Evaluation of patient renal function following endovascular aneurysm repair with suprarenal fixation

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Abstract

This study aimed to assess the mid-term renal function of abdominal aortic aneurysm patients following suprarenal endovascular repair. From March 2005 to December 2009, 290 abdominal aortic aneurysm patients were included in the study and grouped according to whether they had received infrarenal or suprarenal endovascular aneurysm repair. Suprarenal endovascular aneurysm repair was performed in 173 patients, with a mean age of 72(±8) years (85.0% male). Infrarenal endovascular aneurysm repair was performed in 117 patients, with a mean age of 71(±9) years (90.6% male). Preoperative and one week, 1-, 3-, 6- and 12-month postoperative serum creatinine and cystatin C values were recorded. Estimated glomerular filtration rate was calculated by cystatin-based formula and Cr-based Cockcroft formula. The t-test was used to determine statistical differences between or within groups.

All patients received Talent or Zenith endograft. Patients' characteristics and operative files in the two groups were well matched. Preoperative serum creatinine and cystatin C were 82 (±8) μmol/L and 0.89 (±0.11) mg/L for suprarenal endovascular aneurysm repair, respectively, and 81 (±11) μmol/L and 0.87 (±0.15) mg/L, respectively, for infrarenal endovascular aneurysm repair; no differences were observed between the two groups. Compared to preoperative renal markers within each group, a deterioration in serum creatinine, cystatin C and estimated glomerular filtration rate values was found at one week and 12 months after surgery (P<0.05). A deterioration in cystatin C [SR:(0.93±0.17) mg/L, IR:(0.92±0.31) mg/L] and estimated glomerular filtration rate by cystatin C was also found at six months after surgery (P<0.05). However, no differences in patient serum creatinine, cystatin C and estimated glomerular filtration rate values were observed between groups at each follow-up time interval. There was no greater significant difference in the association of the use of suprarenal fixation with mid-term postoperative renal injury than with infrarenal fixation.

Introduction

Abdominal aortic aneurysm (AAA) is currently the most common vascular disease in the elderly in China. Renal impairment is a common risk of mortality following conventional open AAA surgery. Endovascular aneurysm repair (EVAR) has advantages over open surgery. The risk of renal hypoperfusion secondary to hemodynamic instability and cross clamping is eliminated, surgical trauma is reduced, and ischemia-reperfusion injury is attenuated. The fixation strategy in EVAR can be defined as suprarenal (SR) or infrarenal (IR) fixation according to the proximal position of the stent across the renal artery ostia. In evaluating transrenal fixation, one question is whether the bared metal stents across the renal artery ostia used in SR fixation harm renal function more than IR fixation. Although some studies showed the relative safety of this technique,[1-5] most reports drew their conclusions from the study of small numbers of patients or used insensitive markers of renal function, leading to an imprecise assessment.

The purpose of this study was to evaluate the mid-term renal function of AAA patients following suprerenal EVAR compared with infrarenal, using cystatin C (Cys-C) and glomerular filtration rate (GFR) calculated by cystatin C-based equation as the sensitive markers of renal function compared with serum creatinine (SCr) and GFR calculated by the SCr-based method.

Materials and Methods

Patients' demographics and risk factors

From March 2005 to December 2009, 438 patients with infrarenal AAAs in two hospitals were entered retrospectively into a vascular registry for this study. Informed consent was obtained from all patients before surgery. Of these, 148 patients were excluded from analysis because of selective open surgery (n=31, 7.1%), perioperative death (n=18, 4.1%), loss to follow up (n=46, 10.5%), and preoperative SCr more than 130 umol/L or preoperative Cys-C more than 1.55 mg/L (n=53, 12.1%). The remaining 290 patients were divided into two groups according to whether they had received infrarenal or suprarenal EVAR.

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Endovascular AAA repair

All procedures were carried out in an operating theater equipped with a mobile C-arm (Siemens, Siremobil 2000, Erlangen, Germany) with the patient under general anesthesia. Bifurcated self-expanding endograft were implanted primarily according to availability at the time of AAA repair. Talent (Medtronic, Santa Rosa, CA, USA) were used in 92 (31.7%) patients and Zenith (Cook Inc., Bloomington, IN, USA) in 198 (68.3%) patients. Endograft oversize was 10-15% more than diameter of the proximal and distal necks. Contrast (Omnipaque-300) was delivered by power injection and the volume was recorded for each procedure.

Postoperative follow up

For each patient, 64-slice helical computed tomography angiography (CTA) was used to measure the length and diameter of the proximal and distal necks and to ascertain AAA geometry before surgery and one, 6 and 12 months post surgery. SCr and Cys-C values were measured before surgery and again at one week, one, 3, 6 and 12 months post surgery. Estimated GFR (eGFR) were calculated by the SCr-based Cockcroft-Gault method: [(140 - age) × weight (kg) × 88.4/(72 × Cr) for males, (140 - age) × weight (kg) × 88.4 × 0.85/(72 × Cr) for females] or by cystatin-based formula: 74.835/cystatin C (mg/L) 1.333.6.

Definition of renal function

Basline renal insufficiency was defined as SCr more than 130 μmol/L or Cys-C more than 1.55 mg/L. Patients with preoperative renal insufficiency were excluded from this study.

Postoperative renal impairment was defined as an increase in SCr or Cys-C of more than 20%.

Statistical analysis

Data of SCr, Cys-C and GFR were expressed as mean and standard deviation. T-tests were used to compare these data between preoperative and each follow-up time intervals. T-tests were also used to analyze data between groups. Non-continuous data were expressed as percentage and analyzed by χ^2 test. Differences were considered significant if P value was less than 0.05. All statistical analyses were performed using Stata/SE 10.0 software.

Results

Infrarenal fixation was performed in 173 patients (IR group, n=173). Suprarenal fixation was performed in 117 patients (SR group, n=117) because of narrow proximal landing zone (n=65), severe angulation of aneurysm necks (n=32), or implanting a transrenal cuff to treat proximal endoleak (n=20). Also, in 21 patients, only the lower renal arteries were covered by bared stent. The two side renal arteries were covered in 96 patients. Patients' characteristics were well matched between groups (Table 1). No renal ostium was blocked by covered graft.

There were no differences in SCr, Cys-C and eGFR values between the two patient groups at each follow-up time interval. However, comparison of postoperative SCr with preoperative levels revealed a significant increase at one week (SR: P=0.017, IR: P=0.010) and 12 months (P<0.01) post surgery in SR and IR groups. Cys-C in the two groups post surgery, apart from at one week (SR: P<0.01, IR: P=0.014) and at 12 months (P<0.01) post surgery, were significantly higher than preoperative values; differences in elevation were also found at six months post surgery (SR: P=0.022, IR: P<0.01). eGFR caculated by cystatin C-based equation, decreased significantly at one week and at 6 and 12 months post surgery compared to preoperative values in each group (P<0.01). However, eGFR calculated by SCr-based Cockcroft-Gault method only decreased at one week and at 12 months post surgery (P<0.01) (Tables 2 and 3).

Although a postoperative worsening of renal function was observed, values up to the definition of renal impairment only occurred in 7 (6.0%) SR patients and 9 (5.2%) IR patients; there was no statistical difference (P=0.775). These 16 patients were followed-up for more than 12 months and SCr and Cys-C values remained significantly elevated; however, none of these patients progressed to renal dysfunction or required dialysis.

Discussion

Suprarenal endograft fixation is increasingly common in endovascular aneurysm repair, especially in patients with suboptimal proximal aortic neck anatomy. Positioning bare metal struts across the renal ostia aims to prevent stent-graft migration, proximal endoleak,[7] complications due to aortic neck angulation,[8] and to increase the proportion of AAA patients with access to endovascular repair.[9] However, since the bare struts across the renal ostia seem to stand in the way of renal blood flow, we hypothesize a potential additive adverse effect on renal function. The possible connection between renal function and suprarenal stent has been the subject of vigorous debate over the past dacade.[1,10-15] Renal stenosis, occlusion, an increase in SCr levels, and renal dysfunction have all been reported after SR fixation.[16-19] But more studies have revealed the relative safety of SR fixation without significant renal damage.[1-5]

In this study, SCr, Cys-C and eGFR values did not worsen significantly more in patients with suprarenal EVAR than those with infrarenal EVAR. A relative safe effect on renal function of a suprarenal endovascular device was confirmed. Similarly, Cotroneo *et al*.[20] studied 60 patients with an SR stent graft and 42 patients with IR fixation and concluded that the use of endografts with suprarenal fixation did not lead to any significant increase in morphological and/or functional renal complications compared with those with infrarenal fixation. Lalka *et al.*,[2] in a prospective analysis of data from 104 patients, found that the suprarenal fixation does not cause RA stenosis, occlusion, or infarction; nor does it preclude post-EVAR renal artery intervention.

Although no statistical differences were shown between groups, a deterioration in renal function was found at one week post sur-

Table 1. Patients' characteristics and operative data.

	Suprarenal n=117	Infrarenal n=173	P
Mean age (years)	70.6±9	71.8±8	0.235
Male (%)	90.6	85.0	0.159
Hypertension (%)	72.6	74.0	0.800
CAD (%)	79.5	78.0	0.767
Diabetes (%)	9.4	6.9	0.446
AAA size (mm)	54.3±8.3	55.6±11.5	0.294
Contrast volume (mL)	73±15	75±21	0.375

Table 2. Renal function of pre-and post-suprarenal EVAR.

	SCr (umol/L)	Cys-C (mg/L)	eGFR (mL/min) by Cys-c	by SCr
pre-EVAR	82±8	0.89±0.11	63.1±3.1	65.3±5.6
post-EVAR				
1wk	98±11#	1.01±0.15#	55.6±4.8#	56.8±5.2#
1 mo	83±12	0.90±0.13	62.4±5.1	64.5±6.3
3 mo	83±9	0.88±0.10	63.8±3.4	65.8±6.5
6 mo	84±8	0.93±0.17#	58.2±3.2#	63.7±5.9
12 mo	91±15#	1.03±0.20#	54.5±5.7#	58.4±6.8#

EVAR, endovascular aneurysm repair; SCr: serum creatinine (μmol/l); Cys-C, serum cystatin-C (mg/L); eGFR, estimated glomerular filtration rate (mL/min) calculated by cystatin-based formula. Significant difference compared with preoperative values (P<0.05). No significant difference between groups (P>0.05).

Table 3. Renal function of pre- and post infrarenal EVAR

	SCr (umol/L)	Cys-C (mg/L)	eGFR (mL/min) by Cys-c	by SCr
pre-EVAR	81±11	0.87±0.15	64.5±3.8	66.7±6.2
post-EVAR				
1wk	95±13#	0.99±0.10#	56.7±4.9#	57.6±7.8#
1 mo	83±9	0.90±0.11	62.4±5.3	63.3±6.3
3 mo	82±11	0.87±0.09	64.5±5.5	65.3±6.6
6 mo	83±9	0.92±0.13#	61.0±5.1#	63.4±6.1
12 mo	90±12#	1.02±0.21#	55.0±6.2#	57.8±6.7#

EVAR, endovascular aneurysm repair; SCr: serum creatinine (μmol/l); Cys-C, serum cystatin-C (mg/L); eGFR, estimated glomerular filtration rate (mL/min) calculated by cystatin-based formula. Significant difference compared with preoperative values (P<0.05). No significant difference between groups (P>0.05).

gery. There are rational explanations for this. Firstly, controlled intraoperative hypotension when using endografts results in transient renal ischemia. Secondly, a temporary intraoperative femoral artery block causes lower limb ischemia-reperfusion injury. Also, contrast nephropathy is an acute impairment; renal function starts to deteriorate within 24 h, peaking at about 3-5 days after contrast administration.[21] We also found all markers of renal function deteriorated at 12 months post surgery. The fact that there is some decline in renal function due to increasing age may also be a reason. Alsac *et al*.[22] found a 10% per annum deterioration in creatinine clearance in patients over 75 years of age. In addition, each patient had at least 3 contrast-enhanced CT scans during this study period. Repeated frequent contrast exposure may mimic chronic oxidative injury, resulting in a steady decline in renal function. To limit this effect, the use of magnetic resonance angiography or duplex ultrasonography should be considered as an alternative to CTA, especially in those patients at high risk of developing contrast induced nephropathy.[23,24]

Moreover, if using Cys-C or Cys-C-based eGFR as markers, we found a deterioration in renal function not only at one week and 12 months, but also at six months post surgery. The results confirmed that Cys-C and eGFR calculated by cystatin C-based equation could be more sensitive and could reflect the potential renal impairment earlier. Most studies assessed the effect of SR fixation on patient renal function by serial measurement of the biochemical markers SCr and Cockcroft-Gault formulated CCr. However, SCr is not a sensitive indicator of renal damage and alterations in its levels may be caused by a number of factors, such as muscle mass and protein intake. Cockcroft-Gault formula underestimated patients' GFR.[25] Age and body mass are important factors in estimating bias. Many reports suggest using Cys-C as markers,[1,5,13] but few studies have gone any further. In this study, Cys-C and Cys-C-based eGFR values were used to assess renal impairment. Cys-C is not thought to be affected by sex, age, or weight,[6] and not even thought to be influenced by infections, liver diseases, or inflammatory diseases.[26] Moreover, there can be a significant increase in its plasma concentration with a reduction in minimal, subclinical mild glomerular filtration rate (GFR), allowing a more sensitive and possibly an earlier detection of renal dysfunction.[27,28] in addition, Qutb *et al.*[6] suggest that the best correlation, highest precision and least bias were seen when using a cystatin-C based formula.

Another advantage in this study was that 53 patients with pre-existing renal impairment were excluded. Pre-existing renal impairment was considered to have an independent effect on postoperative renal function.[29,30] The purpose of this study was to assess the effects of SR fixation on renal function. So, excluding patients with pre-existing renal impairment from this study reduced influencing factors and improved the accuracy of our results.

However, there are limitations to this study. Patients were studied retrospectively and divided into non-randomized groups. As a result, selection and reporting biases are likely to have occured, even though the use of exclusion criteria should limit this effect. Meanwhile, a retrospective study can limit the amount of information to be gathered about renal artery ostial morphology and renal infarction. In addition, effects on renal function of SR fixation can not be analyzed in more detail. Also, two different endografts (Talent and Zenith) were used in this study and their use was not matched across groups. Different proximal stent struts, barbs, and an unmatched quantity of endograft all add to the complexity of analyzing results. Finally, a one year follow-up period is not long enough to be able to form any useful conclusions and a long-term study needs to be performed.

In conclusion, compared to IR fixation, the use of SR fixation was not significantly associated with medium-term postoperative renal injury. Cys-C and eGFR caculated by cystatin C-based equation could be more sensitive and could reflect the potential renal impairment earlier. Further long-term studies are required to confirm this.

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