OPEN SURGERY OR STENT REPAIR FOR DESCENDING AORTIC DISEASES: RESULTS AND RISK FACTOR ANALYSIS

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Abstract

Objectives. Less invasive stent graft (SG) repair was compared with open surgery for patients with descending thoracic aortic diseases. Design. Thirty six patients undergoing SG repair (SG group) were matched for age, sex, location and pathology of aortic disease with a 36-patient surgical cohort (OS group), and retrospective matched case-control study was performed with respect to outcomes and risk factors for adverse outcomes. Results. Mortality rate was 5.6% in OS group and none in SG group (p = 0.4930), and there was no significant difference in stroke and paraplegia rates between two groups. A higher prevalence of secondary procedures due to endoleak was seen in the patients of SG group (p = 0.0113). Perioperative hypotension was an independent risk factor for in-hospital mortality (p = 0.0071, odds ratio = 34) and preoperative renal dysfunction was independent risk factor for paraplegia (p = 0.0076, odds ratio = 17.6). Conclusions. Although the importance of patient selection is emphasized to prevent endoleak, mortality rate was low in patients who underwent SG repair. SG repair is a promising alternative technique to open surgery for thoracic aortic diseases.

Key words: Thoracic aneurysm, stent graft, open surgery

Surgical repair for thoracic aortic disease remains durable for a long-term and does not require multiple re-intervention, which achieves cure in the case of thoracic aortic aneurysm (1). In recent years, the treatment of thoracic aortic disease has changed with the introduction of less invasive stent graft (SG) repair (2), and properly selected patients with the descending thoracic aortic disease are expected to gain a lot of benefits from SG repair. Treatment by SG repair is governed by anatomic factors, comorbid conditions, the technical skills of the operators and there are no long-term results. However, the indications of SG repair rapidly have expanded to include thoracic aortic tears (3), type B dissection (4), penetrating ulcer (5-7) perforated intramural hematoma (7), pseudoaneurysm (8,9), and distal aortic arch aneurysm (10). SG repair for thoracic aortic disease was initiated in April 2000 in our institute for selected patients. To gain a better understanding of the new alternative less invasive treatment we have reviewed retrospectively our patients treated for descending thoracic diseases, and retrospective matched case-control study was performed with respect to outcomes and risk factors for adverse outcome.

Material and methods

Since April 2000 SG repair was performed in 36 patients (SG group) for descending thoracic aortic disease. From 1980 to August 2007, 365 patients underwent thoracic aortic operation at our institute and open surgical repair for descending thoracic aortic disease (anastomosis cepharad to celiac axis) was done in 98 patients using partial cardiopulmonary bypass. From these 98 patients, a matched group of 36 patients (OS group) was selected based on age, sex, emergency operation,
location of the aortic diseases, and aortic pathology and retrospective matched case-control study was performed. Clinical outcomes of OS group versus SG group were compared, and multivariate analysis was performed to examine which variables increases the risk of adverse outcome and whether SG repair decreases the risk of adverse outcome. Patients variables included preadmission co-morbidities (hypertension, a history of heart disease, chronic obstructive pulmonary disease, a history of cerebrovascular disease, chronic renal dysfunction defined as a serum creatinine levels greater than 1.5 mg/dl, and diabetes mellitus), emergent operation, perioperative hypotension less than 70mmHg of systolic pressure, and location and pathology of aortic disease. Operative variables included cross-clamping the aortic arch, previous of concurrent abdominal aortic aneurysm repair, reattachment of intercostal arteries, and which treatment of SG repair or open surgery was used. Adverse outcomes was in-hospital mortality, stroke which was defined as new onset of focal injury or global cerebral damage after the operation with correlates in cranial computed tomography occurred, and paraplegia which was defined as new onset of loss or impairment of motor function of the legs due to spinal cord ischemia.

We obtained informed consent for the treatment from all patients and the institutional review board approval was obtained for this study.

Indications for SG

Clinical indications. Patients with good operative risks are considered for open surgery. Elderly and high-risk patients unfit for open surgery is considered for SG repair. Patients who preferred SG repair even after additional information was given regarding the limited early and mid-term results of SG repair are underwent this technique.

Anatomical indication. Proximal and distal aortic neck lengths require 20 mm or more and aortic diameter of the neck is not exceeding 38 mm. No aorto-iliac occlusive disease, no sever angulation at the landing zone, and no severe aortic disease. (atheroma, calcification, Marfan syndrome, acute aortic dissection) are also required.

Materials of SG

SG was constructed with Gianturco self-expandable stainless steel Z-stent (Cook Incorporated, Bloomington, IN, USA) covered by an Ube graft (Ube Industries Ltd, Yamaguchi, Japan). The size of graft was decided to exceed by 10–20% the diameter of the proximal and distal aortic necks and the shape of SG were individually designed by connecting the peaks of the stents with struts (11).

Operative technique of SG

All procedures were performed only by general anesthesia in an operating room. After heparinization, vascular access was obtained through the common femoral artery or iliac artery, or the abdominal aorta via laparotomy. Home made SG was housed at the tip of the sheath and was inserted with the guidance of a guide-wire which was introduced from the vascular access site to the brachial artery. SG was deployed in a precise position with the use of high resolution C arm fluoroscopy. Ten patients (29.4%) required covering left subclavian artery to establish a secure landing zone of 2 cm, and pre-endograft axillary to axillary artery bypass was created through bilateral infra-clavicular incisions.

Surgical technique in OS group

All patients underwent graft replacement under partial cardiopulmonary bypass. Intercostal arteries were reattached to the graft in 11 patients. Eight patients (8.2%) had aneurysms adjacent to the origin of the neck vessels underwent graft replacement using a cross-clamping the aortic arch with partial cardiopulmonary bypass.

Statistics

Categorical variables are reported as frequencies and all continuous variables are reported as mean ± standard deviation. The χ² test or Fisher exact test was used for categorical variables and the unpaired 2-tailed t-test for continuous variables between groups. Variables that achieved a p-value of 0.2 or less in the univariate analysis were examined using multivariate analysis by forward stepwise logistic regression to evaluate independent risk factors for in-hospital mortality, stroke, and paraplegia. P-values <0.05 were considered statistically significant. Statistical analysis was performed with SPSS 6.1 for UNIX (SPSS, Inc, Chicago, Ill, USA).

Results

Patients variables

Patients’ demographics and compared risk factors are summarized in Table I. Although the patients in SG group had more preoperative cerebrovascular diseases (p = 0.0457) and underwent more previous or concomitant abdominal aorta repair (p = 0.0113),
all other pre-existing co-morbid conditions were similar between the two groups. Seven patients (19.4%) underwent previous (4 cases) or concurrent (3 cases) abdominal aortic repair in SG group (p = 0.0113).

**Results**

In-hospital mortality was 5.6% in OS group and none in SG group but the difference did not reach statistical significance (p = 0.4930). Stroke occurred in two patients of OS group and one patient of SG group. Paraplegia was identified in two patients in OS group and one patient in SG group. The SG patient who had undergone abdominal aortic repair previously suffered from paraplegia after SG repair and the development of paraplegia was closely associated with a documented postoperative hypotensive episode, and it disappeared completely with the blood pressure increased. There was no significant difference in stroke rate and paraplegia rate. There were more likely to have subsequent need for secondary procedures in SG group than in OS group (p = 0.0113). In SG group, additional SG repair was needed for seven patients (19.4%) due to endoleak and two patients out of them required surgical conversions to open repair because of massive hemoptysis without apparent endoleak diagnosed by CT scan and angiogram after the additional SG repair. On opening aorta, fresh thrombus was found between SG and aneurysmal wall and this led us to be convinced that mere endoleak existed in two cases (Table II).

**Risk analysis for in-hospital mortality**

Univariate analysis revealed no significant risk factor for in-hospital mortality. Three variables including postoperative stroke (p = 0.0822), cross-clamping the aortic arch (p = 0.1350), perioperative hypotension (p = 0.0822) were examined with multivariate analysis, and perioperative hypotension was an independent risk factor for in-hospital mortality (p = 0.0071, odds ratio = 34) (Table III).
Table III. Results of univariate and multivariate analysis for in-hospital mortality.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Univariate analysis (p)</th>
<th>Multivariate analysis (p)</th>
<th>OR</th>
<th>95%CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postoperative stroke</td>
<td>0.0822</td>
<td>0.1352</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cross-clamping the aortic arch</td>
<td>0.1350</td>
<td>0.3063</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perioperative hypotension</td>
<td>0.0822</td>
<td>0.0071</td>
<td>34</td>
<td>1.52-761</td>
</tr>
</tbody>
</table>

Table IV. Results of univariate and multivariate analysis for postoperative stroke.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Univariate analysis (p)</th>
<th>Multivariate analysis (p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross-clamping the aortic arch</td>
<td>0.0114</td>
<td>0.5339</td>
</tr>
<tr>
<td>Hypertension</td>
<td>0.0590</td>
<td>0.1157</td>
</tr>
<tr>
<td>Distal arch aneurysm or proximal descending thoracic aneurysm</td>
<td>0.0169</td>
<td>0.9048</td>
</tr>
</tbody>
</table>

Table V. Results of univariate and multivariate analysis for postoperative paraplegia/paraparesis.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Univariate analysis (p)</th>
<th>Multivariate analysis (p)</th>
<th>OR</th>
<th>95%CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Previous or concurrent AAA repair</td>
<td>0.1862</td>
<td>0.5018</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Renal dysfunction</td>
<td>0.0310</td>
<td>0.0076</td>
<td>17.6</td>
<td>1.3-239</td>
</tr>
</tbody>
</table>

AAA = abdominal aortic aneurysm; CI = confidential interval; OR = odds ratio.

Risk analysis for stroke

Univariate analysis identified that cross-clamping the aortic arch (p = 0.0114), location of the aortic diseases (p = 0.0169) were significant risk factors for stroke. Three variables including hypertension were examined with multivariate analysis and there was no independent risk factor for stroke (Table IV).

Risk analysis for paraplegia

Univariate analysis identified preoperative renal dysfunction was a risk factor for paraplegia (p = 0.0310). Although previous or concurrent abdominal aortic aneurysm repair had a trend of an increased risk of paraplegia (p = 0.1862), there was no significant. Multivariate analysis showed that preoperative renal dysfunction was independent risk factor for paraplegia (p = 0.0076, odds ratio = 17.6) (Table V).

Discussion

The first successful endovascular repair for the abdominal aortic aneurysm was described by Parody et al. in 1991 (12), and Dake et al. reported endovascular SG repair of descending thoracic aortic aneurysms in 1994 (2). Surgical reconstruction for abdominal aortic aneurysm reveals good results with low mortality rate and is widely accepted, however, open surgery of thoracic aortic diseases requires thoracotomy, partial cardiopulmonary bypass with heparinization, aortic cross-clamping, and is followed by relatively high mortality and morbidity. The advantages of SG repair over open surgery are quite obvious in thoracic aortic surgery than in abdominal aortic aneurysm. SG repair for thoracic aortic disease was initially limited to patients deemed to be high or prohibitive risk for open surgery in our institute. Since then we have confirmed our technique and benefits of SG repair, the indication has been gradually liberated and presently most of patients with suitable anatomy would be considered candidates for SG repair.

The indications of SG repair for thoracic aortic diseases have to be made carefully because of the lack of long-term results and high-rate of SG-related complication, however, indications rapidly expanded because of good early and mid-term results (13). The selection of candidate for SG repair depends on the anatomic condition of the aneurysm neck, suitability of the vascular access including no procedure limiting tortuosity of the aorta, and aortic pathology. In our institute proximal and distal aortic neck lengths require 20 mm or more, however, current endovascular literatures demonstrated extended applications through proximal aortic neck extension with or without hybrid procedures (10,14,15). Ehrlich et al. (15) trusted that absolute contraindication for endovascular SG placement was a sever tortuosity of the descending thoracic aorta or iliac arteries where introduction of the stent device to the desired location might be associated with a risk of aortic or arterial rupture. SG repair for acute aortic dissection and Marfan syndrome have begun to be performed in some institutes (4,13). However the feasibility of SG repair in these patients is controversial, because of the particular fragility of the aortic wall (13). We have excluded Marfan syndrome and acute dissection from the indication of SG repair at the present time.

The mortality rate for surgery of descending thoracic and thoracoabdominal aortic lesion is about 8% with paraplegia rates between 2.3–11.4% and increases in ruptured aneurysm and traumatic rupture (1,16–18). Furthermore, the surgical treatment of thoracic aortic disease in the elderly patients is not yet universally recommended because of a perceived
high mortality rate and the dreaded risk of paraplegia (19). However, recent studies of SG repair found no difference in the number of adverse outcomes between elective and emergent repair or no significant differences in morbidity and mortality between elderly and younger patients (20,21). Fattori et al. (13) showed 5% of in-hospital mortality in a wide cohort of 457 patients and Rocco et al. (22) demonstrated the results of 166 SG repairs with eight patients (4.8%) died within the first 30 days and nine other patients died as a consequence of postoperative complications beyond 30 days. Two studies demonstrated significant low mortality in stent graft repair compared with open surgery for the descending thoracic aorta (15,23), and our study showed 5.6% mortality in OS group and none in SG group.

The significant complications in open surgery for thoracic aortic diseases are stroke and paraplegia. In our study, stroke was closely related to cross-clamping the aortic arch in open surgery, and it might have been caused by direct embolization of the atherosclerotic debris at the cross-clamp or after release of the aortic cross-clamp. We abandoned the surgical method of clamping the mid arch for distal aortic arch aneurysm repair in 1995 and we have performed total arch and descending thoracic aorta replacement with open-stent graft using selective cerebral perfusion and open technique for these cases (24). In SG repair, the occlusion of the left subclavian artery without previous revascularization and embolic phenomenon from endovascular manipulation in the aortic arch are major causes of stroke (13,25). Preserving vertebral artery is important to prevent stroke and carotid to subclavian artery bypass (9), subclavian to carotid transposition (14,15), SG with scallop-edged and bare-ended stent graft or with endograft fenestration were utilized for SG repair (26,27). Although axillary to axillary artery bypass was performed to preserve vertebral artery flow in the present study, carotid to subclavian artery bypass has been created now.

Paraplegia is multifactorial, with mechanisms including perioperative hypotension, embolic causes, aortic cross clamping, insufficient collateral circulation, increased cerebrospinal fluid pressure, and interruption of intercostals arterial supply. Estrera et al. (1) reported the incidence of paraplegia after open surgery of the descending thoracic aorta is 2.3% and 1.3% in patients with distal perfusion with cerebrospinal fluid drainage and 6.5% in patients without the adjunct procedure, and it is about 10% after open surgery of thoracoabdominal aorta (28). SG repair is considered to be advantage in preventing spinal cord ischemia because of the lack of the need of aortic cross clamping and sudden deployment of the stent graft does not produce steal phenomenon. However, some literatures showed no difference in the incidence of postoperative paraplegia between SG repair and open repair for thoracic aortic disease (23). Paraplegia rates remains about 3–5% after SG repair for thoracic aortic disease (14,22,23,25,29). Long segment thoracic aortic exclusion was the most important predictor of spinal cord ischemia in SG repair (13,25). Concurrent or previous abdominal aorta repair was another risk factor for paraplegia in SG repair because of insufficient collateral circulation to the spinal cord by the loss of lumbar arteries (2,25). Chiesa et al. (29) analyzed 103 patients underwent elective endovascular repairs of the thoracic aorta and they found that perioperative hypotension (mean arterial pressure <70 mmHg) was a significant predictor of spinal cord ischemia. The latter two reports show that rather than being dependent on single segmental arteries, namely the artery of Adamkiewicz, spinal cord perfusion highly depends on a collateral circulation that is extremely vulnerable to abrupt hemodynamic change. For the patient whose left subclavian artery orifice should be covered by stent graft, we have convinced that axillary to axillary artery bypass may help protect against spinal cord ischemia by preserving important vertebral artery collaterals that contribute to spinal flow. Significant independent risk factor for paraplegia in our study was preoperative renal dysfunction. Renal dysfunction has previously been identified as a risk factor for both death and neurologic injury (1,30).

Endoleak rates were about 10–20% in the literatures and the presence of endoleak allows the persistent risk for rupture (13,22,25). The proximal landing zone was more of a factor determining endoleak rate than was aortic pathology or urgency of the treatment (31). There is an important discussion for proximal neck length necessary to prevent type 1 endoleak which relates to indication for SG repair. Dagenais et al. (10) described that proximal and distal necks 2 cm or more were required and the use of extra anatomic revascularization of subclavian artery increased aortic neck length for SG fixation. Peterson et al. (14) advocated subclavian to carotid transposition when the aortic lesion was within 15 mm of the left subclavian orifice to prevent type 2 endoleak. Severe neck angulation and large proximal neck diameter were reported to be associated with type 1 endoleak (22). Proximal neck dilation is recognized as another cause of late endoleak. Mohan et al. (32) demonstrated the correlation between preoperative aneurysm diameter greater than 6 cm and endoleak development in abdominal aortic aneurysm repair because the larger aneurysm sac might to harbor type 2 endoleak to prevent throm-
bosis. In our series, 7 patients had postoperative endoleaks (type 1) and they underwent secondary SG intervention. Out of these patients, two patients underwent urgent surgical repair because of massive hemoptysis without apparent endoleaks diagnosed by CT scan and angiogram. The diameter of their atherosclerotic aneurysms of both patients was over 7 cm. Furthermore, the other patient who had atherosclerotic aneurysm of 8 cm in diameter died of aortic rupture 3 years after the SG repair. Large atherosclerotic aneurysm might be risk of endoleak followed by aortic rupture in SG repair for the patients with thoracic aneurysm as well as for patients with abdominal aortic aneurysm.

Conclusions

Although, there was no significant difference in stroke, paraplegia, and in-hospital mortality between SG repair and OS repair and was the lack of randomized or concurrent control patient group precluded direct comparison with open surgery, our result with no mortality in SG group shows that SG repair for descending thoracic aortic diseases is a promising alternative technique to open surgery in selected patients. We emphasize the importance of patient selection to prevent endoleak because the apparent limitation for using SG repair is endoleak-related complication. Long-term follow-up is necessary to assess the durability and effectiveness of this new less invasive treatment.

References


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