INFLUENCE OF SUPRARENAL STENTGRAFT FIXATION ON RENAL FUNCTION IN PATIENTS AFTER ABDOMINAL AORTIC ANEURYSM ENDOVASCULAR EXCLUSION

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Currently, there are two methods of stentgraft implantation considering patients with abdominal aortic aneurysms (AAA) undergoing endovascular repair: the suprarenal and infrarenal fixation. It has been suggested that suprarenal fixation may lead towards impaired kidney function.

The aim of the study was to assess the influence of suprarenal stentgraft fixation on kidney function in patients after endovascular repair of abdominal aortic aneurysms.

Material and methods. The inclusion criteria were fulfilled by 118 patients who were subjected to endovascular treatment, due to abdominal aortic aneurysms. They were consequently divided into two groups – suprarenal (NN) or infrarenal (PN) – based on the stentgraft system used. Both groups were compared on the basis of co-morbidities, operative risk (ASA score), and volume of contrast medium used intraoperatively. The creatinine concentration (cr) and creatinine clearance (Cr.cl) were assessed during the preoperative period, between the 3-rd and 7-th postoperative day, and after 3 months.

Results. Increased creatinine level during the first postoperative week was observed in 12 of 118 patients (10.1%): in the suprarenal group – 7 of 66 (10.6%), and in the infrarenal group 5 of 52 (9.96%). During the 3-rd postoperative month the increase (cr >1.5 mg/dL) was present in 3 of 118 patients (2.5%): in the suprarenal group – 2 of 66 (3.03%) and in the infrarenal group-1 of 52 (1.9%). The difference between both groups was statistically insignificant. Furthermore, there was no statistically significant difference between creatinine clearance levels considering both groups.

Conclusions. In case of patients undergoing endovascular repair for AAA, implantation of a suprarenal device is a safe method, which does not significantly impair postoperative renal functioning. This increases the number of patients eligible for AAA treatment by means of stentgraft implantations.

Key words: abdominal aortic aneurysm, endovascular treatment, renal insufficiency

During the past years there has been a significant increase in the number of patients treated for abdominal aortic aneurysms (AAA). This is attributed to the increase in diagnostic modalities, such as Doppler ultrasound and computed tomography, as well as availability of new treatment options (1, 2, 3). One of the greatest breakthroughs in vascular surgery was probably in the early nineties of the past century with the introduction of a minimally invasive method of AAA exclusion by means of a stentgraft introduced by Parodi (4) and Volo- dos (5). This new method enabled surgeons to
treat patients previously disqualified from traditional aneurysmectomy (6, 7).

Nowadays, there are several commercially available stent-grafts with slight differences in their construction. Some have an uncovered proximal stent, which is used to fixate the graft in the aorta above the renal arteries (NN) (fig. 1), while others, with infrarenal fixation, are constructed with only covered segments (PN) (fig. 2).

In both cases, inclusion criteria are determined by the morphological parameters of the aneurysm and the proximal neck (the section of the aorta below the renal arteries). The aneurysmal neck is considered to be the key fixation point which later determines the success rate in AAA exclusion. Lack of proper stent-graft adherence at this point may lead towards a proximal type I endoleak, resulting in an increase in aneurysm diameter with possibility of its rupture (8, 9). It is currently established that the proximal neck should be cylindrical in shape and have at least 15 mm in length. These parameters are the optimal minimum for the use of a system with infrarenal fixation (PN). In cases where these criteria are not fulfilled (aneurysmal neck length <15 mm or a conical neck shape) the system with suprarenal fixation should be considered. This enables better fixation and prevents migration of the stent-graft into the aneurysmal sac. Fixation is achieved by a special wire scaffold, which is suspended across the orifices of the renal arteries (11, 12, 13). Some concern is given to the fact that the stent expanded across the orifices of the renal arteries may lead towards impaired blood flow to the kidneys resulting in renal infarcts or an increased creatinine level (14, 15).

The aim of the study was to assess the results of suprarenal stent graft fixation on renal functioning in patients undergoing endovascular abdominal aortic aneurysm repair.

MATERIAL AND METHODS

During the period between April 1998 and December 2005, 370 patients underwent endovascular exclusion of AAA by means of a stent-graft at the Department of General, Vascular and Transplant Surgery, Medical University in Warsaw. Patients were qualified on the basis of significant co-morbidities of the cardiovascular and pulmonary systems and high operative risk (assessed by the American Society of Anaesthesiology score – ASA), which disqualified them from open aneurysmectomy. Preoperative dia-
gnostics included spiral computed tomography with 3D reconstruction for the assessment of AAA and iliac arterial morphology.

The authors assumed that a proximal neck <15 mm was an indication to use the stent-graft system with suprarenal fixation. Surgery was performed in the operating theatre with the use of a mobile digital substraction angiography C-arm (OEC 9600).

Prospective analysis considered 139 consecutive patients with AAA who underwent elective stentgraft implantation between January 2003 and December 2004. The study group comprised 130 male and 9 female patients. Patient age ranged between 45 and 90 years (mean: 70.3 years).

The inclusion criteria for the prospective trial comprised a documented normal preoperative renal function defined by a creatinine level = 1.5 mg/dL and a minimum follow-up period of 3 months after surgery. These inclusion criteria were fulfilled by 118 patients who were consequently divided into two groups: the suprarenal (NN) or infrarenal (PN) – based on the stentgraft system used (fig. 1 and 2). The suprarenal group consisted of 66 patients (mean age: 70.8±6.7 years), while the infrarenal group consisted of 52 patients (mean age: 70±7.64 years). Both groups were compared on the basis of co-morbidities, operative risk (ASA score) and volume of contrast medium used intraoperatively (Iomeron 300, AstraTech). There were no significant differences concerning these parameters (p<0.05) (tab. 1 and fig. 3). The follow-up period and the number of performed follow-up CT scans was also comparable.

Types of stentgrafts used were presented in tab. 2.

In this study creatinine (cr) and creatinine clearance (Cl. cr) levels were assessed in both groups, before surgery, between the 3rd and 7th postoperative day and 3 months after stentgraft implantation. Thus, renal functioning was evaluated. The Cockraft-Glaut equation was used to calculate creatinine clearance levels:

$$Cl.cr = \frac{(140 – age) \times body\; weight}{cr \times 72}$$

The results were statistically analyzed using the chi-square and t-Student tests. Differences were considered significant at p<0.05. Calculations and graphical analysis were performed using the STATISTICA software program for Windows (StatSoft, Inc 2004; version 6).

RESULTS

Considering all patients intraoperative angiography performed directly after stent-graft implantation showed complete patency of both renal arteries and of the implanted graft. This was further confirmed during scheduled follow-up CT scans, which demonstrated no kidney malperfusion (fig. 4 and 5).

During the follow-up period (between the 3rd and 7th day and 3 months after surgery) in both groups no renal insufficiency was observed requiring dialysis. In 59/66 (89.4%) patients from the suprarenal group, and 47/52 (90.4%) infrarenal group patients normal creatinine values (<1.5 mg/dL) were observed during the first week after surgery. At the same time, in 7 (10.6%) suprarenal group, and 5 (9.6%) infrarenal group patients, an increase in creatinine levels >1.5 mg/dL was observed, although the difference between both groups was statistically insignificant (p=0.83). After three months an elevated creatinine level >1.5 mg/dL was observed in only 2 suprarenal one infrarenal group patients (3% and 2%, respectively; p =0.34).

Mean creatinine values in both groups were also compared without significant increase during the postoperative period, as well as statistically significant differences between suprarenal and infrarenal groups. Table 3 and fig. 6 presented the above-mentioned data.

Creatinine clearance values (Cl. cr) during each time interval were also assessed in correlation to the type of stentgraft used. Statistical analysis showed no significant differences in Cl.cr between both groups during the first week.
Influence of suprarenal stentgraft fixation on renal function in patients after abdominal aortic aneurysm endovascular exclusion

Table 1. Patient characteristics

<table>
<thead>
<tr>
<th></th>
<th>Suprarenal (n=66)</th>
<th>Infrarenal (n=52)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>number</td>
<td>%</td>
<td>number</td>
</tr>
<tr>
<td>Hypertension</td>
<td>53</td>
<td>80.3</td>
<td>42</td>
</tr>
<tr>
<td>Ischemic heart disease</td>
<td>51</td>
<td>77.2</td>
<td>39</td>
</tr>
<tr>
<td>MI</td>
<td>35</td>
<td>53.0</td>
<td>26</td>
</tr>
<tr>
<td>Cardiac arrythmia</td>
<td>5</td>
<td>7.6</td>
<td>3</td>
</tr>
<tr>
<td>COPD</td>
<td>23</td>
<td>34.8</td>
<td>19</td>
</tr>
<tr>
<td>Diabetes</td>
<td>17</td>
<td>25.8</td>
<td>15</td>
</tr>
<tr>
<td>Past stroke</td>
<td>3</td>
<td>4.5</td>
<td>3</td>
</tr>
<tr>
<td>ASA III*</td>
<td>57</td>
<td>86.3</td>
<td>45</td>
</tr>
<tr>
<td>ASA IV**</td>
<td>9</td>
<td>13.7</td>
<td>7</td>
</tr>
</tbody>
</table>

Table 2. Types and number of used stentgrafts

<table>
<thead>
<tr>
<th></th>
<th>Total patients (n=118)</th>
<th>Suprarenal (n=66)</th>
<th>Infrarenal (n=52)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>number</td>
<td>%</td>
<td>number</td>
<td>%</td>
</tr>
<tr>
<td>Zenith</td>
<td>60</td>
<td>50</td>
<td>60</td>
<td>91</td>
</tr>
<tr>
<td>PowerLink</td>
<td>41</td>
<td>35</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>Talent</td>
<td>9</td>
<td>8</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Excluder</td>
<td>8</td>
<td>7</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

(between the 3rd and 7th day), as well as third postoperative month. Also, no negative effects from the endovascular procedure itself were observed in relation to the creatinine clearance. The above-mentioned were presented in tab. 3 and fig. 7.

DISCUSSION

Renal insufficiency is one of the main reasons behind postoperative mortality after traditional aneurysmectomy. This is particularly obvious in patients with high operative risk and...
serious cardiovascular co-morbidities (16, 17). Thus, endovascular methods of AAA repair by means of stentgraft implantation have become increasingly popular. Thanks to the introduction of this method, the amount of intraoperative trauma has been decreased by avoiding laparotomy, compression of the mesentery, preparation of the aneurysm and cross-clamping of the aorta. This decreases the amount of catecholamines, cortyzol and cytokins released, which in turn limits the risk of organ reperfusion injury (18-21).

An important contraindication for endovascular surgery is the morphology of the aneurysmal neck and especially its length. Lawrence-Brown and associates from Australia constructed an endovascular stentgraft, which included a suprarenal fixation segment, which was later on modified to include hooks and barbs (22).

The stentgraft described in this study was used in cases where the aneurysmal neck was <15 mm, which is in accordance with other authors’ opinions (12, 23, 24). The suprarenal system prevents graft migration and at the same time decreases the probability of type I endoleaks, which may lead towards aneurysmal rupture.

On the other hand, some authors pointed out that the implantation of a stent-graft impaired the patients’ renal function in 6 to 10% of cases, independently of the type of graft (25-28, 35).

These results are analogous to our results, where the percentage of patients with a creatinine level >1.5 mg/dL during the first week was as follows: suprarenal group – 10.6% and infrarenal group – 9.6%. This may be explained by the use of iodinated contrast medium during intraoperative angiography (29). Therefore, other safer contrasts such as gadolinium and carbon dioxide are currently beginning to be used for vessel visualization.

In 2000, a study was published in which N-acetylcystein was used prior to surgery which significantly reduced the nephrotoxic effects of the iodinated contrast medium (31).

Table 3. Mean creatinine and creatinine clearance levels in groups NN and PN in different time periods

<table>
<thead>
<tr>
<th></th>
<th>Średnie stężenie kreatyny i Mean creatinine levels (mg/dl)</th>
<th>Średni klirens kreatyniny / Mean creatinine clearance (ml/min/1,73 m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NN / suprrenal (n=77)</td>
<td>PN / infrrenal (n=62)</td>
</tr>
<tr>
<td>Przedoperacyjny / preoperative</td>
<td>1,21</td>
<td>1,23</td>
</tr>
<tr>
<td>3-7 doba po operacji / 3-7 postoperative day</td>
<td>1,31</td>
<td>1,26</td>
</tr>
<tr>
<td>3 miesiące po operacji / 3-rd postoperative month</td>
<td>1,29</td>
<td>1,28</td>
</tr>
</tbody>
</table>
Renal infarctions occurring after non-intentional coverage of the renal artery ostia by the graft material were also observed (15). Renal infarctions caused by transposition of thrombotic material from the aortic wall occurring as a result of guide-wire manipulation were also described (32).

Some authors suggest that the impairment of renal function may depend mostly on the presence of suprarenal fixation. Although, the uncovered part of the proximal segment crossing the renal ostia causes turbulent blood flow, which may exert a thrombogenic effect in this area (33, 34).

Experimental studies have proven that enhancing the endograft construction with extra hooks and barbs increases thrombocyte activation, thrombus formation and stimulates neointimal growth (14).

Considering the above-mentioned doubts, the current opinion is that the increase in serum creatinine levels observed in some cases after endografting is mostly transient and does not impair renal function during long-term follow-up (23, 26, 35, 36). Similar results were observed in this study, where the number of patients with an elevated creatinine level >1.5 mg/dL decreased from 10.6% and 9.6% in the first week to 3% and 2% after 3 months from stentgraft implantation.

**CONCLUSIONS**

1. In case of patients after endovascular exclusion of abdominal aortic aneurysms, the implantation of a stentgraft with suprarenal fixation is a safe method, which does not cause significant renal functioning impairment during the postoperative period.
2. The use of the suprarenal fixation system enables successful AAA elimination, including aneurysms with a short proximal neck (length <15 mm). This in turn increases the number of patients eligible for AAA treatment by means of stentgraft implantation.

**REFERENCES**

COMMENTARY

Several reports were published during the past years discussing the safety of suprarenal stenting. The Author’s study is an important contribution to this subject proving that there are no significant differences between supra and infrarenal stentgrafts, in respect to renal adverse events. Thus, it is clear that the presence or absence of supra renal fixation does not affect the risk of renal deterioration. It is worth mentioning that there are several reasons, which can lead towards renal functioning impairment after stentgraft implantation. Besides bare stent-wires, which can be placed across the renal orifice and produce velocity disturbances influencing renal perfusion one should take into consideration the atheroembolization with microcholesterol particles and nephrotoxicity of contrast media, which equ-
ally affects patients with infra or suprarenal fixation. During stentgraft implantation every step of the procedure, such as wire passage, catheters introduction and finally stentgraft placement is associated with the release of embolic debris. It was shown during autopsy studies that cholesterol emboli were found in kidneys in nearly 30% of cases after diagnostic aortonephrography. Renal impairment after atheroembolisation occurs usually one or even two months after the procedure. Dye-induced nephrotoxicity generally occurs 1 to 2 days after the procedure and often resolves within several days.

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