Use of expanded polytetrafluoroethylene sutures as artificial tendinous cords in children with congenital mitral regurgitation

Youichi Kawahira*, Toshikatsu Yagihara, Hideki Uemura, Toru Ishizaka, Ko Yoshizumi, Soichiro Kitamura

Department of Cardiovascular Surgery, National Cardiovascular Center, Osaka, Japan

Received 16 November 1998; received in revised form 11 January 1999; accepted 13 January 1999

Abstract

Objective: To determine the efficacy in the intermediate term of artificial cords inserted in children with congenital mitral regurgitation.

Methods: We reconstructed the tendinous cords using expanded polytetrafluoroethylene (ePTFE) sutures in 11 children with severe mitral regurgitation. In these patients, the aortic (anterior) leaflet of the mitral valve had been markedly prolapsed, the tendinous cords being partially lacking in seven, and elongated in the remaining four. In addition, one of the papillary muscles was hypoplastic in five and absent in three. The number of artificial cords constructed varied from two to six. Conventional annuloplasty was performed in all to plicate the dilated annular attachment of the valve. Ventricular septal defect was present in four patients, and other associated malformations in another two. Age at operation ranged from 9 months to 9 years old, with a mean of 4.5 years.

Results: All patients survived the operation. No reoperation has been needed thus far. No complications were encountered related to the use of the prosthetic materials or anticoagulation. As judged by echocardiography, regurgitation became trivial or slight immediately after the repair. In two patients, however, regurgitation recurred within 1 year of the operation. Coaptation between the leaflets was maintained by a compensatory growth at the site of attachment of the artificial cords. Catheterization demonstrated significant improvements in the end-diastolic volume of the left ventricle.

Conclusion: Expanded polytetrafluoroethylene sutures can be used as artificial cords when attempting to repair the malformed mitral valve in children, providing excellent results in the short- and the intermediate-term after the surgical procedure. © 1999 Elsevier Science B.V. All rights reserved.

Keywords: Mitral valve plasty; Mitral regurgitation; Polytetrafluoroethylene suture; Congenital heart disease

1. Introduction

The role plasty in repairing the regurgitant mitral valve is well established in adults [1–3]. In children with congenital mitral regurgitation, in contrast, conventional repair of the valve is not always successful [4]. In part, this reflects the complicated abnormalities of the valvar structures, and the associated cardiac malformations [5]. In some patients with abnormalities of the tension apparatus, and prolapse of the leaflets of the mitral valve, use of artificial cords have been suggested to provide efficient results in the short-term [6]. It remains unclear, however, whether or not this alternative approach is appropriate in the longer term. The surgeon should also pay attention to the potential problem of growth after such extensive surgical interventions using prosthetic materials. We describe here, our clinical experience of the use of artificial cords in children with congenital mitral regurgitation, concentrating on our results in the intermediate-term.

2. Materials and methods

From November 1992 to May 1998, we carried out extensive plasty to the mitral valve, combined with reconstruction of its tendinous cords using expanded polytetrafluoroethylene (ePTFE) sutures, in 11 children with severe mitral regurgitation. Age at operation was from 9 months to 9 years old, with a mean of 4.5 years. Body weight ranged from 4.2 to 23.8 kg (mean, 14.5 kg).
Mitrail regurgitation was an isolated lesion, with no other intracardiac malformations, in five patients. In one of these, one of the cords initially for the mural (posterior) leaflet had been previously translocated to the aortic (anterior) leaflet 2 years ago. However, prolapse of the anterior leaflet remarkably progressed due to elongation of the translocated chordae. A ventricular septal defect was present in four patients, the interventricular communication having been previously closed in two, and being concomitantly treated in the other two. In another patient, a 9-months-old infant, coexisting congenital aortic stenosis was dilated by catheter intervention through the aortic root, the maneuver producing significant regurgitation. Acute left ventricular failure because of either aortic or mitral regurgitation promoted us to perform the Ross procedure as an emergency procedure, combining it with extensive mitral plasty. In the remaining patient, complete transposition had been repaired by the arterial switch procedure.

Mitrail plasty was carried out on cardiopulmonary bypass, with cardiac arrest induced by crystalloid cardioplegic solution. At the time of the operation, the annular attachment of the mitral valve proved to be dilated in all patients. The papillary muscles were hypoplastic in five, and one of them was lacking in three. The tendinous cords for the aortic leaflet were partially absent in seven, and markedly elongated in four. In particular, in the patient previously undergoing translocation of the tendinous cords from the mural to the aortic leaflet, the translocated cords were considerably elongated. Absence of some tendinous cords for the mural leaflet was seen in one patient. However, because of these abnormalities in tension apparatus, prolapse of the aortic leaflet was obvious. In addition, regurgitation had been augmented by the presence of a large cleft within the aortic leaflet in one patient.

The artificial cords were constructed as described in the previous report [6]. In ten patients, 4–0 ePTFE sutures manufactured by Gore-Tex (W.L. Gore and Associates, Flagstaff, AZ) were passed through the prolapsed leaflet from its ventricular to atrial aspect, placing pledgets for reinforcement on the ventricular surface of the leaflet. The sutures were then anchored to the papillary muscles in mattress fashion. In the remaining patient, the maneuver was carried out in reversed order. Attaching an ePTFE suture initially to the papillary muscle, the suture was subsequently passed through the leaflet from its ventricular to atrial aspect. In this circumstance, the knot was placed on the atrial aspect of the mitral valve. The number of artificial cords constructed varied from two to six. In addition to construction of artificial cords, plication of the annular attachment of the valve following the method of Kay was performed in all patients. The sizes of the annular attachment, which were initially 28 ± 6 mm (16–38 mm) in diameter corresponding to 142 ± 17% (120–200%) of the anticipated normal value [8], reduced postoperatively to 20 ± 4 mm (14–25 mm) and 97 ± 12% (94–110%), respectively. Some of the native tendinous cords were shortened in six patients, and the cleft within the aortic leaflet seen in one patient was repaired.

Anticoagulative therapy was continued throughout the period of follow-up for all patients, using an anti-platelet drug having administered Warfarin for 1 year.

Cardiac catheterization was performed to evaluate the postoperative circumstances in five patients 1 or 2 years (a mean of 1.5 years) after the surgical procedure, and echocardiography was consecutively carried out in all patients every year. The period of follow-up now extends from 5 to 74 months, with a mean of 32 months.

3. Results

All the 11 patients survived the operation, but one patient died 4 years after the Ross procedure and mitral valvar plasty because of pneumonia. No patients have undergone reoperation thus far. No complications have thus far been encountered due to the use of artificial material, such as bacterial infection and thromboembolism, nor has any hemorrhage been related to the postoperative anticoagulation.

Immediately after using the artificial cords to achieve mitral plasty, echocardiography demonstrated vast reduction in the regurgitation through the repaired valve (Fig. 1). The diastolic dimensions of the left ventricle changed from preoperative values of 150 ± 13% (131–177%) of the anticipated normal values calculated from the body surface area to 105 ± 4% (97–109%) (Fig. 2). Regurgitation, as judged 1 year after the procedure in seven patients, was trivial in one, slight in four, and moderate in two, left ventricular diastolic dimensions being 103 ± 10% (90–118%). No further progression of regurgitation has been found in the longer term (Fig. 1). Left ventricular diastolic dimensions have remained almost normal in these patients (Fig. 2). The patient who has been followed up for more than 6 years has shown excellent growth, with body weight and height changing from 22.5 kg and 110 cm at operation,
respectively, to 58 kg and 160 cm at present. In this particular patient, the leaflets of the mitral valve remained almost competent, although permitting slight regurgitation. The echocardiography performed most recently demonstrated the fact that the aortic leaflet itself, at the site of attachment of the ePTFE cords, has grown to compensate for the lack of growth of the artificial cords (Fig. 3). Catheterization has confirmed the improvements in cardiac performances. Mean left atrial pressure was 13 ± 5 mmHg (9–21 mmHg) preoperatively, whereas postoperative end-diastolic pressure in the left ventricle was 7 ± 6 mmHg (2–16 mmHg). The end-diastolic volume of the left ventricle decreased statistically ($P = 0.001$ by $t$-test) from preoperative values of $152 ± 43$ ml/m$^2$ (93–231 ml/m$^2$) when indexed to body surface area, and $234 ± 61\%$ (173–386\%) when compared with the normal anticipated value from the body surface area, to postoperative values of $68 ± 8$ ml/m$^2$ (58–73 ml/m$^2$) and $112 ± 34\%$ (88–158\%), respectively. Mean pulmonary arterial pressure also significantly changed ($P = 0.001$) from $22 ± 6$ mmHg (14–31 mmHg) to $16 ± 6$ mmHg (10–25 mmHg).

4. Discussion

When planning the optimal surgical repair of the mitral valve, attention must be directed at the annular attachment, the valvar leaflets and the tension apparatus of the valve. In patients with congenital mitral regurgitation, the annular attachment is commonly dilated, and the papillary muscles, as well as their attachments to the ventricular wall, are frequently abnormal. Prolapse, and other abnormalities of the valvar leaflets, are more frequently seen involving the aortic leaflet than the mural one. So, because of these characteristic differences from acquired mitral valvar lesions in adults, the conventional plasties to the leaflets and the annular attachment of the valve [4,5,9,10] are effective only...
transiently in some patients, and regurgitation can recur after the initial repair. In particular, in patients with severely malformed tension apparatus, it is known that plasty to the regurgitant valve is very difficult. Shortening of the elongated cords used to be the only procedure feasible in children with prolapse of the valvar leaflets [5]. In addition, use of a prosthetic ring, which is known to be of great help for annuloplasty in adults, is less attractive in children, in terms of somatic growth [13].

Extensive reconstruction of the tendinous cords by transposing them from the mural to the aortic leaflet was reported by Carpentier et al. in 1983 [11]. They commented that presence of a hypoplastic mural leaflet was less than ideal for the procedure. This surgical option could be attractive in children, because the transplanted cords are autologous tissue, although recurrent regurgitation can also be caused by elongated cords, as documented in one of our patients. An alternative technique, using ePTFE sutures extensively to reconstruct the tendinous cords, was reported by Frater et al. in 1988 [12], and the procedure seemingly provides excellent results in the intermediate-term [7,12]. This alternative operative procedure can also be used in children with marked prolapse of the mitral valve due to abnormalities of the tendinous cords, and has proved efficient in the short-term [6].

As our current experience has demonstrated, results in children in the intermediate-term after reconstruction of the tendinous cords are also acceptable. It was very interesting to find that orientation between the leaflet, the papillary muscle, and the artificial cords had been achieved by compensatory growth of the leaflet itself. Probably, the papillary muscle had also grown appropriately, maintaining subtle balances between the leaflets and the tension apparatus, although we were unable to provide firm evidence of this feature. We believe that stress on the leaflets and tension apparatus is able to produce proper growth and balance of the valvar structure even in the presence of the artificial cords which have no intrinsic potential of growth.

Moderate regurgitation did recur in two patients within the first postoperative year. In one of these two patients, severe myocardial dysfunction of the left ventricle persisted after the Ross procedure was carried out at the same time as mitral plasty. Recurrence of the mitral regurgitation in this case was possibly related to the prolonged myocardial dysfunction. In our other patient, in contrast, the operative procedure employed might itself be one of the causes for the recurrent mitral regurgitation. In this particular patient, the ePTFE suture was attached at first to the papillary muscle, and then fixed to the leaflet placing the knot on the atrial surface of the leaflet. Subsequent to the operative maneuver, a tiny gap was found between the aortic and mural leaflets of the valve due to abnormalities of the tendinous cords, and has proved efficient in the short-term [6].

In this particular patient, the ePTFE suture as artificial cords is attractively applicable in children with congenital mitral regurgitation, when the native tendinous cords are markedly abnormal. The valve can remain competent in the intermediate-term after the surgical repair following growth of the native leaflets and the papillary muscles, even in the presence of the prosthetic material used to replace the cords.

Acknowledgements

We express special thanks to Professor Robert H. Anderson, at the National Heart and Lung Institute in London, for his expert linguistic advise, which has markedly improved our presentation.

References


