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# Long-term results of the Konno procedure for complex left ventricular outflow tract obstruction

Rakesh M. Suri, MD, DPhil, Joseph A. Dearani, MD, Hartzell V. Schaff, MD, Gordon K. Danielson, MD, and Francisco J. Puga, MD



**Objective:** This study was undertaken to determine long-term clinical and echocardiographic outcomes after the Konno procedure.

**Methods:** Fifty-three patients who underwent the Konno procedure between January 1, 1980, and January 1, 2004, were reviewed.

**Results:** Mean age at operation was 19 years (range, 1-65 years). Indications were as follows: complex subaortic or tunnel stenosis in 22 (41%), multilevel left ventricular outflow tract obstruction in 20 (38%), and aortic valve stenosis or hypoplasia in 11 (21%). Before the Konno procedure, 66 operations were performed in 41 (77%) patients. Thirty-three (62%) patients had greater than New York Heart Association class I symptoms preoperatively. A mechanical aortic valve was implanted in 40 (75%), a homograft in 10 (19%), and a xenograft prosthesis in 3 (6%). Mortality at 30 days was 8% (n = 4). Survival at 10 years was 86%. Risk factors for overall mortality were New York Heart Association class (hazard ratio 2.22, $P = .04$) and longer bypass time (hazard ratio 1.93/hour, $P = .04$). The cumulative probability of aortic valve reoperation was 19% at 5 years and 39% at 10 years, occurring in 15 patients at a median of 3.8 years. The average left ventricular outflow tract mean gradients were 19 mm Hg at 1 year (n = 9), 13 mm Hg at 1 to 3 years (n = 9), and 13 mm Hg at 3 to 5 years (n = 5). Pulmonary regurgitation was detected in 6 patients. Pulmonary valve replacement was performed in 3 (6%). At the date of last contact, all patients for whom data was available were in New York Heart Association functional class I or II.

**Conclusion:** The Konno procedure is effective, allowing both long-term reduction of left ventricular outflow tract obstruction and improvement in functional class. Prosthetic aortic valve and native pulmonary valve complications may necessitate reoperation.

From the Division of Cardiovascular Surgery, Mayo Clinic College of Medicine, Rochester, Minn.

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Address for reprints: Rakesh M. Suri, MD, DPhil, Division of Cardiovascular Surgery, Mayo Clinic College of Medicine, 200 First St SW, Rochester, MN 55905 (E-mail: suri.rakesh@mayo.edu).

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The surgical management of simple left ventricular outflow tract obstruction (LVOTO) confined to discrete subvalvular,[1-8] valvular,[9,10] or supravalvular[11-14] levels has been well described in the literature. Complex LVOTO involving two or more levels of the outflow tract is a unique problem for which specific procedures have evolved. The aortoventriculoinfundibuloplasty (Konno procedure), described contemporaneously by both Konno and colleagues[15] and Rastan and Koncz,[16] was initially devised as an alternative to the apicoaortic conduit for the treatment of tunnel subaortic stenosis. The original description involved patch enlargement of both the left and right outflow tracts and the insertion of a mechanical aortic valve prosthesis.[15,16] The Konno procedure has subsequently emerged as the procedure of multilevel LVOTO, particularly those with a small aortic annulus.[17-22] The original technique of valve replacement has broadened recently to include biologic aortic prostheses.[23-27]

Although several studies have examined the midterm results of the Konno procedure, there are few data regarding the long-term results obtained for these

**Abbreviations and Acronyms**
LVOTO = left ventricular outflow tract obstruction
PR = pulmonary regurgitation
PVR = pulmonary valve replacement

patients. Moreover, the effects on left ventricular size and function after elimination of LVOTO remain unclear. The incision across the aortic annulus during the Konno procedure approaches both the conduction system and the native pulmonary valve. Although the risk of heart block has been documented in the literature, there is little information regarding native pulmonary valve function after this operation. The purpose of this study was to review the long-term results of the Konno procedure, including patient survival, reoperation risk, pulmonary valve complications, and effects on left ventricular size and function.

## Methods

The records of 53 patients with complex LVOTO who underwent the Konno procedure at the Mayo Clinic Rochester between January 1, 1980, and January 1, 2004, were reviewed. The study was approved by the Mayo Clinic College of Medicine Institutional Review Board. Excluded from analysis were 5 other patients who underwent the Ross-Konno procedure. Three of those patients had a modified Konno procedure performed, involving septal patch enlargement of left ventricular outflow tract obstruction, before the standard Konno procedure. One patient underwent the first Konno procedure elsewhere and required a reoperative Konno procedure at our institution to correct recurrent stenosis at the valvular and subvalvular levels.

Demographic, morphologic, echocardiographic, and surgical data were obtained from hospital records, and a prospectively accrued SAS (SAS Institute, Inc, Cary, NC) database. There were 4 early (<30 days or in-hospital) and 7 late deaths. Recent cross-sectional follow-up was obtained through the Mayo Survey Research Center by means of telephone calls and written correspondence. Ten patients were unavailable for follow-up or refused further questionnaires; their last observed episodes were used for calculation purposes. The mean (±SD) duration of follow-up for early survivors was 8.2 ± 5.7 years (range 14 days-22 years). There are currently 42 patients still alive, and current follow-up was available for 32 of them.

Echocardiographic data were obtained from the medical records and through contact with outside physicians. All gradients are reported as means and measured in millimeters of mercury. Ejection fraction and left ventricular end-diastolic and end-systolic dimensions were recorded as available.

## Statistical Analysis

Survival and reoperation probabilities and 95% confidence intervals were computed with the Kaplan-Meier method (actuarial). The prognostic significances of potential risk factors were tested with the Cox proportional hazards models.

**TABLE 1. Baseline characteristics**

| | |
|---|---|
| Age (y, mean with range) | 19 (1-65) |
| Age (No.) | |
| <1 y | 0 |
| 1-10 | 20 (38%) |
| >10 | 33 (62%) |
| Sex (No.) | |
| Male | 27 (51%) |
| Female | 26 (49%) |
| Rhythm (No.) | |
| Sinus | 52 (98%) |
| Paced | 1 (2%) |
| NYHA functional class (No.) | |
| I | 20 (38%) |
| II | 30 (57%) |
| III | 2 (4%) |
| IV | 1 (2%) |
| Preoperative echocardiography | |
| Mean aortic gradient (mm Hg, mean with range, n = 25) | 51 (12-87) |
| Ejection fraction (%, mean with range, n = 50) | 66% (15%-89%) |
| LVEDD (%, mean with range, n = 40) | 44% (18%-92%) |
| LVESD (%, mean with range, n = 40) | 25% (6%-84%) |
| Regurgitation (No., n = 41) | |
| 0-1 | 6 (15%) |
| 2 | 7 (17%) |
| 3 | 14 (34%) |
| 4 | 14 (34%) |
| Operation before 1990 (No.) | 37 (70%) |

*NYHA*, New York Heart Association; *LVEDD*, left ventricular end-diastolic dimension; *LVESD*, left ventricular end-systolic dimension.

## Results

Baseline characteristics for the 53 patients included in the study are summarized in Table 1. The age range at operation was 1 to 65 years. Most patients were in normal sinus rhythm before the operation, had minimal symptoms, and underwent operation after 1990. Before the Konno procedure, 41 patients had undergone 70 previous cardiovascular interventions (Table 2). Twenty-two patients (42%) had a second operation before the Konno procedure, and 7 (13%) had a third. Indications for the Konno procedure are described in Table E1. The most frequent reason for operation was to correct multilevel LVOTO (n = 23, 43%), followed by complex subaortic tunnel stenosis (n = 18, 34%) and valvular anomalies with annular hypoplasia (n = 12, 23%).

The technical aspects of the Konno procedure are summarized in Table E2. As described in the classic description of the procedure,[15] a mechanical valve was inserted in most cases (n = 40, 75%). This was followed in frequency by a homograft (n = 10, 19%) and, finally, a xenograft prosthesis (n = 3, 6%). The septal patch was constructed most frequently with untreated Dacron polyester fabric (n = 30,