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Comparison of perioperative oxidative stress in endovascular and open repair of abdominal aortic aneurysm

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Background/aim: To investigate the differences in perioperative oxidative stress (OS) in abdominal aortic aneurysm (AAA) patients treated with either endovascular repair (EVAR) or open repair (OR).

Materials and methods: Twenty patients (11 OR, 9 EVAR) treated for AAA with no known malignant or inflammatory disease and an aneurysm diameter of over 5 cm and no rupture were included in the study. Blood samples were obtained preoperatively, during aortic occlusion, and 1 h and 24 h after reperfusion. Total antioxidant status (TAS), total oxidative stress (TOS), and malondialdehyde (MDA) levels were measured and oxidative stress index (OSI) was calculated.

Results: OSI at 1 h and 24 h after reperfusion was higher in the EVAR group (P = 0.004 and P = 0.002, respectively). TAS levels were higher (P = 0.001, P = 0,029). MDA levels showed no difference (P = 0.291, P = 0.076). TOS levels were lower 24 h after reperfusion in the EVAR group (P = 0.018).

Conclusion: Markers of oxidative stress were lower in the EVAR group. This may be associated with advantages of EVAR. More studies are required for a clear-cut conclusion.

Key words: Abdominal aortic aneurysm, endovascular aneurysm repair, open repair

1. Introduction

Aortic clamping during open repair (OR) of abdominal aortic aneurysms (AAAs) causes ischemia and release of excessive amounts of free oxygen radicals (FOR). After declamping, ischemia and the release of the radicals create oxidative stress (OS) (1). During endovascular repair (EVAR), however, no cross-clamp is applied. There is only a brief period of aortic occlusion, so a different OS response should be expected in this procedure. FORs released in ischemia reperfusion injury (IRI) react with unsaturated fatty acids in the phospholipid layers of cell membranes. This results in lipid peroxidation. Malondialdehyde (MDA) produced by lipid peroxidation was used as a marker of OS (2–4). Total antioxidant status (TAS), total oxidative stress (TOS), and the oxidative stress index (OSI) reflect the balance between oxidants and antioxidants. TAS represents the protective response to free radicals in the plasma. OSI is the ratio of TOS to TAS and an indicator of OS (5,6).

Previous studies showed that IRI is an important factor in morbidity and mortality in OR (2,7). We have studied perioperative differences of OS by considering TAS, TOS, OSI, and MDA levels of patients with AAA that were treated either by OR or EVAR.

2. Materials and methods

AAA patients who had an aortic diameter of at least 5.5 cm or expanding aneurysms of at least 5.0 cm were scheduled for repair. All patients signed informed consent forms and the local ethics committee approved the study. EVAR was performed on patients with favorable aneurysm anatomy, and OR was performed on the remaining patients. Ruptured AAA patients and patients with any known malignancy or inflammatory disease were excluded from the study. Eleven patients(all males) were treated with OR and 9 patients (1 female) were treated with EVAR.

Epidural-spinal combined anesthesia was performed for all EVAR patients. A bifurcated system (EndoLogic,

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USA) was used for 2 patients, an aortoiliac system (Medtronic, US) with a contralateral leg was used for 2 patients, and an aortic graft with bilateral legs (Anaconda; VascuTek, UK) was used for 7 patients. In bifurcated systems, surgical femoral exposure is performed on one side and a 12-F percutaneous sheath is inserted in the other. Both femoral arteries are exposed surgically in other systems. There has been no technical failure or conversion to OR.

OR was performed with a transperitoneal approach under general anesthesia. Etomidate was used for induction and balanced anesthesia was maintained with oxygen, sevoflurane, fentanyl, and rocuronium. Sodium nitroprusside or nitrates were used to decrease the afterload. Aortobifemoral grafts were used in 3 patients, tubular grafts in 2, and aortobiiliac grafts in 6.

There was no mortality or morbidity in either group. No known antioxidant drugs were used perioperatively.

Blood samples were collected preoperatively, during aortic occlusion (Ao), 1 h after reperfusion (Rp1), and 24 h after reperfusion (Rp24). MDA plasma activity was measured as described by Yagi (8). TOS and TAS levels were measured as described by Erel et al. (5,6). OSI was calculated as the ratio of TOS to TAS.

2.1. Statistics

Descriptive statistics were used for data grouping. The Kruskal–Wallis test was performed for analysis of variance. The Student t-test was used for quantitative data that followed a normal distribution and the chi-square test for ordinal data. Variance analysis of repeating measures was used for dependent variables.

3. Results

Mean age was 69.5 (60–79) years in the OR group and 71.7 (53–81) years in the EVAR group. Demographic data and comorbidities are listed in Table 1. Perioperative OSI, TOS, TAS, and MDA levels are listed in Table 2. No difference concerning age and the aneurysm diameter was observed in the 2 groups. While the number of comorbid patients were similar in both groups (OR 6/11 (54.5%), EVAR 6/9 (66.7%)), the number of comorbid diseases was higher in the EVAR group (EVAR 37, OR 8, P = 0.037).

Preoperative MDA and TAS levels were similar (P = 0.054, P = 0.628). Preoperative TOS and OSI levels were higher in the EVAR group (P = 0.001, P = 0.013).

At Rp1, MDA and TOS levels were similar (P = 0.291, P = 0.291). OSI levels were lower (P = 0.004) and TAS levels were higher in the EVAR group (P = 0.001).

Table 1. Demographic data.

	OR (n = 11)	EVAR (n = 9)
Sex, n (male)	11 (100%)	8 (89%)
Age (years)	69.5 (60–79)	71.7 (3–81)
Aneurysm diameter (mm)	60 mm (50–80)	61 mm (50–75)
Clamping period	38 min	NA
Patients with comorbidity, n	6 (55%)	6 (55%)
Hypertension, n	1 (9%)	4 (36%)
Diabetes mellitus, n	2 (18%)	4 (9%)
Hyperlipidemia, n	0 (0%)	3 (27%)
COPD, n	0 (0%)	7 (64%)
CHF, n	0 (0%)	5 (45%)
CAD, n	3 (27%)	7 (64%)
PAOD, n	0 (0%)	4 (36%)
Smoking, n	2 (18%)	4 (36%6)
CVA, n	0 (0%)	2 (18%)

OR: Open repair, EVAR: endovascular aneurysm repair, COPD: chronic obstructive lung disease, CHF: congestive heart failure, CAD: coronary artery disease, PAOD: peripheral arterial occlusive disease, CVA: cerebrovascular accident.

Table 2. Perioperative OSI, TOS, TAS, and MDA levels.

	Preop.	AO	Rp1	Rp24
MDA	O: 0.2374 E: 0.3528	O: 0.2888 E: 0.3898	O: 0.5204 E: 0.2639	O: 1.0730 E: 0.3949
TOS (μmol H_2O_2 eq./L)	O: 9.0796 E: 16.9031 (P = 0.001)	O: 12.7743 E: 11.8160	O: 11.7961 E: 10.1233	O: 16.7090 E: 10.0019 (P = 0.018)
OSI	O: 0.4593 E: 0.8781 (P = 0.013)	O: 0.6401 E: 0.7344	O: 0.6197 E: 0.3655 (P: 0.004)	O: 0.6559 E: 0.3203 (P = 0.002)
TAS (mmol Trolox eq./L)	O: 2.2337 E: 2.1313	O: 2.2194 E: 1.6522 (P = 0.005)	O: 1.9815 E: 2.6874 (P: 0.001)	O: 2.5839 E: 2.9239 (P = 0.029)

Preop.: Preoperative, AO: aortic occlusion, Rp1: 1 h after reperfusion,
Rp24: 24 h after reperfusion, O: open repair, E: EVAR, MDA: malondialdehyde, TOS: total oxidative stress, OSI: oxidative stress index, TAS: total antioxidant status.

At Rp24, MDA levels were similar (P = 0.076). TOS and OSI levels were lower (P = 0.018, P = 0.002) and TAS levels were higher (P = 0.029) in the EVAR group.

4. Discussion

Surgery on infrarenal AAA causes IRI in all organs that are supplied by the inferior mesenteric and iliac arteries. Reperfusion after ischemia results in excessive FORs, which promotes OS (1,9,10). It is well known that a correlation exists between the cross-clamp period and OS. This ischemic period is the main determinant of the magnitude of OS (2,11). As there is only a brief period of aortic occlusion in EVAR, OS response should be less intense than in OR. According to the observation of Thompson et al., production of FORs in EVAR patients is less than in OR patients (10).

EVAR is known to have lower early mortality and morbidity rates (12,13). Being a less invasive procedure, less intense OS may contribute to EVAR's lower mortality and morbidity rates. IRI in OR not only results in local damage but also in distant organ injury (2,7,14). In AAA patients, it is reported that OS is correlated with myocardial infarction and lung damage (3,11,15,16). In a previous study, lower TAS levels were found to be related to lower perioperative complications (11). Papalambros et al. found MDA levels to be higher in patients with long lengths of stay in intensive care after elective or urgent AAA (2).

OS markers (TOS and OSI) were not increased in the EVAR group in our study. Even though there was a significant decrease in TOS at Rp1, an insignificant decrease was detected in OSI levels. The brief ischemia in EVAR patients may have triggered endogenous antioxidant mechanisms that counteracted the OS (17–19). The significant increase in TAS levels in the EVAR group at Rp1, not seen in the OR group, supports this theory. Oxygen radicals produced during brief ischemia are not only lethal products of cellular metabolism but also play a role in cellular communication that evokes antioxidant response (18,20).

Although not significant, MDA levels were also lower in the EVAR group at Rp1 and Rp24. This may be due to the inability of TAS to compensate lipid peroxidation (17). Already-high levels of MDA measured preoperatively in the EVAR group may be another factor. Other OS markers were also high in the EVAR group in the preoperative period. High preoperative OS marker levels in this group may be related to many factors. Advanced age and aneurysm diameters may affect the OS, but the groups were identical in this regard (2,21,22). Although the ratios of comorbid patients were identical, the weight of comorbidity was higher in the EVAR group, which may explain high levels of OS markers (22–25).

In conclusion, OS marker levels in the reperfusion period were lower in the EVAR patients than in OR patients. This may be one of the factors contributing to the early perioperative advantages of EVAR. Further studies are needed in order to understand the effect of OS in this particular patient group.

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