

## Negative results - Aortic and aneurysmal Post-implantation syndrome after endovascular repair of aortic aneurysms: need for postdischarge surveillance

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### Abstract

**Objective:** To present the consequences and the need for readmission due to a vigorous inflammatory response in six patients who underwent endovascular repair of aortic aneurysms and developed post-implantation syndrome (PIS), during the postoperative period. **Methods:** From January 2007 to December 2009, 162 patients underwent endovascular repair of an aortic aneurysm. PIS was recorded in 49 patients. Among these, we present six patients who developed a systemic inflammatory response syndrome (SIRS) after discharge from hospital, which led to readmission within the first 30 postoperative days. **Results:** Five patients were treated for asymptomatic infrarenal abdominal aortic aneurysm and one for a thoracic one. All patients were discharged from hospital in the absence of any complications, fever or leukocytosis, but several days later they developed features of SIRS leading to readmission, even to the intensive care unit in two of them. After the administration of anti-inflammatory drugs all patients showed a complete recovery and finally left hospital several days later. **Conclusions:** In some patients, the initial inflammatory response following endovascular aortic aneurysm repair is not always spontaneously attenuated and could lead to the development of SIRS even several days after the operation. It seems reasonable that patients developing PIS after endovascular aneurysm repair might be better kept under surveillance for the first postoperative month. © 2010 Published by European Association for Cardio-Thoracic Surgery. All rights reserved.

**Keywords:** Aortic aneurysm; Endovascular repair; Post-implantation syndrome; Systemic inflammatory response syndrome

### 1. Introduction

Endovascular procedures have been proposed as minimally invasive alternative treatment, allowing safe and effective aortic aneurysm repair. Despite the potential benefits, it has been demonstrated that endovascular stent grafting may elicit an unexpected systemic inflammatory response, which has been named post-implantation syndrome (PIS) [1]. This is characterized by the presence of fever, leukocytosis and sometimes coagulation disturbances [1–5]. As yet, there is no clear definition of the syndrome from the clinical and pathophysiological point of view [6]. It seems that PIS manifests clinically as a systemic inflammatory response syndrome (SIRS), meeting two of the four criteria according to the definition of SIRS, fever and leukocytosis [7, 8]. The clinical importance of PIS is unclear and the impact of the syndrome on the outcome of the patients is still unknown. In most cases, this transient SIRS state is generally well tolerated, causing no serious consequences. However, it has been reported that a number of patients develop excessive clinical signs of inflammation in the early

postoperative period after endovascular aneurysm repair (EVAR) [6, 9–11]. The excessive inflammatory response raises concerns of inducing postoperative morbidity, especially in patients at high risk, including the elderly with several comorbidities, such as activation of inflammatory pathways and the release of inflammatory cytokines might underpin an already established but still subclinical organ dysfunction [12, 13].

Herein, we describe the clinical setting and consequences owing to a vigorous inflammatory response in six patients who underwent endovascular treatment of aortic aneurysms and developed PIS during the postoperative period.

### 2. Patients and methods

In a three-year period from January 2007 to December 2009, a total of 162 patients underwent an endovascular repair of their aortic aneurysm [148 for an infrarenal abdominal aortic aneurysm (AAA), and 14 for a descending thoracic aorta aneurysm] in the University Hospital of Ioannina. All endovascular procedures were performed under general anesthesia and a standard vascular protocol, by the same anesthesiological and surgical team. All patients were treated with a beta-blocker and a statin for

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at least one week preoperatively and received 5000 IU of heparin intraoperatively, antibiotic prophylaxis (400 mg Teicoplanin, 1 g Ceftriaxone, 500 mg Metronidazole) 30 minutes preoperatively and during the day of operation, as well as 3500 IU of tinzaparin (a low molecular weight heparin) from the first postoperative day until the day of discharge.

PIS was defined in accordance with the definition of SIRS by the presence of fever (continuous temperature  $> 38^{\circ}\text{C}$ ) and leukocytosis [white blood cell (WBC)  $> 12,000/\mu\text{l}$ ] despite antibiotic therapy and negative culture results [7, 8]. As we study PIS systematically, in all patients samples of 15 ml of venous blood were obtained via puncture of peripheral veins, 24 hours prior to surgery and 24 hours after the deployment of the endograft. WBC, hematocrit (Hct) and platelet counts (PLT), serum high-sensitivity C-reactive protein (hs-CRP) and interleukin-6 (IL-6) plasma levels, were measured. Furthermore, none of these patients had any of the following from their history: clinical and/or laboratory suspicion of infection of any site, previous implantation of endoprosthesis, autoimmune diseases, any type of malignancy, use of anti-inflammatory drugs, chemotherapeutic agents or immunosuppressants, gangrene, systemic inflammatory disease, previous trauma or surgery two months earlier, use of warfarin and the presence of any leukocytosis ( $> 10,000/\mu\text{l}$ ) or elevated body temperature preoperatively. According to our protocol, all patients were discharged in the absence of any complications, with a body temperature lower than  $37.5^{\circ}\text{C}$  for at least 24 hours and a WBC count lower than  $12,000/\mu\text{l}$ .

Analysis of dichotomous variables was performed using Fisher's exact and  $\chi^2$ -test as appropriate. Comparisons of continuous variables were performed by Student's *t*-test for normally distributed variables and Mann–Whitney *U*-test for non-normally distributed variables. A *P*-value  $< 0.05$  was considered statistically significant. Statistical analysis was performed using the SPSS software v. 15 (SPSS Inc, Chicago, IL, USA).

### 3. Results

The transfemoral deployment of the endovascular graft was successfully achieved in all 162 patients with no need for open conversion. There were no major intraoperative or postoperative surgical complications observed in any patient. In all cases, blood, urine and sputum cultures were negative. None of the patients had received any anti-inflammatory drug before, during, or after the procedure, at least in the early postoperative period. The diagnosis of PIS was established in 49 patients (30.2%). There were no significant differences in patients' characteristics and intraoperative variables, between the two groups (PIS group and non-PIS group, Table 1).

Here, we present the cases of six patients who underwent endovascular repair, five for an asymptomatic infrarenal AAA and one for a thoracic one. All six patients developed PIS after the operation and were discharged home after this had been attenuated. Several days later, they returned because of continuous fever and a generalized inflammatory response, including dyspnea, tachycardia, leg edema, weakness, anorexia, even renal insufficiency and pleural infusions, which eventually led to readmission. At that

Table 1. Patients' characteristics as well as intraoperative variables, presented according to the presence or not of the post-implantation syndrome (PIS)

	No PIS (n=113)	PIS (n=49)	P-value
Age, years (range)	72 (53–86)	74 (53–91)	0.095
Gender (female/male)	4/109	3/46	0.36
Hypertension (yes/no)	93/20	43/6	0.39
Dyslipidemia (yes/no)	79/34	35/14	0.85
Diabetes mellitus (yes/no)	23/90	8/41	0.55
Active smoking (yes/no)	64/49	28/21	0.95
Cardiac disease (yes/no)	62/51	32/17	0.22
COPD (yes/no)	48/65	25/24	0.32
ASA II	43 (38.1%)	16 (32.7%)	0.51
ASA III	70 (61.9%)	33 (67.3%)	0.51
Aneurysm diameter, cm (range)	5.5 (4.8–12)	5.6 (4.9–11)	0.39
Procedure duration, min (range)	95 (60–310)	100 (60–280)	0.67
Contrast media, ml (range)	135 (30–720)	120 (45–400)	0.37
Transfusions, units (range)	0 (0–4)	0 (0–3)	0.94

All values are expressed as medians.

COPD, chronic obstructive pulmonary disease; ASA, American Society of Anesthesiologists Physical Status Classification System.

point, all patients underwent several examinations and were evaluated by experienced doctors within different specialties (internists, cardiologists, nephrologists, intensivists), but no other diagnosis based on clinical evaluation and laboratory tests could be made, except that all patients were developing SIRS. Interestingly, none of the 113 patients who did not develop PIS after the endovascular procedure experienced such an inflammatory response that led to readmission (Fisher's exact test,  $P=0.001$ , Fig. 1). Furthermore, there were no significant differences observed in various characteristics, between these patients with a recurrence of the inflammatory response and the rest of patients who developed PIS postoperatively (Table 2). Following, we give the brief description of these six cases that had to be readmitted.

#### 3.1. Patient 1

A 73-year-old man with an infrarenal abdominal aneurysm (diameter,  $d=6\text{ cm}$ ) was treated with an endoluminal

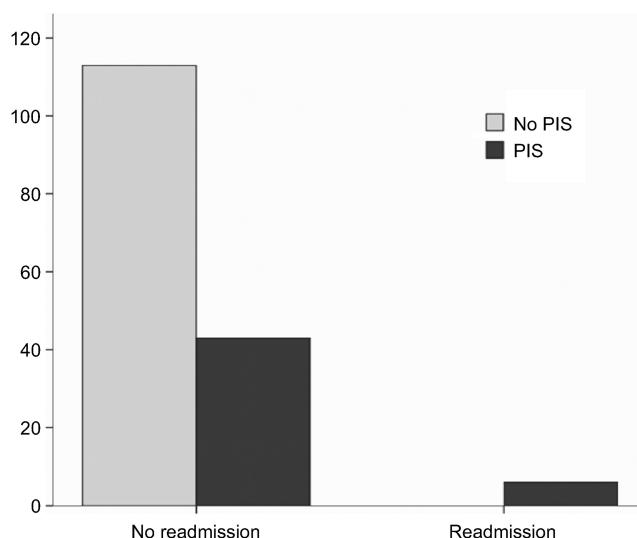


Fig. 1. Patients that had to be readmitted, according to the development of post-implantation syndrome (PIS) postoperatively.

Table 2. PIS patients' characteristics as well intraoperative variables, presented according to the need for readmission

	PIS without readmission (n=43)	PIS with readmission (n=6)	P-value
Age, years (range)	74 (53–91)	77 (60–87)	0.94
Gender (female/male)	3/40	0/6	0.67
Hypertension (yes/no)	39/4	4/2	0.15
Dyslipidemia (yes/no)	30/13	5/1	0.44
Diabetes mellitus (yes/no)	8/35	0/6	0.57
Active smoking (yes/no)	25/18	3/3	0.52
Cardiac disease (yes/no)	29/14	3/3	0.41
COPD (yes/no)	23/20	2/4	0.42
ASA II	13 (30.2%)	3 (50%)	0.38
ASA III	30 (69.8%)	3 (50%)	0.38
Aneurysm diameter, cm (range)	5.8 (4.9–11)	5.6 (5–7.6)	0.78
Procedure duration, min (range)	100 (60–280)	90 (90–105)	0.19
Contrast media, ml (range)	120 (45–400)	100 (80–300)	0.71
Transfusions, units (range)	0 (0–3)	0 (none)	0.24

All values are expressed as medians.

PIS, post-implantation syndrome; COPD, chronic obstructive pulmonary disease; ASA, American Society of Anesthesiologists Physical Status Classification System.

polyesteric bifurcated stent graft (Talent, Medtronic Europe SA, Route du Molliau, Switzerland). Eight months previously he had undergone coronary bypass grafting due to coronary artery disease. The duration of the endovascular procedure was 110 min. On the first postoperative day the patient developed PIS with simultaneous changes in various laboratory parameters and a fever of 38.3 °C. There was an elevation of postoperative WBC, hs-CRP, IL-6 and Fib values, while those of IL-1 and PLT were relatively low (Table 3). The patient was treated with intravenous fluids and paracetamol and was discharged on the fifth postoperative day. At that time the values of WBC were 8990/ $\mu$ l and the temperature 37.3 °C. Twenty days postdischarge, the patient was readmitted with dyspnea and weakness. He complained of a recurrent persistent fever after discharge from hospital (up to 38.3 °C). On clinical examination he was tachypneic with 25 breaths/min and tachycardic with a heart beat rate of 95/min. The chest X-ray showed significant pleural effusion on both sides. There were no electrocardiographic or biochemical signs of acute myocardial infarction or ischemia. However, a trans-thoracic echocardiography revealed mild pericarditis. Laboratory evaluation showed negative culture results, leukopenia, anemia, D-dimers >2000 ng/ml and increased hs-CRP (Table 3). The patient was considered to develop SIRS (fulfilling all three criteria, including fever, tachypnea and tachycardia) and was transferred to the intensive care unit (ICU). He was started on hydrocortisone 50 mg four times daily. After a two-day stay in the ICU and four days on a wards he recovered completely and was discharged symptom-free (Table 3). The patient was followed up for two years thereafter and no morbidity was recorded.

### 3.2. Patient 2

A 63-year-old man with a thoracic aortic aneurysm (d=7.1 cm) was treated with an endoluminal polyesteric stent graft (Valiant, Medtronic Europe SA). Two months earlier, the patient had undergone a successful percutaneous coronary revascularization with deployment of five

drug-eluting stents. A mild renal insufficiency (serum creatinine 2.0 mg/dl) was attributed to the large volume of contrast media (180 ml) administered. Postoperatively, he experienced PIS and he suffered a minor, non-disabling, stroke on the second postoperative day. Postdischarge serum creatinine was 2.5 mg/dl. Twenty-two days later, he was admitted to a district hospital with dyspnea, fever and weakness. There were no signs of acute myocardial infarction or ischemia and there were negative culture results. Nevertheless, the patient had a deterioration of renal function with a serum creatinine of 4.1 mg/dl. Moreover, CRP levels and WBC count were increased (Table 3). He was transferred to ICU of our hospital, suffering from tachypnea, persistent fever and tachycardia. Meanwhile, there was a further increase in serum creatinine levels (5.0 mg/dl). He was started on hydrocortisone (50 mg four times intravenously), resulting in a clinical improvement within 12 hours. He left the ICU on day 2, continued steroid treatment orally and finally was discharged from hospital 15 days later. Thirty days post-discharge, the patient was

Table 3. Laboratory data of the six patients presented in different time periods: preoperative (preop), first postoperative day (postop), first discharge (1st disc), readmission (readm), second discharge (2nd disc)

Patients	Data	Preop	Postop	1st Disc	Readm	2nd Disc
Case 1	WBC	7.1	17.3	8.99	4.1	6.24
	Hct	41.3	31	31.2	27.9	30.8
	PLT	284	178	144	184	370
	hs-CRP	1.54	141	63.5	112.3	44.8
	IL-6	1.92	14	3.44	13.7	9.4
	F	36.7	38.3	37.3	38.3	36.7
Case 2	WBC	7.85	18.8	10.2	15.74	6.4
	Hct	33.2	29.5	30.2	25.4	26.8
	PLT	322	241	307	480	345
	hs-CRP	0.85	138.23	32.55	65	37.45
	IL-6	3.32	102.2	10.4	66.8	25.4
	F	36.4	38.6	37.0	38.5	36.9
Case 3	WBC	6.56	13.57	11.19	14.1	10.69
	Hct	38.9	33.2	32.5	26.5	30.8
	PLT	155	137	145	262	332
	hs-CRP	0.87	120.88	44.86	106	28.6
	IL-6	4.96	98.98	27.46	67.45	22.3
	F	37.0	39.4	36.6	38.1	36.7
Case 4	WBC	10.13	18.74	8.66	15.64	11.41
	Hct	42.9	33.4	30.9	27.8	30.1
	PLT	187	127	126	270	448
	hs-CRP	1.22	148	44.32	97	83
	IL-6	5.28	77.96	13.8	64.55	43.4
	F	36.6	38.8	37.3	38.4	36.6
Case 5	WBC	8.9	21.1	10.76	14.66	9.86
	Hct	48.8	39.9	33.6	31.8	32.7
	PLT	154	55	67	98	112
	hs-CRP	6.17	117	43.25	89.9	54.5
	IL-6	1.85	99.8	23.3	55.6	13.4
	F	36.7	39.0	36.8	38.6	36.8
Case 6	WBC	8.91	17.74	9.85	13.6	10.3
	Hct	43.9	36.2	30.4	31.1	31.6
	PLT	253	107	83	487	441
	hs-CRP	2.95	77.95	22.34	74	36
	IL-6	38	78.4	41.5	65.6	22.4
	F	36.6	38.5	37.2	38.3	36.2

WBC, white blood cell count ( $\times 10^3/\mu$ l); Hct, hematocrit (%); PLT, platelet count ( $\times 10^3/\mu$ l); hs-CRP, high-sensitivity C-reactive protein (mg/l); IL-6, interleukin-6 (pg/ml); F, fever (°C).

still on steroids, and was referred to the Nephrology Department with a serum creatinine of 3.0 mg/dl.

### 3.3. Patient 3

An 86-year-old man with infrarenal abdominal aneurysm (d=5.6 cm) was treated with a polyesteric stent graft (Anaconda, Vaskutek-Terumo Cardiovascular System Corp, Ann Arbor, MI, USA). The history revealed hypertension and diabetes mellitus. The patient developed PIS postoperatively (Table 3). He was discharged home after five days but a week later he was readmitted due to recurrent fever (38.1 °C), leg edema, anorexia and weakness. From the laboratory tests there was an increase in WBC and hs-CRP and creatinine levels (1.7 mg/dl) and a decrease in Hct (Table 3). He was treated with nimesulid (100 mg p.o.) for five days and had an uneventful recovery.

### 3.4. Patient 4

A 68-year-old man with a history of hypertension, hyperlipidemia, and chronic obstructive pulmonary disease (COPD). He was treated with a Talent stent graft (Medtronic Europe SA), for an infrarenal abdominal aneurysm (d=6.5 cm) and due to the development of PIS he was discharged seven days after the procedure. Eight days later, he was readmitted due to recurrent fever and weakness. The laboratory tests revealed increased WBC count and hs-CRP levels. Oral nimesulid was started resulting in a rapid recovery; he left hospital after four days.

### 3.5. Patient 5

A 73-year-old man with a history of hypertension and COPD developed PIS after the deployment of an Endurant stent graft (Medtronic Europe SA) to treat an infrarenal abdominal aneurysm (d=5.5 cm). He left hospital on the fourth postoperative day, but he was admitted to a district hospital after eight days due to fever and fatigue. Nimesulid was administered orally and the patient had a complete recovery being discharged after four days of hospitalization.

### 3.6. Patient 6

A 67-year-old man with a history of hypertension, an aortic valve stenosis and COPD was treated with an Endurant stent graft (Medtronic Europe SA) for an infrarenal abdominal aneurysm (d=5.2 cm); he developed PIS and he was discharged from hospital on day 6 postoperatively. Three days later, he was readmitted due to recurrent fever (38.3 °C), dyspnea, bilateral pleural infusions, weakness, leg edema and anorexia. He had elevated serum markers of inflammation despite the negative culture results (Table 3). He was treated with nimesulid orally and recovered fully after four days.

Fig. 2 shows the distribution of various variables of the six patients that had to be readmitted, in different time slots.

## 4. Discussion

Although it has been well demonstrated that endovascular stent grafting is followed by an acute phase inflammatory response, the potential clinical significance of it is not yet clear [3–6]. There are different conformations of this inflammatory response. In most cases, the syndrome typically resolves within a few days without any serious consequences. Some patients have been reported to experience a severe inflammatory reaction; however, a detailed presentation of these cases is missing [6, 9–11]. The excessive activation of the inflammatory pathways and release of inflammatory cytokines that in turn cause leukocyte activation and proliferation is of serious concern, because of the possibility to increase the risk of postoperative morbidity particularly in high risk patients [12–15]. It seems that a serious inflammatory response may result in an extensive endothelial injury by both the direct effect of the mediating agents and WBC-endothelial interaction leading to severe complications, such as pulmonary dysfunction, cardiovascular events, renal insufficiency and multi-system organ failure [9, 10, 16–18].

The patients we described were elderly with several comorbidities, and postoperatively exhibited markedly elevated levels of IL-6, CRP, and a two-fold raise in WBC count, and met at least two of the SIRS criteria. According to our protocol all patients were discharged home when the body temperature was lower than 37.5 °C for at least 24 hours and the WBC count was lower than 12,000/μl, without receiving any anti-inflammatory drugs. In this respect, the syndrome was considered to resolve as there was a decrease in both body temperature and WBC count. Nevertheless, the inflammatory response proved to not be transient and several days later all patients developed features of SIRS leading to readmission, even to the ICU in two cases, showing that the systemic inflammatory response might be a dynamic process, raising different problems in every particular patient [19]. Four patients showed features of a mild SIRS with recurrent fever, tissue edema, anorexia, fatigue and weakness, and were symptomatically treated with the administration of a non-steroidal anti-inflammatory drug (NSAID) orally. The patients had a rapid recovery and were discharged home, free of any signs of inflammation during the follow-up period. However, the two patients that readmitted due to a pronounced SIRS state, required an initial treatment in the ICU and the administration of corticosteroids intravenously (according to ICUs protocol for the treatment of severe SIRS). Both of them managed to leave hospital after a quite short period of time, and remained under close surveillance thereafter.

It is of serious concern that all six patients developed PIS postoperatively, while not even one from the EVAR patients we followed who did not experience this syndrome had similar symptoms requiring readmission. This probably shows that the initial inflammatory response induced by EVAR is not always spontaneously attenuated, but in some patients could persist during the first month and may result in a mild or even severe SIRS state. It has to be emphasized that the patients (n=4) presenting with a mild SIRS returned, were readmitted and were treated early, whereas

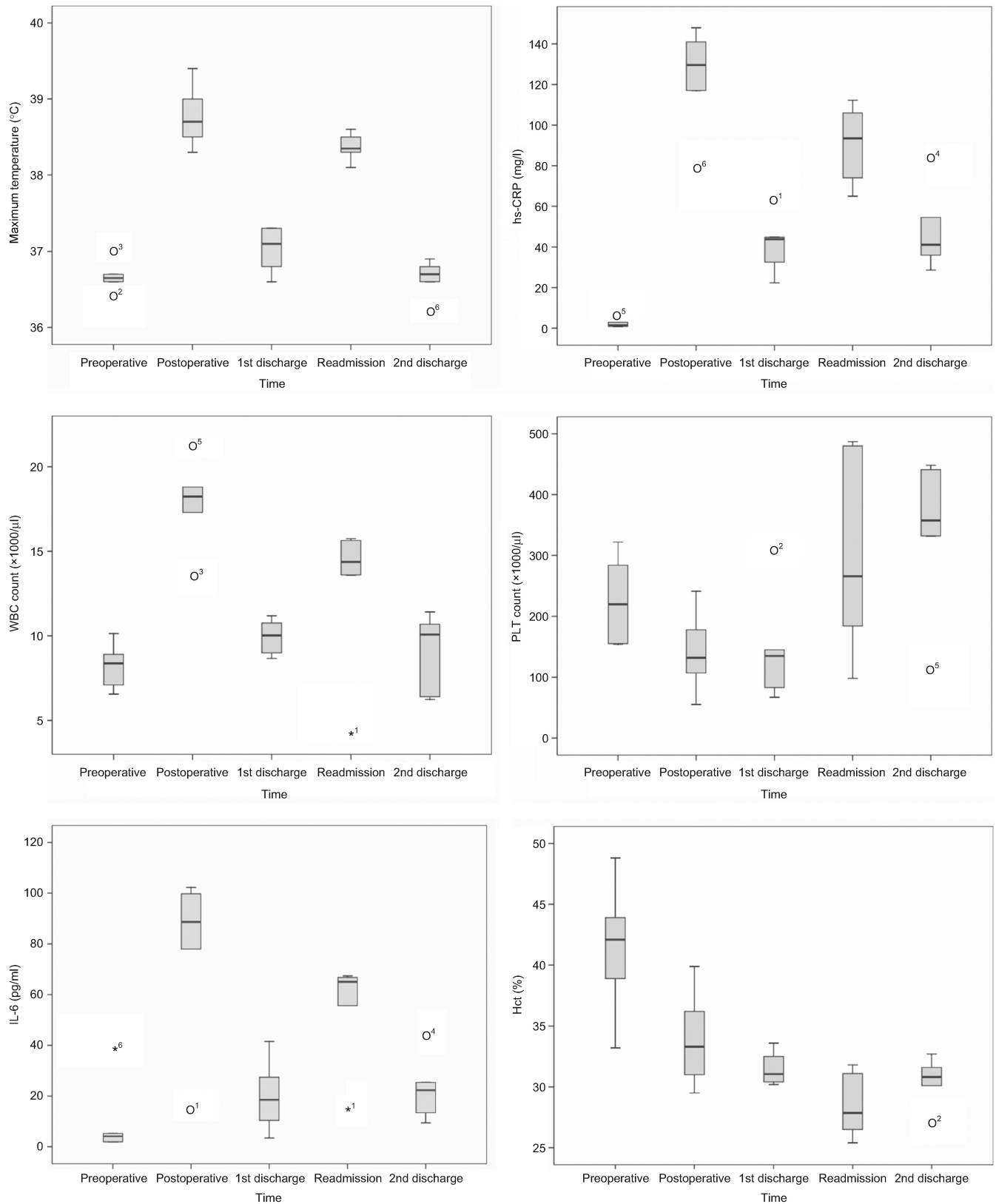


Fig. 2. The distribution of various variables (temperature, WBC count, IL-6, hs-CRP, platelet count and Hct) of the six patients readmitted, in different time slots namely, one day preoperatively, first postoperative day, first discharge (1st), readmission, second discharge (2nd) (boxplots showing the median, quartiles, and extreme values). WBC, white blood cell; IL-6, interleukin-6; hs-CRP, high-sensitivity C-reactive protein; Hct, hematocrit.

those ( $n=2$ ) who developed severe SIRS sought medical attention at a later stage. This shows that patients developing PIS after EVAR should be under surveillance postdischarge. They could be informed that there is a possibility of inflammation relapse during the first month, and given the opportunity of accessing an early assessment at the reappearance of persistent fever within 30 days postoperatively, in order to exclude a SIRS. Early management with NSAIDs orally proved to be an adequate treatment modality in most of these patients.

The literature so far provides few indications regarding the necessity and the duration of any specific treatment in patients who developed an excessive inflammatory response after EVAR. For example, in one study the authors suggest taking careful consideration of the postoperative administration of steroids in order to reduce the biological responses, while others recommend the aggressive use of drugs in the acute phase when patients present with expressive clinical signs of inflammation, without specifying if NSAIDs or steroids should be the treatment of choice [6, 20]. In another study, despite the administration in 22 patients of both NSAIDs perioperatively and steroids consisting of 500 mg of hydrocortisone intraoperatively, there were two patients who developed SIRS [10]. The routine administration of drugs like steroids or NSAIDs is of concern because of their side effects especially in high-risk patients with several comorbidities, including renal failure, heart failure or coronary artery disease. In addition, in the current practice the therapy of SIRS has been mostly symptomatic [21]. Nonetheless, it seems reasonable that in some cases the postoperative administration of anti-inflammatory drugs could be beneficial when high-risk patients present with severe PIS after EVAR, in order to limit the extent of the inflammatory response and preserve consequent serious morbidity. These issues need to be clarified in future studies.

In conclusion, the activation of the inflammatory cascade following endovascular aortic stent grafting for aneurysmal disease, could lead to the development of SIRS even several days after the operation. Patients developing PIS after EVAR might better be kept under surveillance for at least the first postoperative month. Further studies are needed in order to identify risk factors leading to severe systemic inflammatory response, as well to test strategies to control the inflammatory process after EVAR.

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