Effects of ascending aorta replacement on aortic root dilatation

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Abstract

Objective: Because of an increase of aortic root wall stress, prosthetic replacement of the ascending aorta might be a risk factor for the progressive increase of the aortic root dimension. Aim of the present study was to evaluate the aortic root diameter change and the progression of aortic valve regurgitation late after ascending aorta replacement for different etiology. Methods: Sixty-three late survivors after supracoronary ascending aortic replacement were evaluated. Forty-one patients were operated on for acute aortic dissecting aneurysm (group I) and 22 for chronic atherosclerotic non-dissecting aneurysm (group II). Aortic root diameter and aortic valve regurgitation were assessed echocardiographically after a mean follow-up of 63 ± 31 months and were compared with those early after surgery. Results: Seven patients of group I (17%) needed reoperation for aortic root dilatation or dissection. Twenty-five percent of the patients (15 of group I and 1 of group II) showed at least a 10% increase in aortic root diameter at follow-up (46.8 ± 6.1 vs. 38.1 ± 6.1 mm, P < 0.0001). Aortic root diameter increased almost exclusively in patients operated on for acute dissecting aneurysm. A significant worsening of aortic valve insufficiency with time was evident only in patients operated on for acute dissecting aneurysm with an higher incidence in those with progressive root dilatation. Conclusions: Both the increase of aortic root diameter and the progressive worsening of aortic valve insufficiency seem to justify a more aggressive treatment of the aortic root at the time of surgery for acute aortic dissecting aneurysm but not for chronic atherosclerotic non-dissecting aneurysms.

Keywords: Ascending aorta; Aortic root; Dissection; Aortic insufficiency; Aortic aneurysm

1. Introduction

Despite continued refinements in surgical technique and postoperative management, patients undergoing ascending aortic aneurysm repair are at high risk for late cardiac and aortic morbidity and mortality [1]. Schepens and associates [2] clearly demonstrated that in patients with aortic procedures there is a significantly lower survival rate than it would be expected when compared with a background population. Both late development of aneurysms in other segments of the aorta [3] and aortic root aneurysm development requiring reoperation were found in several series of patients. In fact even in a non-Marfan population Detter and colleagues reported a 14% of late death with an overall survival of 69% at ten years [4]. Aortic rupture and dissection is a well-documented late complication, and life-long radiographic surveillance of these patients is recommended.

Recent experimental data, from computer simulation [5] to in vitro and in vivo experiments [6], have hypothesized that ascending aorta replacement with the currently available noncompliant vascular prostheses might cause an increase in aortic root wall stress and in ventricular impedance [7]. In particular Simon-Kupilik and colleagues [6] found that the wall stress index as measured either in vitro or in vivo increased by 22 and 16%, respectively. These unfavourable hemodynamic changes could consequently be a risk factor to late aortic root aneurysm formation. In the present study we attempt to verify in the clinical setting if patients undergone supracoronary ascending aorta replacement by Dacron prosthesis had tendency to develop aortic root pathology. To this extent, we evaluated aortic root diameter changes and the progression of residual aortic regurgitation late after ascending aorta replacement in relation to the underlying pathology whether dissecting or non-dissecting aneurysm.

2. Materials and methods

All long-term survivors (with a follow-up of at least 3 years) operated on for dissecting or non-dissecting aneurysms of the ascending thoracic aorta that received a straight supra-coronary
aneurysm had aortic regurgitation equal or greater than measured before surgery was 41.6. Aneurysms had a significantly higher incidence of bicuspid aneurysms (Table 1). Patients with atherosclerotic prevalence of female among atherosclerotic non-dissecting among acute aortic dissecting aneurysm, whereas a higher aneurysms and 44.1 for dissecting (Group I).

Table 1

<table>
<thead>
<tr>
<th>Variables</th>
<th>Acute dissecting aneurysm (Group I), N=41</th>
<th>Atherosclerotic non-dissecting aneurysm (Group II), N=22</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>58±11</td>
<td>63±11</td>
<td>0.1</td>
</tr>
<tr>
<td>Sex (M/F)</td>
<td>31/10</td>
<td>6/16</td>
<td>0.0004</td>
</tr>
<tr>
<td>Hypertension (%)</td>
<td>22 (53%)</td>
<td>15 (68%)</td>
<td>0.2</td>
</tr>
<tr>
<td>Use of β-blockers (%)</td>
<td>25 (60%)</td>
<td>14 (63%)</td>
<td>0.6</td>
</tr>
<tr>
<td>EF (%)</td>
<td>53±9</td>
<td>57±9</td>
<td>0.14</td>
</tr>
<tr>
<td>Root diameter preop. (mm)</td>
<td>41.6±6.4</td>
<td>44.1±11.9</td>
<td>0.27</td>
</tr>
<tr>
<td>Aortic regurgitation ≥2</td>
<td>25 (61%)</td>
<td>8 (36%)</td>
<td>0.06</td>
</tr>
<tr>
<td>Marfan syndrome (%)</td>
<td>2(5%)</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Bicuspid aortic valve (%)</td>
<td>1 (2.4%)</td>
<td>5 (23%)</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Sex (M/F) 31/10 6/16 0.0004 Age (years) 58 ±11 63 ±11 0.1

3. Results

None of the patients of Group II needed reoperation, whereas 7 patient of Group I (17%) underwent surgery: six of them underwent a Bentall operation and one underwent aortic valve replacement. Another patient with a 6 cm aortic root died because of postoperative infective complications after surgery for a large thoraco-abdominal aneurysm. Criteria for reoperation were either root diameter ≥55 mm or valve regurgitation with a dilated ventricle (ESD=50-55 mm). At reoperation the aortic root was grossly dilated (60-65 mm) but not dissected in two cases while it was normal or slightly dilated (34, 40, 45 and 50 mm, respectively) and re-dissected with partial prolapse of the intima causing valve regurgitation in the other four cases. All these six patients had a dissection involving the non-coronary and part of the right coronary sinus whose integrity was restored by adhesion of the dissected layers using GRF glue. Another patient, who underwent aortic valve replacement, had a normal size non-dissected root wall but an aortic valve with prolapsing leaflets. The mean time from first and second operation was 61 ±33 months.

The root diameter early after operation was within the normal range in both groups of patients (38.8 ±5.1 vs. 36.6 ±5.0). (The small decrease in root diameter in respect to the preoperative measurements reflects the effects of the ST junction dilatation on the proper measurements of the aortic root diameter). However, a residual aortic regurgitation was already evident immediately postoperatively in 4 patients of each group (Table 2). Twenty-five percent of the patients (15 in Group I and one in Group II) showed at least a 10% increase in aortic root diameter at follow-up (38.1 ±6.1 vs. 46.8 ±6.1 mm, P<0.0001). Comparisons between groups...
are shown in Table 2. Aortic root diameter increased almost exclusively in patients operated on for acute aortic dissec
ting aneurysm. A significant worsening of aortic valve regurgitation with time was evident only in patients operated for acute dissecting aneurysm with a higher incidence in those with progressive root dilatation. (Tables 2 and 3). At the time of follow-up all patients were in
class NYHA I or II. Although most of the patients of group I had some degree of residual valve insufficiency (23, 56%), it was mild (2+) in the majority of cases; their ventricular dimension and volumes were within the normal values. All patients were included in a strict follow-up protocol.

4. Discussion

Our common indications for replacing the aortic root along
with a dissecting ascending aortic aneurysm, like for non-
dissecting aneurysm, are mostly based on the diameter of the
aortic root itself. In the presence of an organically diseased
valve a classic Bentall approach is chosen whether in the
presence of a normal aortic valve a valve sparing procedure is
usually preferred. In the presence of a dissected but not dilated
aortic root up to now we have always been trying to repair it with
the aid of glue or Teflon felts depending on the surgeon
preferences. However, the results of this small experience
might indicate that in some cases of dissecting aneurysm a more
radical approach might improve the long-term results.

Careful follow-up and evaluation of patients after aortic
surgery is mandatory even after a satisfactory and complete
primary repair. In fact, a significant morbidity is either
related to the aortic disease itself like re-disssection or
dilatation in other aortic segments either related to the
surgical site like pseudoaneurysm and/or infection [1,2].
Furthermore, the replacement of the ascending aorta, that
is the most common type of operation for aortic disease,
with a non-compliant Dacron graft could potentially increase
the stress on the proximal non-treated aortic segment,
mainly the aortic root, with consequent progressive dilata-
tion and risk of wall dissection [6]. We therefore, evaluated
after a mean follow-up of about 5 years all patients who had
received a supra-coronary ascending aortic replacement for
dissecting and non-dissecting aneurysm to verify if the type
of disease or the type of surgery were affecting the long-
term integrity of the aortic root. To this extent, our study
has provided evidence that the increase in the aortic root
diameter and the worsening of aortic valve insufficiency
after replacement of the ascending aorta is exclusively
present in patients operated on for acute aortic dissecting
aneurysm, while in patients operated on for atherosclerotic
non-dissecting aneurysm, neither the increase in the
diameter of the aortic root nor the valve for regurgitation
are significant from a clinical point of view.

Simon-Kupilik and co-workers [6] have demonstrated
both in vitro and in vivo that the replacement of the ascending aorta by a non-compliant vascular prosthesis leads
to hemodynamic changes in the aortic root, such as a
considerable increase in systolic cross-sectional area of
the aortic root and a significant increase in calculated wall stress index. These modifications can be the cause of later
development of a root aneurysm. However, the fact that in
patients operated on for non-dissecting aneurysm there was
not a progressive dilatation of the aortic root leads us to
think that the increase in aortic wall stress due to the
presence of a non-compliant aortic graft is not, per se, a
sufficient factor to induce progressive weakening and
dilatation of the aortic root wall. Conversely, the increase
in pressure amplitude after prosthetic replacement might
play a role in the presence of an already diseased and fragile
aortic wall. As a matter of fact, in the majority of acute
aortic dissec
ting aneurysm a portion of the aortic root, most
often the non-coronary sinus and sometimes a portion of
the right coronary sinus, have been found involved in the
dissection and needed to be repaired using the GRF glue.
Indeed, the GRF glue was used in 31 (75%) of our patients
with acute aortic dissecting aneurysm. Six of them (6/31;
19%) needed reoperation. This indicates not only that the
aortic root in patients with acute aortic dissecting aneurysm
is at increased risk for further complications but also that
the GRF glue does not seem to guarantees a stable and
durable repair. Bingley and colleagues [9] demonstrated
that at the moment of reoperation the aortic wall in contact
with the GRF glue was macroscopically necrotic.

Table 2

Dimensions of the aortic root and residual aortic regurgitation immediately after surgery and at follow-up in the two groups of patients

<table>
<thead>
<tr>
<th>Variables</th>
<th>Acute dissecting aneurysm (Group I, N=41)</th>
<th>Atherosclerotic non-dissecting aneurysm (Group II, N=22)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Root diameter early postop. (mm)</td>
<td>38.8±5.1</td>
<td>36.6±5.0</td>
<td>0.12</td>
</tr>
<tr>
<td>Root diameter at follow-up (mm)</td>
<td>42.8±6.2</td>
<td>37.7±5.3</td>
<td>0.006</td>
</tr>
<tr>
<td>&gt;10% increase in root diameter</td>
<td>15 (36%)</td>
<td>1 (4.5%)</td>
<td>0.0022</td>
</tr>
<tr>
<td>Aortic regurgitation ≥2 early post-op.</td>
<td>4 (10%)</td>
<td>4 (18%)</td>
<td>0.34</td>
</tr>
<tr>
<td>Aortic regurgitation ≥2 at follow-up</td>
<td>23 (56%)</td>
<td>5 (22%)</td>
<td>0.008</td>
</tr>
<tr>
<td>Reoperation (6 Bentall, 1 AVR)</td>
<td>7 (17%)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Graft diameter (median, mm)</td>
<td>30</td>
<td>30</td>
<td>-</td>
</tr>
<tr>
<td>Follow-up (months)</td>
<td>61±32</td>
<td>68±29</td>
<td>0.44</td>
</tr>
</tbody>
</table>

AVR, aortic valve replacement.

Table 3

Incidence of residual aortic regurgitation at follow-up in patients with and without aortic root dilatation

<table>
<thead>
<tr>
<th>Variables</th>
<th>Increase in root diameter &gt;10%</th>
<th>Increase in root diameter &lt;10%</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aortic regurgitation ≤2</td>
<td>3 (19%)</td>
<td>26 (55%)</td>
<td>0.011</td>
</tr>
<tr>
<td>Aortic regurgitation ≥2</td>
<td>13 (81%)</td>
<td>21 (45%)</td>
<td>-</td>
</tr>
</tbody>
</table>
and microscopically showed a dense acellular fibrous tissue with islands of hyaline material and widespread hemodiecerin deposition. This was considered the possible cause of weakening of the aortic wall leading to re-dissection. Similarly, Kazui and colleagues [10] in patients re-operated on for re-dissection of the aortic root after supra-commisural aortic graft replacement found disappearance of nuclei of the medial smooth muscle cells suggesting tissue necrosis at the site of GRF application. On the other hand, Hata and colleagues reported a satisfactory freedom from reoperation rate as well as normal histo-pathological findings after surgical repair of the dissection with the aid of GRF glue [11]. This was probably due to the fact that the authors were very careful in minimizing the use of GRF glue by not inserting it inside the dissected cavity and in accurately mixing one part formalin to ten-part gelatin [11].

An important and striking finding of this small group of patients is the high incidence of residual aortic insufficiency that was found in patients operated on for acute aortic dissecting aneurysm. It is important to underline that a progression of aortic regurgitation was evident not only in those patients who showed a greater than 10% increase in aortic root diameter but also in those patients who had stable aortic root dimensions. This probably reflects a suboptimal adhesion of the dissected layers with a consequent inadequate support for the commissures. Although most of our patients had mild aortic insufficiency (2+) not clinically relevant, still it was of a greater magnitude as recorded early postoperatively. Repair by glue of a dissected aortic root not only did not seem to contribute to strengthen the aortic wall but it might have been the cause of the increased rigidity and fragility of the aortic wall leading to the possible sudden or progressive wall dissection. In fact, in patients re-operated for root re-dissection we found the aortic wall supporting one commissure calcified and detached from the wall with consequent partial prolapse of the corresponding cusp; the surrounding tissue was brownish and macroscopically necrotic. The interesting finding is that this unfavorable event might occur late after the first operation. In fact the four patients who were found to have a re-dissected but not dilated aortic root underwent surgery 3, 4, 7 and 11 years after the first operation respectively. Although aortic root re-dissection might be difficult to diagnose even by echocardiography or angiography, the sudden appearance or worsening of residual aortic insufficiency in patients with supra-coronary aortic replacement usually indicates the occurrence of aortic root dissection. Our small experience indicates that this event can occur at any time after the first operation and calls for a close follow-up of these patients even after many years from the first operation. As an alternative, it is probably advisable that in those patients with acute aortic dissecting aneurysm involving the aortic root a more radical approach like a valve sparing root replacement or a classic Bentall operation should be considered at the time of first surgery. In fact a complete replacement of the ascending aorta and aortic root at the time of acute presentation completely prevents this type of complication. Other authors suggest replacing the aortic root whenever in the presence of a preoperative moderate-to-severe AR since they noted a higher incidence of early reoperation in this subgroup of patients [12].

As a matter of fact a preoperative moderate to severe AR reflects a greater anatomical involvement of the aortic root in the dissection with its related difficulty in obtaining a stable adhesion and fixation of the dissected layers.

In a recent analysis of reoperation after ascending aortic surgery, Estrella and colleagues [13] reported that 20% of the reoperated patients needed a replacement of the aortic root. The majority of these patients had suffered an acute aortic dissecting aneurysm.

In conclusion, patients with non-dissecting ascending aortic aneurysms can safely undergo supra-coronary aortic replacement by non-compliant Dacron graft without increasing the risk of developing pathology of the aortic root. On the other end, patients with acute dissecting aneurysm involving the aortic root have a high chance of developing aortic root dilatation, re-dissection or both that in some cases will require a second operation. Given the chance that patients with acute aortic dissecting aneurysm might also need other surgical procedures for complication on the distal aorta a more radical treatment of the aortic root at the time of first operation should be considered in those cases where the dissection clearly extends into the aortic root.

References


