Revival of Continuous Suture Technique in Aortic Valve Replacement in Patient With Aortic Valve Stenosis

A Novel Modified Technique

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Objective: The continuous suture technique has numerous advantages as simple, quick, and effective for aortic valve replacement; however, it is technically difficult. We have modified the continuous suture technique and evaluated our new technique in patients with aortic stenosis.

Methods: Between July 2007 and May 2010, 86 patients with aortic valve stenosis underwent aortic valve replacement alone or with other concomitant cardiac procedures including mitral valve surgery in our hospital. The patients were randomly divided into two groups: group A (n = 43) in which the continuous suture technique with some modifications was used and group B (n = 43) in which the conventional interrupted suture technique was used. There were no statistical differences between two groups in age, sex, body surface area, concomitant cardiac procedures, blood loss, and postoperative extubation time.

Results: The aortic cross-clamp time, cardiopulmonary bypass time, operation time, and hospital stay were significantly shorter in group A than that in group B, and the valve size was significantly larger in group A. No perivalvular leak was detected in postoperative echocardiograms. All patients recovered satisfactorily without complications associated with suture technique or prosthesis. During follow-up of 4 to 38 months, there were no clinically significant complications in group A, while one patient in group B developed perivalvular leakage requiring reoperation 3 months after surgery.

Conclusions: Our modified continuous suture method is useful for aortic valve replacement in patients with aortic stenosis and beneficial for the patients because the procedure is less invasive and a larger valve can be implanted.

Key Words: Aortic valve replacement, Aortic valve stenosis, Operative technique.

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The continuous suture technique has numerous advantages as a simple, quick, and effective method for aortic valve replacement (AVR), especially from the viewpoints of less thrombogenic materials around the prosthesis and lower risk of infection because a pledget is not used. However, the continuous suture method is technically difficult. In particular, when tangling of the sutures or tearing of tissue due to excessive tension occurs, adverse complications such as paravalvular leakage may develop. Eventually, the continuous suture technique may take as long as the conventional interrupted suture. We have modified the continuous suture technique aiming to avoid the above technical disadvantages. In this study, we evaluated our new modified technique in patients with aortic stenosis, comparing with the conventional interrupted suture technique.

MATERIALS AND METHODS

Patients

Between July 2007 and May 2010, a total of 86 patients with aortic valve stenosis underwent AVR alone or combined with other cardiac procedures including mitral valve surgery in our hospital. All patients undergoing AVR during this period were eligible for entry into the trial. There were no specific exclusion criteria for the trial. Patients with a history of valve operations or concomitant coronary artery disease were also included. The trial was approved by the institutional ethics committee. Informed consent was obtained from each patient.

Transthoracic echocardiography was done preoperatively in all patients, and the cardiac valvular lesion, heart function, and structure were evaluated in detail. Patients were assigned randomly to two groups according to the suture technique used in AVR: group A in which the continuous suture technique with some modifications was used and group B in which the conventional interrupted suture technique was used. Group A consisted of 22 male and 21 female patients with a mean age of 58.7 (range, 16–86) years and mean body surface area of 1.37 (range, 1.11–1.88) m^2. Twenty-two patients underwent isolated AVR, and 21 patients had AVR combined with other procedures (Table 1). The aortic valve lesion was pure stenosis in 31 and combined dominant stenosis and regurgitation in 12 (Table 2). Group B consisted

TABLE 1. Surgical Procedures in Two Groups

Group A Continuous Suture (n = 43)		Group B Interrupted Suture (n = 43)	
Isolated AVR	22	Isolated AVR	27
Concomitant procedure	21	Concomitant procedure	16
AVR + CABG	8	AVR + CABG	5
AVR + MVP	3	AVR + MVP	3
Bentall procedure	3	AVR + annular enlargement	3
AVR + MVP + TAP	2	AVR + MVP + TAP	2
AVR + TAP	2	Bentall procedure	2
AVR + MVR	1	AVR + MVP + Maze	1
AVR + Maze	1		
AVR + septal resection	1		

AVR indicates aortic valve replacement; CABG, coronary artery bypass graft surgery; MVR, mitral valve replacement; MVP, mitral valve plasty; TAP, tricuspid annuloplasty.

of 17 male and 26 female patients with a mean age of 56.4 (range, 31–85) years and mean body surface area of 1.33 (range, 1.1–2.2) m^2. The aortic valve lesions were pure stenosis in 33 patients and combined stenosis and regurgitation in 10 (Table 2). The etiology of the cardiac valve lesions was degenerative atherosclerosis in the majority of patients in both groups. Bicuspid aortic valves were present in 4 patients in group A and in 6 patients in group B, and there were no rheumatic valves. The operations were done by the same surgical team with the same technique for AVR.

Operative Technique

Endotracheal general anesthesia and cardiopulmonary bypass (CPB) were instituted in the standard manner. For isolated AVR, a bicaval cannula is placed in the right atrium.

TABLE 2. Preoperative Data of the Two Groups

	Group A Continuous Suture (n = 43)	Group B Interrupted Suture (n = 43)	*P*
Mean age (y)	58.7 ± 12.7	56.4 ± 10.6	NS
Male/female	22/21	17/26	NS
Body surface area (m^2)	1.37 ± 0.11	1.33 ± 0.10	NS
Cardiac rhythm			
Normal sinus rhythm	38	36	NS
Atrial fibrillation	5	7	NS
NYHA class			
II	11	6	NS
III/IV	32	37	NS
Aortic lesion			
Pure aortic stenosis (bicuspid)	31 (4)	33 (6)	NS
Aortic stenosis and regurgitation	12	10	NS
Aortic valve area (cm^2)	0.67 ± 0.13	0.53 ± 0.17	<0.01
Left ventricular ejection fraction (%)	54.2 ± 9.9	56.2 ± 11.0	NS
Concomitant surgery	21/43	16/43	NS

NS indicates not significant; NYHA, New York Heart Association.

All the patients had retrograde catheter inserted into the coronary sinus through the right atrium. Tepid hypothermia (30°C–34°C) was established. The aorta was then cross-clamped. Cold blood cardioplegia was infused initially through the retrograde catheter. When the aortic root was open, cardioplegia was delivered directly into the coronary ostia by handheld catheters, followed by repeated doses every 20 minutes in an alternate antegrade/retrograde manner. The affected aortic valve was excised with careful debridement. Special care was taken to prevent debris from entering the coronary ostia and/or the left ventricular chamber. The valve annulus was measured, and an appropriate prosthetic valve was selected and prepared. Three No. 3-0 nonabsorbable monofilament polypropylene sutures were used to suture the valve in place.

The prosthetic valve was held firmly approximately 5 cm above the native valve annulus. For the first suture, the stitch was passed through the commissure between the right and left coronary cusps (R-L commissure), and then the stitch was passed from below the corresponding point of the prosthetic ring and up through the ring. In a counterclockwise direction, the next stitch was inserted into the aortic annulus and again passed through the prosthetic ring, and suture was continued until one stitch before the commissure between the left coronary cusp and noncoronary cusp (L-N commissure). The first suture was completed. For the second suture, the first stitch was placed in the L-N commissure, and stitches were passed through the prosthetic ring in a counterclockwise direction as described above, until reaching the N-R commissure. The third suture was also done as for the above sutures. During suturing, it was important not to allow the sutures to slack but to maintain tension. Four to five stitches were made between two commissures. At each stitching, care was taken to anchor sufficient tissues including the ring.

Next, the prosthetic ring was lowered into its position by manipulating the parachute suture. Here, a new technique was used which was the modification of this study: the outer loops of the parachute suture were drawn together using another suture (gathering suture) and traction was applied not to individual loops but to gathering suture (Fig. 1). When lowering the prosthetic ring onto the nature aortic annulus, the two ends of the 3-0 suture and the gathering suture were pulled simultaneously to lower the ring carefully (Fig. 2). This method allowed the continuous monofilament suture to gradually tighten around the ring, without tangling of the sutures or tearing of the tissue (Fig. 3). The valve holder was removed.

The sutures were tightened carefully in a sequential manner using a nerve hook (Fig. 4), while the area beneath the valve and the left ventricular outflow tract were inspected for any redundant suture loops. The prosthetic valve was tested to ensure unimpaired opening and closing, and then the ends of adjacent stitches were tied at the three commissures. The aortotomy was closed by routine procedures.

Statistical Analysis

Data were compiled and analyzed using Microsoft Access, Microsoft Excel (Redmond, WA USA) and Statview (Cary, NC USA). The baseline characteristics and hospital

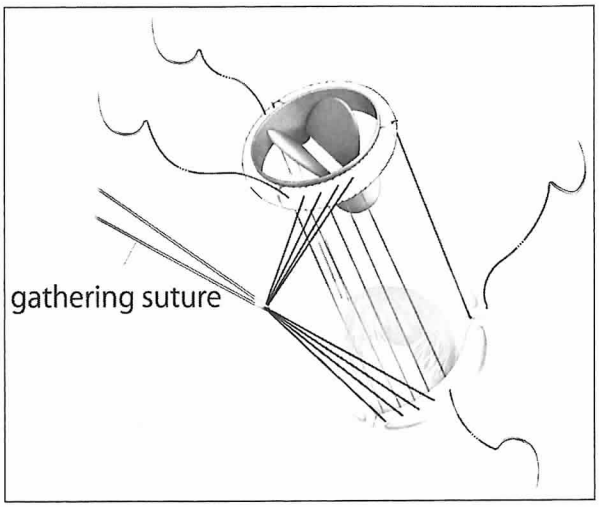

FIGURE 1. The first stitch is inserted from the tip of the commissure of the aortic wall at a point 0.5 cm below the tip of the commissure between the right and left coronary cusps. The other end of the stitch is secured with a rubber shod clamp. The stitch is then passed from below the corresponding point of the prosthetic sewing ring. The suture is continued counterclockwise along the left coronary cusp remnant until reaching the commissure between the left and noncoronary cusps. Another suture is used to draw together the outer loops to form a part of the parachute suture. By applying traction to the gathering suture, tangling of the loops is prevented.

outcomes for the two groups were compared using χ^2 test for categorical data and Mann-Whitney U test for continuous variables. Unless otherwise indicated, data are reported as mean ± standard deviation in the text and tables. Statistical significance was defined as a P value less than 0.05.

RESULTS

There were no significant differences in age, sex, body weight, body surface area, valve lesion, concomitant cardiac procedure, and early mortality between the two groups of patients. The types of valves implanted in group A were Carbomedics mechanical valve in 12, ATS open pivot mechanical valve in 9, Carpentier-Edwards PERIMOUNT (CEP) bioprosthetic valve in 8, CEP Magna bioprosthetic valve in 13, and Edwards Prima stentless bioprosthetic valve in 1 patient. However, the types of valves implanted in group B were Carbomedics mechanical valve in 15, ATS open pivot valve in 11, CEP valve in 8, and CEP Magna valve in 8 patients.

In both groups, the conditions of patients were stable and uneventful during the postoperative period. There were no operative deaths in both groups.

Intraoperative outcome of the two groups were shown in Table 3. Statistical analyses showed that the aortic cross-clamp time, CPB time, operation time, and hospital stay were significantly shorter in group A than in group B. And the implanted valve size was larger in group A than in group B.

All the patients in both groups recovered satisfactorily without any complications associated with suture technique or prosthesis. During follow-up of 4 to 38 months, no patient developed perivalvular leak in group A, while one patient in group B developed perivalvular leakage confirmed by physical examination and echocardiography, necessitating repeat AVR 3 months after surgery.

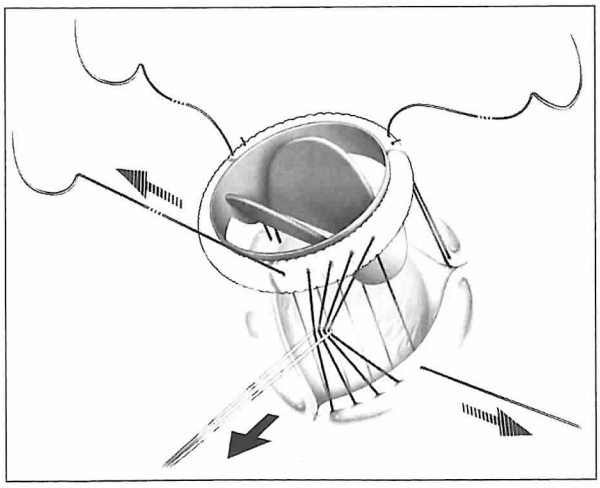

FIGURE 2. By pulling gently the stitch ends and the gathering suture one by one, the prosthetic valve is lowered into its position.

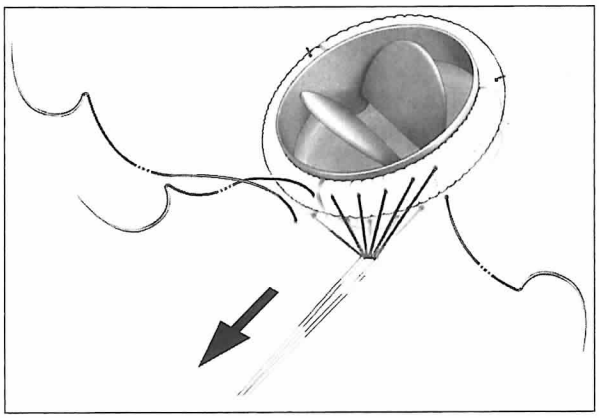

FIGURE 3. Without tangling of the sutures or tearing of the tissue, the prosthetic valve is gradually tightened around the ring.

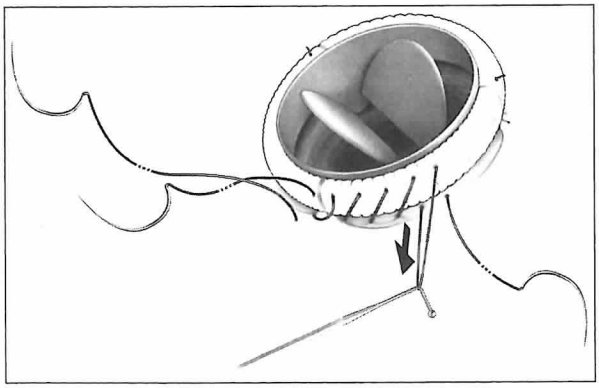

FIGURE 4. The sutures are tightened carefully in a sequential manner using a nerve hook.

TABLE 3. Intraoperative Outcome, Early and Late Morbidity and Mortality

	Group A Continuous Suture (n = 43)	Group B Interrupted Suture (n = 43)	*P*
Cross-clamp time (min)	46.3 ± 20.4	85.9 ± 32.9	<0.01
Isolated procedure	39.6 ± 10.6	70.7 ± 15.7	<0.01
combined procedures	53.6 ± 25.8	75.9 ± 24.6	<0.01
Duration of cardiopulmonary bypass (min)	85.9 ± 32.9	122.7 ± 32.4	<0.01
Isolated procedure	73.0 ± 23.3	110.8 ± 32.4	<0.01
combined procedures	100.9 ± 36.5	129.3 ± 37.6	<0.01
Blood loss (mL)	373 ± 110	342 ± 102	NS
Postoperative extubation time (h)	6.5 ± 6.3	7.9 ± 12.7	NS
Operation time (min)	212 ± 68.5	245 ± 62	<0.05
Hospital stay (d)	12.4 ± 2.1	14.1 ± 2.8	<0.05
Implanted valve size (mm)	21.6 ± 2.2	20.5 ± 2.0	<0.05
Perioperative death	0	0	
Myocardial infarction	0	0	
Pneumonia	0	0	
Ventricular fibrillation	0	0	
Stroke	0	0	
Reexploration	0	0	
Early paravalvular leak	0	0	
Reoperation for early endocarditis	0	0	
Late mortality	0	1	
Late paravalvular leak	0	0	

NS indicates not significant.

DISCUSSION

The results of our series show that AVR using our modified continuous suture technique markedly reduced operation time, CPB time, and aorta cross-clamp time, without serious postoperative complications or long-term disadvantages.

Continuous suture technique in aortic valve and mitral valve replacements has been described in the text book of cardiac surgery since a long time ago. The use of continuous suture may be of benefit to the patients because the cardiac ischemia time is reduced by half with this technique, and myocardial injury is minimized. This may be important in patients with marginal cardiac reserve.[1] Despite these advantages, many cardiac surgeons still tend to favor the interrupted suture technique. Some possible reasons for a lack of popularity of the continuous suture technique are as follows: (1) using the continuous suture technique, a single suture is sufficient for stitching only one-third to one-half of the circumference of the aortic annulus; (2) compared with interrupted suture, tissue tearing occurs easily at sites where the needle traverses the tissue; and (3) once tissue tearing occurs, perivalvular leak develops easily from the breakage site. To address these issues, various modifications of the continuous suture method have been attempted.[2,3] Putting it the other way, if the above-mentioned disadvantage can be prevented, the merit of the continuous suture method will be great.

The incidence of arteriosclerotic aortic stenosis in the elderly (aged 75 years or older) continues to increase.[4] Furthermore, patients with a small aortic annulus have also increased. In this patient population, less invasive surgery is desirable compared with young patients with aortic valve insufficiency.[5] Although transcatheter aortic valve implantation may be an option in the future, complications of this procedure have been reported, and surgery definitely remains the first choice of treatment.

With regard to the new modified continuous suture technique reported in this study, the following points should be emphasized. First, the aortic annulus is divided into three sections at the commissures, and continuous suturing is conducted using one thick 2-0 monofilament for each of the three sections. Second, during lowering of the prosthetic ring into the position of the native annulus, a separate suture for drawing together the loops and for applying traction is used to prevent tangling of the sutures during this maneuver. Parachute suture is done by applying traction at three points: two ends of the monofilament suture and the gathering suture, which facilitates drawing of the monofilament suture rapidly and tightly to the annulus. Otherwise, if a monofilament suture becomes caught under an adjacent suture or if a slacken suture gets tangled with another suture on the opposite side of the ring, then untangling these sutures will take a long time. Another big advantage of our modification is that by applying three-point traction, the tension of each loop is equalized, which prevents tearing of the tissue. This method of three-point traction using a gathering suture is a totally novel technique and a good method that allows rapid and safe continuous suture surgery.

As a result of using this novel technique, we achieve a shorter aortic cross-clamp time that reduces myocardial ischemic injury and a shorter bypass time that minimizes complications of extracorporeal circulation. All of these conduce to the patients' early recovery. Another major advantage of the continuous suture technique is less thrombogenic material such as pledgets around the prosthesis compared with the conventional interrupted suture technique. Furthermore, our technique does not require a pledget inside the aorta, which further reduces complications associated with thrombogenic material. Prosthetic valve endocarditis is one of the common postoperative complications after cardiac valve replacement.[9] Because there is no pledget in the aorta to expose the blood to foreign material, our modified continuous suture technique may help reduce the incidence of this severe complication. In aortic root replacement using an allograft for infectious endocarditis, the use of continuous suture technique using a monofilament suture has been shown to be useful even in active infectious foci.[10]

In the continuous suture technique, the prosthesis is seated on the aortic annulus rather than being wedged into it such as in the everting mattress technique.[11] Moreover, similar to the interrupted single suture without pledget, a valve of a larger size can be fitted. According to our experience using continuous suture technique, a prosthesis one size larger than that used in the conventional interrupted mattress technique can be implanted smoothly on the patient's aortic annulus.

There are some controversies about the incidence of perivalvular leak in continuous suture technique for AVR. Nair et al[12] reported a higher incidence of paravalvular leakage when using continuous suture, both in aortic valve and mitral valve replacements. Hjelms et al[13] reported an incidence of perivalvular leak of 8.8% in 80 patients with pure aortic insufficiency who underwent AVR using the continuous suture technique and suggested that the continuous suture technique is not suitable for patients with pure aortic insufficiency. On the other hand, Laks et al[14] reported that the incidence of perivalvular leak using the continuous suture technique was only 2.3% and that the incidence of perivalvular leak in AVR was comparable in continuous suture technique and conventional interrupted technique. Qicai et al[15] observed low incidence of both paravalvular leakage and infectious endocarditis with the continuous suture technique and reported the advantages of this method. Therefore, in the case of AVR, the occurrence of paravalvular leakage is probably not related to whether continuous suture or interrupted suture is used. Instead, reliable surgery, particularly whether stitches are made with firm anchoring to the tissue, is a factor that determines the outcome. The reason is that if paravalvular leakage is an inherent problem with continuous suture, then the use of continuous suture for proximal anastomosis in aortic root replacement using composite graft or homograft would not have been established.[16,17]

In the present series, during follow-up of 4 to 38 months, none of the patients who had continuous suture developed perivalvular leak, while one patient who had interrupted suture developed paravalvular leakage in the late phase, necessitating reoperation. Selection of a valve of appropriate size and reliable suture of the tissue probably contributed to avoid complications in our patients.

CONCLUSIONS

Our modified continuous suture method using monofilament suture is useful for AVR in patients with aortic stenosis, and it is a beneficial method for the patients because the procedure is less invasive and a larger valve can be implanted.

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CLINICAL PERSPECTIVE

This article describes a novel modification of the continuous suture technique for aortic valve replacement from Dr. Go Watanabe and his group at Kanazawa University. The authors used a gathering suture to seat the valve. They performed a randomized study in which they compared the continuous suture technique with conventional interrupted sutures. They found that cross-clamp time, cardiopulmonary bypass time, operative time, and hospital stay were significantly shorter in the continuous suture group. This is a well-illustrated report that provides a nice technique for the continuous suturing of aortic valve prostheses.