate positioning the septum was punctured under echocardiographic guidance. A 10 mm × 20 mm Courier balloon catheter (Meditech, Watertown, MA) was then advanced through the septum over a 0.038″ Schneider valvuloplasty wire (Schneider, Minneapolis, MN). Two inflations were performed at 6 atm. Color Doppler was used to obtain hemodynamic data after each balloon inflation.

RESULTS

Images of the LA, RA, and IAS are shown in Figure 1A. Figure 1B shows the typical tenting of the IAS by the Mullins sheath and the transseptal needle during advancement of the system. This appearance is indicative of appropriate positioning of the Brockenbrough needle against the interatrial septum. Advancement of the Mullins sheath through the septum and inflation of the balloon are shown in Figure 1C and D. The iatrogenic atrial

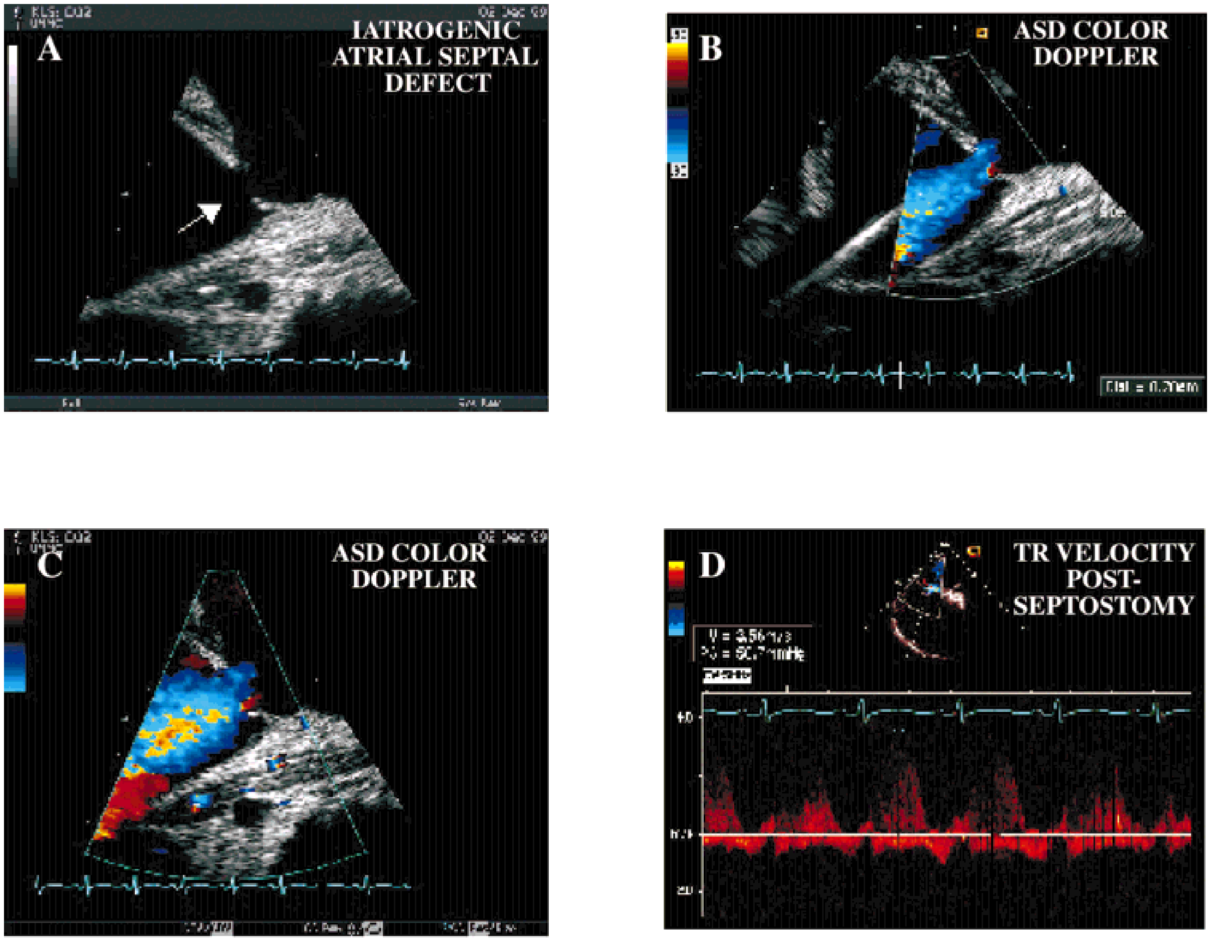

Fig. 2. **A: Iatrogenic atrial septal defect (ASD). B and C: Color Doppler flow through a moderate-size ASD with continuous right-to-left flow. D: Tricuspid regurgitant velocity.**

septal defect (ASD) is shown in Figure 2A. Color Doppler (Fig. 2B and C) revealed a moderate-size ASD with continuous right-to-left flow. The baseline systemic oxygen saturation was 92%; it decreased to 82% after the second balloon inflation. Based on the intracardiac Doppler echocardiographic measurements, it was felt that the size of the ASD (Fig. 3) was adequate and it was decided not to perform additional balloon inflations. The postprocedure course was uncomplicated, and the patient was weaned off the Neo-synephrine. After hospital discharge, at 2-month follow-up the patient was alive although still with class IV symptoms.

DISCUSSION

The use of intracardiac echocardiography has been limited by suboptimal imaging depth, large transducer size with poor steerability, and lack of Doppler capabilities. However, with the recent advent of lower-frequency (5.5–12.5 MHz) ultrasound catheters with expanded imaging ability and smaller size (6–10 Fr), the safety and feasibility of ICE has been demonstrated [11,12]. Among the many potential clinical applications of ICE, its utility during electrophysiologic procedures [7,8,10] and transseptal catheterization [6–9] has been well established.

To our knowledge, this is the first report on using this versatile, phased-array intracardiac catheter to image anatomy and blood flow to guide atrial septostomy as a palliative treatment for pulmonary hypertension. As mentioned above, we used a 10 Fr catheter with a phased-array 5.5–10 MHz transducer with full Doppler capability. We did not encounter any problems with catheter handling in the right atrium despite the 10 Fr size because of the non–over-the-wire catheter design and its steerable tip. The four-way tip articulation permitted optimal transducer positioning. We obtained high-quality images of the IAS, including the adjoining structures such as the aorta (AO, Fig. 1A). Using the articulation function, imaging of the IAS was optimized to guide the

Fig. 3. Long-axis measurement of ASD size.

needle away from the superior and inferior limbus and toward the thin portion of the IAS. We were also able to use color Doppler to assess the size of the ASD, visualize right-to-left flow, and sample tricuspid velocity (3.56 m/sec) with the catheter. The assessment of the hemodynamic significance of the ASD is particularly relevant because the goal of the procedure is to create a right-to-left shunt to increase left ventricular filling while avoiding excessive systemic desaturation secondary to oversizing of the ASD. The current guidelines for balloon atrial septostomy recommend as a target a post–balloon dilatation oxygen saturation of 80%. However, there is always the risk of exceeding this target with additional balloon dilatations, and marked systemic desaturation and systemic hypotension presumably secondary to an excessively large atrial septal defect have been reported as causes of postprocedure death. In the case described, we elected not to perform further dilatations with a larger balloon after intracardiac 2D and color Doppler echocardiography demonstrated the presence of a moderate-size ASD with continuous right-to-left flow. Thus, we believe that this modality allows an overall assessment of the adequacy of the atrial septal defect and that it allows us to avoid additional balloon inflations that could lead to marked systemic oxygen desaturation. One limitation that we encountered was difficulty in obtaining Doppler velocity values of flow through the ASD, as it was almost perpendicular to our cursor.

Although fluoroscopy was used to guide the ultrasound catheter and the septostomy apparatus, we believe that with further experience, there is potential for this catheter to be used without flouroscopy (if not needed for other reasons at the same time). In one animal study, Epstein et al. [13] has demonstrated the safety of ICE with nonflouroscopic transseptal catheterization. More recently, Ewert et al. [14] have described nonfluoroscopic transcatheter closure of atrial septal defects with transesophageal echocardiographic guidance. We believe that ICE can be helpful in immediately identifying peri- or postprocedural complications, and that it could be used for guiding closure of atrial septal defects, for guiding balloon mitral valvuloplasty, and for continuously monitoring patients in an intensive care setting. In addition, when compared with transesophageal echocardiography, intracardiac ultrasound imaging has a clinical advantage related to the fact that it can be performed in unstable patients during interventional endovascular or intracardiac procedures without the need of deep sedation, and that it allows excellent resolution of intracardiac structures with the patient in a supine position. Future studies may help us in further defining these issues.

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