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*Original Article*

# Bentall procedure versus valve-sparing ascending aortic replacement in the treatment of aortic dissection involving the aortic root

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**Abstract:** Objective: To compare the outcomes of valve-sparing ascending aortic replacement versus the Bentall technique in the treatment of aortic dissection with involvement of the aortic root. Methods: Between January 2014 and December 2015, 50 patients with Stanford acute type A aortic dissection with involvement of the aortic root were given surgical treatment. The patients were randomly divided into the Bentall group (n=28) and the valve-sparing ascending aortic replacement group (hereinafter referred to as VSAAR group, n=22). The two groups were compared regarding cardiopulmonary bypass time, aortic cross-clamp time, postoperative complications, and surgical outcomes. Results: Cardiopulmonary bypass time and aortic cross-clamp time were markedly longer among the patients with Bentall surgery than those with valve-sparing ascending aortic replacement (Both P<0.001); the incidences of acute renal failure and neurological complications, assisted ventilation duration and hospitalization duration differed insignificantly between the two group in the perioperative period (All P>0.05); compared with those before operation, postoperative aortic sinus diameter and left ventricular end-diastolic diameter (LVEDD) were reduced significantly, but aortic valve regurgitation and left ventricular ejection fraction (LVEF) were improved significantly among the patients with valve-sparing ascending aortic replacement (All P<0.001); the LVEF was improved but the LVEDD was decreased among those with Bentall procedure (Both P<0.001); all the patients, regardless receiving Bentall procedure or valve-sparing ascending aortic replacement, were not substantially different in postoperative LVEDD and LVEF (Both P>0.05). Conclusion: The short-term outcomes of valve-sparing ascending aortic replacement in the treatment of patients with Stanford acute A aortic dissection with involvement of the aortic root are basically equivalent to those of Bentall procedure.

**Keywords:** Stanford A aortic dissection, aortic root replacement, aortic valve insufficiency

## Introduction

Stanford acute type A aortic dissection is a risky cardiovascular disease due to its acute onset, severity, high mortality and disability. It has been reported that the mortality of aortic dissection in the first 48 h after onset can reach 50%, namely, with a mortality of 1% hourly [1, 2]. Early and timely surgical procedure is the only effective way to save a patient's life [3]. Standford acute type A aortic dissection without involving the aortic root requires no aortic root replacement, with simple operation but good prognosis. Nevertheless, the dissection involving the aortic root is more likely to cause aortic valve insufficiency, tears in the coronary ostia leading to acute myocardial infarction, and ruptured hemorrhage leading to acute pericardial tamponade and other complications [4-6]. Accordingly, adopting optimal methods to treat the dissection with involvement of the aortic root and eliminate the hidden fatal hazard has become one of the goals of emergency operation [7]. Currently, the controversy concerning the surgical techniques for the aortic dissection is mainly about which alternatives of aortic root replacements to select [8, 9]. Therefore, choosing optimal strategies to improve the surgical outcomes of aortic dissection involving the aortic root has become the focus of cardiac surgeons [10, 11].

The Bentall technique is a mature surgical procedure with proven efficacy. However, mechani-

cal prosthetic aortic valve replacement requires life-long postoperative anticoagulation, but long-term use of anticoagulants may lead to high risk of related complications. Besides, the postoperative bioprosthetic aortic valve implantation may give birth to bioprosthetic valve failure. All of the above factors affect the quality of life of the patients. With a better understanding of the physiological and anatomical features of the aortic root and the aortic valves, great progress has been made in valve-sparing aortic root replacement. Aortic valve preservation precludes lifelong anticoagulation and associated complications including bleeding or thrombosis. Valve-sparing aortic root replacement has shown to effectively protect against postoperative dilatation of aortic annulus [12]. However, there is a paucity of systematic clinical studies on the feasibility and safety of valve-sparing ascending aortic replacement. Therefore, the current study was designed to provide a good strategy for the aortic root replacement in clinical practice, for which we compared the short-term outcomes of the Bentall procedure versus the valve-sparing ascending aortic replacement by taking 50 patients as subjects who had Stanford acute type A aortic dissection with involvement in the aortic root and had been admitted to the emergency department.

## Materials and methods

### *Patients*

This study got approval from the Hospital Ethics Committee and written informed consent was collected from each patient. Between January 2014 and December 2015, a total of 50 patients with Stanford acute type A aortic dissection admitted in our hospital were recruited in this study. All the patients were diagnosed by preoperative thoracoabdominal aortic computerized tomography angiography (CTA), and underwent echocardiography to assess severity of aortic valve regurgitation, aortic sinus diameter, left ventricular end-diastolic diameter (LVEDD) and left ventricular ejection fraction (LVEF). All the patients were randomly assigned to the Bentall group or the valve-sparing ascending aortic replacement group (hereinafter referred to as VSAAR group) in terms of a random number table. Patients older than 18 years were eligible for the study if they had aortic dissection involving the aortic root, widening aortic sinus, presence or absence of aortic valve insufficiency, the dissection without involvement of the coronary ostia and more than 1 year of follow-up. Patients had rheumatic or senile degenerative changes in the aortic valves were excluded from the study. The eligible patients included 36 males and 14 females, with 31-55 years of age (mean 42.7±8.4 years). The interval between onset and surgery was 6-42 h, with a mean of 11.2±5.4 h.

### *Interventions*

At admission, all the patients received symptomatic treatment such as sedation, analgesia and blood pressure control, and then underwent emergency operation after full preoperative preparation. The patient was placed in a supine position under general anesthesia, with the left radial artery and left dorsal artery punctured for blood pressure monitoring. The chest was dissected by the median sternotomy, which allowed an exposure of the heart, the ascending aorta, the aortic arch and the branch vessels above the arch, with cannulation of the right femoral artery, the right subclavian artery and the right atrium for establishment of cardiopulmonary bypass. The ascending aorta was cross-clamped when cooling to 28°C. After the ascending aorta was incised, cardioplegic arrest was induced by infusion of solution for myocardial protection directly into the left and right coronary ostia. It continued to cool down to 20°C for hypothermic circulatory arrest, and then the aortic cross-clamp was released for antegrade cerebral perfusion. Replacements of the distal ascending aorta and the aortic arch, and the stented elephant trunk implantation were performed following the standard practice [5]. For management of the aortic root, distinct surgical strategies were adopted for the patients in the Bentall group and the VSAAR group. The patients in the Bentall group underwent the aortic valve replacement, the aortic root replacement, and the coronary artery ostia grafting. For those in the VSAAR group, surgeons crosscut the aortic segment above the sinotubular junction, sutured the torn aortic valve junction to the corresponding adventitia, performed the aortic sinus angioplasty and concurrently sutured the residual aortic intima and adventitia above the sinotubular junction, followed by distal artificial vascular anastomosis. Good aortic valve closure was checked by

**Table 1.** Preoperative characteristics of the patients

| Variable | Case | Age (year) | M/F (n) | Hypertension (n, %) | PT (n, %) | PE (n, %) | HI (n, %) |
|---|---|---|---|---|---|---|---|
| Bentall group | 28 | 41.4±7.5 | 20/8 | 20 (71.4) | 5 (17.9) | 15 (53.6) | 4 (14.3) |
| VSAAR group | 22 | 44.1±6.7 | 16/6 | 15 (68.2) | 4 (18.2) | 12 (54.5) | 3 (13.6) |
| $t/\chi^2$ value | | 2.819 | 1.839 | 2.138 | 0.348 | 1.047 | 1.152 |
| *P* value | | 0.382 | 0.173 | 0.149 | 0.549 | 0.311 | 0.297 |

Note: MF denotes Male/Female, PT pericardial tamponade, PE pericardial effusion, HI hemodynamic instability, VSAAR valve-sparing ascending aortic replacement.

**Table 2.** Preoperative aortic root and cardiac function parameters

| Variable | Bentall group | VSAAR group | $t/\chi^2$ value | *P* value |
|---|---|---|---|---|
| Case | 28 | 22 | | |
| AR | | | 1.243 | 0.651 |
| None | 1 (3.6) | 1 (4.5) | | |
| Mild | 13 (46.4) | 10 (45.5) | | |
| Moderate | 11 (39.3) | 9 (40.9) | | |
| Severe | 3 (10.7) | 2 (9.1) | | |
| ASD (mm) | 45.8±6.7 | 46.9±7.2 | 2.484 | 0.096 |
| LVEDD (mm) | 50.9±5.8 | 52.1±7.8 | 1.142 | 0.112 |
| LVEF (%) | 57.5±8.3 | 58.4±8.6 | 1.183 | 0.702 |

Note: VSAAR denotes valve-sparing ascending aortic replacement, AR aortic regurgitation, ASD aortic sinus diameter, LVEDD left ventricular end-diastolic diameter, and LVEF left ventricular ejection fraction.

**Table 3.** Comparisons of perioperative variables

| Variable | CP (min) | ACC (min) | RS (n, %) | AKI (n, %) | NC (n, %) | AV (h) | Hospitalization (d) |
|---|---|---|---|---|---|---|---|
| Bentall group | 275.2±76.4* | 146.9±48.7* | 3 (10.7) | 7 (25) | 2 (7.1) | 40.2±9.5 | 26.5±9.7 |
| VSAAR group | 189.4±63.5 | 95.3±28.6 | 2 (9.1) | 6 (27.3) | 1 (4.5) | 43.8±8.7 | 24.3±8.8 |
| $t/\chi^2$ value | 14.361 | 18.283 | 1.325 | 0.849 | 0.338 | 2.354 | 2.102 |
| *P* value | <0.001 | <0.001 | 0.554 | 0.671 | 0.871 | 0.107 | 0.142 |

Note: Compared with the valve-sparing ascending aortic replacement group, *P<0.05. CP denotes cardiopulmonary bypass, ACC aortic cross-clamp, RS re-sternotomy, AKI acute kidney injury, NC neurological complications, AV assisted ventilation, and VSAAR denotes valve-sparing ascending aortic replacement.

transesophageal echocardiography after cardiac cardioversion.

*Follow up*

All patients were followed for a period of 1 year. With clinic visits or telephone calls, they received routine echocardiography every 3 months, and an annual thoracoabdominal aortic CTA to assess the aortic root profile.

*Outcome measures*

The time for cardiopulmonary bypass, aortic cross-clamp time and the rate of complications of patients were compared between the two study groups; in addition, the predictors for the aortic root profile including the severity of aortic regurgitation, the aortic sinus diameter, LVEDD and LVEF before operation and the last postoperative follow-up were also compared between the two groups. Between-group comparison also went for surgical results.

*Statistical analysis*

The SPSS software (version. 21) was utilized for analyses on all the statistical data. Measurement data were expressed as mean ± standard deviation, with the independent sample t-test for inter-group comparisons and the paired t-test for intra-group comparisons before and after operation. Enumeration data were presented as rates, with the chi square test for inter-group comparisons. P<0.05 was deemed to be statistical significance.

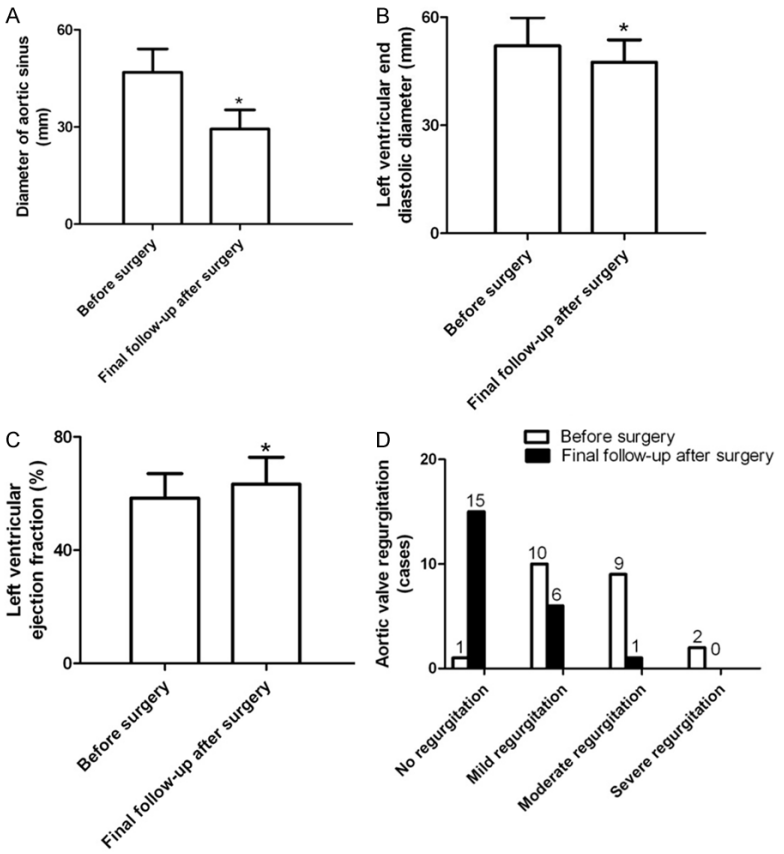


**Figure 1.** Comparisons of the aortic root profile before and after operation. in the valve-sparing ascending aortic replacement group; for comparison with those before operation, *, P<0.001.

## Results

### *Patient characteristics*

The Bentall group consisted of 28 patients, with 20 males and 8 females, a mean age of 41.4±7.5 years, and the average interval from onset to surgery of 10.8±4.9 h. Among the 28 patients, preoperative hypertension occurred in 20, pericardial tamponade in 5, pericardial effusion in 15 and unstable hemodynamics in 4. The VSAAR group included 22 patients, with 16 males and 6 females, a mean age of 44.1±6.7 years and the average time from onset to surgery of 11.6±4.2 h. Of 22 patients, preoperative hypertension was present in 15, pericardial tamponade in 4, pericardial effusion in 12 and unstable hemodynamics in 3. Insignificant differences were observed between the two groups with regard to preoperative clinical data, and they were comparable (P>0.05, **Table 1**).

### *Preoperative aortic root and cardiac function parameters*

The patients in both groups suffered from aortic dissection with involvement of the aortic root before operation. The patients in the two groups were generally well-balanced in the severity of aortic regurgitation, the aortic sinus diameter, LVEDD and LVEF (P>0.05, **Table 2**).

### *Cardiopulmonary bypass time, aortic cross-clamp time and complications*

The cardiopulmonary bypass time, aortic cross-clamp time of the patients prolonged substantially in the Bentall group versus those in the VSAAR group (P=0.000), but the incidence of acute kidney failure, the rate of neurological complications, assisted ventilation duration and hospitalization differed insignificantly between the two group (P> 0.05, **Table 3**).

### *Surgical outcomes*

After operation, striking improvements in the aortic valve regurgitation and LEVF but markedly reduction in the aortic sinus diameter and LVEDD of the patients were observed in the VSAAR group, as compared with those before operation (All P<0.001, **Figure 1**). Likewise, significantly improved LEVF and reduced LVEDD of the patients were also found in the Bentall group (Both P<0.001).

The LVEDD and LVEF of patients at the final follow-up after operation differed slightly between the VSAAR group and the Bentall group (Both P>0.05, **Table 4**).

### *Mortality*

Postoperative death was present in four patients in the Bentall group, with a mortality of 14.3%, including 2 deaths from multiple organ failure, gastrointestinal hemorrhage in 1 patient

**Table 4.** Comparison of postoperative LVEDD and LVEF of the patients

| Variable | LVEDD | LVEF |
|---|---|---|
| Bentall group | 47.9±7.1 | 65.7±8.9 |
| VSAAR group | 47.5±6.2 | 63.3±9.5 |
| t value | 1.629 | 2.578 |
| *P* value | 0.267 | 0.115 |

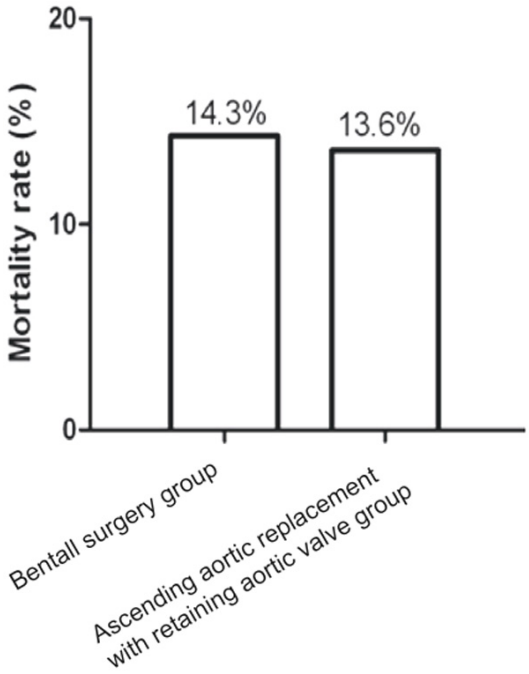


**Figure 2.** Comparison of mortality of the patients between the two groups.

and pulmonary infection in1. By contrast, postoperative death occurred in 3 patients in the VSAAR group, with a mortality of 13.6%, including 2 deaths from multiple organ failure and large-area cerebral infarction in 1 patient. The difference in the mortality of patients was not striking between the two groups (P=0.238, **Figure 2**).

## Discussion

Bentall surgery, a classic technique for the treatment of the dissection involving the aortic root, can remove all proximal dissection tissues, achieve total aortic root replacement, and eliminate the hidden threat of recurrent dissection involving the aortic root, which is a good option particularly for patients with dissection involving the coronary artery [13-15]. However, with long and complex procedures, prosthetic valve replacement and associated anticoagulation not only significantly impact the quality of life in patients, but also delay the false lumen thrombosis in the distal aortic dissection, and affect the long-term outcomes of the patients [16]. The valve-sparing aortic root replacement was proposed based on the recognition of the aortic root that the aortic sinus and all the components of the aortic valves play a crucial role in maintaining the normal functions of aortic valves [17-20]. This technique has overcome the drawbacks of the Bentall procedure, but its long-term outcomes need further follow-up observations. The findings in the current study showed that the short-term outcomes of the valve-sparing aortic root replacement was evident, with significantly decreased aortic sinus diameter and LVEDD but strikingly improved preoperative aortic regurgitation and LVEF at 1-year follow-up. Moreover, no significant difference with regard to mortality of patients was noted between the two groups (P>0.05); the major causes of death included multiple organ failure, recurrent pulmonary infection, recurrent gastrointestinal hemorrhage and large-area cerebral infarction. Multiple organ failure, pulmonary infection and gastrointestinal hemorrhage may be attributed to large surgical trauma, long bedrest, long recovery duration, coexisting underlying diseases and long cardiopulmonary bypass [21, 22]. Large-area cerebral infarction may be due to false-lumen minimal residual thrombus, deep venous thrombosis or hypothermic circulatory arrest [23]. Although the incidence of complications was basically similar between the two groups, the aortic cross-cramp and cardiopulmonary bypass duration of patients were both substantially longer in the Betall group compared with those in the VSAAR group, which also brought higher risks for postoperative cardiopulmonary by pass-associated complications and myocardial injury in the Bentall group. In addition, the differences in LVEF and LVEDD between the two groups differed insignificantly, indicating that the valve-sparing ascending aortic replacement is effective.

In conclusion, Standford acute type A aortic dissection involving the aortic root should be treated according to the conditions of the patients. The valve-sparing ascending aortic replacement for the management of Standford acute type A aortic dissection achieved short-

term outcomes basically equivalent to those of the Bentall surgery, so it is worthy of extensive use in clinical practice. Therefore, the current study provides experimental evidence for the selection of aortic dissection with involvement of the aortic root replacement. There are some limitations in this study, including the small sample size, a single center study and a short-term follow-up. However, given the emergency of the surgery for aortic dissection, it is difficult to conduct a randomized, multicenter, and controlled trial. Therefore, additional trials are required to make further follow-up for assessment of the long-term outcomes of valve-sparing ascending aortic replacement.

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## Disclosure of conflict of interest

None.

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