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PSEUDOANEURYSMS AFTER CORONARY INTERVENTIONS: RISK FACTORS, DIAGNOSIS, AND CRITERIA FOR SURGICAL TREATMENT

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PSEUDOANEURIZME NAKON KORONARNIH INTERVENCIJA: FAKTORI RIZIKA, DIJAGNOSTIKA I KRITERIJUMI ZA HIRURŠKO LEČENJE

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ABSTRACT

Introduction: Pseudoaneurysm (PSA) is defined as a defect in the arterial wall at the puncture site, leading to an extraluminal blood collection surrounded by fibrous tissue, and represents the most common vascular complication after coronary angiography. The aim of this study was to identify risk factors for PSA development after coronary interventions and to define criteria for surgical treatment.

Materials and Methods: A retrospective analysis was conducted on 32 patients treated at CHC Zemun over a ten-year period (2012–2022). During the observed period, 16,787 coronary procedures were performed (10,498 coronary angiographies, 6,289 PCIs). The study group included 17 patients with PSA, and 15 patients in the control group with a hematoma that did not progress to PSA. Demographic data, comorbidities, laboratory parameters, therapy, smoking habits, procedural details, and PSA characteristics were recorded, with comparison between surgically and conservatively treated patients.

Results: The mean time to PSA diagnosis was 3.29 ± 4.7 days, whereas hematomas were diagnosed within 24 hours. No significant differences in sex or age were observed between groups. More than half of the patients had hypertension, hyperlipidemia, and chronic cardiac or renal diseases. Low hemoglobin, thrombocytopenia, and INR >3 were identified as independent risk factors. Most interventions were performed via the right femoral artery, with PSA most commonly located in the common femoral artery. Medi-

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an PSA diameter was 44 mm in surgically treated patients and 19 mm in conservatively treated patients. No deaths occurred; the most common postoperative complication was residual hematoma.

Conclusion: The first 72 hours after intervention represent the most critical period for PSA detection. PSA diameter is a key factor in therapy selection, lesions >2 cm and complicated ones require surgical intervention, while smaller lesions can be treated conservatively. Timely diagnosis and treatment improve outcomes, and our findings may help optimize patient monitoring protocols and early surgical intervention selection.

Keywords: pseudoaneurysm, PCI, coronary angiography, transarterial approach

SAŽETAK

Uvod: Pseudoaneurizma (PSA) se definiše kao defekt arterijskog zida na mestu punkcije, sa formiranjem vanluminalne kolekcije krvi, obavijene fibroznim tkivom i najčešća je vaskularna komplikacija nakon koronarografije. Cilj rada bio je identifikacija faktora rizika za nastanak PSA nakon koronarne intervencije i definisanje kriterijuma za hirurško lečenje.

Materijal i metode: Retrospektivno su analizirana 32 pacijenta lečena u KBC Zemun u periodu od deset godina (2012–2022), tokom kojih je izvedeno 16.787 koronarnih procedura (10.498 koronarografija, 6.289 PCI). Studijsku grupu činilo je 17 pacijenata sa PSA, a kontrolnu 15 sa hematomom koji nije progredirao u PSA. Beleženi su demografski podaci, komorbiditeti, laboratorijski parametri, terapija, navike pušenja, tehnički detalji procedure i karakteristike PSA, uz poređenje hirurški i konzervativno lečenih pacijenata.

Rezultati: Prosečno vreme do dijagnoze PSA bilo je 3,29 ± 4,7 dana, dok su hematomi dijagnostikovani unutar 24 sata. Nije uočena značajna razlika u polu i starosti između grupa. Više od polovine pacijenata imalo je hipertenziju, hiperlipidemiju i hronične kardiološke ili nefrološke bolesti. Nizak hemoglobin, trombocitopenija i INR >3 identifikovani su kao nezavisni faktori rizika. Većina intervencija izvedena je kroz desnu femoralnu arteriju, a PSA su najčešće na a. femoralis communis. Medijana prečnika PSA iznosila je 44 mm kod hirurški, odnosno 19 mm kod konzervativno lečenih pacijenata. Nije bilo smrtnih ishoda; najčešća postoperativna komplikacija bio je rezidualni hematom.

Zaključak: Najkritičniji period za detekciju PSA je prvih 72 sata. Prečnik PSA je ključan za izbor terapije, lezije >2 cm, kao i komplikovane, zahtevaju hiruršku intervenciju, dok manje mogu biti tretirane konzervativno. Pravovremena dijagnoza i lečenje poboljšavaju ishod, a rezultati mogu unaprediti protokole praćenja i selekciju kandidata za hirurško lečenje.

Ključne reči: pseudoaneurizma, PCI, koronarografija, transarterijski pristup

INTRODUCTION

Cardiovascular diseases represent one of the leading causes of mortality worldwide among non-communicable diseases, making them a significant global public health concern. In recent decades, an increase in incidence has been observed, which has led to a growing use of interventions on the coronary arteries for diagnostic and therapeutic purposes.(1,2)

Coronary angiography is a key diagnostic procedure for the assessment of coronary artery disease.(3) It is performed after local anesthesia at the arterial puncture site and involves advancing an arterial guidewire and a specialized catheter through a peripheral artery up to the coronary arteries, under continuous radiological control using X-ray imaging.(1-3) The most commonly used vascular access routes are transradial and transfemoral. Today, the transradial approach is considered the "gold standard" due to its safer access, lower complication rates, and faster patient recovery compared to the transfemoral approach.(4)

Coronary angiography can be urgent, performed as part of percutaneous coronary intervention (PCI) in acute coronary syndrome, or elective, as part of planned diagnostic evaluation.(1) Although generally safe in the majority of cases, the procedure carries a risk of various vascular complications. The most common complications after coronary intervention include pseudoaneurysm (PSA), thrombosis and spasm of the access artery, dissection, arteriovenous fistula, hematomas with or without compartment syndrome, arterial perforation, distal ischemia, peripheral nerve injury, and granuloma formation at the puncture site.(4,5)

Injuries to punctured arteries are relatively rare, but their actual incidence is likely underestimated, as they often remain asymptomatic, unrecognized, and untreated.(2,6) The development of vascular complications is influenced by patient-related risk factors and procedural factors. High-risk patients include individuals over 75 years of age, females, those with obesity, hypertension, diabetes mellitus, hyperlipidemia, chronic kidney disease, atrial fibrillation, thrombocytopenia, coagulation disorders, peripheral arterial disease, variant vascular anatomy, or those on long-term antiplatelet or anticoagulant therapy. Procedural risk factors include arterial location and repeated puncture, urgent and therapeutic interventions, prolonged procedure duration, use of larger-diameter guidewires, and inadequate hemostasis after the intervention.(5,7,8,9)

Pseudoaneurysm (PSA) is one of the most common complications after coronary intervention.(10) It is defined as a defect in the arterial wall at the puncture site, through which arterial blood leaks into the surrounding extraluminal space, forming a collection of blood confined solely by fibrous tissue. Unlike a true aneurysm, a PSA does not involve all three layers of the arterial wall (intima, media, and adventitia).(7) Clinically, it presents as a pulsatile hematoma, local pain, swelling, or, in rare cases, active bleeding in the affected limb.(9,10,11)

Definitive diagnosis is made via ultrasonography of the arteries, which can reveal pulsations, turbulent flow, and the presence of a hematoma. On color Doppler, a pathognomonic finding is the so-called "yin-yang" sign, which results from the characteristic changes in blood flow direction through the PSA neck during systole and diastole.(2)

The aim of this study was to identify risk factors contributing to the development of pseudoaneurysm after coronary intervention and to define the criteria guiding the decision for surgical treatment.

MATERIALS AND METHODS

This retrospective, observational study included 32 patients treated at the Cardiology and Surgery Departments of the Clinical Hospital Center Zemun over a ten-year period (January 2012 – January 2022). During this period, a total of 16,787 coronary procedures were performed, including 10,498 coronary angiographies and 6,289 PCIs. Included patients underwent diagnostic or therapeutic coronary interventions due to their presenting pathology (acute coronary syndrome or stable angina pectoris). Interventions were classified according to urgency as either urgent or elective. Data were collected on the arteries used for cannulation, the arterial guidewire diameter and the administered heparin dose.

The study group consisted of 17 patients diagnosed with PSA, while the control group included 15 patients with hematomas that did not progress to pseudoaneurysm. All patients underwent post-procedural clinical evaluation, after which suspicion of PSA formation was raised in 32 patients, who were subsequently referred for further radiological diagnostics. For all patients, the time from intervention to diagnosis and the time from diagnosis to treatment were recorded. Data on demographic characteristics, comorbidities, pre-hospitalization therapy, therapy administered during hospitalization, and smoking habits were collected from medical records. Overweight was defined as a BMI >25 kg/m^2. Chronic cardiac and renal diseases were confirmed by echocardiography and eGFR assessment.

Laboratory parameters (hemoglobin, platelet count, INR) at admission were compared with the reference values of the Clinical Hospital Center Zemun. The location and maximal diameter of the PSA were determined via ultrasonography. The treatment method (surgical or conservative) was documented in detail.

Data were analyzed in Excel and statistically processed using SPSS software. Nominal variables are presented as frequencies and percentages, while normally distributed numerical variables are presented as mean ± standard deviation. For variables deviating from normal distribution, the median and interquartile range (Q1–Q3) were applied.

RESULTS

A total of 32 patients were included in the study, 17 with PSA and 15 with hematoma. Demographic characteristics, comorbidities, smoking status, and use of antiplatelet/anticoagulant therapy are presented in Table 1. Table 2 summarizes data on the urgency of the intervention, guidewire sheath size, and the administered heparin dose.

		Pseudoaneurysm n (%)	Hematoma n (%)	Total n (%)	p value
N		17 (46.88%)	15 (53.12%)	32	
Female gender		8 (47.1%)	10 (66.7%)	18(56.25%)	p=0.308
Age (years)	Mean ± SD	67 ± 14.9	65.8 ± 9.1	66.44±12.4	p=0.789
	Median	69	66	66.5	
	Min-Max	29-89	53-84	29-89	
	>75	6 (35.3%)	3 (20%)	9	
Diabetes mellitus		5 (29.4%)	4 (26.7%)	9 (28.12%)	p=1
Hypertension		15 (88.2%)	14 (93.3%)	29 (90.62%)	p=1
Hyperlipidemia		11 (64.7%)	12 (80%)	23 (71.88%)	p=0.444
Chronic kidney disease		10 (58.8%)	9 (60%)	19 (59.38%)	p=1
Chronic heart disease		10 (53.3%)	8 (58.8%)	18 (56.25%)	p=1
Overweight		2 (11.8%)	5 (33.3%)	7 (21.88%)	p=0.209
Cigarette smoking		6 (35.3%)	6 (40%)	12 (37.5%)	p=1
Previous antiplatelet therapy		10 (58.8%)	10 (66.7%)	20 (62.5%)	p=0.726
Intrahospital dual antiplatelet therapy		17 (100%)	15 (100%)	32 (100%)	/
Previous anticoagulant therapy		3 (17.6%)	0	3 (9.38%)	P=0.229
Intrahospital anticoagulant therapy		8 (47.1%)	5 (33.3%)	13 (40.62%)	P=0.491
Acute coronary disease		13 (76.5%)	10 (66.7%)	23 (71.88%)	p=0.699

Table 1: Patient characteristics, comorbidities and drug regimens before and during the hospitalization

		Pseudoaneurysm		Hematoma	Total	p value
N		17 (46.88%)		15(53.12%)	32	
Urgent coronary intervention, n (%)		13 (76.5%)		11 (73.3%)	24 (75%)	p=1
Coronarography	AF*		12 (70.6%)	8 (53.3%)	20 (62.5%)	p=0.525
	AR**		4 (23.5%)	6 (40%)	10 (31.25%)	
	none		1 (5.9%)	1 (6.7%)	2 (6.25%)	
Percutaneous coronary intervention, n (%)	AF		13 (76.5%)	14 (93.3%)	27 (84.38%)	p=0.789
	AR		1 (5.9%)	1 (6.7%)	2 (6.25%)	
	none		3 (17.6%)	0	3 (9.38%)	
Sheath size (French)	Mean ± SD		6.125 ± 0.5	6 ± 0.4	6.06 ± 0.4	p=0.441
	Median		6	6	6	
	Min-Max		5-7	5-7	5-7	
Intraoperative heparin (IU)	Mean ± SD		7142.86±2097.9	7133.33±1922.3	7137.93± 1972.6	p=0.99
	Median		7500	7000	7000	
	Min-Max		3000-10000	3000-10000	3000-10000	
Intervention -diagnosis (days)	Mean ± SD		3.29 ± 4.7	1	2.22 ± 3.6	**p<0.01**
	Median		1	1	1	
	Min-Max		1-20	1	1-20	
Diagnosis – treatment (days)	Mean ± SD		3.3 ± 2.3	/	3.3 ± 2.3	/
	Median		3	/	3	
	Min-Max		1-9		1-9	
Localization, n (%)	AF		15 (88.2%)	13 (86.7%)	28 (87.5%)	p=1
	AR		2 (11.8%)	2 (13.3%)	4 (12.5%)	
Size (mm)	Mean ± SD		34.875 ± 22.3	24.67 ± 6	33.26±20.8	p=0.467
	Median		30	25	27	
	Min-Max		10-96	18.5-30.5	10-96	
*AF – femoral artery, **AR – radial artery						

Table 2: Procedure characteristics and pseudoaneurysm characteristics

The time from intervention to PSA diagnosis was on average 3.29 ± 4.7 days, whereas hematomas in the reference group were diagnosed within the first 24 hours. The location and dimensions of the PSAs are presented quantitatively, and the comparison between surgically and conservatively treated PSAs is shown in Table 3. Table 4 presents the laboratory parameters at admission.

	Surgically treated PSA	Conservatively treated PSA	p value
N	10	7	
Urgent coronary intervention, n (%)	7 (70%)	6 (85.7%)	p=0.603
Sheath size (Mean ± SD)	6 ± 0.5	6.29 ± 0.5	p=0.271
Intraoperative heparin (IU), (Mean ± SD)	7214.29 ± 2038.3	7071.43 ± 2317.1	p=0.905
Intervention – diagnosis (days), median (Q1-Q3)	1 (1-20)	1 (1-4)	P=0.701
Lowered hemoglobin, n (%)	7 (70%)	4 (57.1%)	p=0.644
Trombocytopenia, n (%)	2 (20%)	2 (28.6%)	p=1
Localization, n	AFC* 7 AFS** 3 AR*** 0	AFC 3 AFS 2 AR 2	p=0.294
Size (mm), median (Q1-Q3)	44 (20-96)	19 (10-36)	**p<0.01**
*AFC – a.femoralis communis, **AFS- a.femoralis superficialis, ***AR-a. radialis			

Table 3: Comparison of characteristics of surgically and conservatively treated PSA

		Pseudoaneurysm	Hematoma	Total	p value
N		17	15	32	p=0.942
Hemoglobin (g/L)	Mean ± SD	130.7 ± 18.0	130.27 ± 15.4	130.5±16.57	
	Median	134	138	134	
	Q1-Q3	101-163	92-148	92-163	
	<138	11 (64.7%)	7 (46.67%)	18 (56.25%)	p=0.476
	Referent value	138-175 g/L			
Platelet number ($x10^9$)	Mean ± SD	198 ± 54.7	208.4 ±50.3	202.875±52.12	p=0.582
	Median	204	194	191	
	Q1-Q3	135-324	150-311	135-324	
	<150	4 (23.5%)	0	4 (12.5%)	p=0.104
	Referent value	150-450 x 10^9/L			
INR	>3	0	0	0	/
	Referent value	2-3.5			

Table 4: Laboratory values on the admission to the hospital.

The most common complication after PSA treatment was residual hematoma, which resolved spontaneously. A significant drop in hemoglobin was observed in eight patients, necessitating blood transfusion. No deaths occurred in the study.

DISCUSSION

Vascular complications result in prolonged hospitalization and increased treatment costs, but they also represent an undeniable risk to the patient, due to higher morbidity and mortality rates (2,10). Progression of vascular complications can lead to further consequences in the affected limb, making early diagnosis and treatment crucial (1,12).

We analyzed risk factors for PSA formation after coronary interventions and compared them with a reference group to identify predictive factors indicating PSA development following initial hematoma formation. Reports suggest that women and patients over 75 years have a higher incidence of PSA (11,12), but our study did not find a statistically significant difference between the two groups. More than half of our patients had hypertension, hyperlipidemia, chronic kidney disease, and chronic heart disease. Chronic diseases accelerate atherogenesis, identifying them as risk factors for PSA formation, along with active smoking and overweight (9, 13,14). Six (35.3%) of our PSA patients were active smokers, and two (11.8%) were overweight. Literature reports that frequent use of antiplatelet and anticoagulant therapy increases the incidence of vascular complications (10). Collins et al. reported that 80% of patients developing PSA after transradial catheterization were on full anticoagulant therapy (13). In our study, regular use of antiplatelet and anticoagulant therapy was not a significant factor.

At hospital admission, 11 patients (64.7%) with PSA had low hemoglobin levels and 4 patients (23.5%) had thrombocytopenia. In the control group, 7 patients (46.7%) had low hemoglobin and none had thrombocytopenia. There was no statistically significant difference between PCA and hematoma patients, nor between surgically and conservatively treated PCA patients. No patient had elevated INR. Low hemoglobin and thrombocytopenia are independent hematological predictors of PSA and other vascular complications (6,15). Patients with INR values above 3 prior to intervention had a threefold increased risk of hemorrhage, possibly due to delayed activation of the coagulation cascade (12,14,18). At admission, all patients were on dual antiplatelet therapy, and 8 (47.1%) of PSA patients were on full anticoagulation, with no significant difference compared to the control group.

Therapeutic coronary interventions are associated with a risk of 2–6%, while diagnostic procedures have a risk of 0.5–2% (19). The majority of PSA patients (76.5%; 13 out of 17) underwent urgent coronary intervention for acute coronary syndrome, which is a known risk factor for PSA; however, this association did not reach statistical significance in our study. The initial radiological diagnostic method for all vascular complications is arterial Doppler ultrasound (11). According to multiple studies, most PSAs are diagnosed within the first 7 days after intervention (2). In our study, all patients who developed hematoma were diagnosed within the first 24 hours after coronary intervention, while PSA patients were diagnosed within 20 days. The average time to PSA diagnosis was 3.29 ± 4.7 days. Our study indicates that clinically significant PSA formation requires more time than hematoma diagnosis. Accordingly, if a hematoma does not worsen after 72 hours, it is unlikely that a PSA will form. Kim et al. reported large variations between coronary intervention and PSA diagnosis (median 191.7 days) (2), whereas our study showed a much shorter timeframe.

The main access sites for coronary interventions are the radial and femoral arteries. Femoral cannulation can be performed at the common femoral artery (CFA) or superficial femoral artery (SFA). CFA access is preferred due to better post-procedural hemostasis achieved by femoral head compression. SFA access is typically used only in overweight patients for easier arterial access (5). Radial artery puncture is preferred due to dual hand perfusion, which provides a safety mechanism against ischemia in case of vessel occlusion. Radial artery PSA incidence is <0.1%, while femoral PSA incidence ranges from 0.5 to 14% (15). In our study, the right femoral artery was the most common access site for coronary angiography and PCI, and most surgically treated PSAs were punctured at the CFA. The higher CFA PSA incidence likely reflects its status as the preferred access site. No correlation was found between access site and PSA formation or the need for surgical intervention. Guidewire sheath size and heparin dose were not associated with PSA formation or the need for surgical treatment.

In a study analyzing 132 iatrogenic PSAs, the median maximal diameter was 50 mm (40–59 mm) (12). Based on ultrasonography, the maximal PSA diameter in our study had a median of 30 mm (10–96 mm); 44 mm in the surgically treated group and 19 mm in the conservatively treated group. PSAs requiring surgery were significantly larger than those managed with compression.

Spontaneous regression is most commonly observed in smaller PSAs and in those with a narrow, long neck or low blood flow (11). Persistent PSA growth may compress the vein, nerves, and skin, leading to limb edema, deep vein thrombosis, compressive neuropathy or skin necrosis (9). Conservative treatment is attempted for PSAs <2 cm and in our study mainly included compression, with three patients additionally treated with compression bands or closure devices (TR band, Angioseal) or Agrastat (GP IIb/IIIa antagonist). Surgical treatment is required in approximately one-third of patients and is considered when PSA diameter is larger, when signs of infection or complications are present, or conservative treatment fails (7,10,16). Ten patients underwent surgical intervention, and seven were treated conservatively. Surgical exploration, vessel repair, and hematoma evacuation represent standard surgical modalities for vascular complications (16,17). Surgical treatment has a higher success rate, making it the preferred modality, though it carries higher complication and reintervention rates (17,18).

Analysis of the time from PSA diagnosis to surgical treatment showed a mean of 3.3 ± 2.3 days and a median of 3 days (range 1–9). Literature suggests that PSA should be surgically treated if persistent beyond 3 weeks (2). At our institution, a prompter surgical approach was adopted. Given the absence of major complications in our patients and the potential to shorten hospitalization with early surgery, reevaluation of the optimal timing for surgical management of these complications may be warranted.

CONCLUSION

Analysis of 17 patients with PSA following coronary intervention showed that the time from intervention to diagnosis was significantly longer compared to patients with hematoma. The critical monitoring period for patients is the first 72 hours, during which the majority of PSAs can be detected.

PSA size is an important prognostic parameter, pseudoaneurysms requiring surgical treatment had a significantly larger diameter (median 44 mm) compared to those managed conservatively. These findings may serve as guidance in determining the optimal therapeutic approach, aiming to reduce risk, shorten hospitalization, and improve treatment outcomes.

CONFLICT OF INTEREST AND FUNDING

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