Sutureless Patch Angioplasty for Postoperative Pulmonary Artery Stenosis in Congenital Cardiac Surgeries

Hyungtae Kim, MD, Si Chan Sung, MD, Kwang Ho Choi, MD, Hyoung Doo Lee, MD, Gil Ho Ban, MD, Geena Kim, MD, and Hee Young Kim, MD

Departments of Thoracic and Cardiovascular Surgery, Pediatrics, and Anesthesia and Pain Medicine, Research Institute for Convergence of Biomedical Science and Technology, Pusan National University Yangsan Hospital, Yangsan-si, Gyeongsangnam-do, Republic of Korea

Background. **Reconstruction of branch pulmonary arteries (PAs) can be demanding in redo congenital cardiac surgeries. Sutureless patch angioplasty could be a useful method to solve this problem, and we evaluated the feasibility of sutureless patch angioplasty for postoperative PA stenosis in patients who underwent congenital cardiac surgery.**

Methods. **We retrospectively reviewed 28 patients (19 males and 9 females) who underwent sutureless patch angioplasty for postoperative PA stenosis between November 2004 and April 2015. The median age was 7.3 months (range, 4.3 to 54.7), and the median weight was 7.2 kg (range, 5.3 to 12.2 kg). Right PA angioplasty was performed in 5, left PA angioplasty in 10, and both sides in 13 patients. The most common original diagnosis was hypoplastic left heart syndrome (n = 18 of 28, 64.3%). Concomitant surgeries were the bidirectional cavopulmonary shunt in 24 patients, the Fontan operation in 3, and the Rastelli operation in 1 patient.**

Results. **No operative death occurred. However, 2 late deaths were recorded, and both were unrelated to PA angioplasty. Mean follow-up duration was 60.9 ± 33.1 months. None of the patients had postoperative bleeding or thrombotic occlusion. No reoperation for PA restenosis was performed, and only 1 patient (3.6%) had a PA balloon angioplasty with a good result 12.9 months after the operation. Echocardiography or computed tomography angiography at the recent follow-up showed good branch PAs in all patients.**

Conclusions. **Sutureless patch angioplasty for postoperative PA stenosis could simplify PA angioplasty, and be a safe and effective method for PA reconstruction in patients who undergo congenital cardiac surgery.**

(Ann Thorac Surg 2015;■:■–■)

Branch pulmonary artery (PA) stenosis can occur either as an isolated lesion or in association with other congenital heart disease (CHD). It can also occur after a previous surgical repair. Management of the postoperative branch PA stenosis could be demanding, and the treatment options include conventional surgical patch angioplasty, percutaneous balloon angioplasty, and hybrid intraoperative stent implantation [1–5]. In cases of the complex CHD requiring redo surgeries, surgical patch angioplasty for small PAs in small babies can be technically difficult and yield suboptimal results [6, 7]. Percutaneous catheter ballooning or stenting can also be difficult in these patients due to the complex anatomy and difficult vascular access [8]. To solve these problems, we have adopted sutureless patch angioplasty for postoperative PA stenosis since 2004, which is technically easy and simple.

Accepted for publication Sept 21, 2015.

Address correspondence to Dr Sung, Department of Thoracic and Cardiovascular Surgery, Pusan National University Yangsan Hospital, Mulgeum-eup, Yangsan-si, Gyeongsangnam-do 626-770, Republic of Korea; e-mail: scsung21@hanmail.net.

The most frequent procedure in our institution for postoperative PA stenosis is forceful dilation using a dilator or a Kelly clamp after making multiple intimal incisions at the stenotic site. This approach, "sutureless angioplasty," has been highly effective and is a routine procedure for postoperative PA stenosis in our institution. However, a patch is occasionally needed to cover the stenotic sites after an extensive excision of the hypertrophic intima or whole blood vessel wall. We call this "sutureless patch angioplasty." We describe the technique and our experience, and midterm results using sutureless patch angioplasty for postoperative PA stenosis in patients who underwent congenital cardiac surgery.

Patients and Methods

Patients

This study was approved by the Institutional Review Board at Pusan National University Yangsan Hospital (approval no. 05-2015-006), and individual consent for the study was waived. We retrospectively reviewed the medical records of 28 patients (19 males, 9 females) who

0003-4975/$36.00
http://dx.doi.org/10.1016/j.athoracsur.2015.09.083

underwent sutureless patch angioplasty for postoperative PA stenosis between November 2004 and April 2015. During the same period, 53 patients underwent sutureless angioplasty. All patients had one or more previous operations at our institution. The primary anatomic diagnoses of the patients are presented in Table 1, and the most common original diagnosis was hypoplastic left heart syndrome (n = 18 of 28, 64.3%). The mean interval between the prior operation and sutureless patch angioplasty was 9.2 ± 6.0 months (median, 6.8; range, 4.1 to 29.3). The mean number of operations before sutureless patch angioplasty was 1.14 ± 0.45 (range, 1 to 3). The median age at the time of PA angioplasty was 7.3 months (range, 4.3 to 54.7), and the median weight was 7.2 kg (range, 5.3 to 12.2 kg). Right pulmonary artery (RPA) angioplasty was performed in 5, left pulmonary artery (LPA) angioplasty in 10, and both sides in 13 patients. Concomitant operative procedures were the bidirectional cavopulmonary shunt (BCPS) in 24 patients (85.7%), the Fontan operation in 3 (10.7%), and the Rastelli operation in 1 patient (3.6%). Other concomitant cardiac or noncardiac procedures were performed in 9 patients (32.1%; Table 1).

Surgical Technique

After resternotomy, aortic and right atrial cannulations with mild hypothermia (33°C to 35°C) without aortic crossclamping were used when concomitant intracardiac procedures were not required. Bicaval cannulation and aortic crossclamping were utilized for concomitant intracardiac procedures that required cardioplegic arrest. Some of the intracardiac procedures were performed under ventricular fibrillation. After limited mobilization of the RPA or LPA, the PA was longitudinally opened crossing the stenotic site, and then the previous patch materials were enucleated from surrounding fibrotic tissue, which was used as a new vessel wall (Fig 1A and 1B). The stenotic site was forcefully dilated with a dilator (Tubular Probes; Fehling Instruments, Karlstein, Germany) or a Kelly clamp after making two or three small intimal incisions at the stenotic site. The hypertrophied intima around the stenotic site was excised, and the whole layer of stenotic or hypertrophic vessel wall was occasionally removed, leaving the perivascular fibrotic tissue intact (Fig 1C). In hypoplastic left heart syndrome cases, the posterior wall of the reconstructed neoaorta was part of the anterior wall of the reconstructed PA. The fibrous floor of the PA bed was maintained and preserved. The opening of the PA was covered with a bovine pericardium patch (all 28 patients, 100%) by placing stitches at the perivascular fibrotic tissue and usually adjacent to the aorta, not the intima of the PA itself at the stenotic area (Fig 1D). After completing the PA angioplasties, we usually performed the main operative procedures. An anterior aortopexy was also performed in 2 patients with RPA compression by a large aorta. We routinely infused heparin immediately after postoperative bleeding stopped, and the patients were put on a regimen of coumadin as oral intakes started. Coumadin was given for 1 or 2 months postoperatively, and then aspirin therapy was given indefinitely.

Table 1. Anatomic Diagnoses and Other Procedures

Diagnoses and Procedures	No. of Patients (%)
Anatomic diagnosis	
Hypoplastic left heart syndrome	18 (64.3)
Unbalanced AVSD	4 (14.3)
Pulmonary atresia with IVS	2 (7.1)
DILV, FSV	2 (7.1)
Pulmonary atresia with VSD	1 (3.6)
Corrected TGA with pulmonary atresia	1 (3.6)
Concomitant procedure	
Bidirectional cavopulmonary shunt	24 (85.7)
Fontan operation	3 (10.7)
Rastelli operation	1 (3.6)
Other concomitant procedure	
Atrioventricular valve repair	4 (14.3)
Anterior aortopexy	2 (7.1)
Atrial septectomy	1 (3.6)
Clipping of both internal mammary arteries	1 (3.6)
Intraoperative balloon aortoplasty	1 (3.6)

AVSD = atrioventricular septal defect; DILV = double inlet left ventricle; FSV = functional single ventricle; IVS = intact ventricular septum; TGA = transposition of great arteries; VSD = ventricular septal defect.

Statistical Analysis

The data were collected and managed using Microsoft Excel 2010 (Microsoft, Redmond, WA) and analyzed using SPSS, version 17.0 (SPSS, Chicago, IL). They are reported as median (range) or mean ± SD, as appropriate. The PA sizes at discharge after sutureless patch angioplasty and before the Fontan operation were compared using Student's *t* test. The Kaplan-Meier method was used to analyze overall survival rate. Probability values of less than 0.05 were considered significant.

Results

No surgical mortality was observed in this cohort of 28 patients. The mean cardiopulmonary bypass time was 143.8 ± 44.3 minutes (range, 76 to 281). Aortic crossclamping was required in 3 patients, and the mean cross-clamp time was 67.3 ± 27.7 minutes (range, 38 to 93). The mean hospital stay was 18.3 ± 16.0 days (range, 7 to 90; median 14). Three complications occurred postoperatively in 2 patients (7.1%): postoperative wound problems in 2 patients and diaphragm palsy in 1 patient. No postoperative bleeding or PA thrombotic occlusion was detected.

The mean follow-up duration was 60.9 ± 33.1 months (range, 0.9 to 125.5). Two late deaths occurred during the follow-up period. The first patient had RPA and LPA angioplasties using sutureless patch angioplasty for PA stenosis with BCPS and anterior aortopexy due to RPA compression by a large ascending aorta at 9 months of age. The patient's initial diagnosis was hypoplastic left