Interventional Catheterization: A Novel Technique for Ventricular Pacing During Valvuloplasty

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Objectives: The main objective of this study is to describe a new technique for rapid ventricular pacing to maintain balloon stability during balloon aortic valvuloplasty (BAV) without using transvenous temporary pacemaker electrode. Background: The safety and efficacy of rapid right ventricular pacing to facilitate balloon stability during BAV has been previously reported. However, it necessitates an additional femoral venous access, an additional sheath, and a temporary pacemaker electrode. Methods: This was a prospective pilot study. Rapid ventricular pacing was performed through back-up guidewires inserted into the left ventricle for balloon advancement and by an adhesive patch placed on the back of the patient. The technique was performed during BAV procedure in all of 15 consecutive children diagnosed as congenital aortic stenosis. Pacing was performed at a rate decreasing systolic aortic pressure to the point of 40–50% of baseline. Results: The technique was successful in all patients. Effective capture, stable pacing, and balloon stability were achieved in all children using very low outputs. No sustained arrhythmias or other procedure-related complications occurred. Degree of aortic regurgitation progressed from grade 0 to 1 in three patients and remained unchanged in 12 patients. Conclusions: This study demonstrated that back-up guidewires can be used effectively and safely for pacing during BAV procedures. This technique omits probable complications related to a second vascular access and may shorten the procedure time and decreases costs by eliminating the use of an additional sheath and a temporary pacemaker electrode.

Key words: congenital heart disease; balloon dilatation; interventional catheterization; ventricular stimulation; aortic valve stenosis

INTRODUCTION

Balloon aortic valvuloplasty (BAV) is an established procedure in the treatment of congenital aortic stenosis (AS) [1–4]. During the procedure, cardiac contractions and pulsatile blood flow may cause instability of the inflated balloon, leading to failure of the procedure, suboptimal results, or damage to vessels and intraluminal structures. Adenosine has been reported to be a safe and effective method to create transient cardiac standstill in catheter interventional procedures for congenital heart disease [5]. However, the wide range of effective doses and significant variations in time intervals from adenosine injection to asystole and duration of asystole complicate its use. Rapid right ventricular (RV) pacing has been previously reported as an alternative, safe and effective method to stabilize the balloon during BAV [6,7]. We report herein on a new technique for balloon stabilization during BAV—rapid
left ventricular (LV) stimulation—which was performed in 15 pediatric patients.

**METHODS**

**Patients**

Between January and December 2007, rapid LV pacing technique was used during BAV in all of 15 consecutive children diagnosed as congenital AS, who were prospectively studied after obtaining written informed consent. All patients had a complete echocardiographic examination before the intervention. The indication for BAV was the presence of clinical symptoms and a strain pattern in electrocardiogram, a peak Doppler gradient higher than 70 mm Hg, or a mean gradient higher than 40 mm Hg in the absence of symptoms. In children with critical AS and heart failure, BAV was performed irrespective of their Doppler gradients. All patients except four had bicuspid aortic valve on two-dimensional (2D) echocardiography. In 13 patients, BAV was performed as the first interventional procedure; one patient had aortic valve restenosis following surgical commissurotomy and one patient had restenosis after the first BAV procedure. Three patients also had severely impaired LV function on 2D echocardiography.

**Technique**

The balloon dilatation procedure was performed under sedation with midazolam and/or ketamine anesthesia (1 mg/kg). A defibrillator charged at 2 J/kg was available during the procedure. An appropriately sized sheath in accordance with the selected balloon size was placed into the right or left femoral artery percutaneously. Aortic root angiograms were obtained before and after the procedure to assess aortic valve morphology and aortic regurgitation. Aortic regurgitation was graded by means of angiography as described by Hunt and colleagues [8]. A 4–5-Fr Cournand, Cobra, Right Judkins catheter and Roadrunner guidewires or glide-wires were used to pass retrogradely through the stenotic aortic valve. The wires were exchanged with appropriately sized exchange guidewires according to the selected balloon lumen. In small babies, 0.014-in. Roadrunner guidewires used for passing through the aortic valve were also used for balloon advancement, as a back-up guidewire. The distal tip of the guide-wires was advanced into the LV without making any special configuration. Basal LV and aortic pressures were recorded. The diameter of the dilatation balloon was chosen to be almost the same as the aortic valve diameter measured echocardiographically. The balloon was introduced over the guidewire.

**Rapid Left Ventricular Pacing**

Rapid LV pacing was performed by an external programmable cardiac stimulator (FIAB® 8817, Vicchio, Florence, Italy). The proximal end of the back-up guidewire was connected to the positive end of the cardiac stimulator with the help of a sterilized connection cable with an alligator head (Fig. 1). An adhesive patch (PolyHesive®, ValleyLab, Boston Scientific Corporation, EP Technologies, MA) placed on the back of the patient was connected to the negative end of the stimulator. Threshold value for stimulation was determined for each patient. The amplitude was usually set at twice the threshold value. A pacing rate decreasing the systolic aortic pressure to 40–50% of baseline was determined by using an incremental ventricular pacing (Fig. 2). The pacing was started just before inflation and continued until the complete deflation. Balloon dilatation was performed once or twice in all patients.

Finally, the balloon catheter was exchanged with a 3–5-Fr Multitract or Cournand catheter and pressure recordings of the LV and aorta were repeated.

**RESULTS**

Mean age of the patients was 41.6 ± 58.3 months (range, 1 month to 13 years). Mean body weight was 14.4 ± 12.8 kg (range, 4–45). Mean aortic valve diameter was 12.0 ± 4.8 mm (range, 6–20). Pacing rate ranged from 230 to 280 min⁻¹. Effective capture and stable pacing were achieved in all patients using very low pulse amplitudes (5–15 mA) and widths (1–2 ms). Balloon stability at time of inflation was achieved in all cases. Mean preprocedural aortic valve gradient was 68.5 ± 20.4 mm Hg (range, 40–120 mm Hg), which successfully decreased to 20.1 ± 10.2 mm Hg
Balloon valvuloplasty was successful in 14 patients and partially successful in one patient who had aortic valve restenosis following surgical commissurotomy. Before the intervention, aortic regurgitation was absent (grade 0) in seven patients, trivial (grade 1) in seven patients, and mild (grade 2) in one patient. The degree of aortic regurgitation progressed from grade 0 to grade 1 in three patients and remained unchanged in 12 patients. No sustained arrhythmias or other procedure-related complications occurred during or after the procedure.

**DISCUSSION**

Balloon dilatation of the aortic valve is an established procedure in the treatment of congenital AS [1–4]. During the procedure, cardiac contractions and pulsatile blood flow may cause instability of the inflated balloon, leading to failure of the procedure. Extra-stiff wires, long balloons, and long sheaths have been used to give additional support and to reduce the risk of displacement [6].

Adenosine has been reported as a safe and effective method to create transient cardiac standstill by causing a sinoatrial and atrioventricular (AV) block during balloon dilatation procedures. When adenosine is used, duration of asystole is dose-dependent and is influenced by the rapidity and the site of administration. Furthermore, cardiac output and other drugs used concomitantly cause a wide variation in effective doses of adenosine, duration of asystole, and the time delay after drug injection during balloon dilatation procedures.

De Giovanni et al. reported the use of intravenous adenosine in 13 patients with congenital stenotic lesions (congenital AS in six, coarctation in three, and RV outflow obstruction in four) [5]. Mean age was 9.9 years (2 months to 30 years). Two patients developed sinus bradycardia and 11 had a period of asystole, varying in range from 2.4 to 10.8 s. Total AV block period ranged from 5.0 to 21.2 s. The interval between adenosine injection and the onset of asystole varied from 2.4 to 15.8 s, depending on the cannula size, site of administration, and cardiac output. The peak gradient across the stenotic lesions fell from 52 ± 24 mm Hg to 18 ± 12 mm Hg. One patient had atrial fibrillation.

Daehnert et al. reported the use of rapid RV pacing as an alternative to adenosine in 14 patients undergoing BAV [7]. Rapid RV pacing was performed at a rate of 220 min⁻¹ to facilitate balloon stability. The balloon remained in stable position in 11 patients and was displaced in three. An increase of the pacing rate to 240 beats/min provided balloon stability in an additional two patients. In one patient, stability was obtained at an unchanged pacing rate after correction of a suboptimal balloon position. No arrhythmias or other procedure-related complications occurred.

David et al. reported 10 children with a mean age of 10.2 ± 4.3 years (range, 3–16) with aortic valve stenosis, who were treated with BAV and rapid RV ventricular pacing [9]. Rapid RV pacing was initiated...
at a rate of 150 min\(^{-1}\) and was gradually increased to achieve a 50% drop in systemic pressure. The balloon was inflated after the pacing rate was reached and the blood pressure dropped. Pacing rate ranged between 170 and 250 min\(^{-1}\) (Mean ± SD, 209 ± 25). Balloon stability at the time of inflation was achieved in all cases. Preprocedural aortic valve gradient decreased from 69 ± 20 mm Hg (40–110) to 20 ± 8 mm Hg (5–28). In all cases, there was no change in aortograms, except in one patient who developed grade 1 aortic regurgitation. Rapid ventricular pacing was reported to be an effective and safe procedure to stabilize the balloon during BAV and to decrease the incidence of aortic regurgitation.

In our study, we described a new technique of rapid LV pacing during BAV, which was successfully performed in 15 patients. Our technique can be performed using only a femoral arterial access. Procedure and fluoroscopy times during BAV are expected to be shorter because a second femoral access is not necessary. This technique also obviates the need of an extra pacing electrode by using the back-up guidewire in the LV as a pacing electrode. The technique was as successful as the RV pacing method. No significant increase in aortic valve regurgitation was observed in any patient after the procedure.

**CONCLUSION**

This study demonstrated that back-up guidewires can be used effectively and safely as a pacemaker electrode during balloon aortic valvuloplasty procedures. This technique omits probable complications related to the second vascular access, shortens the procedure time, and decreases costs.

**REFERENCES**