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# Effects of postimplantation systemic inflammatory response on long-term clinical outcomes after endovascular aneurysm repair of an abdominal aortic aneurysm

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#### Abstract

The aim of this study was to determine the association between postimplantation syndrome (PIS) and long-term clinical outcomes after elective endovascular aneurysm repair (EVAR) of an abdominal aortic aneurysm.

In this single-center, observational cohort study, a total of 204 consecutive patients undergoing EVAR were included. Primary outcome was long-term mortality from any cause; secondary outcomes included long-term mortality, systemic or implant-related complications, and secondary therapeutic procedures.

The diagnosis of PIS was established in 64 patients (31.4%). PIS patients were more likely to receive woven polyester endografts and have a longer postoperative hospital stay and lower incidence of type II endoleaks. In multivariate analysis, PIS was significantly associated with a decreased risk of developing type II endoleaks (P=0.044). During follow-up period of 44 months, clinical outcomes showed no significant differences in mortality (P=0.876), systemic (P=0.668), or implant-related complications (P=0.847), although rates of secondary therapeutic procedure were significantly higher in non-PIS patients (P=0.037). The groups had similar rates of overall survival (P=0.761) and other clinical outcomes (P=0.562).

Patients with and without PIS had similar long-term overall survival rates and other clinical outcomes. PIS was beneficial in preventing type II endoleaks during postoperative period.

**Abbreviations:** AAA = abdominal aortic aneurysm, CI = confidence interval, CRP = C-reactive protein, CTA = computed tomography angiography, ePTFE = expanded polytetrafluoroethylene, EVAR = endovascular aneurysm repair, OR = odds ratio, PIS = postimplantation syndrome, SIRS = systemic inflammatory response, WBC = white blood cell.

Keywords: aneurysm, aorta, endovascular, outcome, postimplantation syndrome, treatment

# 1. Introduction

Endovascular aneurysm repair (EVAR) of an abdominal aortic aneurysm (AAA) was introduced in the 1990s as a minimally invasive procedure in comparison with conventional open repair. Short-term survival rates are significantly higher in patients who have undergone EVAR than in those who have undergone open

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AAA repair, but long-term survival rates are similar.<sup>[1-5]</sup> This advantage of EVAR is not sustained because it is associated with more postoperative aneurysm-related complications than open AAA repair.<sup>[1-5]</sup>

Postimplantation syndrome (PIS), defined as continuous pyrexia coinciding with a rise in inflammatory marker levels despite antibiotic therapy, has been used to describe a clinical entity characterized by an acute-phase systemic inflammatory response shortly after EVAR of an AAA.<sup>[6–12]</sup> Although PIS, observed in nearly one-third of EVAR patients, is believed to be transient and harmless in most cases, its effect on patient outcomes is a concern because it may lead to prolonged hospitalization and a more complicated postoperative recovery.<sup>[8–12]</sup> The exact pathophysiology of PIS remains debatable, and there is presently no consensus on its effect on clinical outcomes during long-term follow-up after elective EVAR.

Here we aimed to evaluate the risk factors responsible for an increased risk of developing a post-implantation systemic inflammatory response and to determine the association between PIS and long-term clinical outcomes in patients who had undergone elective EVAR of an AAA.

# 2. Subjects and methods

#### 2.1. Study design and patient population

This was a single-center, retrospective, observational study using data extracted from medical records. The study protocol was

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approved by the Institutional Review Board of Asan Medical Center. A total of 240 consecutive patients who underwent EVAR of an AAA at our institution from January 2008 to December 2013 were included.

Exclusion criteria for the study included ruptured AAA, clinical and/or laboratory evidence of a recent infection, previous major trauma or surgery 2 weeks before enrollment, combined major operation, and perioperative complications (within 30 days) associated with EVAR. Of the 240 patients, 36 (15.0%) were excluded for the following reasons: ruptured AAA (n=2); evidence of a recent infection (n = 13), comprising a foot wound with lower limb ischemia (n=6/13), cholecystitis (n=2/13), upper respiratory tract infection (n = 4/13), and cholangitis (n = 1/13)13); previous major trauma or surgery (n=5); combined major operation (n=4); and perioperative complications (n=12). Perioperative complications within 30 days comprised pneumonia (n=3/12), wound complications (n=3/12), ischemic colitis (n=1/12), myocardial infarction (n=1/12), distal embolization (n = 1/12), limb graft occlusion (n = 1/12), aortic dissection (n = 1/12)12), and common iliac artery dissection (n = 1/12). Endovascular procedures were performed under general or regional anesthesia and followed a standard vascular protocol. According to the hospital protocol, all included patients received prophylactic antibiotics 30 minutes before EVAR as well as 5000 U of heparin intravenously before introduction of the stent graft deployment system during EVAR.

Demographics, risk factors of interest, and other data, including clinical presentation, morphological characteristics of the aneurysm, operative and postoperative characteristics, and long-term outcomes, were recorded for each patient. All morphological characteristics of the aneurysm were recorded in the official computed tomography angiography (CTA) report by a radiologist, who was unaware of the patients' general health status, according to the reporting standards of the Ad Hoc Committee for Standardized Reporting Practices in Vascular Surgery of the Society for Vascular Surgery/American Association for Vascular Surgery.<sup>[13]</sup> Temperature was recorded every 8 hours during the entire duration of hospitalization. Body temperature, white blood cell (WBC) and platelet counts, and serum C-reactive protein (CRP) concentrations were serially assessed 1 day before EVAR and during hospitalization, depending on the clinical status of the patient. The highest pre- and postoperative values and changes in the WBC count, platelet count, and CRP concentrations were considered for the analyses. Patients were discharged in the absence of any complications, as confirmed via follow-up CTA, with a body temperature of <37.5°C for at least 24 hours and a WBC count of <12,000/mm<sup>3</sup>. Follow-up visits were scheduled at 1 month after discharge, as well as at 6 and 12 months after EVAR, and annually thereafter. All follow-up visits included CTA and plain radiography of the abdomen. All data were prospectively collected for all consecutive patients in an Excel database (Microsoft Corp., Redmond, WA) and retrospectively analyzed.

#### 2.2. Definition

PIS was defined as a continuous temperature of  $>38^{\circ}$ C lasting for >1 day and a WBC count of  $>12,000/\text{mm}^3$  despite antibiotic therapy and negative culture results. This definition is in accordance with that of systemic inflammatory response syndrome (SIRS),<sup>[14,15]</sup> with PIS fulfilling at least 2 of the 4 SIRS criteria: temperature, WBC count, respiration rate, and heart rate.<sup>[6]</sup> In the present study, we used the definition of SIRS in

patients presenting with an acute systemic inflammatory response after EVAR; enrolled patients were divided into 2 groups: PIS and non-PIS. To assess long-term systemic or implant-related complications, we referred to the reporting standards of the Ad Hoc Committee for Standardized Reporting Practices in Vascular Surgery of the Society for Vascular Surgery/American Association for Vascular Surgery.<sup>[13]</sup> Based on these guidelines, we defined a complication when patients encountered a grade 2 or 3 complication and reviewed systemic and implant-related complications. As per to the definition of endoleaks,<sup>[5]</sup> endoleaks were subdivided into 2 categories: no or spontaneously resolved, transient endoleaks and persistent or new endoleaks. The primary outcome was long-term mortality from any cause; secondary outcomes included long-term mortality, systemic or implant-related complications, and secondary therapeutic procedures.

# 2.3. Statistical analysis

Categorical variables presented as counts and percentages were analyzed using  $\chi^2$  and Fisher's exact tests, as appropriate. Continuous variables, presented as mean±standard deviation, were compared using Student's *t* test. Logistic regression analysis was used to evaluate the risk factors for type II endoleaks following EVAR. The risk factors associated with type II endoleaks that showed significance with a cutoff *P* value of 0.1 in the univariate analysis were introduced into a multivariate logistic regression model using a conditional forward selection method. Cumulative event risks were estimated from Kaplan– Meier survival curves and compared using the log-rank test. All statistical analyses were performed using SPSS (version 18.0; SPSS, Chicago, IL), and  $P \leq 0.05$  was considered statistically significant.

#### 3. Results

Of the 240 patients, 204 consecutive patients (85.0%) were included in the present study (Fig. 1). Of these, PIS diagnosis was established in 64 patients (31.4%); there were no significant differences between the PIS and non-PIS groups with regard to demographics, atherosclerotic risk factors, clinical characteristics, AAA morphology, or perioperative clinical outcomes, except that PIS patients were more likely to receive woven polyester endografts (73.6% vs 83.3%; P=0.001) and have a longer postoperative hospital stay ( $4.9 \pm 2.2$  days vs  $6.0 \pm 3.4$  days; P=0.010) (Table 1). The incidence of type II endoleaks was





Table 1

Patient demographics, risk factors and clinical characteristics according to the presence or absence of postimplantation syndrome after endovascular aneurysm repair.

Variable	PIS	Non-PIS	<i>P</i> -value
Number of patients	64 (31.4)	140 (68.6)	
Mean age, y	71.7±7.1	$71.1 \pm 6.1$	0.532
Male gender	53 (82.8)	132 (94.3)	0.012
BMI, kg/m <sup>2</sup>	$24.1 \pm 4.3$	$26.1 \pm 17.6$	0.387
Medical history			
Diabetes mellitus	7 (10.9)	21 (15.2)	0.514
Hypertension	45 (70.3)	99 (71.7)	0.868
Smoking	36 (56.3)	93 (67.4)	0.156
Cancer other than skin cancer	13 (20.4)	27 (20.1)	0.449
CAD	16 (25.0)	50 (36.2)	0.147
CVA	10 (15.6)	15 (10.9)	0.363
COPD	25 (39.1)	59 (42.8)	0.648
CRF	2 (3.1)	9 (6.5)	0.508
Medications			
Antiplatelet agent	33 (51.6)	59 (42.9)	0.288
Statin	29 (45.3)	60 (43.8)	0.880
Anatomic data, mm	× ,		
Aneurysm sac diameter*	$56.8 \pm 9.7$	$56.9 \pm 10.5$	0.939
Aneurysm sac length	$74.8 \pm 20.5$	$78.4 \pm 22.2$	0.291
Neck diameter	$23.9 \pm 4.4$	$22.8 \pm 3.6$	0.080
Neck length	$33.8 \pm 16.0$	$34.3 \pm 14.1$	0.803
Neck angle (degree)	$48.5^{\circ} \pm 21.6^{\circ}$	$47.0^{\circ} \pm 25.3^{\circ}$	0.686
CIA involvement	24 (40.0)	44 (33.6)	0.562
Thrombus thickness			
Preoperative CTA	$15.6 \pm 14.0$	17.0±11.7	0.496
Last F/U CTA	$17.0 \pm 11.6$	$18.9 \pm 10.8$	0.327
Clinical characteristics			
General anesthesia	41 (64.1)	88 (62.9)	0.877
Graft type			
Woven polyester	60 (83.8)	103 (73.6)	0.001
ePTFE	4 (6.3)	37 (26.4)	
Operation time, h	$2.9 \pm 1.1$	$3.1 \pm 1.1$	0.369
Postoperative endoleaks	4 (6.3)	19 (13.6)	0.155
Type la	2 (3.1)	0 (0.0)	0.097
Type Ib	0 (0.0)	6 (4.3)	0.113
Type II	2 (3.1)	18 (12.9)	0.040
Type III	1 (1.6)	0 (0.0)	0.314
Postoperative hospitalization, d	$6.0 \pm 3.4$	4.9±2.2	0.010

Continuous data are shown as mean ± standard deviation, and categorical data are shown as number (%).

BMI=body mass index; CAD=coronary artery disease; CIA=common iliac artery; COPD=chronic obstructive pulmonary disease; CRF=chronic renal failure; CTA=computed tomography angiography; CVA=cerebrovascular accident; ePTFE=expanded polytetrafluoroethylene; F/U=follow-up; PIS=postimplantation syndrome.

Maximum aneurysm diameter measured perpendicular to the flow line of the vessel with three-dimensional reconstructed CTA images.

significantly higher in non-PIS patients (12.9% vs 3.1%; P = 0.040). In multivariate analysis, female gender [odds ratio (OR): 5.67; 95% confidence interval (CI): 1.36–23.62; P = 0.017], preoperative internal iliac artery embolization (OR: 3.69; 95% CI: 1.28–10.65; P = 0.016), and PIS (OR: 0.18; 95% CI: 0.04–0.96; P = 0.044) were significantly associated with an increased risk of type II endoleaks during the postoperative period (Table 2). There was a trend toward an increased incidence of type II endoleaks without any statistical significance in patients receiving expanded polytetrafluoroethylene (ePTFE) endografts for EVAR of an AAA (OR: 2.55; 95% CI: 0.90–7.20; P = 0.077).

Body temperature and laboratory data are shown in Table 3. The incidence of postoperative fever (body temperature > 38°C) was significantly higher in the PIS group than in the non-PIS group (P < 0.001), but there were no significant differences in the onset (P = 0.202) and duration (P = 0.093) of fever between the groups. There were significant differences in the preoperative

counts of WBC and platelet between the groups (WBC count, P < 0.001; platelet count, P = 0.023), although the counts were within the normal range. With respect to postoperative laboratory data, the highest mean WBC count and CRP concentration were significantly higher in the PIS group than in the non-PIS group (WBC count, P < 0.001; CRP concentration, P < 0.001). However, the lowest mean platelet count did not significantly differ between the groups (P = 0.505). In comparison with preoperative baseline values, the postoperative increase in WBC count and CRP concentration was significantly higher in the PIS group than in the non-PIS group (WBC count, P < 0.001; CRP concentration, P < 0.001; DRP concentration, P < 0.001). There was also a significant difference between the groups in the postoperative decrease in platelet count (P = 0.025). In all patients in the PIS group, the cultures from blood, urine, and sputum were all negative.

During the mean follow-up period of 44 months ( $44.1 \pm 23.8$  months), clinical outcomes showed no significant differences in long-term mortality (P=0.876) and systemic (P=0.668) or

Table 2

Univariate and multivariate analyses of risk factors associated with type II endoleaks during the postoperative period.

	Univariate analysis		Multivariate analysis	
	OR (95% CI)	<i>P</i> -value	OR (95% CI)	P-value
Age	0.98 (0.91-1.05)	0.547	NA	NA
Female gender	2.82 (0.84-9.51)	0.095	5.67 (1.36-23.62)	0.017
BMI, kg/m <sup>2</sup>	1.00 (0.96-1.04)	0.926	NA	NA
Diabetes mellitus	1.19 (0.32-4.36)	0.799	NA	NA
Hypertension	1.57 (0.50-4.95)	0.441	NA	NA
Smoking	1.25 (0.45-3.45)	0.664	NA	NA
Sac diameter	0.98 (0.93-1.03)	0.387	NA	NA
Sac length	0.99 (0.97-1.01)	0.446	NA	NA
Neck diameter*	0.86 (0.73–1.00)	0.054	NA	NA
Neck angle	1.00 (0.98-1.02)	0.880	NA	NA
IMA occlusion	0.37 (0.05-2.88)	0.342	NA	NA
IIA embolization <sup>†</sup>	2.84 (1.08-7.47)	0.035	3.69 (1.28-10.65)	0.016
Thrombus thickness				
Initial CTA	0.98 (0.94-1.02)	0.336	NA	NA
Last CTA	0.98 (0.94-1.03)	0.380	NA	NA
Graft type				
Woven polyester	Reference			
ePTFE	3.89 (1.49-10.15)	0.006	2.55 (0.90-7.20)	0.077
PIS	0.22 (0.05–0.97)	0.046	0.18 (0.04–0.96)	0.044

BMI=body mass index; CI=confidence interval, CTA=computed tomography angiography; ePTFE=expanded polytetrafluoroethylene; IIA=internal iliac artery; IMA=inferior mesenteric artery; NA=not applicable; OR=odds ratio; PIS=postimplantation syndrome.

\* Significant variables with a cutoff *P* value of 0.1 in the univariate analysis were introduced into the multivariate logistic regression model using a conditional forward selection method: neck diameter was not selected as a significant factor during multivariate analysis.

<sup>†</sup> Preoperative embolization of the internal iliac artery.

implant-related complications (P=0.847) between the groups, although the rates of secondary therapeutic procedures were significantly higher in non-PIS patients (P=0.037) (Table 4). Kaplan–Meier survival analysis showed that the groups had similar rates of overall survival (P=0.761) and other clinical outcomes (P=0.562), although the rate of secondary therapeutic

procedures was significantly higher in the non-PIS group (P = 0.049) (Fig. 2).

## 4. Discussion

In the present study, there was a substantial incidence of PIS in patients undergoing elective EVAR of an AAA, similar to that

Table 3						
Body temperature and pre- and postoperative laboratory data.						
Variable	PIS (n=64)	Non-PIS (n=140)	P-value			
Body temperature						
Fever*	55 (85.9)	38 (27.1)	< 0.001			
Fever onset (POD)	$0.95 \pm 0.73$	1.15±0.86	0.202			
Fever duration, d	2.05±1.85	$1.53 \pm 0.60$	0.093			
WBC count, $\times 10^{3}/\mu$ L						
Preoperative value	$7.2 \pm 1.5$	$6.3 \pm 1.5$	< 0.001			
Highest value <sup>†</sup>	14.1 ± 3.5	10.4 ± 2.9	< 0.001			
$\Delta$ WBC $^{\ddagger}$	$6.9 \pm 3.2$	4.2 ± 2.5	< 0.001			
Platelet count, $\times 10^{3}/\mu L$						
Preoperative value	215.2±71.7	194.6 ± 52.7	0.023			
Lowest value <sup>†</sup>	132.0±45.3	127.9±39.6	0.505			
$\Delta$ platelet <sup>‡</sup>	83.2±56.9	68.9±33.0	0.025			
CRP, mg/dL						
Preoperative value	0.90±2.18	0.49±1.09	0.150			
Highest value <sup>†</sup>	13.40±6.10	7.87±6.73	< 0.001			
$\Delta$ CRP <sup>‡</sup>	$12.50 \pm 6.10$	$7.33 \pm 6.70$	< 0.001			

Continuous data are shown as mean  $\pm$  standard deviation, and categorical data are shown as number (%).

CRP = C-reactive protein; PIS = postimplantation syndrome; POD = postoperative day; <math>WBC = white blood cell.

\* Body temperature > 38°C.

<sup>+</sup> Postoperative highest or lowest value.

\* Postoperative increase (decrease) in the values in comparison with baseline values.

Table 4						
Long-term clinical outcomes after endovascular aneurysm repair.						
Outcome	PIS (n=64)	Non-PIS (n = 140)	P-value			
All deaths	14 (21.9)	32 (22.9)	0.876			
Cause of death						
Aneurysm-related cause	0 (0.0)	0 (0.0)				
Cardiovascular cause	0 (0.0)	2 (1.4)	1.000			
Cancer	3 (4.7)	10 (7.1)	0.505			
Pneumonia or other infection	2 (3.1)	3 (2.1)	0.647			
Other cause	5 (7.8)	9 (6.4)	0.717			
Unknown cause	4 (6.3)	8 (5.7)	0.880			
Secondary therapeutic procedures						
No. of patients	25 (17.9)	5 (7.8)	0.060			
No. of procedures	27 (19.3)	5 (7.8)	0.037			
Systemic complications	9 (14.1)	20 (14.3)	0.668			
Cardiac	6 (9.4)	8 (5.7)				
Pulmonary	2 (3.1)	7 (5.0)				
Cerebrovascular	1 (1.6)	4 (2.9)				
Renal	2 (3.1)	2 (1.4)				
Gastrointestinal	0 (0.0)	1 (0.7)				
Implant-related complications	2 (3.1)	3 (2.1)	0.847			
Graft infection	1 (1.6)	1 (0.7)				
Limb occlusion	1 (1.6)	2 (1.4)				
Follow-up period (months)	46.14±24.29	$43.29 \pm 23.60$	0.430			

Values are numbers of patients (%).

PIS = postimplantation syndrome.





reported in the literature by most authors,<sup>[6–12]</sup> and PIS did not affect all-cause mortality and other clinical outcomes. However, the incidence of type II endoleaks was significantly higher in the non-PIS group, and an unexpected beneficial effect of PIS in preventing type II endoleaks during the postoperative period was observed.

Since the first description of systemic inflammatory response shortly after EVAR by Velázquez et al<sup>[16]</sup> in 1999, recent reports have mentioned that endovascular procedures may initiate PIS, and the incidence has been reported to vary widely between 14% and 60%.<sup>[1]</sup> Although the pathophysiology underlying PIS is not well understood and the relation of this systemic inflammatory response with patient outcomes has not been well established, PIS is considered to be a well-tolerated, benign state in most studies, except that it may lead to prolonged hospitalization and a more complicated postoperative recovery.<sup>[6-11]</sup> However, recently, several studies have reported that a serious systemic inflammatory response might result in a cardiovascular or any other adverse event during the first year after EVAR or a lower quality of life during a mean follow-up of 4 years.<sup>[12,17]</sup> In this study, during the mean follow-up of 44 months, patients with and without PIS showed similar long-term overall survival rates and other clinical outcomes, except that a longer postoperative hospital stay was noted in the PIS group; we did not assess patient quality of life.

Despite the higher short-term survival rates of EVAR of an AAA compared with open AAA repair, long-term survival rates are similar, considering that EVAR is associated with more postoperative aneurysm-related complications than open AAA repair.<sup>[1-5]</sup> Endoleaks are the most common complication of EVAR and are a frequent indication for secondary therapeutic procedure.<sup>[5]</sup> Although type I and III endoleaks necessitate secondary therapeutic procedure and repair, the clinical significance of type II endoleaks remains controversial; most type II endoleaks spontaneously resolve, but there is evidence that persistent type II endoleaks are associated with an increased risk of adverse outcomes.<sup>[5,18-20]</sup> Current recommendations suggest intervention for type II endoleaks in the presence of aneurysmal growth and/or persistent endoleaks.<sup>[20-22]</sup> In a recent large retrospective study involving 2367 EVAR patients by Lo et al,<sup>[5]</sup> persistent type II endoleaks were reported to be associated with hypogastric coil embolization, distal graft extension, absence of chronic obstructive pulmonary disease, age of  $\geq 80$  years, and graft type. Patients with persistent type II endoleaks are more likely to show a sac expansion and to undergo secondary

therapeutic procedure during follow-up.<sup>[5]</sup> In the analyses of the graft type, Lo et al<sup>[5]</sup> found that the use of ePTFE endografts resulted in higher rates of new or persistent type II endoleaks compared with other types of endiografts, although these analyses did not include PIS as a significant factor in multivariate analyses.

Graft type plays a primary role in PIS development, and woven polyester endografts reportedly result in a stronger systemic inflammatory response.<sup>[6-12]</sup> In this study, persistent or new type II endoleaks were statistically and significantly associated with female gender, preoperative embolization of the internal iliac artery, and PIS. There was a trend toward an increased incidence of type II endoleaks without any statistical significance in patients receiving ePTFE endografts. The exact pathophysiology of PIS and the relationship between graft type, PIS, and type II endoleaks remain largely unknown. However, based on these observations, we speculate that systemic inflammatory response, significantly associated with graft type, could result in a high rate of obliteration of relatively low-pressure, small arteries, such as lumbar arteries and the inferior mesenteric artery, followed by a reduced risk of developing type II endoleaks and rates of secondary therapeutic procedures during follow-up. Although the retrospective nature and small sample size of our study made it particularly challenging to arrive at definitive conclusions about the beneficial effects of PIS in preventing the risk of type II endoleaks, the significant association between type II endoleaks and ePTFE reported by Lo et al<sup>[5]</sup> lends support to our speculation. Further studies involving larger cohorts are warranted.

Several limitations should be noted. Although we prospectively collected data from our AAA registry, it was conducted in a retrospective nonrandomized fashion using a small cohort of patients. The decision for the selection of a graft type was mainly made as per the surgeons' preference based on the expected level of technical difficulty of the procedure, and the number of patients receiving ePTFE endografts was relatively small. For this reason, the incidence of systemic inflammatory response may have been underestimated in these patients. Moreover, we did not assess other important inflammatory markers such as interleukins and tumor necrosis factors. Another limitation concerns the methodology for measuring the morphological characteristics of the aneurysm based on CTA images. To measure the preoperative and follow-up thrombus burden of the aneurysmal sac, we used the maximum recorded thickness, which may be less accurate than the volume of the thrombus. In addition, all morphological data were recorded by a radiologist in the official CTA report. The intra- and interobserver variation of diameter measurements obtained using CTA images range between 2 and 5 mm or 5% and 15%;<sup>[23,24]</sup> this may have created a bias in our analyses. Finally, our findings were obtained at a single center, resulting in a small sample size and limiting the general relevance of our results. Future prospective trials with larger cohorts should lead to a better understanding of the pathophysiology and clinical outcomes of PIS after elective EVAR of an AAA.

In conclusion, despite the potential limitations, our study showed the benign nature of PIS after elective EVAR and revealed no association between the occurrence of PIS and long-term clinical outcomes. However, considering that the incidence of type II endoleaks was significantly higher in non-PIS patients, PIS is somehow beneficial in preventing type II endoleaks in the long term, given the lack of evidence for that.

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