Life-table Analysis of Primary and Assisted Success Following Endoluminal Repair of Abdominal Aortic Aneurysms: the Role of Supplementary Endovascular Intervention in Improving Outcome*

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Aim: the aim of this study was to analyse the effect of supplementary endovascular intervention on the outcome of primary endoluminal repair of abdominal aortic aneurysm (AAA).

Methods: between May 1992 and December 1998, 266 patients underwent endoluminal repair of AAA. Minimum period of follow-up was 6 months. Those patients in whom the endoprosthesis could not be deployed were converted to open repair at the primary operation. Patients developing an early endoleak, within 31 days, were treated by a period of observation and secondary endovascular intervention in persistent cases. Patients developing a late endoleak were treated similarly, without a period of observation. Outcome was analysed by the life-table method. Primary success was defined as exclusion of the aneurysm from the circulation resulting from the original operation. Assisted success occurred when aneurysms with endoleaks became excluded from the circulation as a result of supplementary endovascular intervention.

Results: endoluminal repair failed in 17 patients requiring conversion to open repair at the original operation. Supplementary endovascular intervention was undertaken in 26 patients, with early endoleaks (n = 6) and late endoleaks (n = 20). Interventions involved deployment of secondary endoluminal grafts within the primary grafts (n = 22), and coil embolisation (n = 4). Successful exclusion of the aneurysm sac was achieved in 22 of 26 (85%) patients undergoing supplementary endovascular procedures. Conditional cumulative incidence of primary graft failure and secondary graft failure in the presence of all-cause mortality at 6 years was 47% and 25% respectively.

Conclusions: supplementary endovascular intervention is an important adjunct to endoluminal AAA repair with the potential to improve outcome and avoid conversion to open repair. Successful supplementary endovascular intervention was achieved in 85% of patients in whom it was attempted. Life-table analysis showed these supplementary procedures to be durable in the long term.

Key Words: Endovascular aortic aneurysm repair.

Introduction

Despite improvements in technique and technology, endoluminal repair of abdominal aortic aneurysms (AAAs) fails in a proportion of patients.1 Supplementary endovascular intervention is commonly used in these patients where primary endoluminal repair of AAA has failed.2 The success and durability of these supplementary procedures, however, has not been documented. We present an analysis of the effect of supplementary endovascular intervention on the outcome of primary repair of AAA over a seven-year period of time.

Methods

Between May, 1992 and December, 1998, 266 patients underwent endoluminal repair of AAA. Two hundred
Success Following Endoluminal Repair of AAA

Fig. 1. (a) Aortogram demonstrating migration of prosthesis and proximal aortic endoleak. (b) Post-procedure aortogram following deployment of secondary cuff endograft between renal arteries and prosthesis in the position of migration.

Fig. 2. (a) On-table pre-procedure aortogram demonstrating distal aortic endoleak following original tube endograft. (b) On-table post-procedure aortogram following deployment of cuff endograft between the original prosthesis and the aortic bifurcation.
Fig. 3. (A) Aortogram demonstrating distal aortic endoleak and proximal migration of original tube prosthesis. (B) On-table post-procedure aortogram following conversion from tube to aortoiliac prosthesis by deployment of tapered prosthesis. (Reproduced with permission from Seminars in Vascular Surgery, Robert B. Rutherford, MD (Ed.).)

and forty-nine (249) were male and 17 were female, with a mean age of 72 years. The minimum period of follow-up was 6 months. Those patients in whom the endoprosthesis could not be deployed were converted to open repair at the primary operation. Patients developing an early endoleak within 31 days were treated by a period of observation and secondary endovascular intervention in persistent cases. In the majority of patients the period of observation was 6 months, as the follow-up protocol required contrast computed tomography (CT) before discharge and at 6 months after operation. In patients with large (>6-cm diameter) AAA and endoleak, CT was performed at 3 months after operation. Supplementary endovascular intervention consisted of deployment of a supplementary endograft or coil embolisation. Patients developing a late endoleak were treated similarly without a period of observation.

Primary success was defined as exclusion of the aneurysm from the circulation resulting from the original operation. Assisted success occurred when aneurysms with endoleaks became excluded from the circulation as a result of supplementary endovascular intervention.

Secondary endoluminal AAA techniques

Proximal aortic endoleaks and migration of the prosthesis in the proximal aortic neck were treated by the deployment of tubular endografts or “cuffs”. These were introduced either via a femoral arteriotomy in a retrograde manner or via a right common carotid arteriotomy in an antegrade manner (Fig. 1). Patients with a distal aortic endoleak and proximal migration of an original tube endograft from the distal aortic neck were treated by three techniques. These were, firstly, deployment of a secondary tube endograft or cuff within and overlapping the original prosthesis and extending down to the aortic bifurcation (Fig. 2). Alternatively, the original tube endograft was converted to either an aortoiliac endograft (Fig. 3) or a bifurcated endograft (Fig. 4). Endoleaks around the limbs of bifurcated endografts were treated by limb extension endografts.
Endoleaks between two component parts of a modular prosthesis (trombone technique) were treated by deployment of a secondary tubular endograft between the two components of the modular prosthesis. Dislocation of the contralateral limb from the contralateral stump of a bifurcated modular endograft was treated by realigning the contralateral limb and stump with a through-and-through brachial to femoral guidewire and deploying a secondary intersegmental endograft to join the limb and stump. The technique is illustrated in Figure 5.

Techniques of coil embolisation

Tracker catheters and guidewires were used to obtain access to the inferior mesenteric (IMA) and lumbar arteries for coil embolisation. In the case of the IMA the following arteries were selectively catheterised in sequence: the superior mesenteric, the mid-colic, the marginal artery of the splenic flexure and descending colon, leading to the IMA. In the case of the lumbar arteries, the internal iliac, its superior gluteal branch and collateral channels were selectively and se-
Sequentially catheterised to reach the ipsilateral fourth lumbar artery. The contralateral fourth lumbar artery was reached via the AAA sac (Fig. 6).

Statistical analysis

Kaplan–Meier curves were constructed to show percentage success probability out to 6 years. Since some patients died with successfully treated aneurysms, conditional cumulative incidence of primary graft failure and secondary graft failure in the presence of a competing risk of all-cause mortality were also calculated. Without this adjustment, failure would have been artificially minimised by those patients whose grafts would never fail due to a competing risk, namely death.

Results

Endoluminal repair failed in 17 patients, requiring conversion to open repair at the original operation. The causes of failure leading to conversion are listed in Table 1. Secondary endovascular intervention was undertaken in 26 patients. The indication for secondary endovascular intervention was endoleak in 18 patients, endoleak and migration in seven patients and migration without endoleak in the remaining patient. Details of the site of the endoleak are listed in Tables
Table 1. Causes of failure leading to open repair.

<table>
<thead>
<tr>
<th>Cause</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access problems</td>
<td>2</td>
</tr>
<tr>
<td>Balloon malfunction</td>
<td>1</td>
</tr>
<tr>
<td>Aortic/iliac rupture</td>
<td>2</td>
</tr>
<tr>
<td>Migration of prosthesis</td>
<td>5</td>
</tr>
<tr>
<td>Graft thrombosis</td>
<td>1</td>
</tr>
<tr>
<td>Inability to deploy bifurcated graft</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>17</td>
</tr>
</tbody>
</table>

Table 2. Indication for secondary endoluminal AAA repair.

A. Endoleak
- Proximal aortic endoleak: 3
- Distal aortic endoleak: 4
- Limb endoleak: 5
- Intersegmental endoleak: 2

B. Endoleak and migration
- Proximal aortic endoleak and migration: 2
- Distal aortic endoleak and migration: 4
- Intersegmental endoleak and dislocation: 1

C. Migration
- Proximal aortic migration: 1

Interventions involved deployment of secondary endoluminal grafts within the primary grafts in 22 patients with Type I endoleaks ($n=21$) and migration ($n=1$) and coil embolisation of collateral channels in four patients with Type 2 endoleaks. Details of the type of secondary endoluminal grafts deployed and their outcome are listed in Table 3. Of the 22 patients undergoing secondary endoluminal graft repair there were 4 immediate failures and two late failures at 28 and 30 months. Tertiary endoluminal AAA repair procedures were successful in the two patients with late failure. Thus, there are 16 patients with excluded AAA resulting from secondary endoluminal repair and 18 of 22 (82%) with excluded AAA due to secondary endoluminal repair and tertiary endoluminal repair. Tertiary endoluminal repair was also attempted without success in two high-risk patients with early failure of secondary endoluminal repairs.

The site of the collateral arteries treated by coil embolisation are listed, together with the outcome, in Table 4. All four Type 2 endoleaks were successfully treated. Successful exclusion of the aneurysm sac was therefore achieved in 22 of 26 (85%) patients undergoing supplementary endovascular procedures.

Life-table studies

Overall survival probability is shown in Fig. 7. Survival probability at 4 years was 88%.

Kaplan–Meier curves for primary and assisted success following endoluminal AAA repair are shown in Figure 8.

Fig. 6. (a) Selective arteriogram demonstrating left fourth lumbar Type II endoleak. (b) Selective arteriogram demonstrating coil embolisation of right and left fourth lumbar arteries. (Reproduced with permission from Advances in Vascular Surgery, Anthony D. Whittemore, Dennis Bandyk, Jack Cronenwett et al. (eds.).)
Table 3. Outcome following secondary endoluminal repair of AAA.

<table>
<thead>
<tr>
<th>Secondary endograft</th>
<th>Number</th>
<th>AAA exclusion</th>
<th>Immediate failure</th>
<th>Late failure (months to failure)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proximal aortic cuff</td>
<td>6</td>
<td>4</td>
<td>1</td>
<td>1* (28)</td>
</tr>
<tr>
<td>Distal aortic cuff</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>1* (30)</td>
</tr>
<tr>
<td>Limb extension</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Aortoiliac endograft within original prosthesis</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Bifurcated endograft within original prosthesis</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Intersegmental endograft in modular prosthesis</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>22</td>
<td>16</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

* AAA exclusion restored with tertiary endograft.

Table 4. Outcome following secondary intervention by coil embolisation.

<table>
<thead>
<tr>
<th>Site of embolisation</th>
<th>Number</th>
<th>AAA exclusion</th>
<th>Immediate failure</th>
<th>Late failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contralateral common iliac artery in aorto-uni-iliac repair</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Inferior mesenteric artery</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4th lumbar arteries</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Conditional cumulative incidence of primary graft failure and secondary graft failure in the presence of all-cause mortality is shown in Figure 9. At 6 years the proportion of primary grafts failing was 0.47 compared with 0.25 for secondary grafts.

### Discussion

The aim of the supplementary endovascular interventions described in this paper was to exclude the aneurysm sac from the circulation and avoid the need for conversion to open repair. This is particularly important in that group of high-risk patients who are unfit for open repair. The commonest indications for secondary endovascular intervention were endoleak and endoleak plus migration. In one patient, migration was detected and treated before an endoleak occurred. With closer follow-up it should be possible to identify more patients in this latter category and simplify the technique of secondary endoluminal AAA repair.

The limitations of this study must be addressed. The combined analysis of first and second generation prostheses over a 6-year period may not accurately reflect the results that are currently being achieved.
The four patients with Type 2 endoleaks were successfully treated with coil embolisation. Resch and his colleagues have reported that these endoleaks do not result in increase in size of AAA with resultant risk of rupture and may be managed conservatively. Darling et al., however, have reported increase in size of AAA following surgical operations which have isolated the aneurysm by ligation of the neck of the aneurysm and ligation of the common iliac arteries. The mean time taken for collateral circulation to produce an increase in aneurysm size was four years. Longer follow-up of Type 2 endoleaks may result in increasing AAA size and the need for oil embolisation.

We conclude from this study that supplementary endovascular intervention is an important adjunct to endoluminal AAA with the potential to improve outcome and avoid conversion to open repair. Supplementary endovascular intervention was successful in excluding AAA in 85% of patients in whom it was attempted. Life-table analysis has shown these supplementary procedures to be durable in the long term.

References


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