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Comparison of renal function after Endovascular Aneurysm Repair and Open Aneurysm Repair in patients treated with abdominal aortic aneurysm below the renal artery

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Introduction: In addition to open endoaneurysmorrhaphy (EA) for treating the abdominal aortic aneurysm (AAA), other approaches such as endovascular aneurysm repair (EVAR) is gaining attention. Renal dysfunction could be a complication of these surgical techniques. We decided to compare renal function in EVAR vs. EA in patients operated for infrarenal AAAs.
Methods: Two groups of patients with AAA were included in this retrospective study. The first group (28 cases) consisted of patients who underwent AAA repair by EA technique and the second group included 12 patients who underwent EVAR for AAA repair. Serum creatinine levels measured one week, one month, three months, six months, and one year after the surgeries were documented. Through calculating the glomerular filtration rate (GFR) and scoring by the RIFLE criteria (Risk, Injury, Failure, Loss of kidney function, and End-stage kidney disease), the patients' renal function was evaluated.
Results: Of 40 patients included, three cases had diabetes mellitus (7.5%), 16 cases had hypertension (40%), 16 were smokers (40%), and 12 cases had a ruptured AAA (30%). The mean time of onset or increase of renal dysfunction compared to baseline in both groups was 6.45 days. The lowest time for patients with renal dysfunction (GFR less than 60) was from the onset and the highest time was 90 days after surgery. GFR of patients before surgery (76.9 in the EVAR group, vs. 56.2 in the EA group; $P = 0.015$) and one year after the surgery (84.1 in the EVAR group, vs. 57.7 in the EA group; $P = 0.027$) was differed significantly. The RIFLE criterion also was significantly different at the end of the first year in the two groups ($P = 0.042$).
Conclusion: Based on the results, we concluded that the changes in renal function in EA group were more than EVAR group during one year. It may be necessary to follow patients undergoing these surgeries for a longer period to understand the prognosis of these patients better.

Conflict of interest: The authors declare that they have no conflict of interest.

Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent: Informed consent has been obtained from the patient for publication of the case report and accompanying images.

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Introduction

There is a 2% incidence of AAA, however with such a low incidence there is a high mortality risk.[1] An aneurysm is typically the enlargement of a portion of the vessel wall more than 50% of its normal size. This vascular dilatation is specifically about 3 cm in the abdominal aorta.[2] The greater the vasodilation, the more difficult it is to repair and the greater the risk of rupture of the aneurysm. The growth rate of vessel dilatation is another predictive and influential factor in the treatment of aneurysm, so that aneurysm with a growth rate of 0.5 cm per year needs further assessment. AAAs are usually asymptomatic until they expand or rupture. An expanding AAA causes sudden, severe, and constant low back, flank, abdominal, or groin pain. Syncope may be the chief complaint, however, with pain less prominent. Most clinically significant AAAs are palpable upon routine physical examination. The presence of a pulsatile abdominal mass is virtually diagnostic but is found in fewer than half of all cases. The common threshold for aortic repair treatment for men is more than 5 cm and for women is more than 4.5 cm.[3] AAAs can be managed using a variety of surgical treatments including open endoaneurysmorrhaphy (EA), endovascular aneurysm repair (EVAR) with stents, and regulatory treatment. In most cases, treatment is chosen based on the size of the aneurysm, its shape, and patient characteristics. EA procedure that is performed more than 50 years involves replacing the abdominal aorta located below the renal arteries with prosthesis. This procedure is considered a major surgery and its mortality during surgery is about 3-5%.[4] Recently, less invasive approaches such as EVAR are gaining more attention considering its lower mortality rate during surgery (about 1%). These approaches are used for AAA as well as thoracic aortic aneurysm (TAA).[5] Currently, about 80% of patients with AAA are treated by EVAR in the United States.[6] Renal dysfunction is one of the most important postoperative complications after AAA repair. Renal dysfunction is defined as new postoperative dialysis or creatinine increase greater than 2mg/dL. Renal dysfunction is also an important determinant of prognosis. Both methods of repairing an aneurysm including open endoaneurysmorrahphy (EA), and EVAR can affect renal function and cause short-term and long-term disorders. Hypovolemia and using aortic clamps during EA, and the use of the contrast media in EVAR are some of the causes of renal dysfunction in these two methods.[7,8] Renal dysfunction after aneurysm repair reduces survival in long-term follow-up.[9,10]

The aim of this study was to compare changes in renal function and duration of postoperative renal dysfunction after EVAR and EA in patients with infra-renal (below renal arteries) AAA. Comparison of renal function also was performed as one of the factors influencing patients' survival chance using protein/creatinine ratio (PCr) and glomerular filtration rate (GFR) before and after repair. The results can be considered along with other factors in choosing the tailored treatment for a particular patient.

Materials and Methods

This was a retrospective study conducted in two university hospitals in Kermanshah, west of Iran. Out of a total of 120 cases registered with the AAA diagnosis in the systems of these two hospitals from 2014 to 2018, 40 cases have inclusion criteria and 80 cases were excluded from the study due to the patient not continuing the treatment process and dissatisfaction with the treatment process, and some were excluded due to insufficient information recorded and lack of necessary criteria. The study patients consisted of two groups. The first group included 28 cases who had been operated by EA. The second group consisted of 12 cases who treated by EVAR.

Serum creatinine level and GFR before and after treatment were used to evaluate the renal function of the patients. Acute renal failure was also rated using the RIFLE criteria, which measures the change in urine volume over 24 hours in addition to measuring serum creatinine. We used RIFLE criteria (Risk, Injury, Failure, Loss of kidney function, and End-stage kidney disease) because it may be difficult to diagnose acute renal failure in the early stages using serum creatinine alone (significant renal tubular damage occurs before an increase in serum creatinine and asymptomatic stage), and a number of patients may not be diagnosed in the early stages of the damage.

According to the results of a similar study[11] which reported the prevalence of AKI (acute kidney injury) after EA and EVAR operations as 42.8% and 27.1%, respectively, and with confidence level of 95%, and a power of 80%, the minimum required sample size in each group was 133 and total sample size as 266 people. However, from 2014 to 2019, the number of patients diagnosed with AAA and with medical intervention was lower than the calculated amount, so the number of final samples that were eligible for study was 40 patients. Data collected based on observations and documentary evidence in patients 'files, in which patients' renal function was assessed using serum creatinine levels at intervals of one week, one month, three months, six months, and one year after the surgery. Finally, by calculating the glomerular filtration rate (GFR) and scoring by the RIFLE criteria, the patients' renal function was evaluated.

A checklist containing the required research variables was prepared and the necessary data were obtained from the medical records of the patients.

Statistical Analyses

Data were analyzed using SPSS (ver. 16.0) software. The quantitative variables were first checked for data normality using the Kolmogorov-Smirnov (KS) test. In the case of normal distribution, independent t-test was used for comparison of the variables between the two groups. The paired t-test was used to compare continuous variables before and after the operations in each group. In cases where the KS normality test showed non-normal distribution of the variables, nonparametric tests including Mann-Whitney-U, Wilcoxon, and Friedman tests were used.

Findings

Among the 12 patients in the EVAR group, there were eight men (66.7%) and four women (33.3%). In EA group, there were 24 men (85.7%) and four women (14.3%). Among 40 patients, 16 had high blood pressure (40%) and 24 had normal blood pressure (60%). According to the chi-squared test, comparing the frequencies of the two groups in terms of variable renal dysfunction before treatment is statistically significant (10.370, $P = 0.001$).

CT angiography of patients during the diagnosis procedure showed that 12 patients had aneurysm rupture (30%). In EA group, 11 cases (39.3%) had aneurysm rupture. In comparison, only one of patients (8.3%) in EVAR group had aneurysm rupture. The independent t-test performed on data with normal distribution showed that there was a significant difference between the surgical method and the age of patients ($P = 0.023$). On the other hand, the patient's weight ($P = 0.198$) had no significant difference according the type of surgery (Table 1).

Nonparametric tests performed on non-normal data showed that some factors such as GFR before surgery ($P = 0.015$), RIFLE before surgery ($P = 0.019$), GFR one year after ($P = 0.027$), and RIFLE one year after surgery ($P = 0.042$), were significantly different ac-

Table 1
Comparison of variables between patients with abdominal aortic aneurysm who operated by open endoaneurysmorrhaphy (EA) or endovascular aneurysm repair (EVAR)

Variables	Category	EVAR (N=12)	EA (N= 28)	P value
Age, mean value	-	64.57	73.21	0.023
Weight, mean value	-	76.67	71.32	0.191
LVEF	-	49.58	50.71	0.413
Diabetes mellitus	No	11 (91.7%)	26 (92.9%)	0.896
	Yes	1 (8.3%)	2 (7.1%)	
Hypertension	No	7 (58.3%)	17 (60.7%)	0.888
	Yes	5 (41.7%)	11 (39.3%)	
Smoker	No	8 (66.7%)	16 (57.1%)	0.573
	Yes	4 (33.3%)	12 (42.9%)	
Ronal dysfunction	No	4 (33.3%)	0	0.001
	Yes	8 (66.7%)	28 (100%)	
Aneurysm rupture	No	11 (91.7%)	17 (60.7%)	0.05
	Yes	1 (8.3%)	11 (39.3%)	
Gender	Male	8 (66.7%)	24 (85.7%)	0.168
	Female	4 (33.3%)	4 (14.3%)	

Table 3
Mean ranks of creatinine, and GFR in EVAR and EA groups based on Friedman test

	Creatinine Mean Rank		GFR Mean Rank	
	EVAR group	EA group	EVAR group	EA group
Before	3.88	3.70	3.12	3.26
After	4.38	3.57	3.62	3.43
One month	4.31	3.22	2.69	3.80
3 months	3.19	2.93	3.81	4.09
6 months	2.50	3.52	4.50	3.84
One year	2.75	4.07	4.25	2.93
Chi-square	9.695	6.307	9.695	6.745
P value	0.084	0.278	0.084	0.240

cording to the type of surgery. Other findings did not show a statistically significant difference (Table 2).

Friedman nonparametric test based on serum creatinine level at baseline and 4 times after interventions for the EVAR group (P = 0.084), and for EA group (P = 0.278) showed no significant difference between patients' creatinine levels in frequent measurements, in both groups. The level of creatinine in frequent measurements including before and 5 times after interventions in EVAR group (P = 0.084), and open surgery group (P= 0.278) was not significant according to Friedman test (Table 3).

Discussion

The aim of this study was to compare renal function after EVAR and EA in patients with AAA who underwent surgery for infrarenal AAA repair. The results showed that changes in renal function were not statistically significant in either group. Renal function after different surgical approaches for operation of AAAs is a challenging topic in the literature. In a systematic review performed on six primary studies, the authors reported that there is not enough evidence in the literature regarding superiority of one approach (e.g., endovascular approach) against open surgery.[12] There is evidence favoring endovascular approach regarding renal function in long-term follow-up over open surgery.[13] However, covariates such as baseline GFR, need for blood product transfusion during surgery, and other surgical techniques should be addressed when comparison is made between surgeries. Compared to the results of some previous studies,[14-16] it can be said that the mean age of patients in this study is similar to the mentioned studies. There are differences in other risk factors. For example, the proportion of hypertensive patients who were receiving anti-hypertensive medications was higher in the mentioned study when compared to the current study.

Comparison of patients' serum creatinine level in five follow-ups during one year was not significantly different between the two groups, while comparison of GFR value before intervention (P= 0.015) and after one year (P= 0.027) was significantly different. The results in this regard showed that the mean GFR before surgery was 76.88 in the EVAR group and 56.22 in EA group, and also, mean GFR value was 84.1 in EVAR group one year after the intervention and 57.7 in EA group. It shows that patients in EA group had more significant renal dysfunction than the other method. In a study conducted by Zettervall et al[13], out of 4503 patients, renal dysfunction occurred in 1% of EVAR patients and 5% of patients with EA. GFR levels less than 60 before the intervention were strongly associated with postoperative renal dysfunction (EVAR group 81% vs. 37%: $p < .01$; EA group 60% vs. 37%: $P < 0.01$), which is consistent with results of the present study. Also, in a previous study the results showed that in the long term (4 years) renal dysfunction in the EVAR group was higher than in EA group, while the results were not significantly different during the one year after surgery[17] which shows that the one-year result was different from the present study. Since in the mentioned study,[17]

Table 2
Assessing differences between serum creatinine levels, GFR (glomerular filtration rate), and RIFLE degree in open endoaneurysmorrhaphy (EA) or endovascular aneurysm repair (EVAR)

Variable	Category	Mann-Whitney U	Wilcoxon W	Z	P value
Serum Creatinine, mg/dL	before	126.500	204.500	-1.236	0.216
	after	153.500	231.500	-0.260	0.794
	One month	142.500	220.500	-0.246	0.806
	3 months	116.000	182.000	-0.389	0.697
	6 months	77.500	122.500	-1.098	0.272
	1 year	60.500	96.500	-1.436	0.158
GFR, mL/min/1.73 m2	before	85.500	491.500	-2.435	0.015
	after	109.000	487.000	-1.613	0.107
	One moon later	94.500	419.500	-1.801	0.072
	3 months	87.000	363.000	-1.454	0.146
	6 months	60.000	36.000	-1.824	0.068
	1 year	43.000	319.000	-2.213	0.027
RIFLE degree	before	95.000	173.000	-2.351	0.019
	after	111.000	189.000	-1.708	0.088
	1 moon later	106.500	184.500	-1.497	0.134
	3 months	82.000	148.000	-1.737	0.082
	6 months	79.500	124.500	-1.085	0.278
	1 year	50.000	86.000	-2.033	0.042

the prevalence of high blood pressure was 78% and the underlying renal dysfunction was 31%, and these values were different from our study (40% and 90%, respectively), it can be said that the difference in the number of patients with blood pressure and renal dysfunction have been effective in the postoperative course, although further investigation is needed.

Given that short-term results in other similar studies were similar to those found in the present study, it is useful to conduct further studies over a longer period of time to compare long-term results. In the present study the findings of the end of the first year showed a significant difference in the amount of GFR obtained in the two groups ($P = 0.027$). Similar results were also obtained in comparing the RIFLE criterion in the two groups, and considering that the RIFLE criterion is calculated using creatinine and GFR values, it is not unexpected to see consistent results with GFR (comparison of the two groups in terms of RIFLE criteria before surgery ($P = 0.019$) and one year after surgery ($P = 0.042$). Finally, blood pressure and renal dysfunction had different values in different studies, which could be a factor in the postoperative course of patients.

Limitations

This was a retrospective study. Usually in retrospective studies gathering of the required data cannot be done perfectly. It is recommended to design future prospective studies so that comparison between surgical techniques can be done more comprehensively.

Due to the fact that the risk factors for aortic aneurysm and the possibility of developing renal dysfunction in the present study were not significantly different from other studies, further studies for assessing the different risk factors such as hypertension in patients can help to verify the results.

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