

# ATLAS

## of Angiography in Patients with Diabetes

Edited by  
Drapkina O.M., Mamedov M.N., Rudenko B.A.

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In this atlas we present angiographic features in patients with diabetes and atherosclerosis of coronary, carotid, kidney, and peripheral arteries. Some chapters contain angiographic features and descriptions of angioplasty and stenting of various arteries. The atlas contains 10 chapters. In the first two chapters we describe the characteristics of atherosclerosis in diabetes and the approach towards its medical and surgical management. This book was developed in collaboration with the leading specialists from 3 federal medical research centers.

This atlas was created for cardiologists, endocrinologists, medical residents, and researchers.

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## Abbreviations

ABI	— ankle brachial index	IGT	— impaired glucose tolerance
ACS	— acute coronary syndrome	iSGLT-2	— sodium-glucose-transporter-2 inhibitors
aGLP-1	— glucose-like peptide agonists	LAD	— left anterior descending artery
AH	— arterial hypertension	LCA	— left coronary artery
ASCVD	— atherosclerotic cardiovascular disease	LCX	— circumflex artery
BP	— blood pressure	LVEF	— left ventricular ejection fraction
CABG	— coronary artery bypass graft surgery	MI	— myocardial infarction
CAD	— coronary artery disease	MVD	— multivessel coronary artery disease
CAS	— carotid artery stenting	OMB	— obtuse marginal branch
CCA	— common carotid artery	PAD	— peripheral artery disease
CCS	— the Canadian Cardiovascular Society classification	PCI	— Percutaneous coronary intervention
CEA	— carotid endarterectomy	PDA	— posterior descending artery
CHF	— congestive heart failure	PLB	— posterolateral branch
CI	— confidence interval	RA	— renal artery
CIA	— common iliac artery	RCA	— right coronary artery
CVD	— cardiovascular disease	RR	— risk ratio
DES	— drug-eluting stent	SFA	— superficial femoral artery
DFA	— deep femoral artery	STEMI	— ST-Elevation Myocardial Infarction
DM	— diabetes mellitus	TIA	— transient ischemic attack
ECA	— external carotid artery	VA	— vertebral artery
HbA1c	— hemoglobin A1c	WHO	— World Health Organization
ICA	— internal carotid artery		



Chapter 1

**DIABETES MELLITUS: DEFINITION,  
EPIDEMIOLOGY, AND CARDIOVASCULAR  
DISEASE**

Diabetes mellitus (DM) presents serious medical and social challenges for health policy and healthcare in all advanced countries. The prevalence of DM is increasing rapidly and reached the level of global epidemic [1, 2]. Longer life-expectancy and world population aging make the problem of DM management and prevention of complications more and more relevant. According to the International Diabetes Federation, in 2019 there were more than 463 million people with DM aged 20–79 years and by 2045 this number is expected to rise to 700 million with more cases among people aged 60–79 years [1]. The total global costs of treatment of DM and its complications are up to 12 % of global gross domestic product. In Russia, there are over 4.584 million patients with DM, which comprises around 2.97 % of the country population. Type 2 diabetes (T2D) is present in 92 % (4 million) individuals with DM [2].

The latest DM classification that is still used worldwide was developed in 1999 and is based on the etiology of diabetes (Table 1).

Table 1. WHO classification of diabetes 1999

Type 1 diabetes	Autoimmune Idiopathic Beta-cell destruction, usually leading to absolute insulin deficiency
Type 2 diabetes	May range from predominantly insulin resistance with relative insulin deficiency to a predominantly secretory defect with or without insulin resistance
Other specific types	Genetic defects of beta-cell function Genetic defects in insulin action Diseases of the exocrine pancreas Endocrinopathies Drug- or chemical-induced Infections Uncommon forms of immune-mediated diabetes Other genetic syndromes sometimes associated with diabetes
Gestational diabetes	Impaired glucose tolerance (IGT) first detected at any time during pregnancy

In 2019 WHO updated 1999 classification for it to facilitate three primary purposes: clinical care, etiopathology and epidemiology. However, this is not possible with our current state of knowledge. The Expert group considered it best to define a classification system that prioritizes clinical care and helps health professionals choose appropriate treatments, and whether to start treatment with insulin, particularly at the time of diagnosis (Table 2).

Table 2. WHO classification of diabetes 2019 [4]

Types of diabetes	Description
Type 1 diabetes	Immune-mediated beta-cell destruction and absolute insulin deficit. Onset occurs in childhood and young adults
Type 2 diabetes	Most common in adults. Different stages of beta-cell dysfunction and impaired glucose tolerance. Usually in overweight and obese people.
Hybrid forms of diabetes:	New types
Slowly evolving immune-mediated diabetes of adults	Similar to slowly evolving T1D in adults but often associated with metabolic syndrome, positivity for GAD autoantibodies and greater $\beta$ -cell function
Ketosis prone type 2 diabetes	Affected individuals present with ketosis and evidence of severe insulin deficiency but later go into remission and do not require insulin treatment. Frequent ketosis episodes. No evidence of autoimmunity.
Other specific types	
Monogenic diabetes Monogenic defects of $\beta$ -cell function Monogenic defects in insulin action	Caused by specific gene mutations, has several clinical manifestations that require different approach; occurs in childhood and in young adults. Caused by specific gene mutations; severe IR in the absence of obesity; Manifests when beta-cells can no longer compensate IR
Diseases of the exocrine pancreas	Caused by diseases and trauma of the exocrine pancreas
Endocrine disorders	

Drug- or chemical-induced Infections	Caused by drugs and certain toxins
Uncommon specific forms of immune-mediated diabetes	Associated with immunological diseases
Other genetic syndromes sometimes associated with diabetes	Many genetic syndromes are accompanied by an increased incidence of diabetes
Unclassified diabetes	This category should be used temporarily when there is not a clear diagnostic category especially close to the time of diagnosis of diabetes
Hyperglycemia first detected during pregnancy	
Diabetes mellitus in pregnancy	T1D or T2D first recognized in pregnancy
Gestational diabetes mellitus	Hyperglycemia that doesn't reach diabetes cut-off points

Cardiovascular disease (CVD) is the leading cause of early mortality in patients with T2D [1]. CVD associated with T2D is a global healthcare and social issue. The total global costs of treatment of DM and its complications are up to 12 % of global gross domestic product (GDP) [15]. In the middle of the 20<sup>th</sup> century, it was shown that patients with T2D are at high risk of vascular complications such as myocardial infarction (MI) and stroke. Cardiovascular disease (CVD) is associated with increased mortality in this patient group. Although prognosis after MI has improved over the last decades, the overall life expectancy is still significantly shorter compared with general population [7]. T2D patients without history of MI are at a significantly higher risk of MI in the following 7 years (20 %) compared with general population (3.5 %). Similarly, T2D patients with a history of previous MI are also at a higher risk of MI (40.5 %) compared with individuals without DM (18.8 %) [8]. 7-year risk of MI in patients with T2D was similar to MI risk in individuals without diabetes but with a history of previous MI. Thus, DM plays a ma-

ajor role in MI development probably as high as CAD.

Higher risk of CAD, association between DM and other CVD, such as congestive heart failure, arrhythmias and PAD are of great interest. A large prospective cohort study Clinical Disease Research Using Linked Bespoke Studies and Electronic Health Records (CALIBER) that included 1921 260 patients, 34.198 (1.8 %) of whom had T2D showed that CAD and CHF were the first manifestations of CVD in 16.2 % and 14.1 % of patients with T2D over the 5.5-year follow-up period [9]. Moreover, patients with co-existent CHF and T2D had inferior prognosis compared to those without T2D [10].

Hyperglycemia, a key feature of T2D, is a connecting link between diabetes and CVD. This connection was shown in 1920s after insulin was introduced [11]. Association between high glucose levels and CVD was confirmed in several populations [12, 13]. Therefore, most early anti-diabetes medications aimed to reduce hyperglycemia.

Diabetes also has vegetive effects on CAD treatment. The risk of stent restenosis, recurrent MI, and death from all causes after percutaneous coronary intervention (PCI) in patients with ST elevation myocardial infarction (STEMI) was higher in those with co-existent T2D. In patients in whom a drug-eluting stent (DES) was placed after MI restenosis occurred more frequently in those with T2D [14], even after 1 year after the stent was placed [15]. Patients with T2D are at higher risk of operative mortality during coronary artery bypass surgery (CABG) (RR 1.67) compared with individuals without diabetes [16].

T2D is also a risk factor for stroke. The case-control INTERSTROKE study that was carried out in 22 countries and included patients with and without acute stroke showed that individuals with T2D were at 35 % higher risk of

stroke compared with the participants without T2D [17]. Metanalysis of 102 prospective studies showed that the risk of ischemic stroke was 2.3 times higher, and the risk of hemorrhagic stroke was 1.6 times higher in patients with T2D [17].

Moreover, T2D is associated with worse outcomes and higher risk of disability after stroke. Among patients with acute stroke T2D was associated with high mortality rates and functional dependence (assessed by The Modified Rankin Scale) [19]. The Australian Stroke Clinical Registry showed worse functional results in patients with T2D 3 months after the stroke [20]. Patients with IGT also had worse functional outcomes and lower rate of home discharge after hospitalization for stroke [21].

Risk of recurrent stroke is also closely associated with diabetes. The Dutch TIA trial that included patients with nondisabling stroke or transient ischemic attacks showed that the risk of non-fatal stroke was 2.1 times higher in individuals with T2D [22].

Peripheral artery disease (PAD) is a common macrovascular complication in diabetic patients. German Epidemiological Trial on Ankle Brachial Index (getABI) Study showed that more patients aged 65 years and older with T2D had PAD (ABI<0.9) and claudication [23]. Patients with PAD had 20% higher risk of ischemic ulcers at 10 years and 3 times the chance of being diagnosed with T2D. Moreover, 30% of patients were diagnosed with ischemic rest pain and the presence of T2D 1.8 times increased the risk of this diagnosis [24].

ABI is commonly used to diagnose PAD and to assess its severity. The 0.9 cut-off is used to diagnose the presence of arterial occlusion. However, in patients with T2D occlusions can be found in the presence of higher values of ABI. That is associated with frequent underdiagnosis PAD in this population [25]. Clairotte et al. showed that the most sensitive cut-off value for PAD in T2D is between 1.0–1.1 [25]. ABI sensi-

tivity is limited in patients with T2D probably due to increased arterial stiffness [27]. PAD is often diagnosed in patients with T2D and especially in those with kidney disease and with ABI>1.4 [28].

Patients with T2D are also at risk of worse outcomes after peripheral artery revascularization [29]. Apart from higher risk of limb loss individuals with PAD suffer from more frequent cardiovascular events.

Development of new diagnostic approaches to T2D over the last decades resulted in better control of glycemia, HbA1c, blood pressure and lipid profile as well as lower risk of CVD compared with the end of 20<sup>th</sup> century.

The UK Prospective Diabetes Study (UK-PDS) showed that 10-year risk of CAD in diabetic patients was 16.4% lower in 2007–2208 compared with 1999–2000 (21.1%) [30]. In adult US population CVD mortality in diabetic patients decreased by 40% in 2003–2004 compared with 1997–1998. Mortality from CVD associated with T2D reduced by 60% [31]. Similar trends were seen in Sweden where the risk of CAD reduced from 37.6% in 2003 to 19<1% in 2008 [32].

Over the last decades the prevalence of stroke decreased, and the outcomes improved. In Finland between 1992 and 2002 the incidence of first CVD including CAD and ischemic stroke decreased in diabetic patients [33]. Other studies showed that the rates of mortality associated with T2D decreased over 1988–2002 but was still higher in patients with diabetes after the first stroke compared to the individuals without diabetes [34].

Multiple studies associate these changes with two factors:

- The development of effective pharmacologic therapy that changed both the approach towards glycemia control and the understanding of cardiovascular risk in T2D.
- Better access to surgical revascularization such as PCI with drug eluting stents that

reduced the incidence of restenosis and the need of revascularization in patients with T2D.

The association between T2D and pre-diabetes with CVD and the developments in diabetes treatment imply that the risk of CVD can be reduced by tighter glycemia control. Due to the role of hyperglycemia in the development of CVD tighter glycemia control seemed to be a logical approach towards CVD prevention (Table 3).

In the ACCORD study patients were randomized into two groups: tight glucose control with HbA1c target <6.0% and standard glucose control with HbA1c 7.0–7.9%. At 1-year patients with tight glycemic control had lower incidence of CVD but no changes in macrovascular events. Moreover, mortality and hypoglycemia rates and weight gain were significantly higher in the tight glucose control group compared with the standard therapy group [35].

Similarly ADVANCE study compared standard treatment with tight glucose control with gliclazide and other glucose lowering agents that were used as needed. 11,140 patients with T2D were randomized into two groups. In the tight glycemia control group mean HbA1c was 6.5% compared with the 7.3% in the control group at 5 years. According to the results of the study there were no significant differences in the incidence of macrovascular complications, car-

diovascular and all-cause death between the two groups. However, the incidence of severe hypoglycemia was higher in the tight glucose control group (RR 1.86) [36].

Similar results were shown in the VADT study that included 1791 patients with type 2 diabetes. Patients were randomized into the standard therapy group and tight glucose control group. At 5.6-year-follow-up there were no statistically significant differences in the incidence of CVD, cardiac death, and other macrovascular complications. Incidence of adverse events, primarily hypoglycemia, was significantly higher in the tight glucose control group compared with the standard therapy group [37].

Moreover 2 meta-analyses showed that tight glucose control reduces the risk of cardiovascular events primarily non-fatal MI. Cardiac death and all-cause death however did not differ significantly and the risk of hypoglycemia was higher in the tight glucose control group compared with the standard therapy group [38, 39].

Results of these studies show that tight glucose control alone is not sufficient for macrovascular complications prevention in diabetic patients. However, an approach based on multifactorial control of macrovascular diseases leads to the reduction of mortality and incidence of macro and micro vascular events as was shown in the STENO-2 study [40, 41].

Table 3. **Tight glycemic control and cardiovascular events in T2D according to ACCORD, ADVANCE and VADT studies. Hypoglycemia risk was significantly higher in patients with tight glycemic control**

Study	ACCORD		ADVANCE		VADT	
Number of participants	10,251		11,140		1,791	
Median follow-up	3.5 years		5 years		5.6 years	
Study group	Tight control	Standard therapy	Tight control	Standard therapy	Tight control	Standard therapy
Mean HbA1c	6.7%	7.5%	6.5%	7.3%	6.9%	8.4%
CV event	6.9% (p=0.16)	7.2%	10.0% (p=0.32)	10.6%	30.0% (p=0.14)	34.0%
Cardiac death	2.6% (p=0.02)	1.8%	4.5% (p=0.12)	5.2%	4.5% (p=0.29)	3.7%
All-cause death	5.0% (p=0.04)	4.0%	8.9% (p=0.28)	9.6%	11.4% (p=0.62)	10.6%
Hypoglycemia	10.5% (p<0.001)	3.5%	2.7% (p<0.001)	1.5%	1333 cases (p<0.001)	383 cases

Table 4. Effects of different SGLT-2 inhibitors on cardiovascular outcomes in diabetic patients

Study	Medication	Number of patients	Follow-up	Patients with CVD	Patients with CHF	MACE	Hospitalizations for CHF	Cardiovascular death
EMPAREG OUTCOME [45]	Empagliflozin	7020	3.1 y.	7020 (100%)	706 (10.1%)	-14% 0.86 (0.74–0.99)	-35% 0.65 (0.50–0.85)	-38% 0.62 (0.49–0.77)
CANVAS Program [46]	Canagliflozin	10142	2.4 y.	6656 (65.6%)	1461 (14.4%)	-14% 0.86 (0.75–0.97)	-33% 0.67 (0.52–0.87)	-13% 0.87 (0.72–1.06)
CREDESCENCE [47]	Canagliflozin	4401	2.6 y.	2220 (50.4%)	652 (14.8%)	0 (0.67–0.95)	-39% 0.61 (0.47–0.80)	-22% 0.78 (0.61–1.00)
DECLARE-TIMI 58 [48]	Dapagliflozin	17160	4.2 y.	6974 (40.6%)	1724 (10.0%)	-7% 0.93 (0.84–1.03)	-27% 0.73 (0.61–0.88)	-2% 0.98 (0.82–1.17)
DAPA-HF [49]	Dapagliflozin	4744	1.5 y.	–	4744 (100%)	–	-30% 0.70 (0.59–0.83)	-18% 0.82 (0.69–0.98)
EMPEROR-R [50]	Empagliflozin	3730	1.3 y.	–	3730 (100%)	–	-31% 0.69 (0.59–0.81)	-8% 0.92 (0.75–1.12)
VERTIS CV [51]	Ertugliflozin	8238	3.5 y.	CAD 6256 (75.9%) Cerebral atherosclerosis 1889 (22.9%) PAD (18.7%)	672 (24.5%)	-3% 0.97 (0.85–1.11)	-30% 0.70 (0.54–0.90)	-8% 0.92 (0.77–1.11)
SCORED [52]	Sot gliflozin	10584	1.3 y.	MI 2108 (20.0%) Revascularization 2375 (22.4%) Stroke 946 (8.9%)	3283 (31.0%)	-16% 0.84 (0.72–0.99)	-23% 0.77 (0.66–0.91)	-10% 0.90 (0.73–1.12)

As was discussed above insulin resistance plays a major role in the pathogenesis of cardiovascular disease and therefore can be used as a possible therapeutic target as was shown in several clinical studies. Metformin was associated with all-cause death reduction from 9.8% to 6.3% in patients with type 2 diabetes and atherosclerosis [42]. In the UKPDS study patients who were recently diagnosed with diabetes were randomized into diet therapy group and tight glucose control group with sulfonylurea, insulin, or metformin. Patients who took metformin had smaller reduction of HbA1c compared with patients who took sulfonylurea or insulin. However significant reduction of MI incidence and overall

mortality was shown in the metformin group at five-year follow up [43].

The trial of pioglitazone vs placebo in 3876 patients without type 2 diabetes but with insulin resistance and a history of stroke or TIA showed that the use of pioglitazone was associated with reduced risk of fatal or non-fatal stroke or MI [44].

These studies show that increased insulin sensitivity can not only reduce the risk of cardiovascular complications in patients with a history of type 2 diabetes but also in patients with insulin resistance but no diabetes.

Lately it was shown that two classes of new anti-diabetic medications — Glucagon-like

Table 5. Effects of different GLP-2 agonists on cardiovascular outcomes in diabetic patients

Study	Medication	Number of patients	Follow-up	Patients with CVD	Patients with CHF	MACE	Hospitalizations for CHF	Cardiovascular death
ELIXA [53]	Lixisenatide	6068	2,1 r.	6068 (100%)	1358 (22 %)	+2% 1.02 (0.89-1.17)	-4% 0.96 (0.75-1.23)	-2% 0.98 (0.78-1.22)
LEADER [54]	Liraglutide	9340	3,8 r.	7598 (81%)	1667 (18 %)	-13% 0.87 (0.78-0.97)	-13% 0.87 (0.73-1.05)	-22% 0.78 (0.66-0.93)
SUSTAIN 6 [55]	Semaglutide	3297	2,1 r.	2735 (83%)	777 (24%)	-26% 0.74 (0.58-0.95)	+11% 1.11 (0.77-1.61)	-2% 0.98 (0.65-1.48)
EXSCEL [56]	Exenatide	14752	3,2 r.	10782 (73%)	2389 (16 %)	-9% 0.91 (0.83-1.00)	-6% 0.94 (0.78-1.13)	-12% 0.88 (0.76-1.02)
Harmony Outcomes [57]	Albiglutide	9463	3,8 r.	7598 (81%)	1667 (18 %)	-22% 0.78 (0.68-0.90)	-29% 0.71 (0.53-0.94)	-7% 0.93 (0.73-1.19)
REWIND [58]	Dulaglutide	9901	5,4 r.	3114 (31%)	853 (9%)	-12% 0.88 (0.79-0.99)	-7% 0.93 (0.77-1.12)	-9% 0.91 (0.78-1.06)
PIONEER 6 [59]	Semaglutide (per os)	3183	1,3 r.	2695 (85%)	388 (12%)	-21% 0.79 (0.57- 1.11)	-14% 0.86 (0.48-1.44)	-51% 0.49 (0.27-0.92)

peptide-1 agonists (GLP-1 agonists) and Sodium-glucose co-transporter-2 (SGLT2) inhibitors are able to reduce the risk of CVD in and cardiovascular events in patients with type 2 diabetes and a history of CVD or at high risk of CVD.

Recent meta-analysis of five studies that used SGLT 2 inhibitors showed a significant risk reduction of a combined MACE (non-fatal MI, non-fatal stroke cardiovascular death) endpoint: RR 0.9, 95 % CI 0.85 to 0.95. These advantages were shown for patients with a history of atherosclerosis.

It was shown that most SGLT 2 inhibitors reduce the risk of hospitalizations for congestive heart failure (CHF) (table 4). meta-analysis of trials that investigated the effects of SGLT 2 inhibitors on HF showed the reduction in the hospitalization for HF decompensation by 32 %.

A class of GLP-1 antagonists became one of the recognized therapeutic options for glycemia and body weight control for the treatment of T2D.

As for now, four GLP-1 agonists (liraglutide, subcutaneous semaglutide, albiglutide

and dulaglutide) were shown to reduce MACE. Meta-analysis of seven studies of clinical outcomes in GLP one agonists that included a total of 56.004 participants showed that the use of GLP-1 agonists reduces MACE risk by 12 % (HR 0.88, 95 % CI 0.82-0.94), cardiovascular death by 12 % (HR 0.88, 95 % CI 0.81-0.96), fatal or non-fatal MI by 9 % (HR 0.91, 95 % CI 0.83-0.99) and fatal or non-fatal stroke by 16 % ((HR 0.94, 95 % CI 0.76-0.93) (Table 5).

In 2019 The American Diabetes Association (ADA) and The European Association for the Study of Diabetes (EASD) release new guidelines for the treatment and prevention of CVD in patients with T2D or prediabetes [60]. this document emphasizes the need of cardiovascular risk assessment (moderate, high, very high) and recommends GLP-1 agonists or SGLT-2 antagonists as first line agents in patients with high or very high cardiovascular risk. These agents are recommended independently from the use of metformin or the glycemic status.

## Conclusion

Diabetes mellitus is associated with high risk of macrovascular complications due to the hyperglycemia hyperinsulinemia and insulin resistance. Tight glycemic control alone doesn't guarantee the reduction of mortality and cardiovascular events, and a complex approach that consists of lifestyle changes hyperglycemia

control and CVD risk factor treatment is necessary for cardiovascular risk reduction in these patients. The use of modern medications with positive cardiovascular effects can reduce the risk of CVD, cardiovascular events, and revascularization in patients with diabetes.

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Chapter 2

**ANGIOGRAPHY AND STENT PLACEMENT  
IN PATIENTS WITH DIABETES AND  
ATHEROSCLEROSIS: USES AND LIMITATIONS**

T2D is a major risk factor for CVD including coronary artery disease, stroke, PAD and CAD, that is caused by rapid total diffuse atherosclerosis [1]. Patients with T2D more often undergo coronary and peripheral artery revascularization including repeat revascularisation compared with general population [2, 3]. Therefore, the correct choice of atherosclerosis

management in patients with T2D that includes pharmacologic agents and surgical interventions plays a major role in clinical prognosis [4, 5].

In this chapter we present latest information on coronary and peripheral artery revascularization and concurrent pharmacologic management in patients with T2D.

### **The role of coronary and peripheral artery angiography in patients with diabetes**

CAD in patients with diabetes is characterized by diffuse rapid multiple vessel involvement with calcinosis that often requires corner with vascularization in addition to optimal pharmacologic management. CAD in T2D is associated with rapid multivessel damage with vessel calcinosis that frequently requires coronary revascularization in addition to standard pharmacologic management. Atherosclerotic plaques secondary to T2D are less stable due to the high-lipid core, macrophage accumulation and thin fibrotic capsule [6].

Coronary angiography results in patients with diabetes correlate poorly with hemodynamic changes. Fractional flow reserve invasive assessment is a more precise method that allows to determine coronary artery stenoses that cause significant hemodynamic changes and myocardial ischemia. Myocardial perfusion visualization with emission computed tomography (ECT) is a non-invasive technique that allows to identify hemodynamically significant coronary artery stenosis that can cause MI. However, these complicated and expensive techniques can't always rule out myocardial ischemia in patients with T2D compared with patients without T2D. Therefore, a delay in revascularisation due to the absence of proven ischemia (revasculariza-

tion only in patients with proven ischemia) isn't safe in patients with T2D. Among the possible causes of this phenomenon are high prevalence of microvascular dysfunction, rapid diffuse atherosclerosis, and specific characteristics of atherosclerotic plaques (larger necrotic core and higher concentration of calcium) in patients with T2D [7].

Severity of atherosclerosis can be assessed with intravascular ultrasound or with non-invasive coronary artery CTA with coronary artery calcium (CAC) scoring. One step increase in CAC score (1–99 to 100–399 and  $\geq 400$  Aratston units) is associated with higher mortality risk [8].

Ultrasound assessment of carotid intima-media thickness in patients with T2D doesn't lead to better prediction of CAD and CV events risk compared with CAC score. On the contrary, large atherosclerotic plaques are independent predictors of CVD and CV events (CAD, ischemic stroke, PAD) [9].

PAD screening is currently performed by calculation of ankle-brachial index (ABI).  $ABI < 0.9$  or  $> 1.4$  is associated with higher risk of all-cause and cardiovascular mortality in patients with T2D [10].

## **Myocardial revascularization in acute coronary syndromes in patients with diabetes**

Atherosclerosis in diabetes is associated with many factors other than hyperglycemia that frequently lead to left coronary artery (LCA) stenosis, multivessel coronary artery disease (MVD), diffuse coronary artery changes with frequent distant branch involvement [1]. Percutaneous intervention (PCI) with coronary revascularization is the first line treatment in patients with and without diabetes and with acute coronary syndrome (ACS) with ST-elevation [11]. However, PCI isn't the best choice for patients with T2D and MVD. A study from British Columbia, Canada, investigated the outcomes of all revascularization procedures in ACS in 2947 patients with T2D and MVD from 2007 to 2014. The total number of all severe complications that included all-cause death, MI and stroke was lower in CABG compared with PCI (4.3 % vs 8.2 %;  $p < 0.01$ ) after 30 days and 3.3 years (20.8 % vs 33.4 % respectively;  $p < 0.01$ ). CABG was associated with lower rates of repeat revascularization (8.2 % vs 22.6 % after PCI respectively;  $p < 0.01$ ), MI (9.9 % vs 17.6 % respectively;  $p < 0.01$ ) and all-cause death (12.4 % vs 22.3 % respectively;

$p < 0.01$ ). There were no significant differences in the frequency of stroke in these two groups (6.2 % vs 5.8 % respectively;  $p = 0.97$ ) [12].

Current European guidelines on coronary revascularization in patients with T2D and non-STEMI are primarily based on the results of stable CAD studies and expert opinion due to the lack of reliable data [11]. Only one third of patients with T2D and MVD undergo CABG in non-ST-elevation acute coronary syndrome [13]. Overall, we can see that management of patients with ACS is based on stable CAD guidelines that don't consider pathophysiological mechanisms of coronary atherosclerosis in T2D — diffuse artery involvement. CABG is more effective in T2D as PCI targets more pronounced plaques without managing other lesions that can cause new atherothrombotic events, especially in the pro-inflammatory state associated with ACS. Moreover, patients with T2D usually have high burden of comorbidities (AH, CKD, CHF) and are at higher risk of post-PCI complications such as stent thrombosis and restenosis, that is associated with worse prognosis [14].

## **Myocardial revascularization in patients with diabetes and stable coronary artery disease**

### ***Stents vs bypass surgery***

Several studies compared CABG and PCI in patients with T2D and stable CAD. CABG was associated with higher risks of cardiovascular events in the first days-months after the procedure, primarily stroke. However, in the long-term perspective CABG was associated with reduced MI and revascularization incidence. In the randomized FREEDOM study (Future Revascularization Evaluation in Patients with Diabetes Mellitus: Optimal Management of

Multivessel Disease) CABG in patients with T2D was associated with lower risks of major cardiovascular events (all-cause death, MI, and stroke) compared with PCI at 3.8-year follow-up (18.7 % против 26.6 %,  $p = 0.005$ ). 7.5-year-follow-up showed lower mortality rates in CABG group compared with PCI group (18.3 % and 24.3 % respectively;  $p = 0.01$ ) [15]. Meta-analysis of 11 randomized studies ( $n = 11\,518$ ) including FREEDOM trial, showed higher rates of 5-year mortality in patients with T2D and stable

CAD after PCI compared with CABG (RR 1.48, 95 % CI 1.19–1.84;  $p=0.0004$ ) [16].

Later, a large retrospective study carried out in Ontario, Canada, in 2008–2017 compared PCI ( $n=4519$ ) and CABG ( $n=9716$ ) outcomes in patients with T2D and MVD [17]. Propensity score matching was used to reduce the baseline differences between the two groups and get 4301 pairs with 23 well-balanced parameters. Early mortality rates were similar in both groups (2.4 % in PCI vs 2.3 % in CABG;  $p=0.721$ ) but at 5.5-year follow-up all-cause death rates (RR 1.39 95 % CI 1.28–1.51) and the total incidence of major cardiovascular events (RR 1.99, 95 % CI 1.86–2.12) were significantly higher in the PCI group.

A recent meta-analysis that included 9 randomized studies of myocardial revascularization in patients with T2D and CAD ( $n=4566$ ) showed that PCI was associated with higher rates of all-cause death (RR 1.41 95 % CI 1.22–1.63;  $p<0.001$ ), death due to cardiovascular causes (RR 1.56 95 % CI 1.25–1.95;  $p<0.001$ ) and repeat revascularization (RR 2.68 95 % CI 1.86–3.85;  $p<0.001$ ) and with similar rates of MI (RR 1.20 95 % CI 0.78–1.85;  $p=0.414$ ) and lower rates of stroke (RR 0.51 95 % CI 0.34–0.77;  $p=0.001$ ) compared with CABG. A cumulative meta-analysis of all-cause death showed that the differences in CABG and PCI outcomes reached statistical significance 3 years after the procedure [18].

Another recent meta-analysis of 3 randomized and 5 observational studies ( $n=3835$ ) compared 10-year outcomes of CABG and PCI in patients with T2D and CAD with LCA stenosis. Patients who had undergone CABG had lower mortality rates (RR 0.85, 95 % CI 0.73–1.00,  $p=0.05$ ), MI risk (RR 0.53, 95 % CI 0.35–0.8,  $p=0.002$ ), repeat revascularization (RR 0.34, 95 % CI 0.26–0.46,  $p=0.00001$ ) and coronary revascularization.

Recently, the results of the study that assesses the 10-year clinical outcome of newgen-

eration biodegradable polymer-based sirolimus-eluting stents (Yukon Choice PC,  $n=1299$ ) versus permanent polymer-based enviroximes-eluting stents (Xience; Abbott,  $n=652$ ) in patients with and without DM were announced [23]. At 10 years patients with DM showed significantly higher major adverse cardiac event rates than patients without DM (hazard ratio [HR], 1.41; 95 % CI, 1.22–1.63;  $P<.001$ ). There was no significant difference between patients treated with Yukon Choice PC versus Xience. Rates of definite/probable stent thrombosis were 2.3 % in patients with DM and 1.9 % in patients without DM (HR, 1.27; 95 % CI, 0.34–2.60;  $P=.52$ ), without significant differences between study devices. The investigators concluded that the clinical outcome of patients with T2D versus patients without T2D after PCI with different new-generation DES is considerably worse, with event rates constantly increasing out to 10 years. However, it is unlikely that use of different new-generation DES in diabetic patients will result in equivalent efficacy and safety as compared with CABG.

### ***The need of MVD severity assessment***

SYNTAX scale assesses the number of atherosclerotic lesions, their severity and associated functional changes. SYNTAX score calculation helps identify patients at low ( $\leq 22$  points), medium (23–32 points) and high ( $\geq 33$  points) risk. Patients at high risk have better outcomes after CABG compared with PCI. However, results of the FREEDOM [15] study have casted some doubts on the use of the SYNTAX scale to guide revascularization method in patients with diabetes and MVD. According to the FREEDOM study CABG was associated with better outcomes irrespectively of the SYNTAX score. FREEDOM has shown no significant association between the better CABG outcomes and SYNTAX score [24].

CABG is a completely different approach to revascularization compared with PCI considering the procedure is performed with minimal risks. CABG is associated with several beneficial effects: (1) Graft perfusion with additional benefits of distal protection from new lesions in the proximal and middle segments, (2) Improved endothelial function due to additional NO from arterial grafts. On the contrary, PCI is associated with endothelial dysfunction and chronic inflammation that can worsen CAD [25]; (3) Collateral perfusion development in the myocardium where perfusion was recently restored [26]. Graft occlusion after CABG isn't as dangerous as stent occlusion that is associated with high morbidity and mortality [27]. On the contrary, graft occlusion is asymptomatic in most cases. There are also many opportunities for improvement of CABG such as wider use of arterial grafts, development of less invasive accesses, reduction of the risk of stroke and better secondary pharmacologic prophylaxis.

### ***Revascularization in patients with peripheral artery disease and diabetes***

Diabetes is the second most significant risk factor for PAD after smoking. 20–30 % of patients with PAD have diabetes, and diabetes increases the risk of PAD 2–4-fold [29, 29]. In diabetic patients PAD develops quickly and is associated with more functional disorders, poor quality of life, frequent cardiovascular events, and limb amputations [30–32]. Goals of PAD treatment are as follows: (1) Improvement of symptoms; (2) Prevention of PAD relapse, (3) Prevention of MI and stroke. Revascularization is recommended in patients with severe claudication and critical ischemia that can lead to limb amputation.

Endovascular treatment is the preferred option in symptomatic PAD, but the outcomes of this procedure haven't been properly compared with surgical revascularization. The choice between endovascular and surgical revascular-

ization depends on the location, morphology and extent of occlusion and is discussed in detail in the guidelines of the PAD diagnosis and management [10]. These guidelines, however, don't describe the specific features of PAD in T2D due to the lack of clinical studies.

An analysis of 14,012,860 cases from the PAD and DM hospitalized patient's registry (5.6 % of patients had T1D, n=784,720) showed that the incidence of severe chronic lower limb ischemia (45.2 % vs 32.0 %), ischemic ulcers (25.9 % vs 17.7 %) or complicated ulcer (16.6 % vs 10.5 %) was higher in T1D patients compared with T2D (all  $p < 0.001$ ). T1D was an independent predictor of limb amputation (corrected RR 1.12, 95 % CI 1.08–1.16,  $p < 0.001$ ) [33]. Further studies of the underlying mechanisms and new preventive approaches are required.

Endovascular or surgical revascularization is the first line treatment in critical lower limb ischemia and ischemic ulcers [34]. Negative pressure therapy, platelet-rich plasma and modern healing bandages, systemic anti-inflammatory and antimicrobial therapy are used to accelerate ischemic ulcer healing [35].

### ***Revascularization in patients with carotid artery disease and diabetes***

Most patients with asymptomatic extracranial coronary artery stenosis (60–99 %) and high surgical risk should be treated with pharmacologic therapy. Carotid endarterectomy (CEA) or carotid artery stenting (CAS) can be considered in patients with <3 % pre-operative risk of stroke/MI and life expectancy of >5 years.

In patients with asymptomatic 70–99 % carotid stenosis CEA is recommended. It should be considered in symptomatic 50–69 % stenosis. CAS should be considered in recently identified symptomatic 50–99 % carotid stenosis with comorbidities or high-risk anatomic factors.

Symptomatic 50–99 % carotid stenosis should be performed in the first 14 days after the

symptom onset. Carotid artery revascularization in each symptomatic patient poses a <6% risk of perioperative stroke/death. Revascularization is not recommended in patients with <50% carotid artery stenosis [10].

According to the analysis of 752 carotid artery revascularizations (CAS 58.2% and CEA 41.8%), DM is associated with a higher perioperative risk of any stroke or death (3.6% in DM vs 0.6% in no DM;  $p < 0.05$ ), TIA (1.8% in DM vs 0.2% in no DM), restenosis (2.7% in DM vs 0.6% in no DM;  $p < 0.05$ ). In the 36-month follow up period there were no significant differences in mortality rate, stroke, and TIA incidence in patients with and without DM for CAS and CEA subgroups. The incidence of restenosis was higher in patients with diabetes (21.2% in DM vs 12.5% in no DM;  $p < 0.05$ ) [36]. Other authors have also described that diabetes was one of the leading risk factors for restenosis after carotid artery revascularization [37]. Patients with diabetes are at a higher risk of cerebral ischemic damage during CAS despite the use of protective systems [38].

### ***Pharmacologic prophylaxis of atherosclerosis complications in patients with diabetes***

Lifestyle interventions such as smoking cessation, eating a healthy diet, weight control and regular exercise are crucial for the prevention of complications along with pharmacologic management.

Undoubtedly, a good control of glycemia is necessary for successful revascularization. HbA1c level >8% and especially >9% is associated with increased mortality and adverse cardiac events after CABG [39]. Lee HF et al. [39] have shown that, compared with DPP-4 inhibitors, SGLT-2 inhibitors decreased the risk of lower limb ischemia requiring revascularization (RR 0.66, 95% CI 0.49–0.89,  $p = 0.0062$  vs 0.73, 95% CI 0.54–0.98;  $p = 0.0367$ ) or amputation (RR

0.43, 95% CI 0.3–0.62,  $p < 0.0001$ ) and cardiovascular death (RR 0.67, 95% CI 0.49–0.9;  $p = 0.0089$ ) [40]. GLP-1 agonists (dulaglutide, liraglutide, semaglutide) are preferred in patients with CVD and atherosclerosis [5]. Large randomized clinical trials that would compare aGLP-1 with iSGLT-2 are lacking. According to the meta-analysis that included 8 studies in T2D patients ( $n = 77,242$ ) aGLP-1 and iSGLT-2 had comparable effects on the risk of major cardiovascular events (RR 0.87, 95% CI 0.82–0.92 and 0.86, 95% CI 0.8–0.93) [41].

AH and T2D management should include ACEi or ARB with CCB and/or diuretic to achieve target blood levels (systolic blood pressure <130 mmHg but >120 mmHg; in patients >65 years old 130–139 mmHg, diastolic <80 mmHg, but no <70 mmHg). Statins should be used in patients with T2D. High-dose statins are recommended in patients with atherosclerosis (target low density lipoprotein in very high cardiovascular risk <1.4 mmol/l). The use of statins reduces the risk of cardiovascular events after PCI and CABG [4, 5, 42]. However, triglycerides can remain high in individuals taking statins increasing the risk of cardiovascular adverse outcomes [43]. In this case additional use of omega-3 acid ethyl esters can significantly reduce the need in PCI (RR 0.68, 95% CI 0.59–0.79,  $p < 0.0001$ ) and CABG (RR 0.61, 95% CI 0.45–0.81;  $p = 0.0005$ ) [44].

Antiplatelet therapy with 75–100 mg of aspirin is recommended for secondary prevention of cardiovascular events in patients with DM or for primary prevention in patients at high/very high risk. The use of direct-acting P2Y<sub>12</sub>-receptor antagonists ticagrelor or prasugrel together with aspirin is recommended in diabetic patients for 1 year after ACS or CABG/PCI [4, 5]. The use of 2.5 mg of apixaban twice daily together with 100 mg of aspirin has been shown to reduce the total risk of MI, stroke, cardiovascular death, and major amputations compared with

**Table. Revascularization and pharmacologic management that improve the clinical outcomes in patients with DM**

ACVD	Preferred revascularization	Pharmacologic management	Additional pharmacologic options if indicated
ACS	CABG	Dulaglutide/liraglutide/ semaglutide Empagliflozin/Dapagliflozin Statins/ aspirin	direct-acting P2Y12-receptor antagonists
Stable CAD with MVD	CABG		Rivaroxaban
PAD	Endovascular treatment		
Carotid artery stenosis	CEA		

aspirin alone [45]. Thus, the use of combined antithrombotic therapy shows promising results.

## Conclusion

Management of diabetic patients with atherosclerotic CVD (ACVD) should be carried out by the endocrinologists and cardiologists together. Patient-centered team-based care allows to choose the most effective and safe treatment that should include coronary and peripheral artery

revascularization. New pharmacologic agents of diabetic patients with ACVD reduce the need in surgical procedures and improve the outcomes if the procedure were performed. Different types of management that are associated with better clinical outcomes are presented in the Table.

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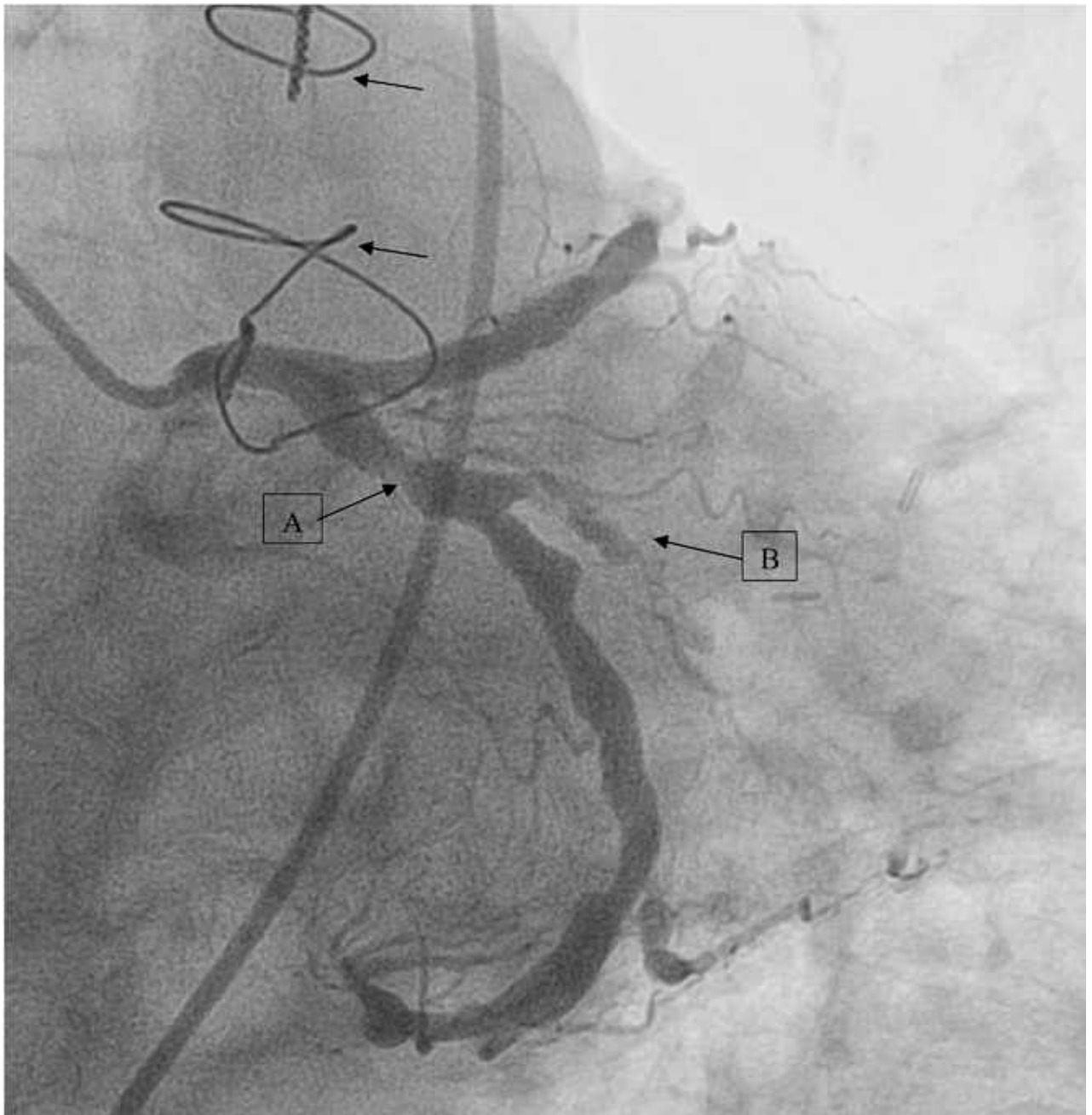
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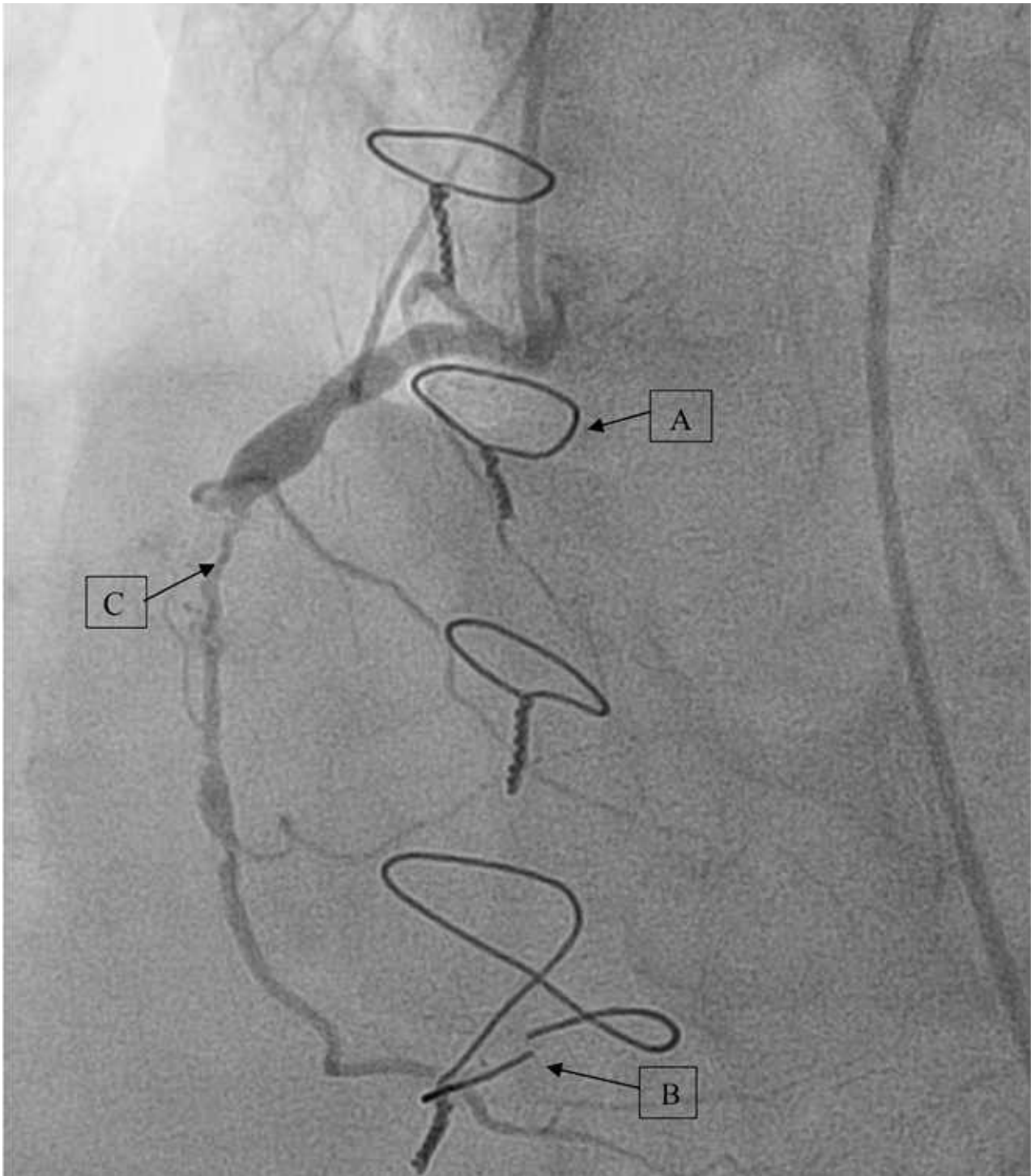
Chapter 3  
**CORONARY ANGIOGRAPHY IN PATIENTS  
WITH DIABETES**



**A 77-year-old male** with a history of CAD, class III stable angina according to the Canadian Cardiovascular Society (CCS) classification and CABG 10 years ago. Arrow shows at midline sternotomy wires.

The circumflex artery (LCX) graft occlusion, proximal (A) LCX 80% stenosis and obtuse marginal branch (OMB) thrombotic occlusion (B). Areas of

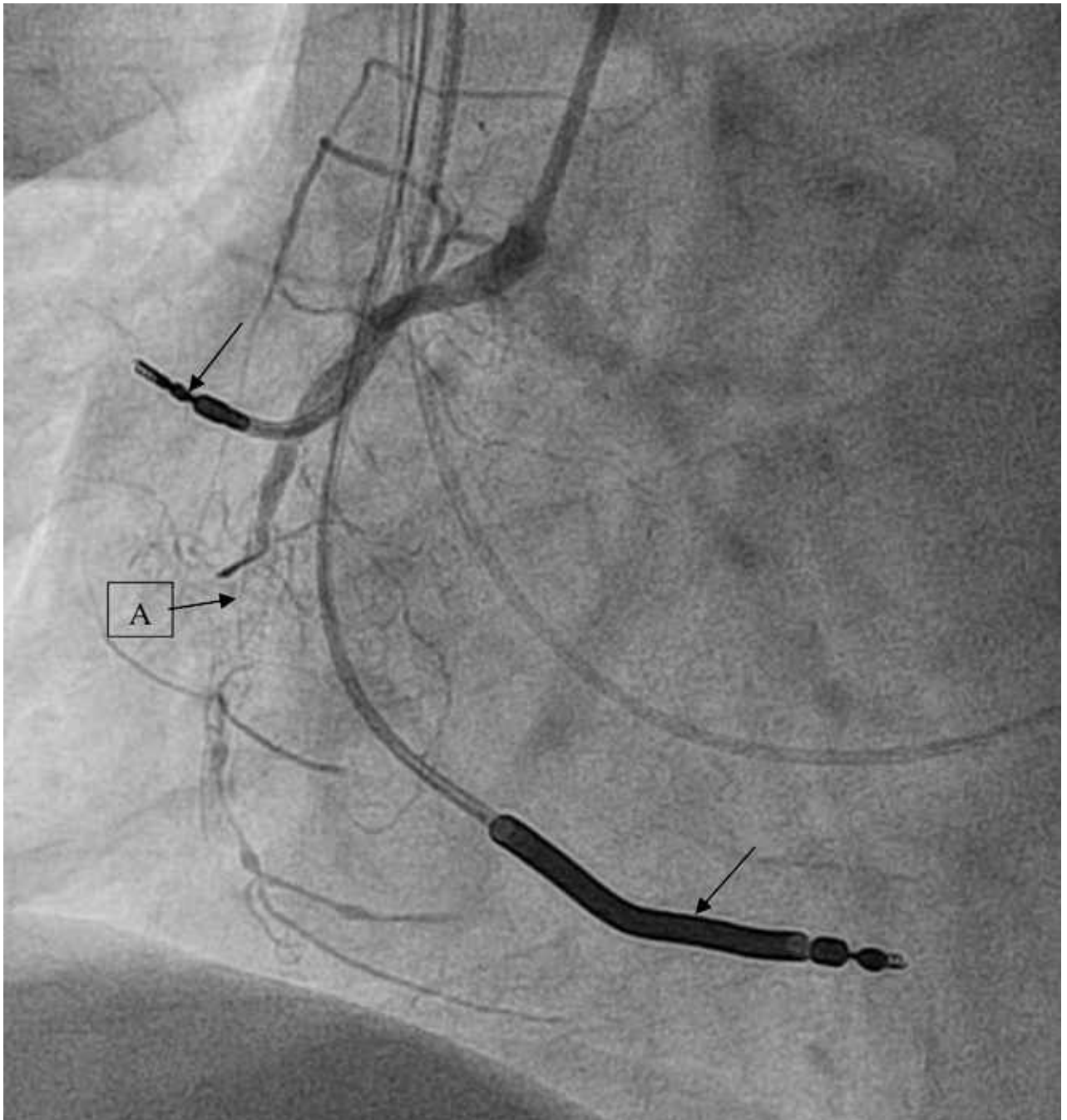
intraluminal lucency and coronary filling defects are characteristic of arterial thrombosis. PCI of LCX is planned.



**A 75-year-old female** with a history of CAD, CCS class III stable angina and CABG 7 years ago. Midline sternotomy wires (A). Lower wire deformation (B) is a common finding and is not dangerous.

Angiographic features of right coronary artery (RCA) occlusion (B). Antegrade flow is present only

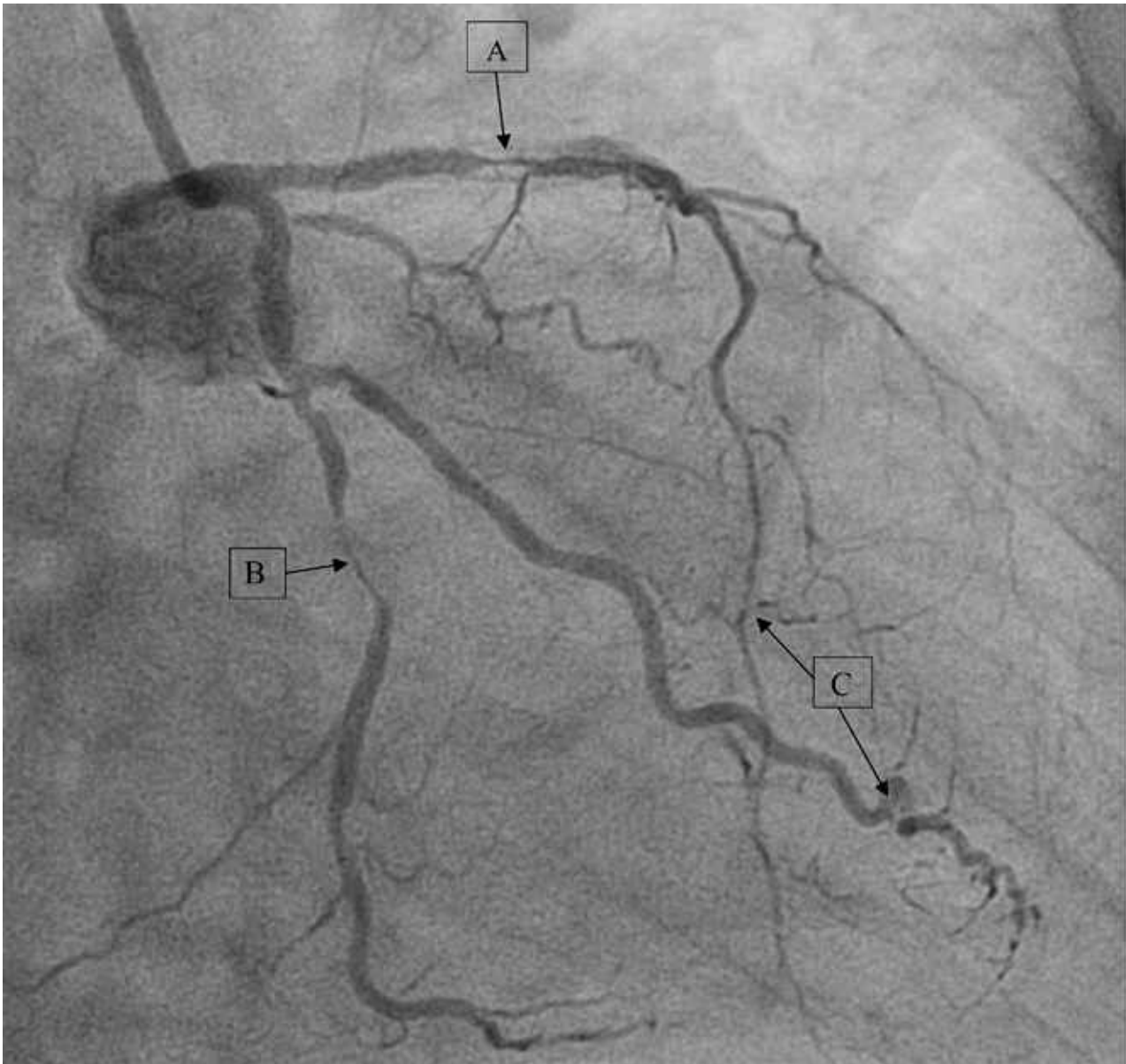
in the right marginal branch (RMB). Distal segments of RCA are filled by collateral supply.



**A 65-year-old male** patient with a history of CAD, CCS class III stable angina and postinfarction cardio-sclerosis due to left ventricular anterolateral and inferior MI.

An implantable cardioverter-defibrillator (ICD) electrodes (arrows). Echochardiography showed a 30% left ventricular ejection fraction (LVEF), anterior, anterolateral and inferior wall hypokinesia.

Occlusion and restenosis in mid-RCA (A). RCA PCI was performed to restore blood flow.

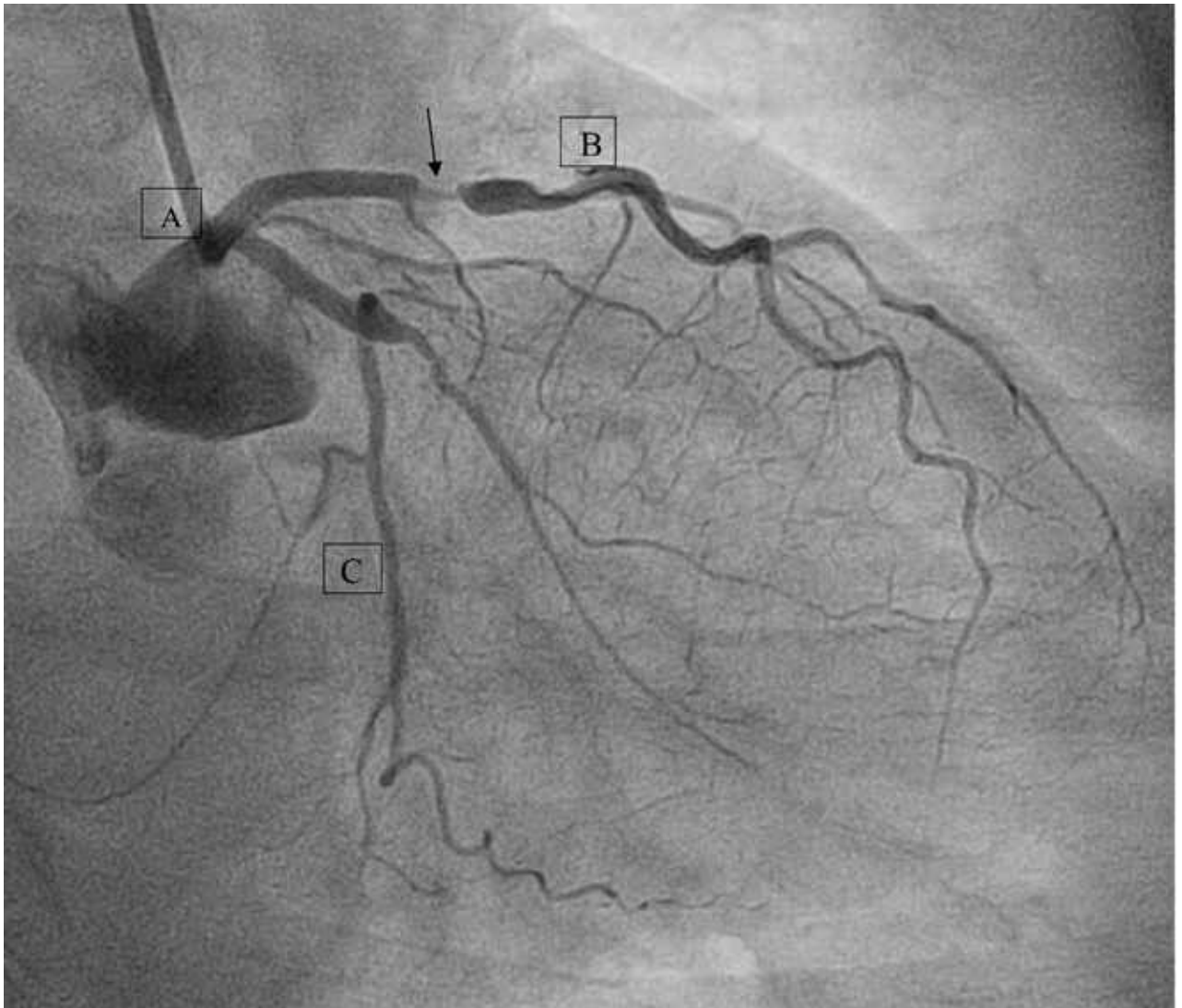


**A 83-year-old female** with a history of CAD, CCS class III stable angina, T1D, left anterior descending artery (LAD) stenting 7 years ago.

Coronary angiogram shows a 90% LAD stent restenosis (A), distal LCX with 99% stenosis (B). Syntax-Score I = 9.

LAD and LCX stenting was performed to improve quality of life. Diffuse atherosclerosis of distal arteries is a common finding in patients with diabetes (B).

The patient was discharged, referred for diabetes education and advised on healthy diet and glycemia control.



**A 28-year-female** with a history of familial hypercholesterolemia and T1D presented with substernal chest pain that started abruptly 2 hours ago and was diagnosed with non-ST segment-elevation ACS.

Coronary angiogram shows proximal LAD 85% stenosis (intraluminal lucency is suggestive of probable mural thrombus — arrow).

PCI with LAD stent placement was performed. Patient was successfully discharged home, described

feeling healthy and was referred to a lipidologist for follow-up treatment.

(A) — *left main coronary artery (LMCA)*,  
(B) — *left anterior descending artery (LAD)*,  
(C) — *circumflex artery (LCX)*.



**A 44-year male** presented with chest pain at rest that started 1.5 hours prior to admission was diagnosed with II, III, aVF ST-elevation ACS.

Coronary angiogram shows a thrombotic occlusion of the proximal-to-middle RCA segment (arrow). Areas of intraluminal lucency, luminal filling defect with a surrounding rim of contrast are characteristic

of arterial thrombosis. PCI with thrombectomy and stent placement was performed.

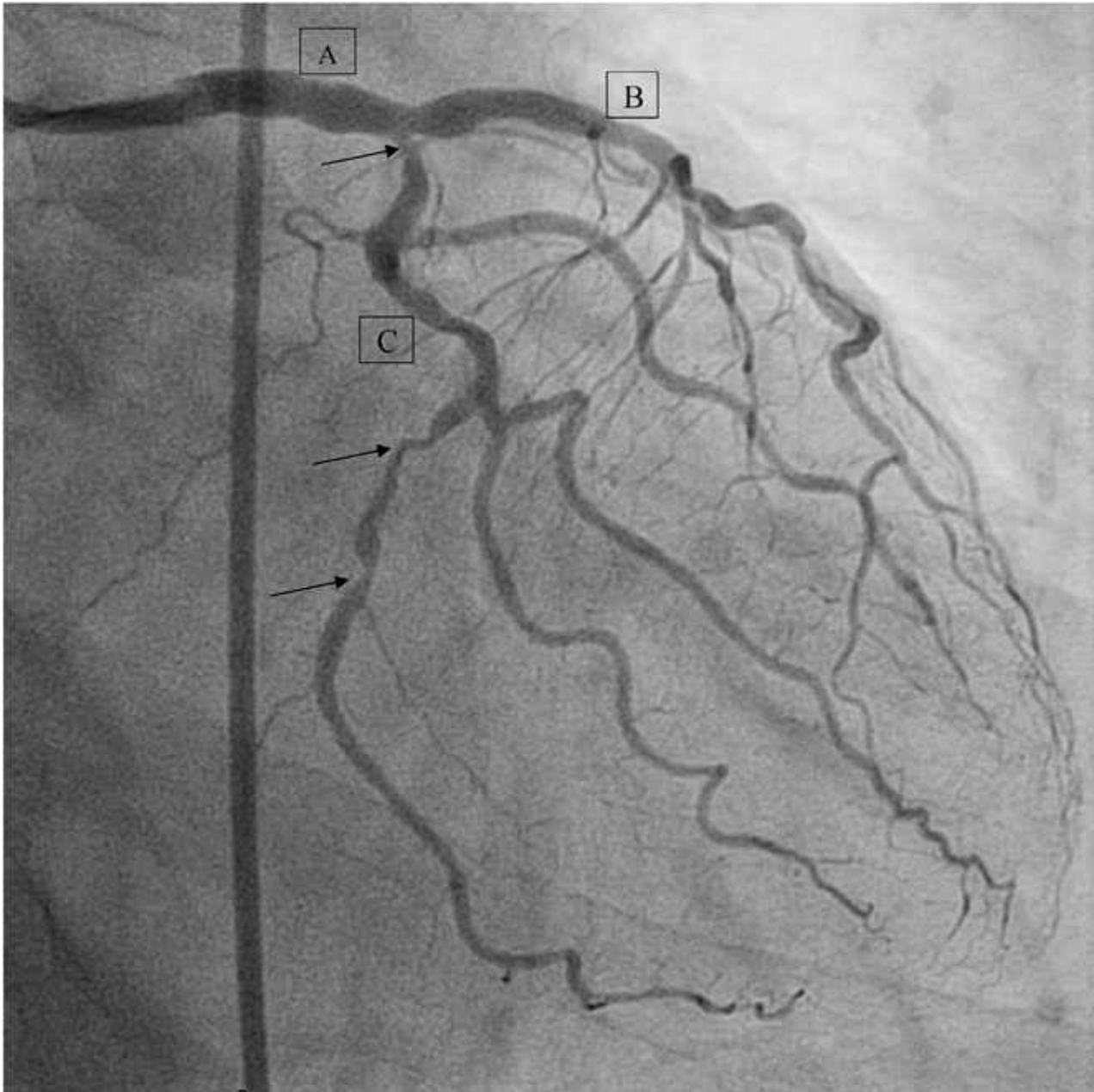
(A) — *right coronary artery (RCA)*,  
(B) — *right marginal artery (RMA)*.



**A 58-year old male** with a history of RCA stenting 3 months ago presented with fatigue and shortness of breath at rest.

ECG showed ST elevation in II, III and aVF. The patient missed 3 days of dual antiplatelet therapy and developed stent thrombosis (arrow). Repeat RCA stenting was performed, patient was instructed on treatment adherence.

(A) — *right coronary artery (RCA)*,  
(B) — *right marginal branch (RMB)*,  
(C) — *posterior descending artery (PDA)*



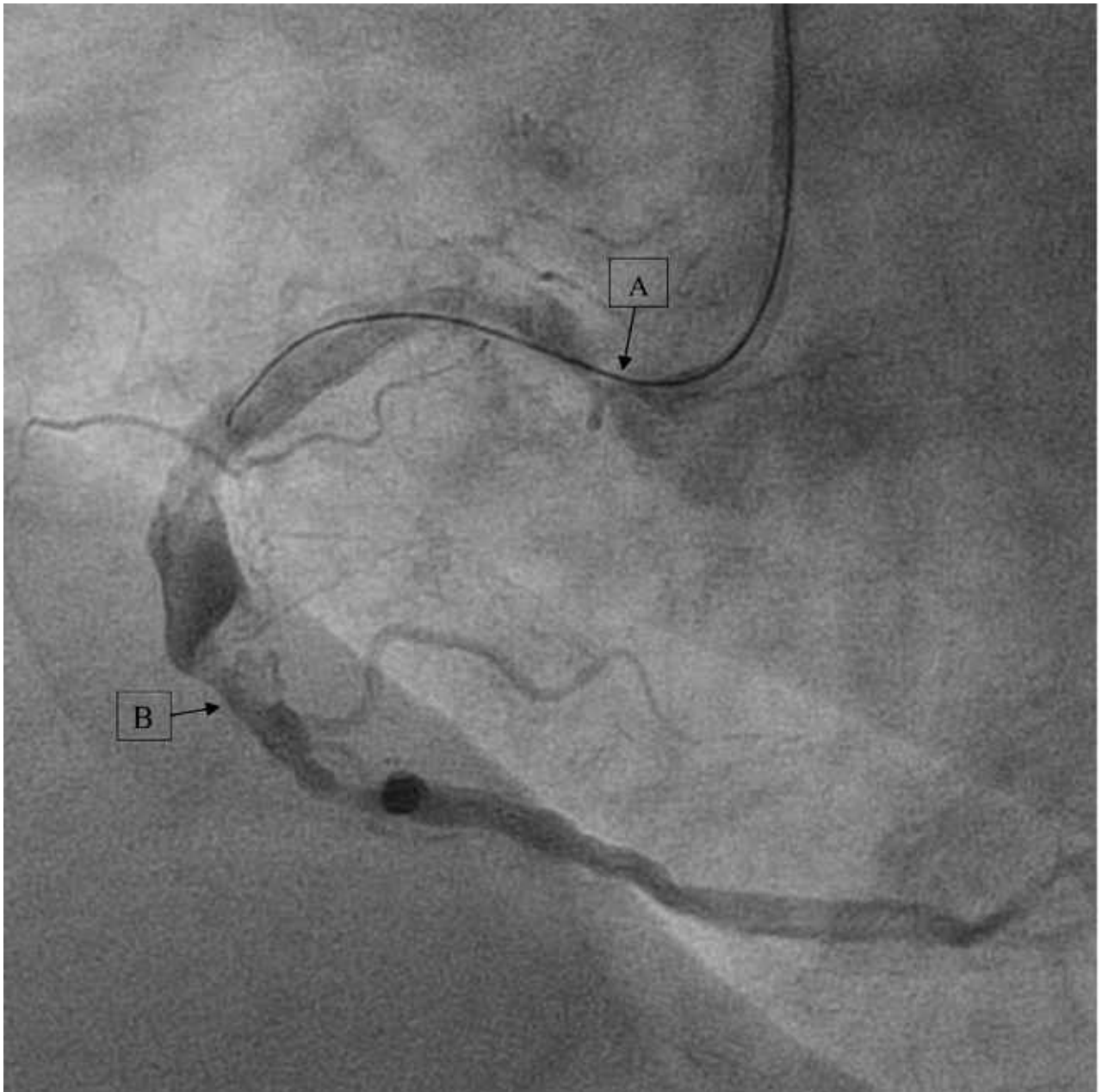
**A 73-year-old female** with a 10-year history of CAD, stable angina CCS class III, hypertension, and T2D.

Coronary angiogram shows a tandem<sup>1</sup> 80% and 90% LCX stenosis (arrows).

Distal artery twisting is a sign of long-term hypertension.

(A) — *left main coronary artery (LMCA)*,  
(B) — *left anterior descending artery (LAD)*,  
(C) — *circumflex artery (LCX)*.

<sup>1</sup> A coronary tandem lesion was defined as 2 separate stenoses with 50% diameter stenosis determined by visual estimation, separated by an angio-graphically normal appearing segment.

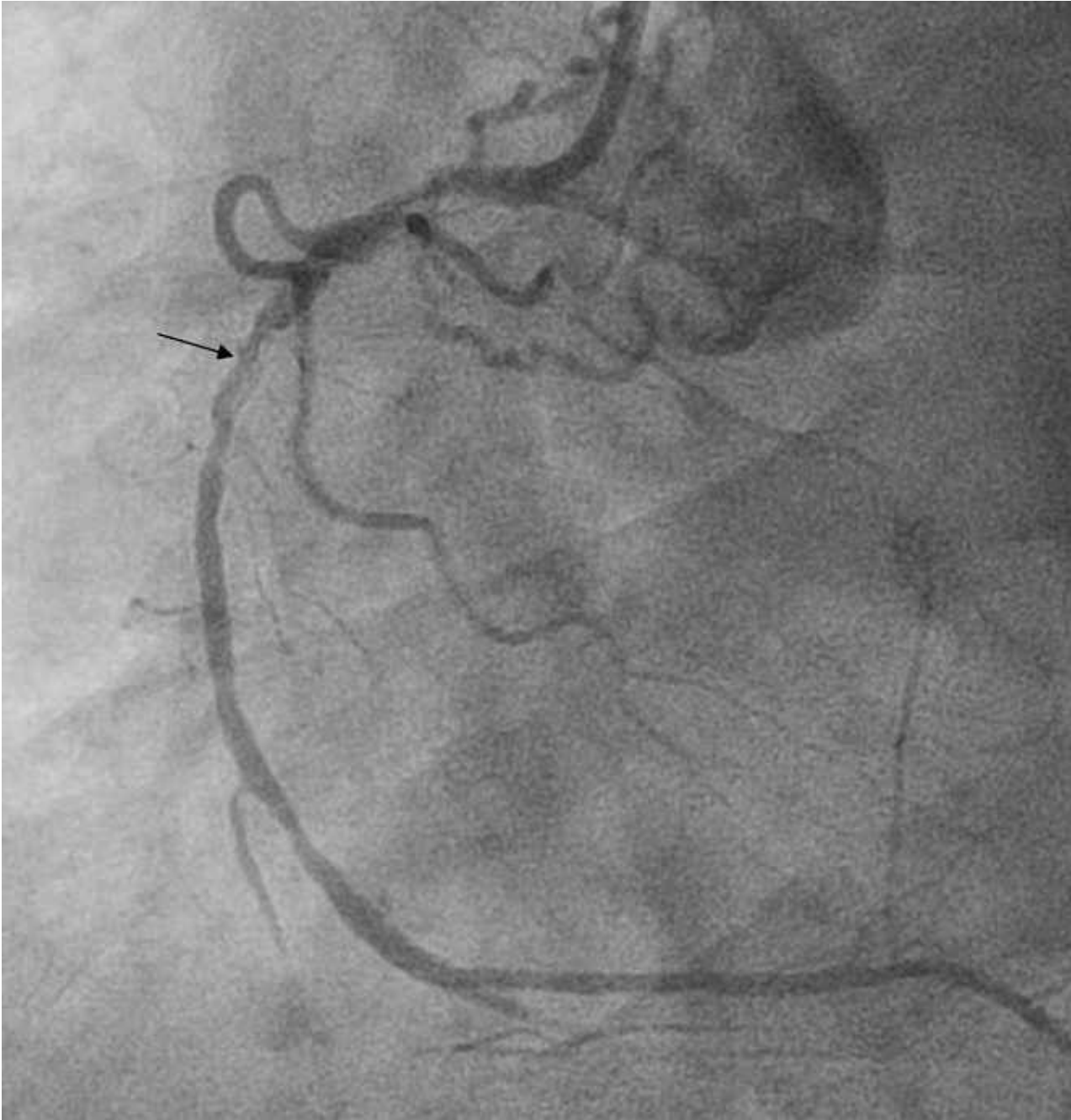


**A 71-year-old male** with a history of CAD, CCS III stable angina and T1D.

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Coronary angiogram shows diffuse RCA stenosis: a 90% orifice stenosis (A), 80% mid-RCA stenosis. Diffuse coronary artery atherosclerosis is a typical finding in patients with poorly controlled diabetes. Mid-artery atherosclerosis is characterized by calcinosis, marginal ulceration, plaque contrast enhance-

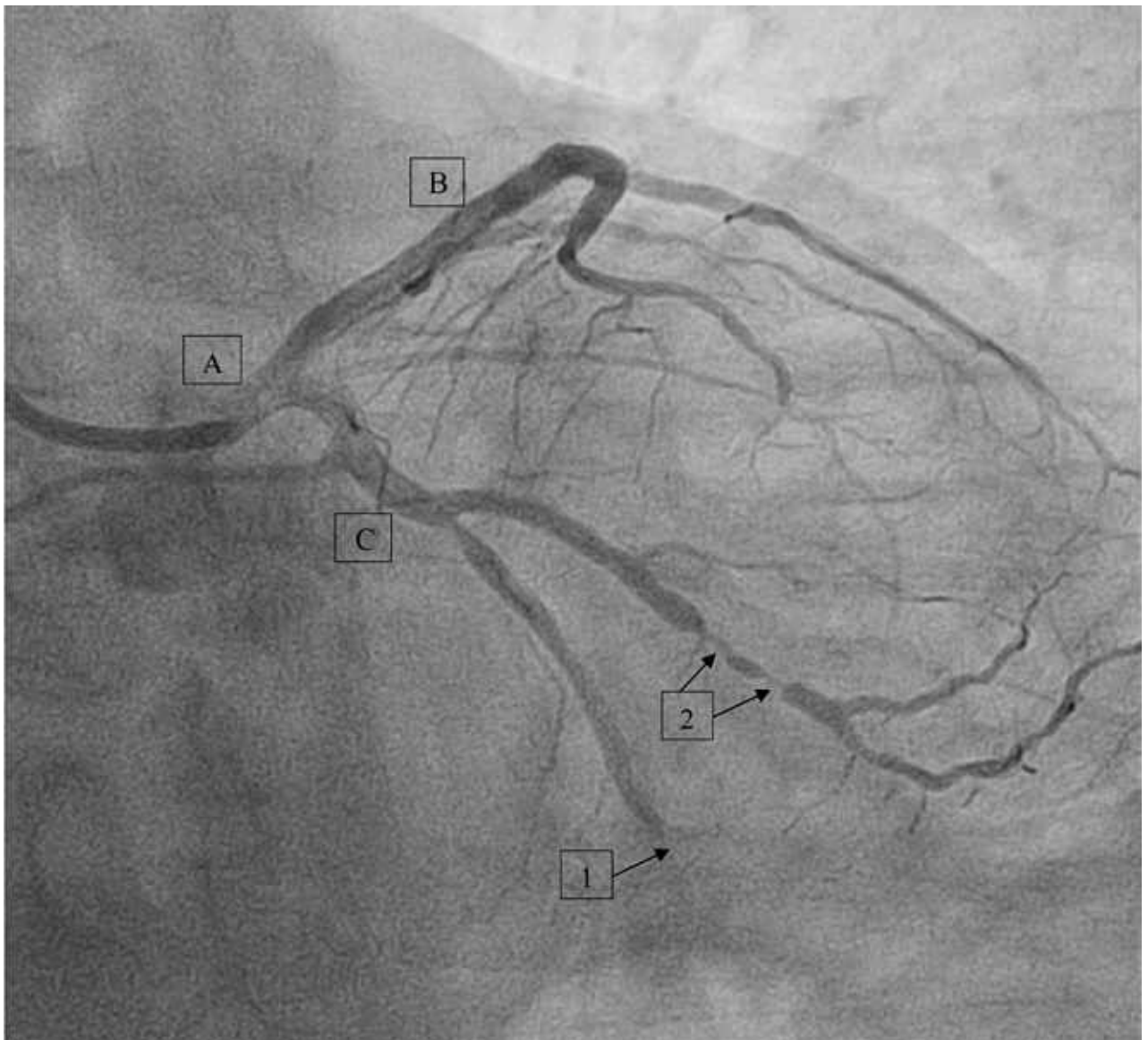
ment, and high risk of thrombosis. PCI was performed and the patient was instructed on keeping a healthy diet and tight glycemia control.



**A 69-year-old male** with a history of CAD, CCS class III stable angina, T2D, and placement of non-drug-eluting stent a year ago.

Coronary angiogram shows an 80 % proximal RCA restenosis (arrow). Stent restenosis is one of the main long-term complications of endovascular myocardial revascularization. PCI with drug-Coated Bal-

loon (DCB) angioplasty to help prevent restenosis. The patient was discharged home and instructed on keeping a healthy diet and regular glycemia control.

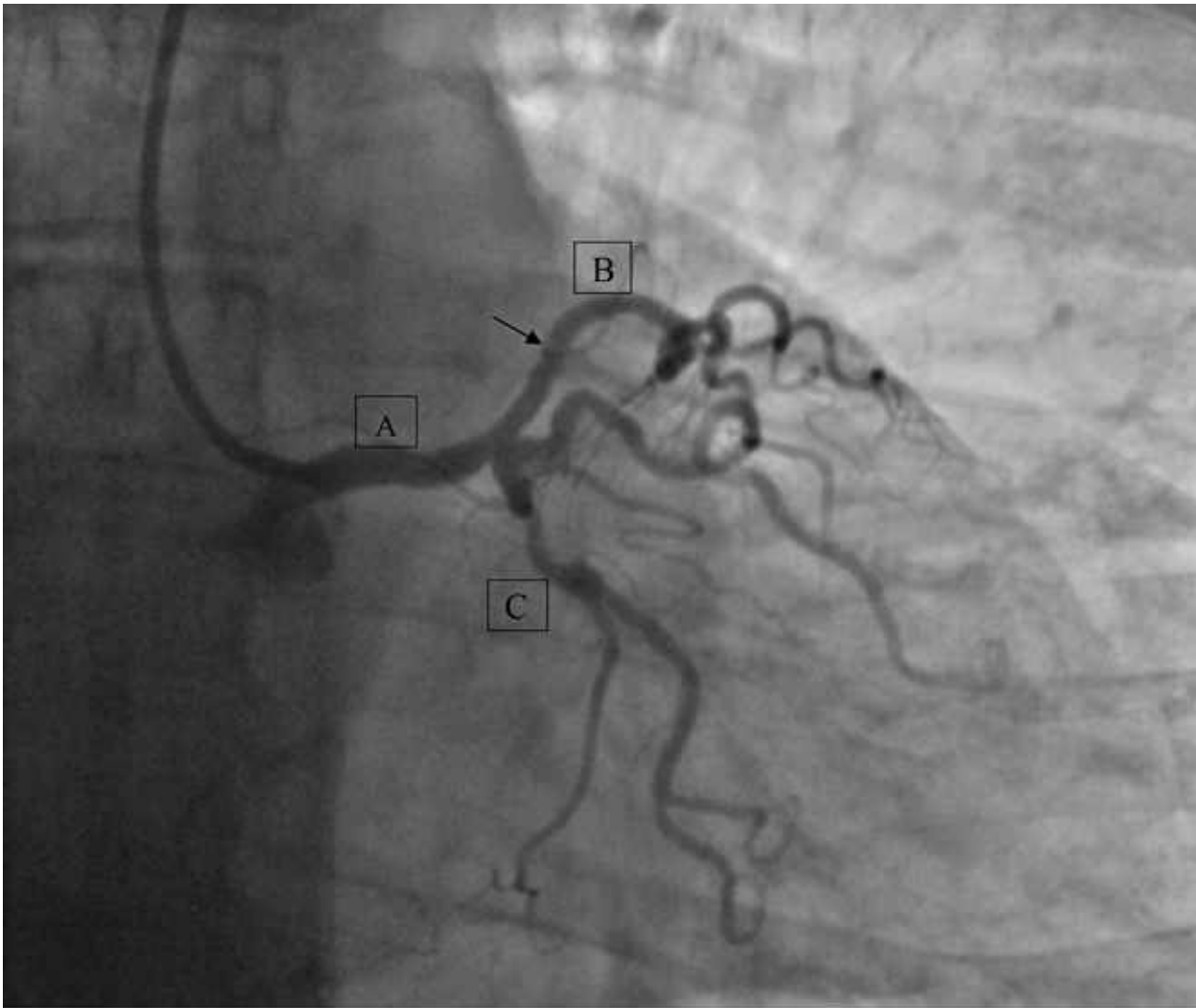


**A 64-year-old female** with a history of CAD, CCS class III stable angina, and T2D.

Chronic distal LCX (arrow 1) occlusion and 90% large marginal branch stenosis (arrow 2). PCI with large marginal branch stenting was performed. Stress echocardiography was used to assess the severity of transient myocardial ischemia and the need of chronic LCX occlusion recanalization. Stress test

was negative, LCX revascularization wasn't performed.

- (A) — *left main coronary artery (LMCA)*;
- (B) — *right coronary artery (RCA)*;
- (C) — *circumflex artery (LCX)*.

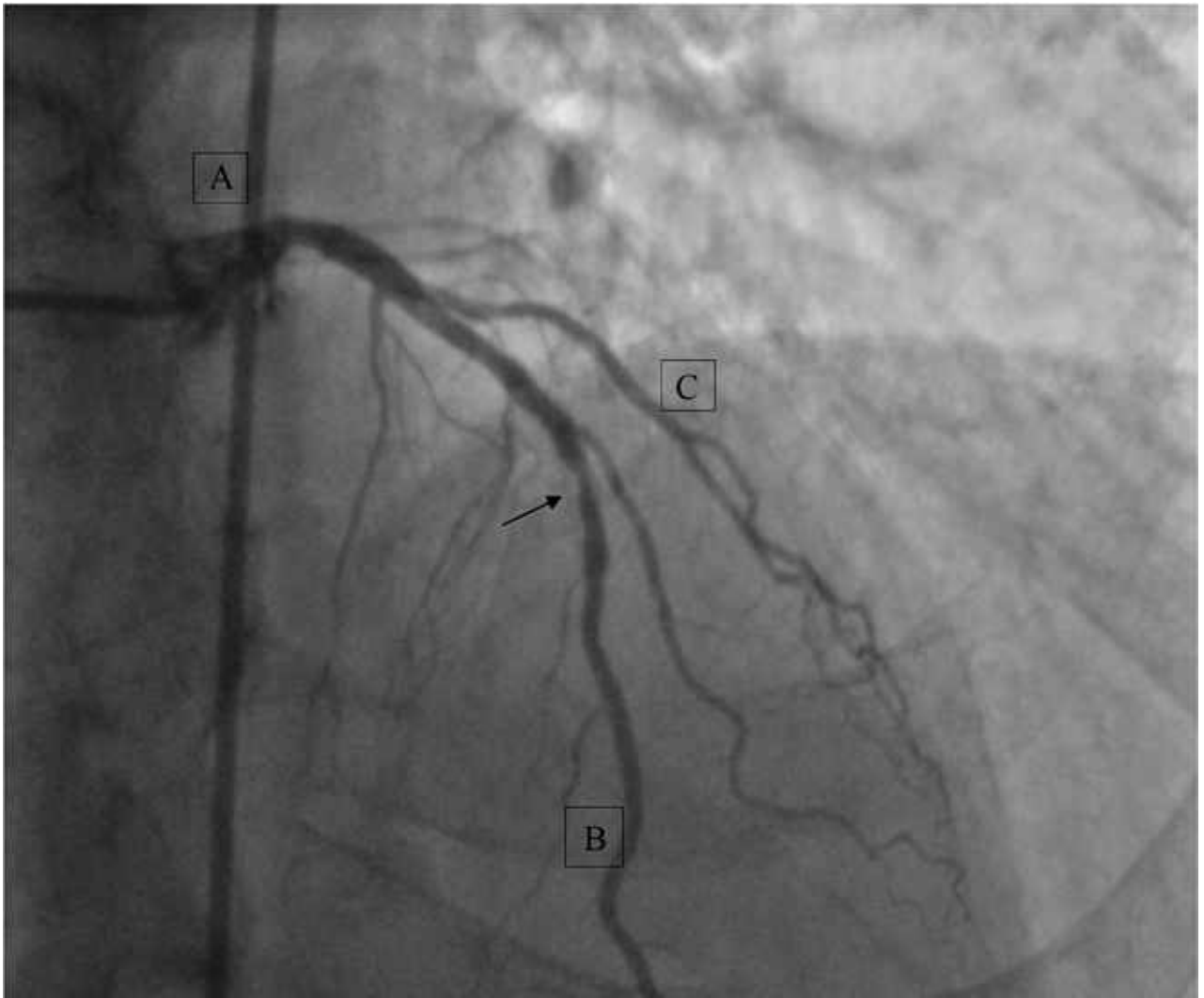


**A 45-year-old firefighter** with LV anterior wall ST-elevation ACS and type 2 diabetes.

Was hit in the chest and complained on substernal chest pain. ECG showed ST elevation in I, II, aVL, V1–V4. By the time of hospital admission ACS symptoms improved and ST elevation regressed.

Local proximal LAD dissection (arrow), most probably due to trauma. PCI with LAD stenting was performed.

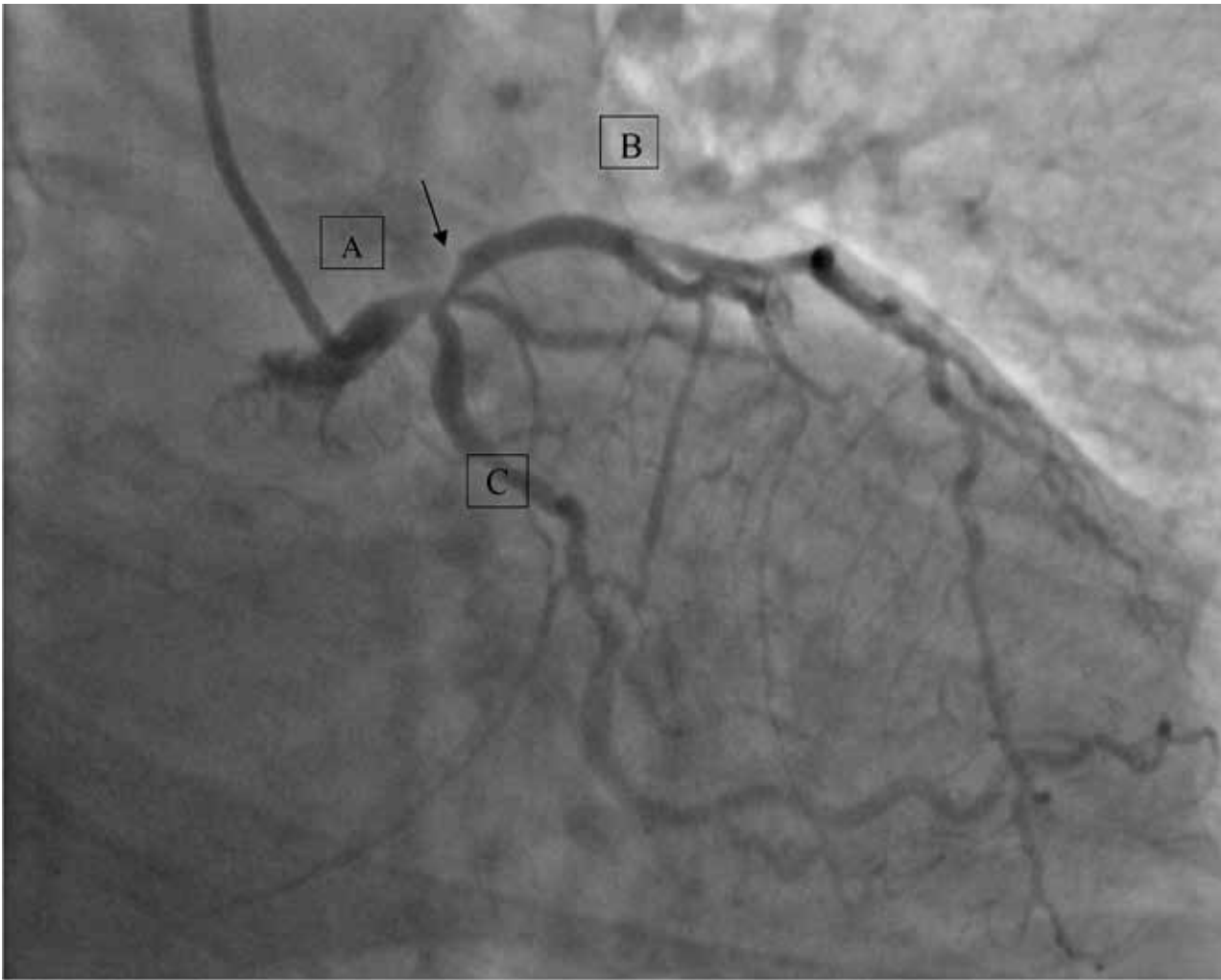
- (A) — *left main coronary artery (LMCA)*,
- (B) — *left anterior descending artery (LAD)*,
- (C) — *circumflex artery (LCX)*



**A 42-year male** with non-ST-elevation ACS, type 2 diabetes presented with anterior chest pain after hitting steering wheel in a car accident.

At admission no progression on ECG, echocardiography showed decreased LV anterior wall global myocardial contractility. Troponin 5 times upper the normal limit. Local dissection of mid-LAD (arrow), PCI of culprit artery.

(A) — *left main coronary artery (LMCA)*; ,  
(B) — *left anterior descending artery (LAD)*,  
(C) — *diagonal branch*.



**A 72-year-old male** with a history of CAD, stable angina CCS class III, type 1 diabetes, obesity, hypercholesterolemia, and smoking for 20 years complains of typical angina — acute fatigue after physical activity.

Pre-test CAD probability was high, and visualization wasn't available. Coronary angiography was performed and identified left coronary artery bifurcation atherosclerosis that involved LAD and LCX ostium (1.1.1 according to Medina classification<sup>1</sup>, arrow).

PCI with endovascular revascularization was performed.

(A) — *left main coronary artery (LMCA)*;

(B) — *left anterior descending artery (LAD)*

(C) — *circumflex artery (LCX)*.

<sup>1</sup> A coronary bifurcation lesion occurs at or near a division of a major coronary artery. Characterizing bifurcation lesions involves assessing the lesion morphology in three important anatomic segments: (1) proximal main branch (MB); (2) distal MB; and (3) side branch (SB). The Medina classification assesses plaque burden based on the presence («1») or absence («0») of stenosis in the proximal MB, distal MB, and SB.



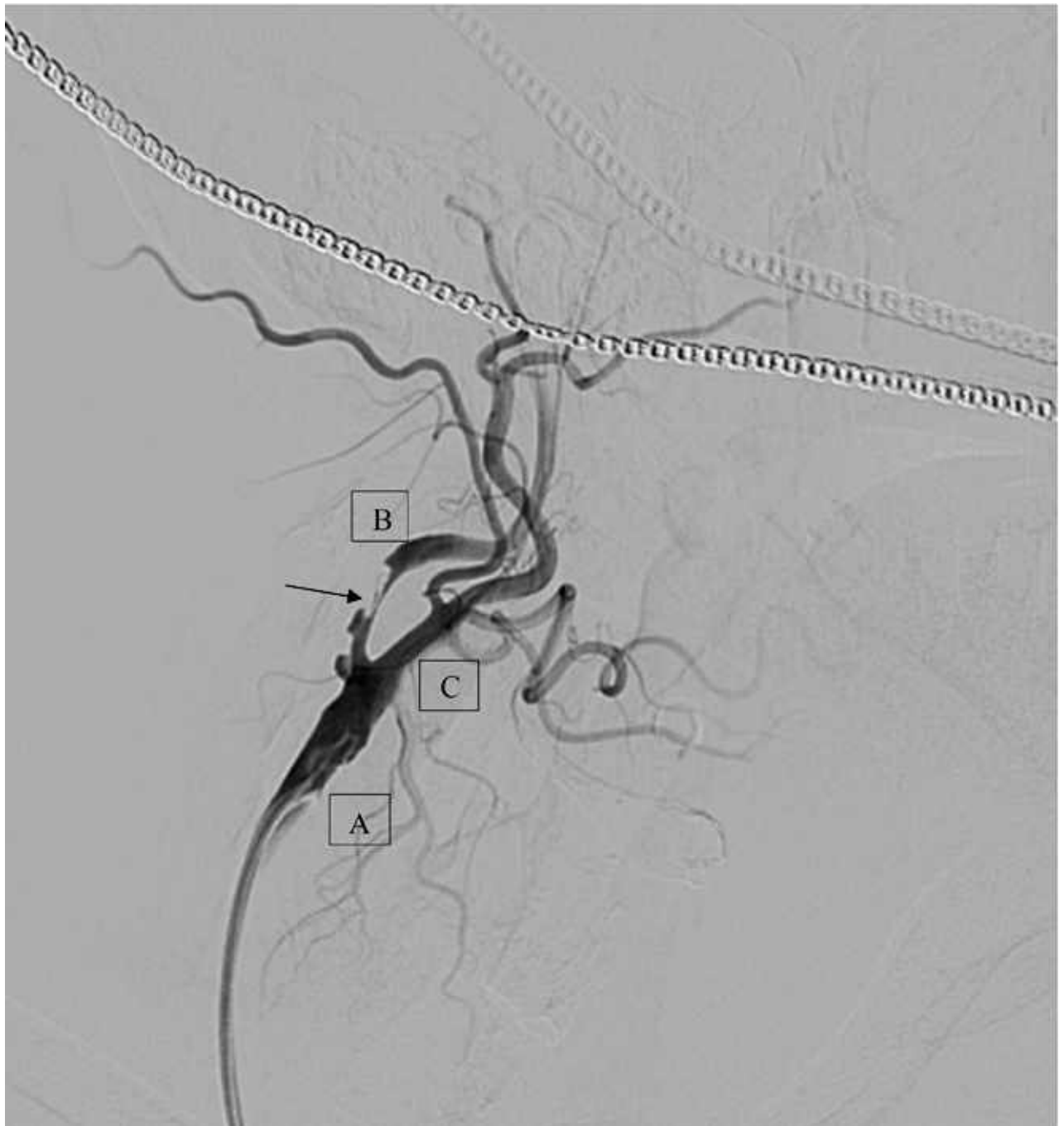
**A 76-year-old female** with a history of CAD, stable angina CCS class III.

Coronary angiogram shows RCA calcinosis with up to 85 % stenosis of the proximal and mid-segments (A) and local 90 % stenosis in the mid-PDA.

Artery calcinosis is a typical feature of coronary atherosclerosis. CT with Agatston calcium score calculation is a standard method used to assess the extent of coronary artery calcification. The grade of CAD is based on the total calcium score: no evi-

dence of CAD: 0 calcium score: minimal: 1–10; mild: 11–100; moderate: 101–400; severe: >400. Calcium score >400 is associated with a high risk of coronary artery obstruction. CT angiography (CTA) may be a superior front-line diagnostic test for patients with diabetes. Severe micro- and macroangiopathy leads to peripheral artery atherosclerosis that makes it harder for patients to undergo stress tests.

Chapter 4  
**CAROTID ATHEROSCLEROSIS IN PATIENTS  
WITH DIABETES**



**A 64-year-old female** with carotid artery disease, transitory ischemic attack 5 days prior to admission.

Right carotid artery angiogram shows a complicated (ulcerated with irregular margins and contrast enhanced plaque) right internal carotid artery atherosclerosis (arrow).

To prevent acute stroke internal carotid artery stenting was performed.

- (A) — *right common carotid artery (CCA)*,
- (B) — *right internal carotid artery (ICA)*,
- (C) — *right external carotid artery (ECA)*



**A 73-year female** with a history of carotid artery disease, transient ischemic attack 2 weeks prior to hospitalization.

80% left internal carotid artery stenosis with signs of mural thrombosis (intraluminal lucency in ICA — arrow). Left carotid artery stenting was performed.

(A) — *left common carotid artery (CCA)*,  
(B) — *left internal carotid artery (ICA)*,  
(C) — *left external carotid artery (ECA)*.



**A 65-year-old male** with a history of carotid artery disease complains of intermittent dizziness and tinnitus.

These symptoms are not the classic presentation of carotid artery stenosis. Carotid ultrasound performed as a part of annual check-up showed a 70% left internal carotid artery stenosis with 4 times increased blood flow velocity.

70% stenosis was confirmed by angiography (arrow) and internal carotid artery stenting was performed to prevent acute stroke.

(A) — *left common carotid artery (CCA)*,  
(B) — *left internal carotid artery (ICA)*,  
(C) — *left external carotid artery (ECA)*.



**A 72-year-old female** with a history of carotid artery disease, a left hemispheric stroke 2 months prior to hospital admission.

Carotid angiogram shows a 40% left internal carotid artery stenosis (arrow). Pharmacologic management was chosen, and the patient was followed-up by a neurologist (surgical revascularisation is a treatment of choice for patients with more than 50% stenosis and a history of stroke and TIA in the last

6 months or with more than 70% stenosis in the absence of ischemic changes).

(A) — *left common carotid artery (CCA)*,

(B) — *left internal carotid artery (ICA)*,

(C) — *left external carotid artery (ECA)*.



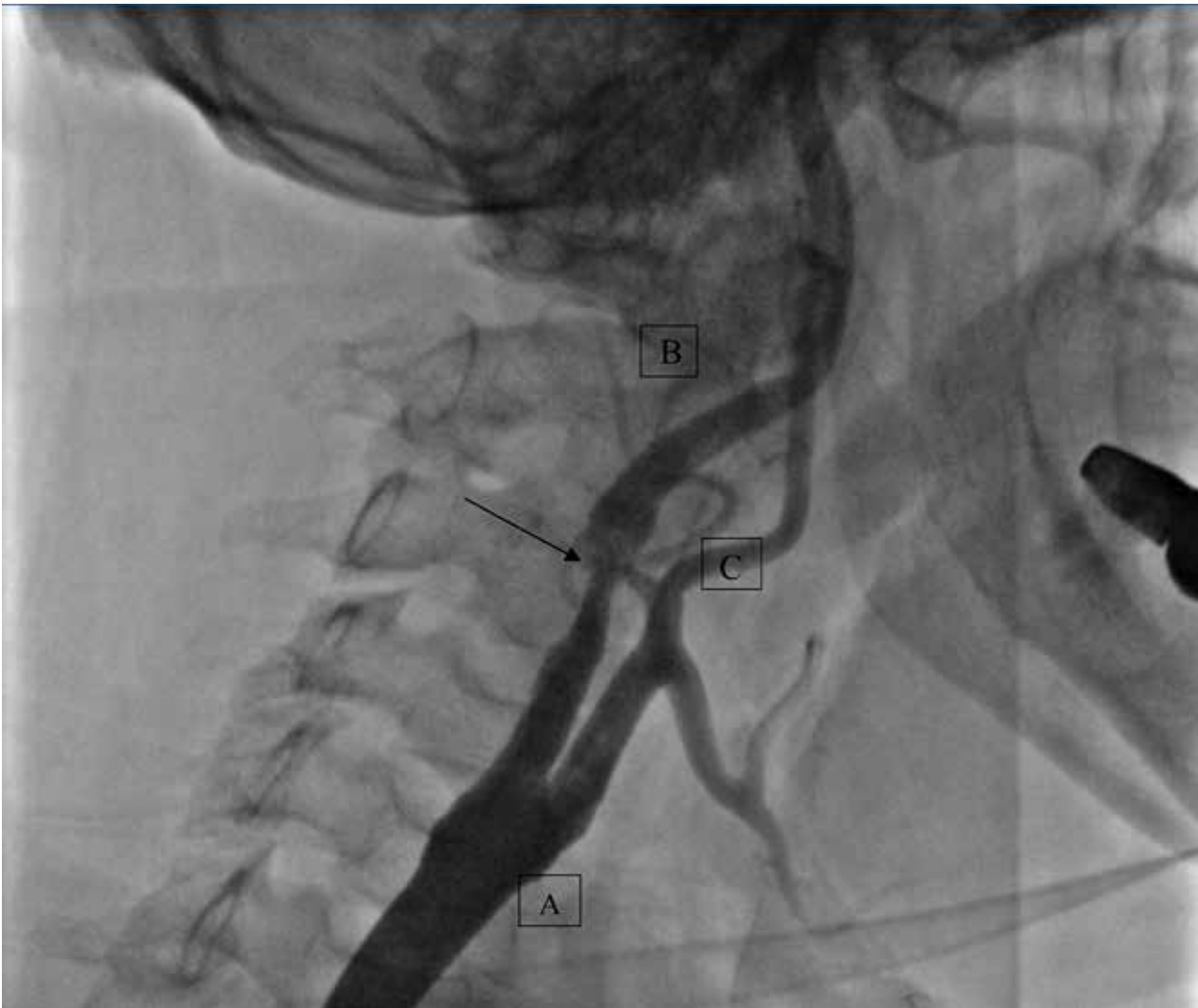
**An 80-year-old male** with carotid artery disease, symptomatic 90 % left internal carotid artery stenosis.

Symptomatic stenosis is defined as 50 % to 99 % carotid artery stenosis in patients with a history of amaurosis fugax, transient ischemic attacks, or ischemic stroke over the last 6 months.

The patient has 90 % complicated stenosis in the left common carotid artery with the involvement of left internal carotid artery orifice (arrow).

To prevent acute stroke internal carotid artery stenting was performed.

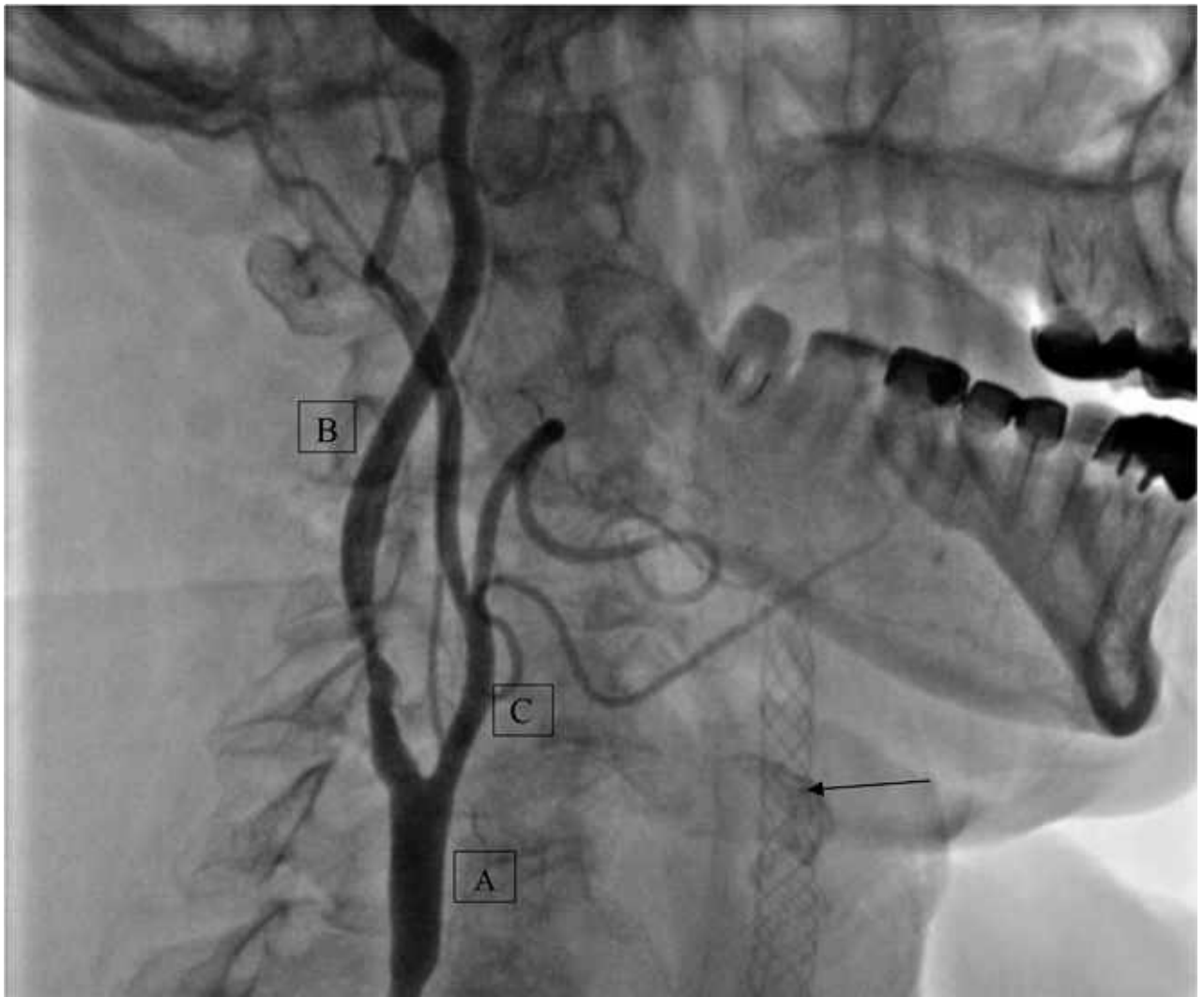
- (A) — left common carotid artery (CCA),
- (B) — left internal carotid artery (ICA),
- (C) — left external carotid artery (ECA).



**A 65-year-old female** with carotid artery disease, TIA 2 months prior to admission complains of dizziness and headaches.

Angiography showed 80% complicated right carotid artery stenosis with ulcerated margins and intraluminal lucency (arrow). Right carotid artery stenting was performed.

(A) — *right common carotid artery (CCA)*,  
(B) — *right internal carotid artery (ICA)*,  
(C) — *right external carotid artery (ECA)*.



**A 68-year-old female** with carotid artery disease, asymptomatic 80 % right internal carotid artery stenosis and a history of right ICA stenting (arrow).

Carotid artery US showed a 60 % stenosis of right ICA with 4-times increased blood flow velocity. Repeat angiography showed an 80 % right ICA stenosis (current angiogram). Right ICA was performed.

(A) — *right common carotid artery (CCA)*,  
(B) — *right internal carotid artery ICA*,  
(C) — *right external carotid artery (ECA)*.



**A 57-year-old male** with carotid artery disease, and TIA 7 days prior to admission. Carotid artery US revealed a 90 % stenosis of right ICA.

This angiogram shows right ICA 99% ostial stenosis with intraluminal lucency and uneven margins. Right ICA stenting was performed.

(A) — *right common carotid artery (CCA)*,  
(B) — *right internal carotid artery, (ICA)*  
(C) — *right external carotid artery (ECA)*.

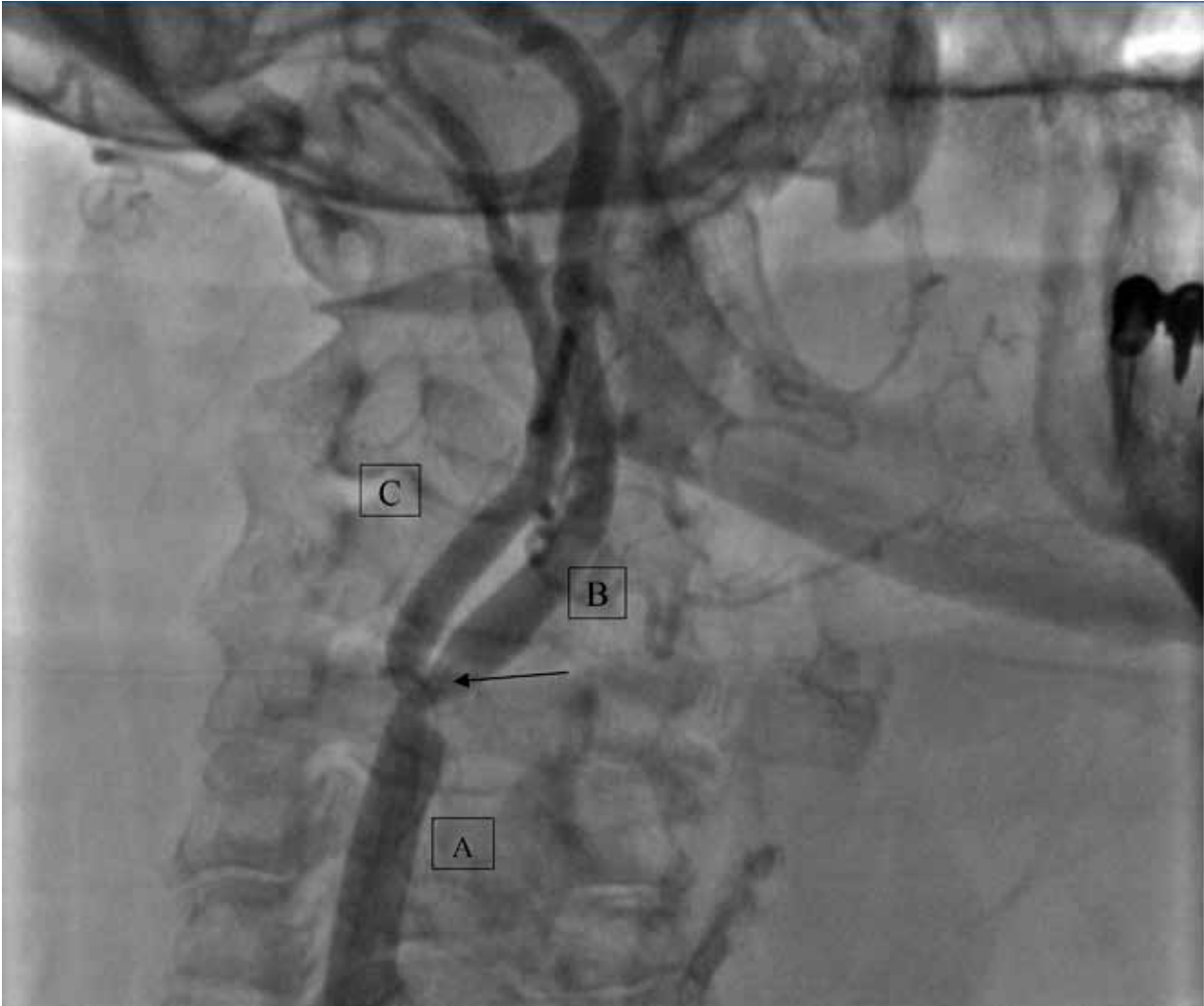


**A 53-year-old female** with left ICA 80 % stenosis revealed on an outpatient carotid artery US and a with no history of ischemic stroke or TIA or any other complaints.

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Carotid artery angiography didn't confirm left ICA stenosis but revealed mild atherosclerosis in the left proximal ICA (arrow).

(A) — *left common carotid artery (CCA)*,  
(B) — *left internal carotid artery (ICA)*,  
(C) — *left external carotid artery (ECA)*.



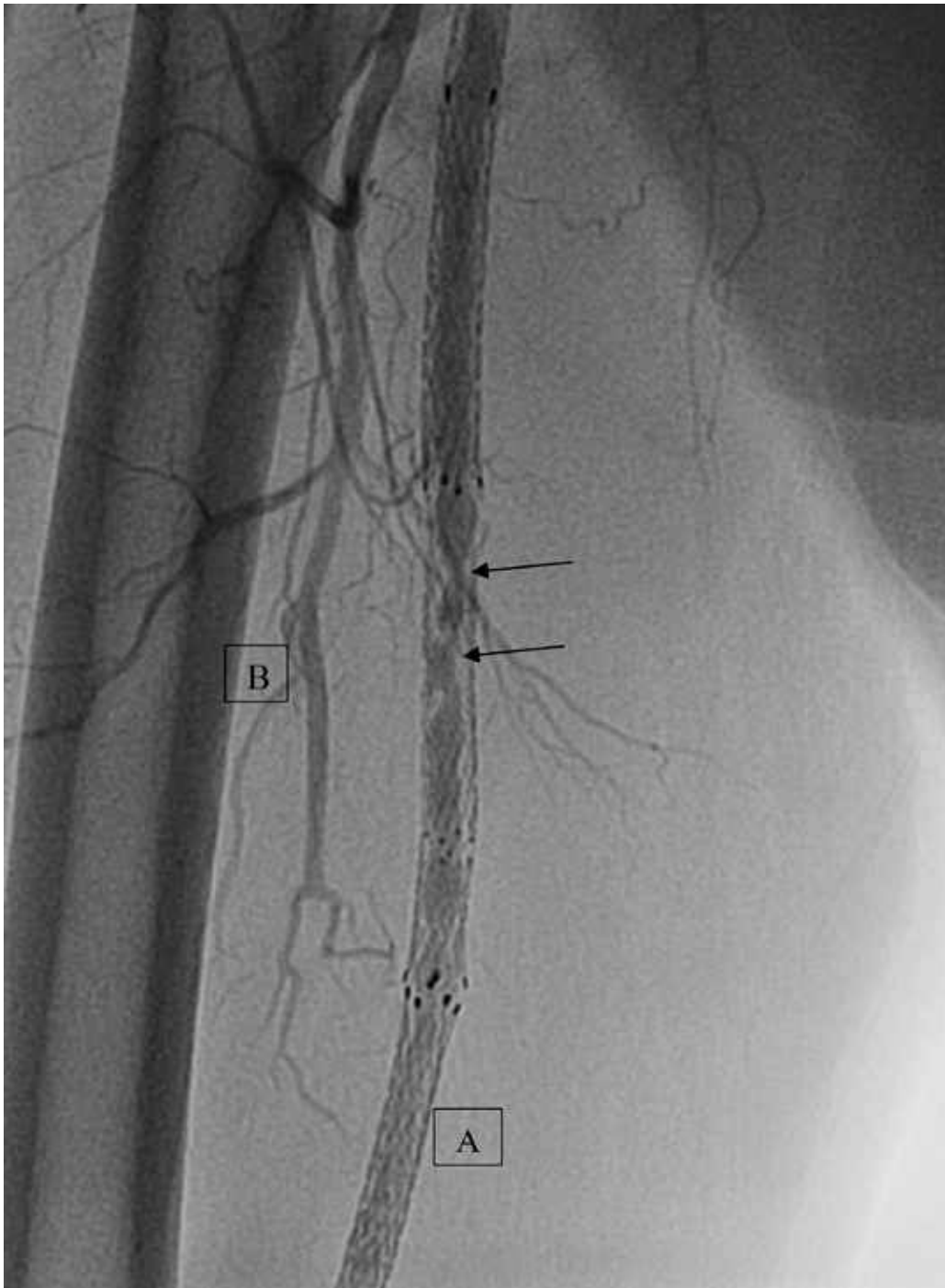
**A 64-year-old female** with asymptomatic carotid artery disease and no history of ischemic stroke, TIA.

Carotid duplex ultrasound revealed a 70% stenosis with increased blood flow velocity. Carotid angiogram shows a spike-like eccentric 80% stenosis of the carotid bifurcation (arrow). Carotid artery stenting was successfully performed.

(A) — *right common carotid artery (CCA)*,  
(B) — *right internal carotid artery (ICA)*,  
(C) — *right external carotid artery (ECA)*.



Chapter 5  
**PERIPHERAL ARTERY DISEASE IN  
PATIENTS WITH DIABETES**



**A 73-year-old male** with PAD, stage III chronic limb ischemia (according to the Fontaine classification modified by A.V. Pokrovsky), 30-year smoking history and T2D.

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The current angiogram shows right SFA stent with a 90% restenosis (arrow) that lead to right calf claudication.

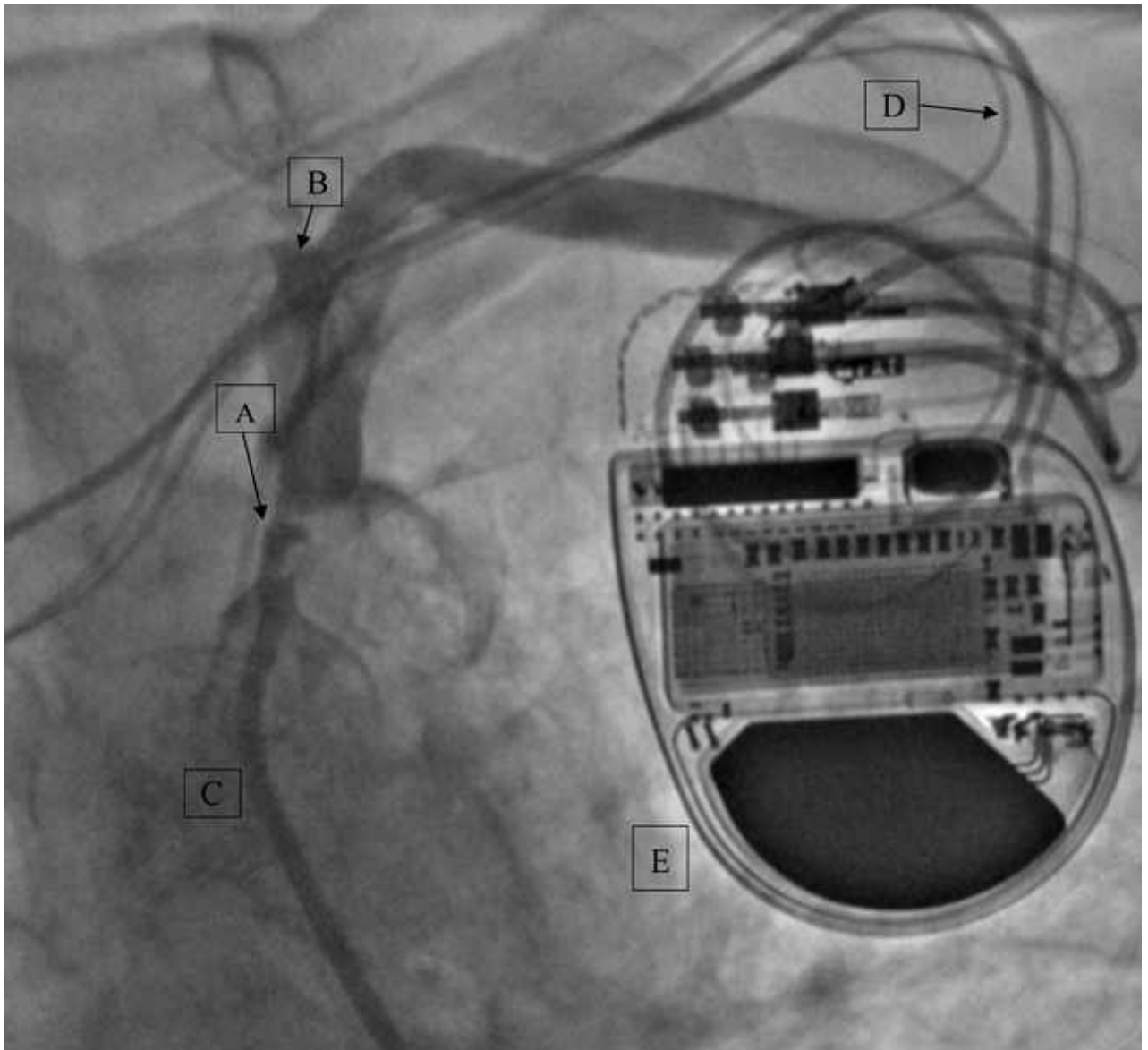
(A) — *superficial femoral artery (SFA)*,  
(B) — *deep femoral artery (DFA)*.



**A 70-year-old male** with a history of PAD, stage IV chronic limb ischemia (according to the Fontaine classification modified by A.V. Pokrovsky), and left foot ischemic ulcers.

The current angiogram shows left SFA occlusion (arrow) with collateral blood flow towards the popliteal arteries through the DFA system.

(A) — *common femoral artery (CFA)*,  
(B) — *superficial femoral artery (SFA)*,  
(C) — *deep femoral artery (DFA)*

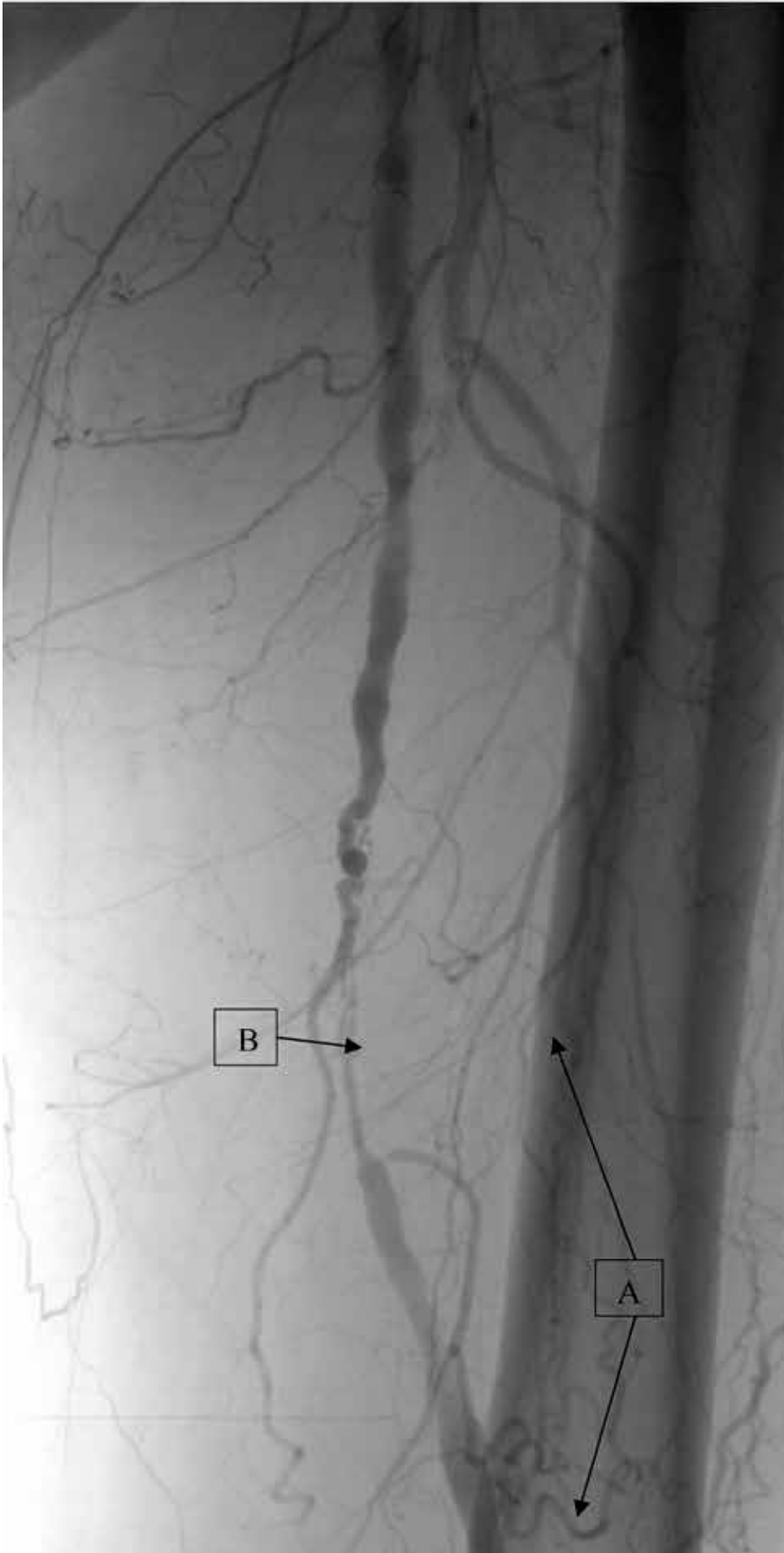


**A 65-year-old male** with an 85 % stenosis of the left subclavian artery (LSA) (A)

with the development of subclavian steal syndrome (SSS)<sup>1</sup> (Dizziness, Ataxia and Exercise-induced arm pain), LSA stenting was performed.

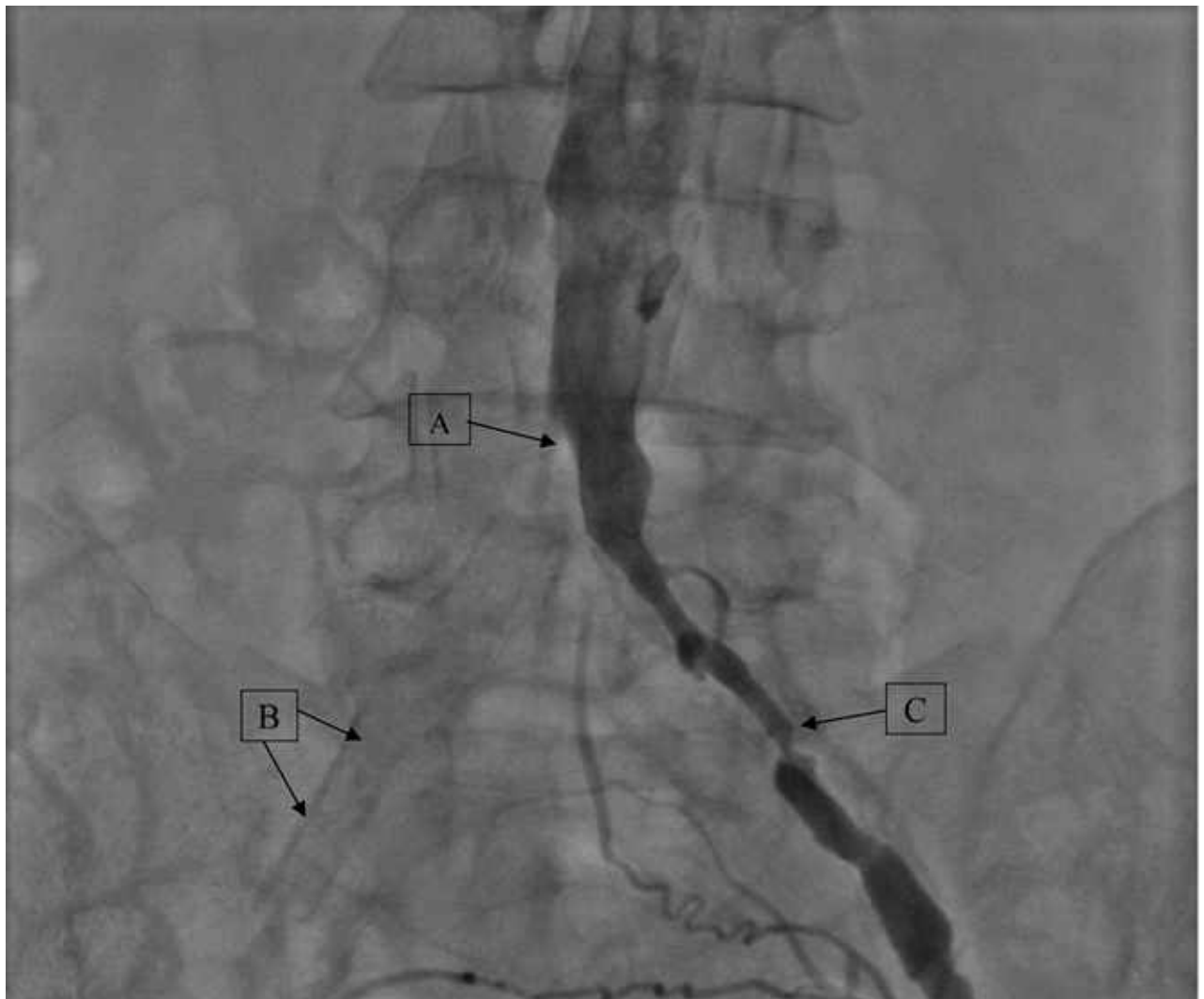
*B—left vertebral artery ostium and catheter that delivers the contrast agent, guidewire, balloon, and stent, C—stimulator electrodes, D—pacemaker.*

<sup>1</sup> Subclavian steal syndrome (SSS) is a constellation of signs and symptoms that arise from retrograde (reversed) blood flow in the vertebral artery or the internal thoracic artery, due to a proximal stenosis (narrowing) and/or occlusion of the subclavian artery.



**A 76-year-old male** with multifocal atherosclerosis, stage III chronic limb ischemia (according to the Fontaine classification modified by A.V. Pokrovsky), complains of left calf and foot claudication.

The current angiogram shows left SFA occlusion that causes the ischemia. Distal part of SFA fills through the DFA collateral system (A) and through bridge DFA collaterals (B).



**A 74-year-old patient** with multifocal atherosclerosis, critical limb ischemia (CLI), limb pain at rest and ischemic changes in the right foot and calf.

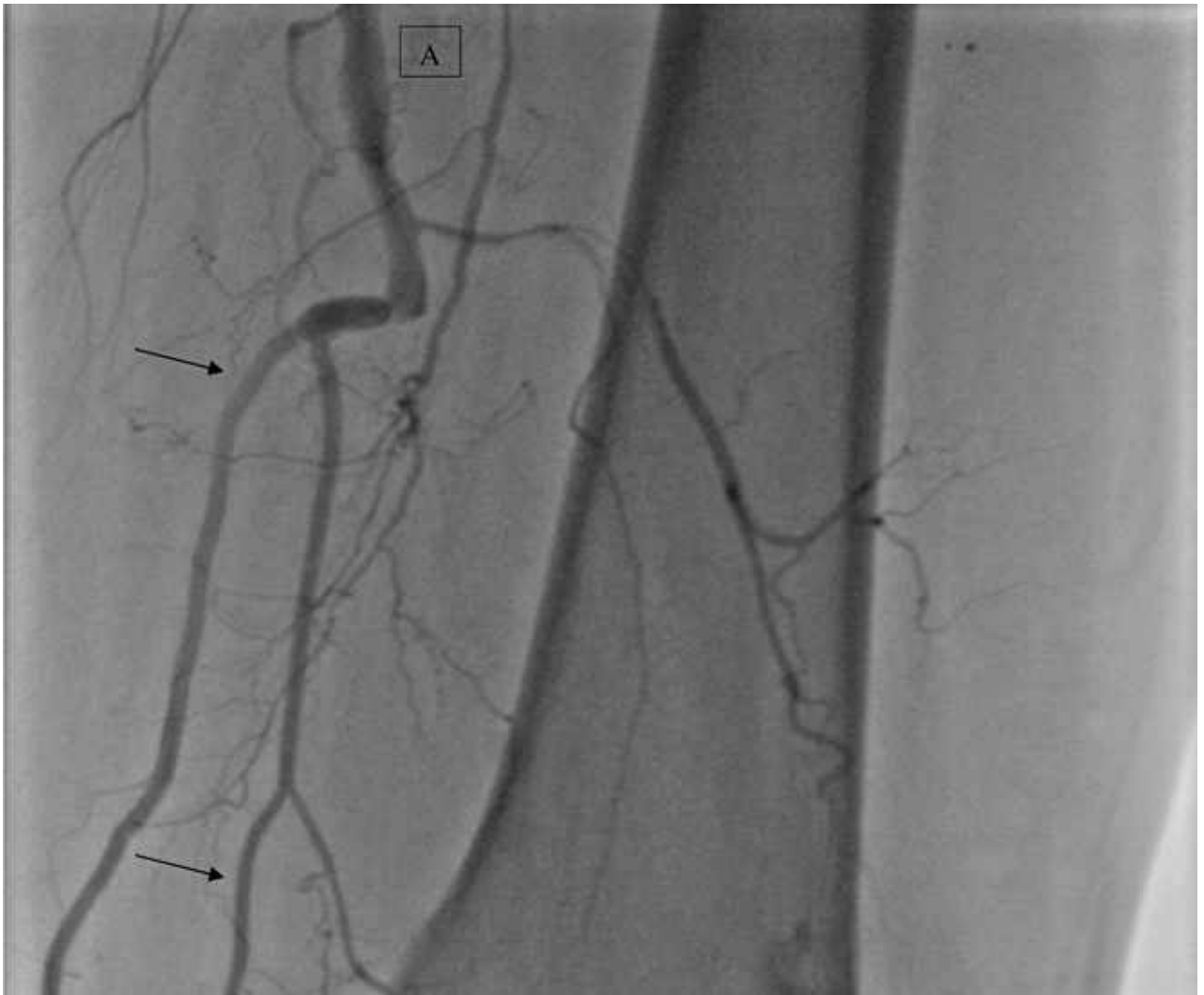
The current angiogram shows right common iliac artery occlusion (A), calcification of the right iliac artery (B), 90% stenosis in the left iliac artery (C). Occlusion recanalization with iliac bifurcation stenting was performed.



**A 38-year-old male** with peripheral artery disease, stage 2B chronic limb ischemia (according to the Fontaine classification modified by A.V. Pokrovsky) that significantly affects his quality of life.

The current angiogram shows local calcified subtotal (99%) right SFA stenosis (A). Intravascular atherectomy was successfully performed and stenting wasn't

necessary due to good angiographic results and young age.



**A 78-year-old male** with multifocal atherosclerosis, stage III chronic limb ischemia (according to the Fontaine classification modified by A.V. Pokrovsky) and a 40-year history of smoking.

The current angiogram shows chronic left SFA occlusion that involves popliteal artery. Distal segments were supplied by collateral blood flow (arrows).

(A) — *superficial femoral artery (SFA)*.



**A 73-year-old male** with multifocal atherosclerosis, stage III chronic limb ischemia (according to the Fontaine classification modified by A.V. Pokrovsky).

The current angiogram shows a significant aortic bifurcation atherosclerosis. Arrow points at atherosclerotic plaque over left CIA bifurcation.

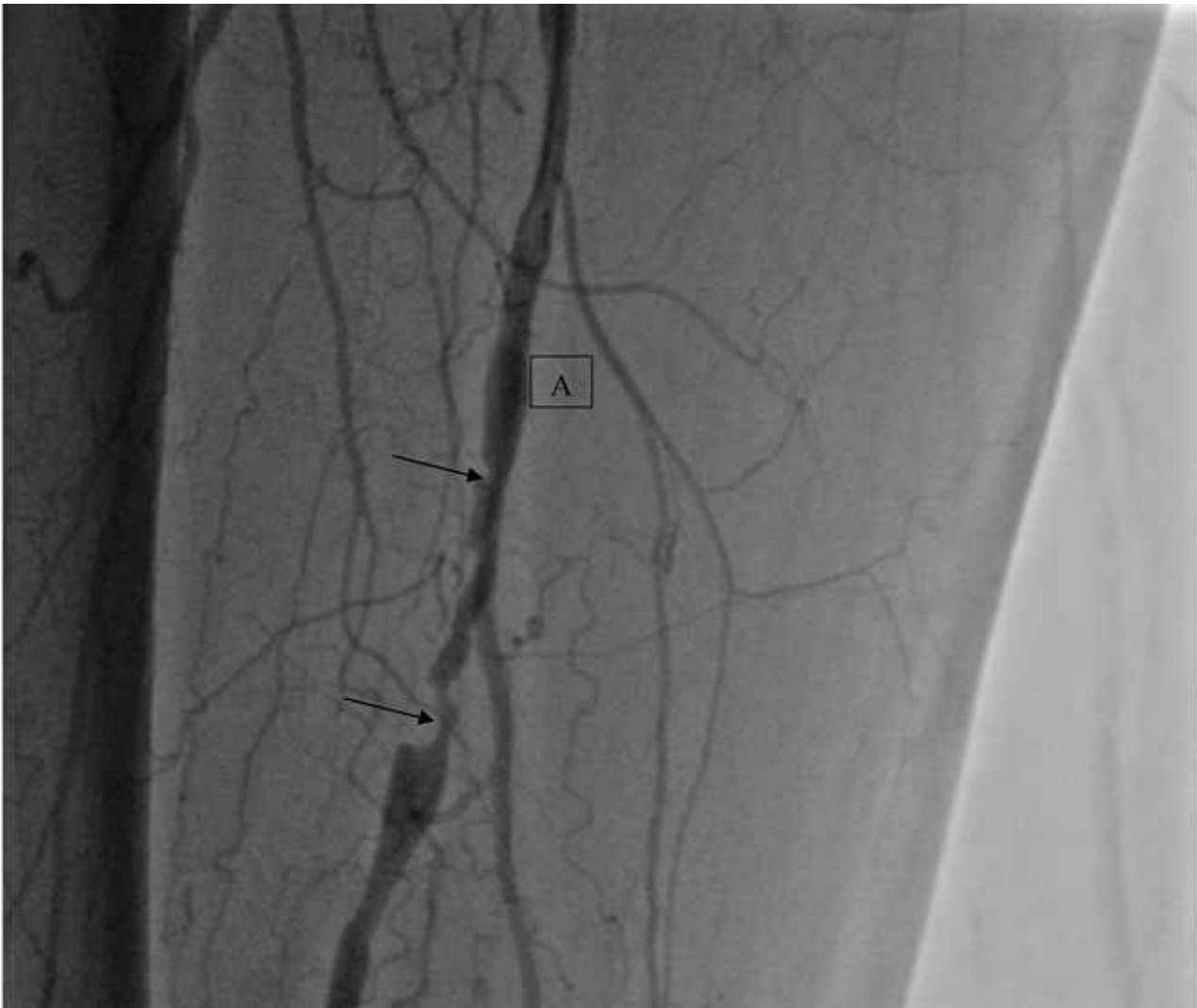
(A) — *right common iliac artery (CIA)*,  
(B) — *left common iliac artery (CIA)*,  
(C) — *lumbar arteries*.



**A 67-year-old female** with PAD, stage III chronic limb ischemia (according to the Fontaine classification modified by A.V. Pokrovsky).

The current angiogram shows abdominal aorta (A), 80% stenosis of the left CIA (arrow), right inferior polar renal artery arises from the abdominal aorta (B). Left CIA stenting was performed.

(A) — the abdominal aorta,  
(B) — right inferior polar renal artery,  
(C) — right common iliac artery (CIA),  
(D) — left common iliac artery (CIA).



**A 68-year-old male** with multifocal atherosclerosis, stage IIB chronic limb ischemia (according to the Fontaine classification modified by A.V. Pokrovsky) and significantly decreased quality of life.

The current angiogram shows a complicated right SFA stenosis with ulcerations and intraluminal lucency (arrow).

Right SFA drug-eluting balloon angioplasty was performed.

(A) — *superficial femoral artery (SFA)*



Chapter 6

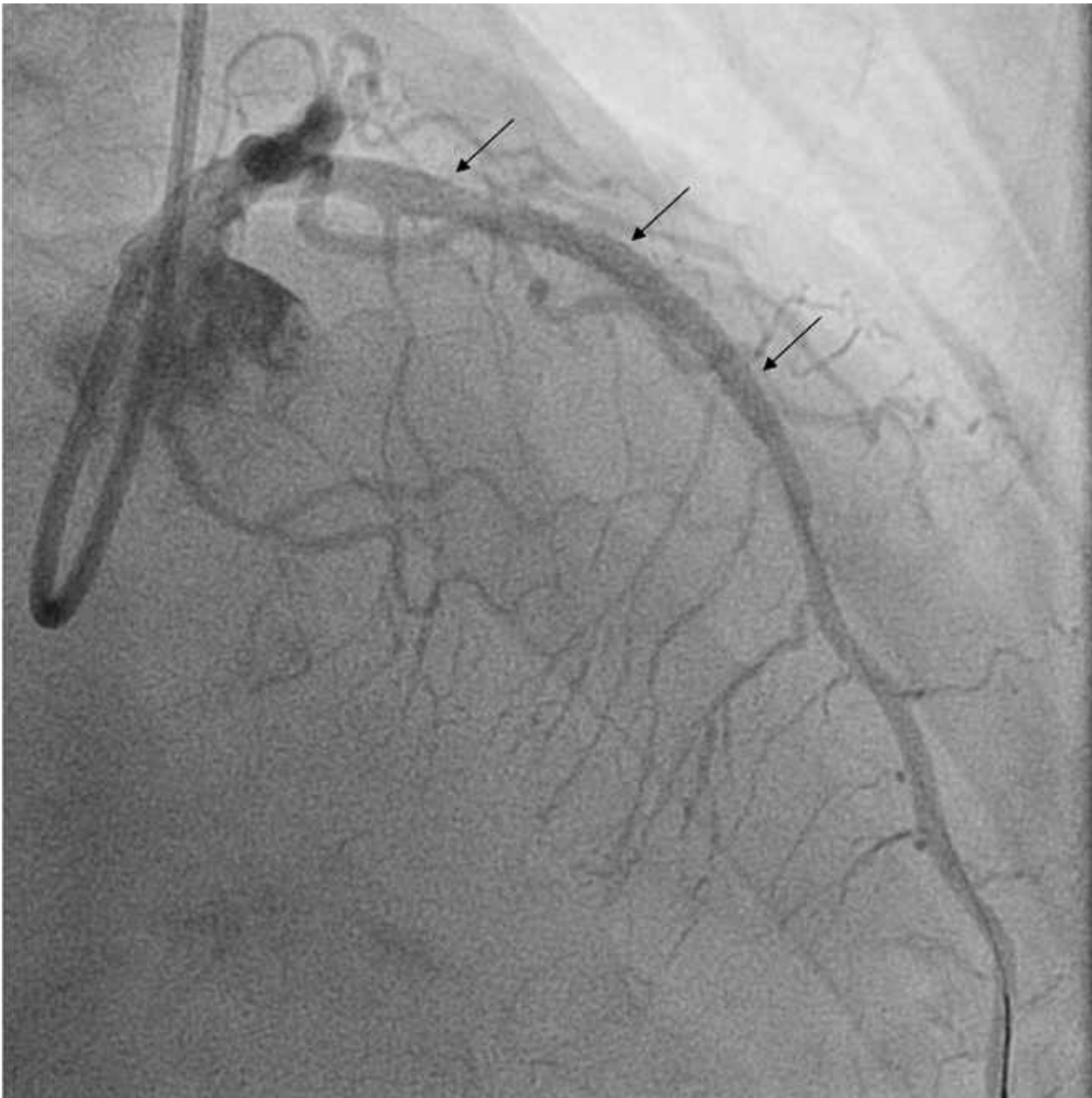
**CORONARY ANGIOPLASTY AND STENTING IN  
PATIENTS WITH DIABETES**



**A 38-year-old male** with non-ST-elevation ACS that manifested with chest pains with exercise 1 hour prior to hospitalization.

The patient is a professional wrestler and has the characteristic enhanced microvascular function (arrows). The current angiogram shows a 99% mid-

LAD stenosis (arrow A). LAD stenting was performed.

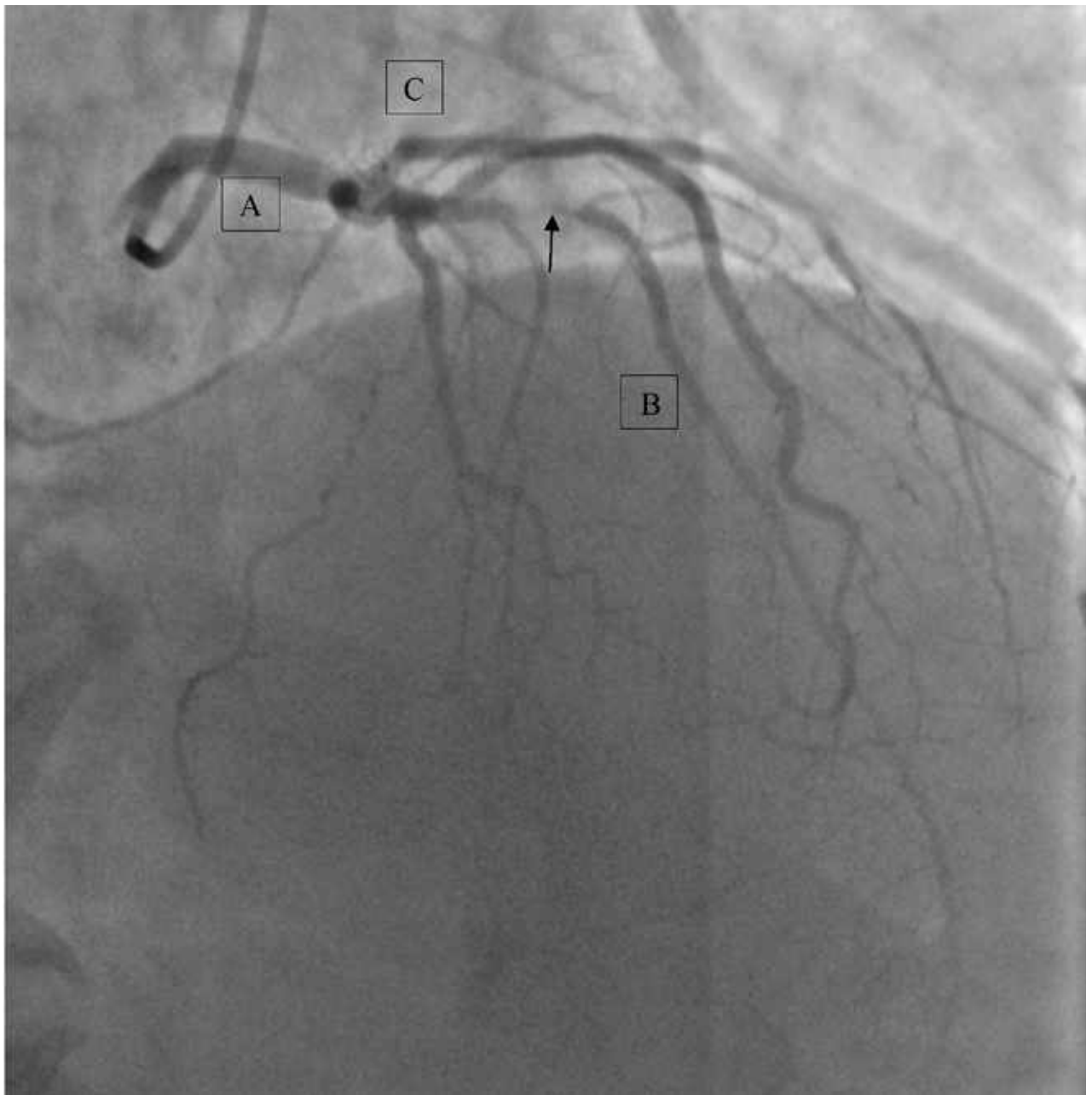


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The current angiogram shows the results of LAD stenting (arrow).

Angiographic features of a successful stent implantation include the absence of contrast filling deficits and full stent expansion.

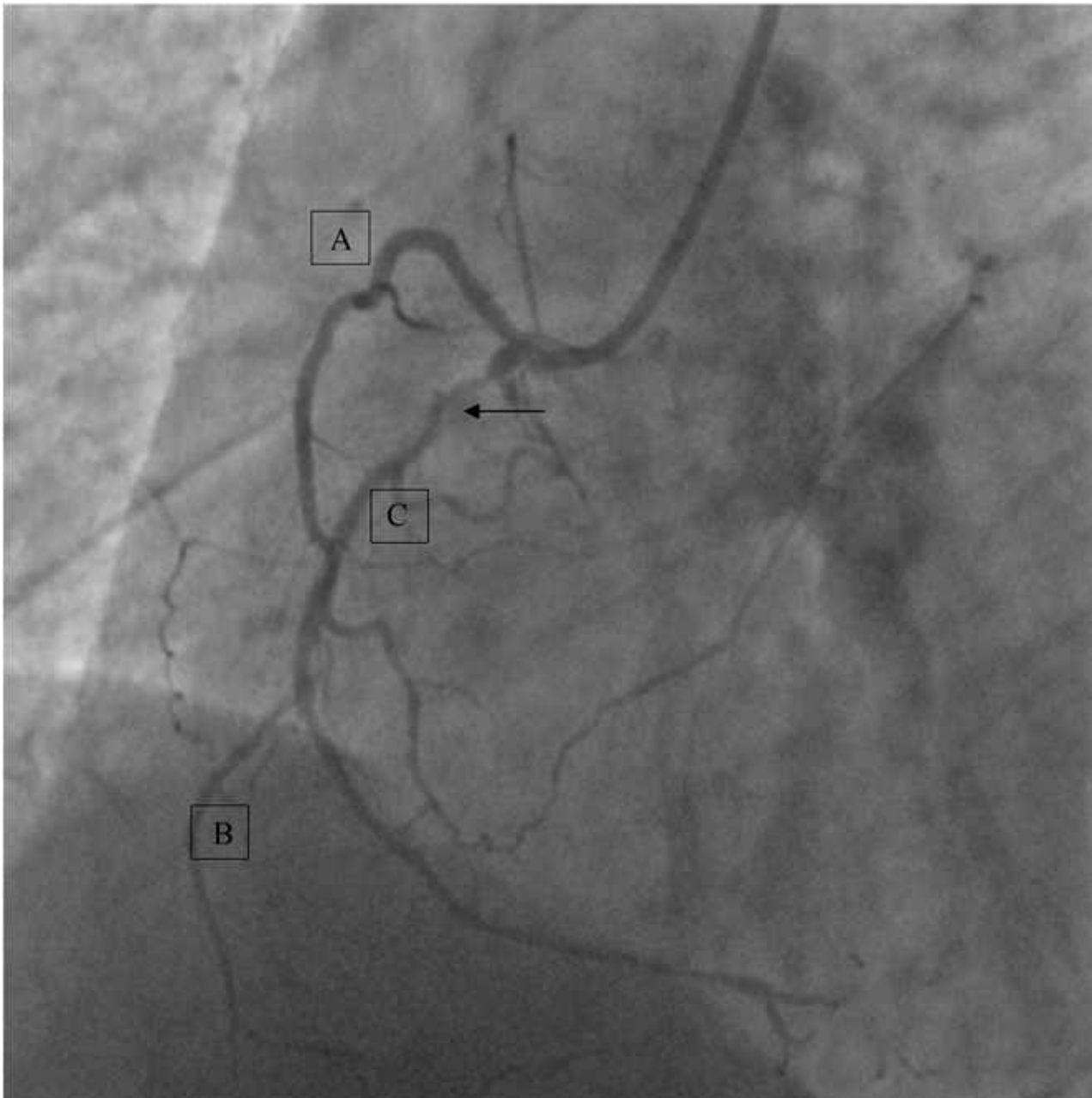
After the successful discharge and recovery, the patient returned to regular training.



**A 72-year-old** male with CAD, stable angina CCS class II, and T2D presented complaining of substernal chest pains that start with slow pace walking for up to 200 m or fast pace walking and stop at rest or 1 minute after using nitroglycerin spray.

Stress echocardiography showed the reduction of global myocardial contractility, local contractility and the areas of hypokinesia in the anterior and posterior left ventricular walls.

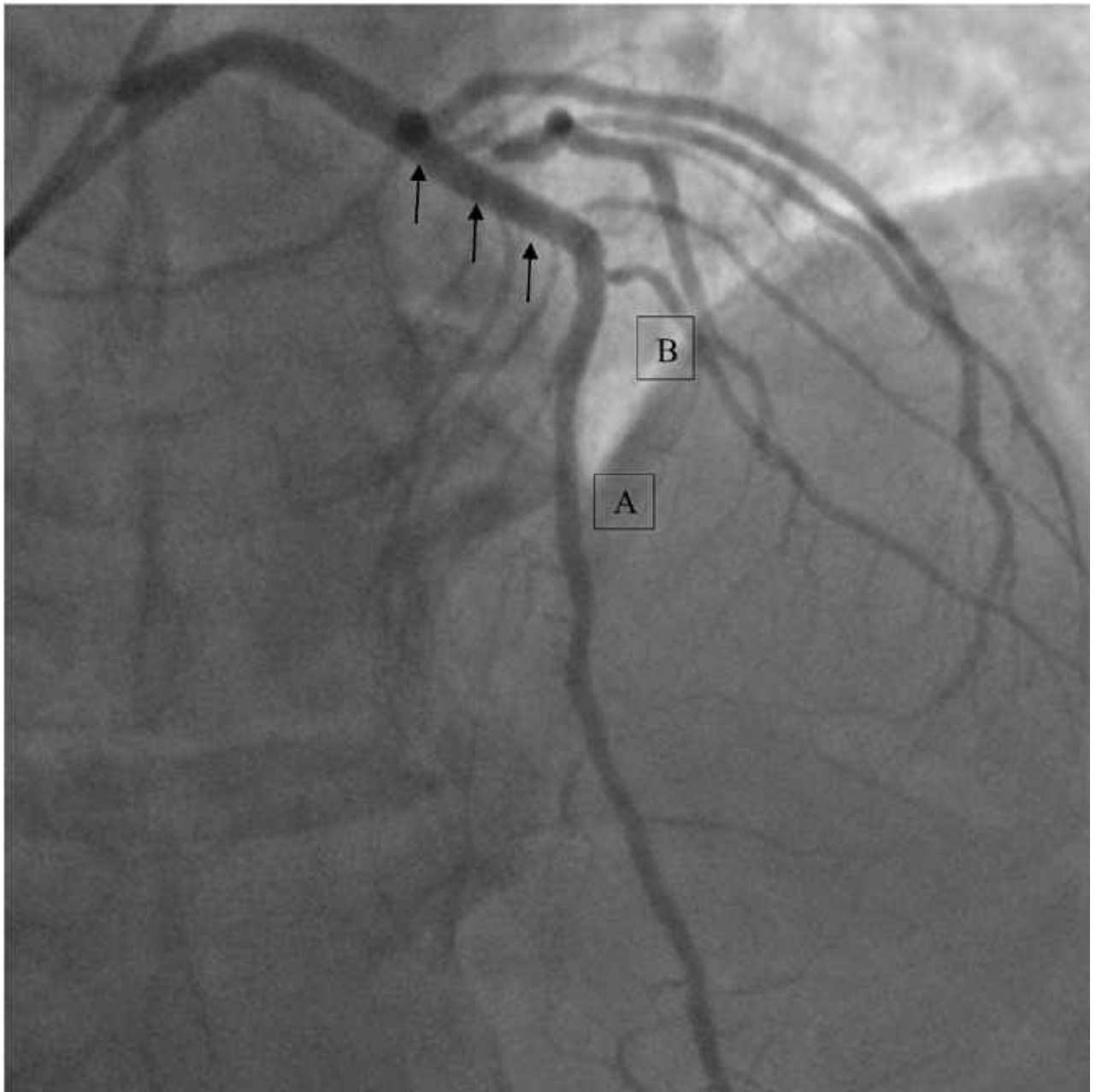
Coronary angiogram in right cranial projection shows 99% proximal LAD stenosis (arrow).  
(A) — left main coronary artery (LMCA),  
(B) — left anterior descending artery (LAD),  
(C) — circumflex artery (LCX).



*continued*

Coronary RCA angiogram shows a 95% atherosclerotic stenosis in the proximal RCA (arrow). Endovascular revascularization in LCA and RCA was performed simultaneously.

(A) — right ventricular branch,  
(B) — right marginal artery,  
(C) — right coronary artery (RCA).

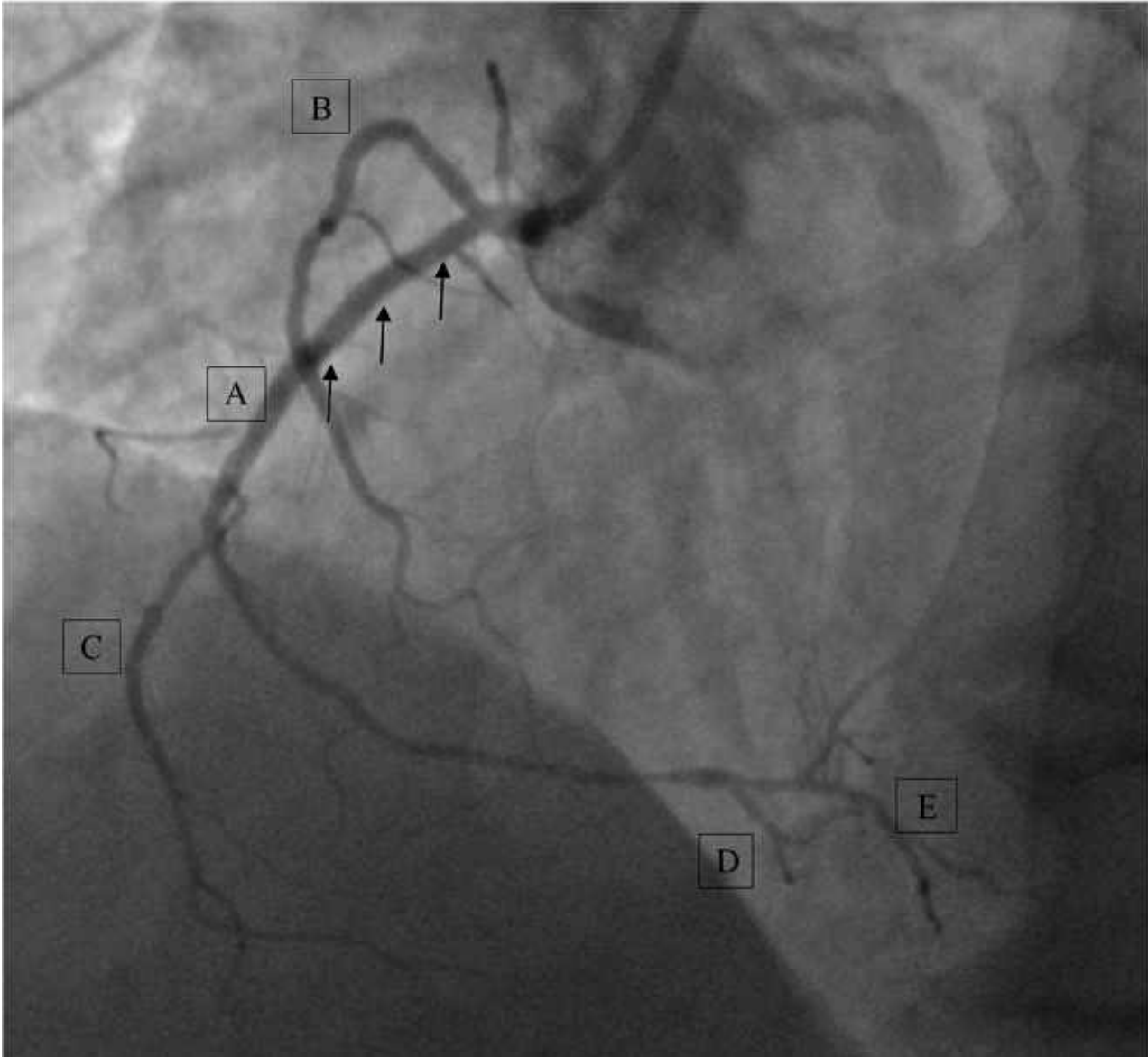


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Post-procedure angiogram shows an LAD stent. The stent has fully expanded with restoration of blood flow TIMI<sup>1</sup>-3.

(A) — *left anterior descending artery (LAD)*,  
(B) — *diagonal branch*.

<sup>1</sup> The TIMI (Thrombolysis in Myocardial Infarction) flow grade is a widely used method for the assessment of coronary artery flow in acute coronary syndromes. Flow in coronary arteries is classified as grade 0 (no flow), grade 1 (penetration without perfusion), grade 2 (partial perfusion) or grade 3 (complete perfusion).



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Right coronary artery angiogram shows the results of proximal segment stenting.

Arrows show the area of previous stenosis and stent. Angina symptoms have fully regressed in this patient after stenting.

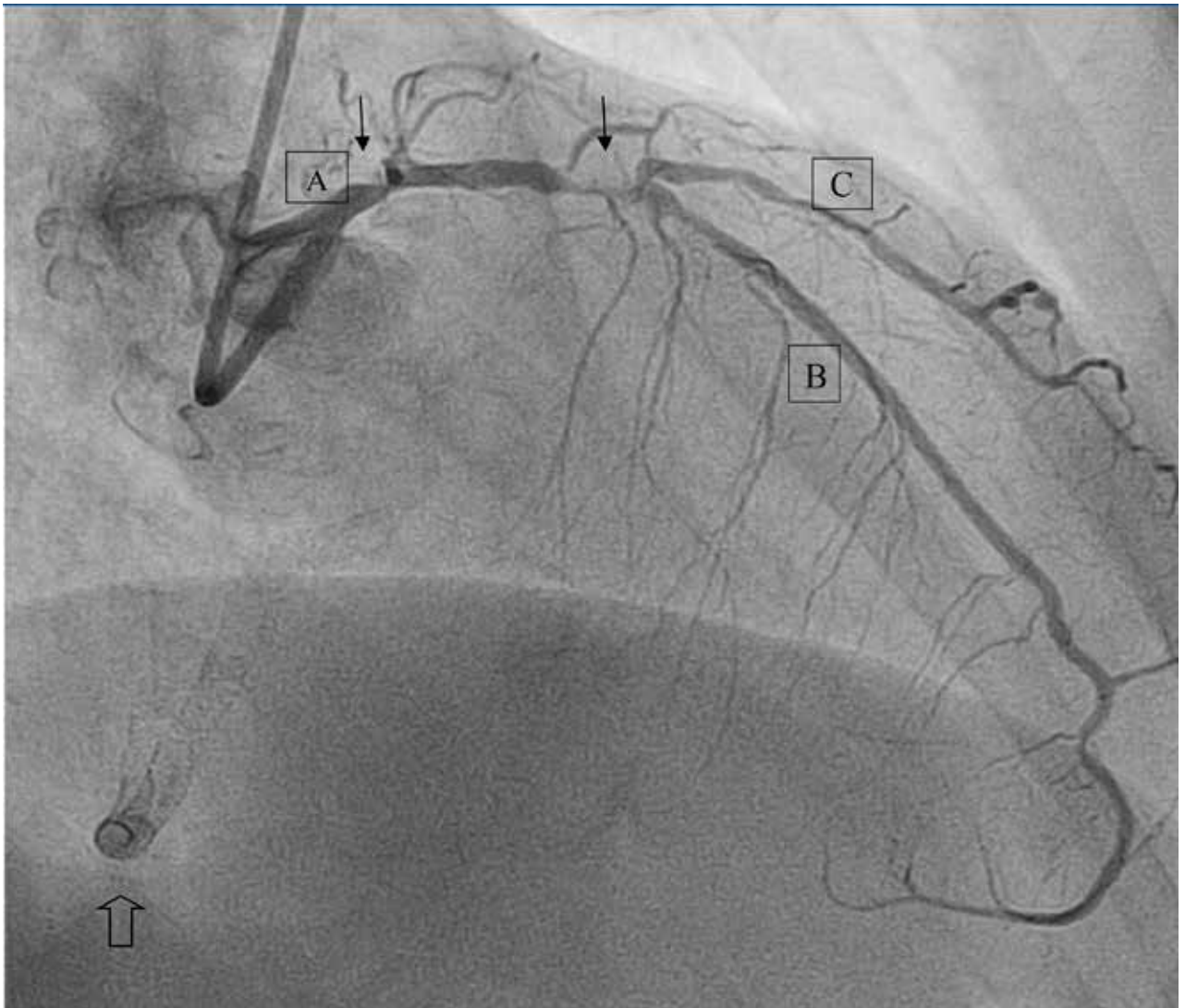
(A) — right coronary artery (RCA),

(B) — conus (arteriosus) artery,

(C) — right marginal artery,

(D) — posterior descending artery (PDA),

(E) — Posterolateral branch.

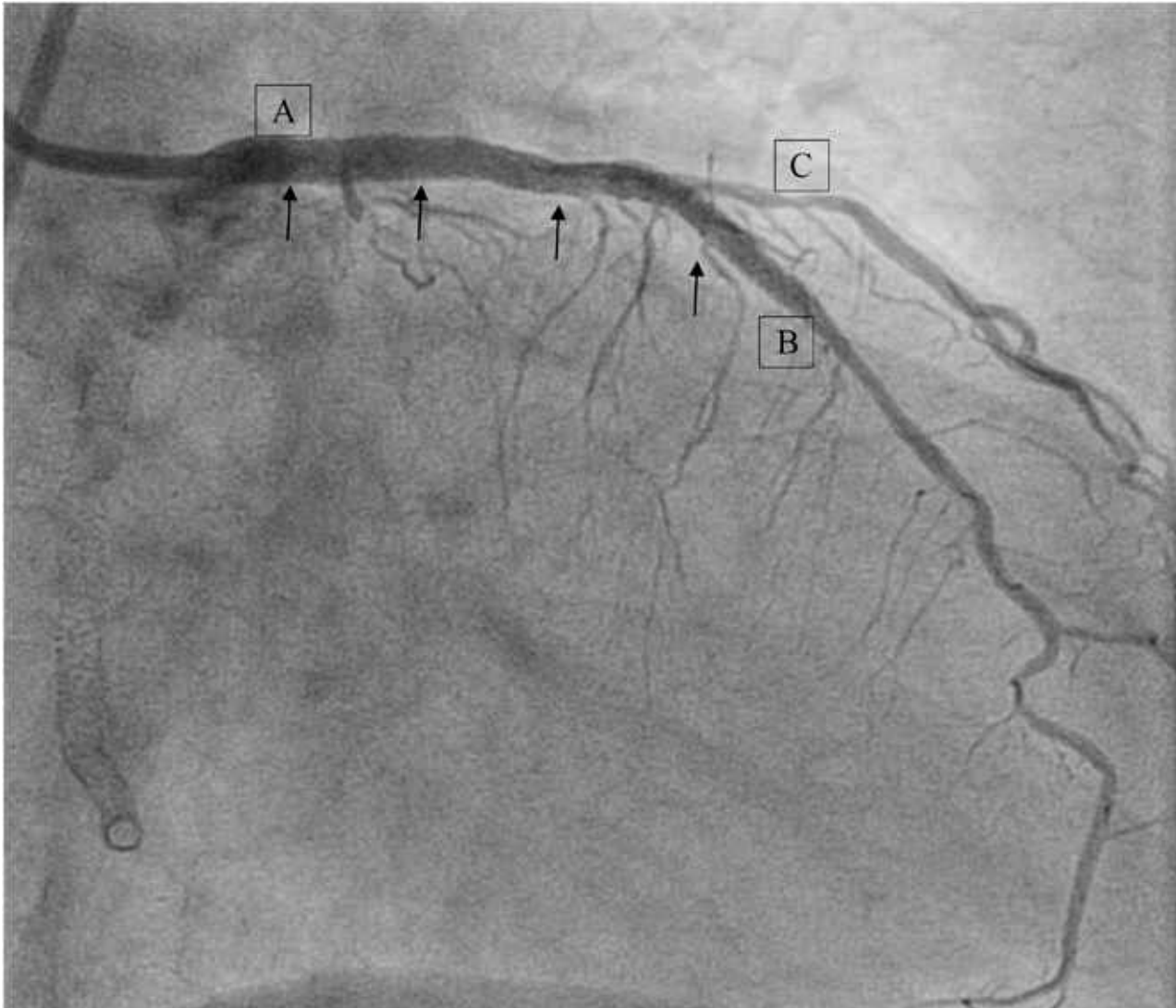


**A 67-year-old female** with unstable angina, T2D complains of shortness of breath during exercise, chest pain with radiation to interscapular region that is almost constant.

Coronary angiogram shows 70% stenosis of the circumflex branch bifurcation and 90% stenosis of the LAD (arrows). Atherosclerotic plaques with uneven ulcerated margins are the signs of complicated

atherosclerosis. Also, previously placed stents in the RCA are visualized (large arrow).

- (A) — left main coronary artery (LMCA),
- (B) — left anterior descending artery (LAD),
- (C) — diagonal branch

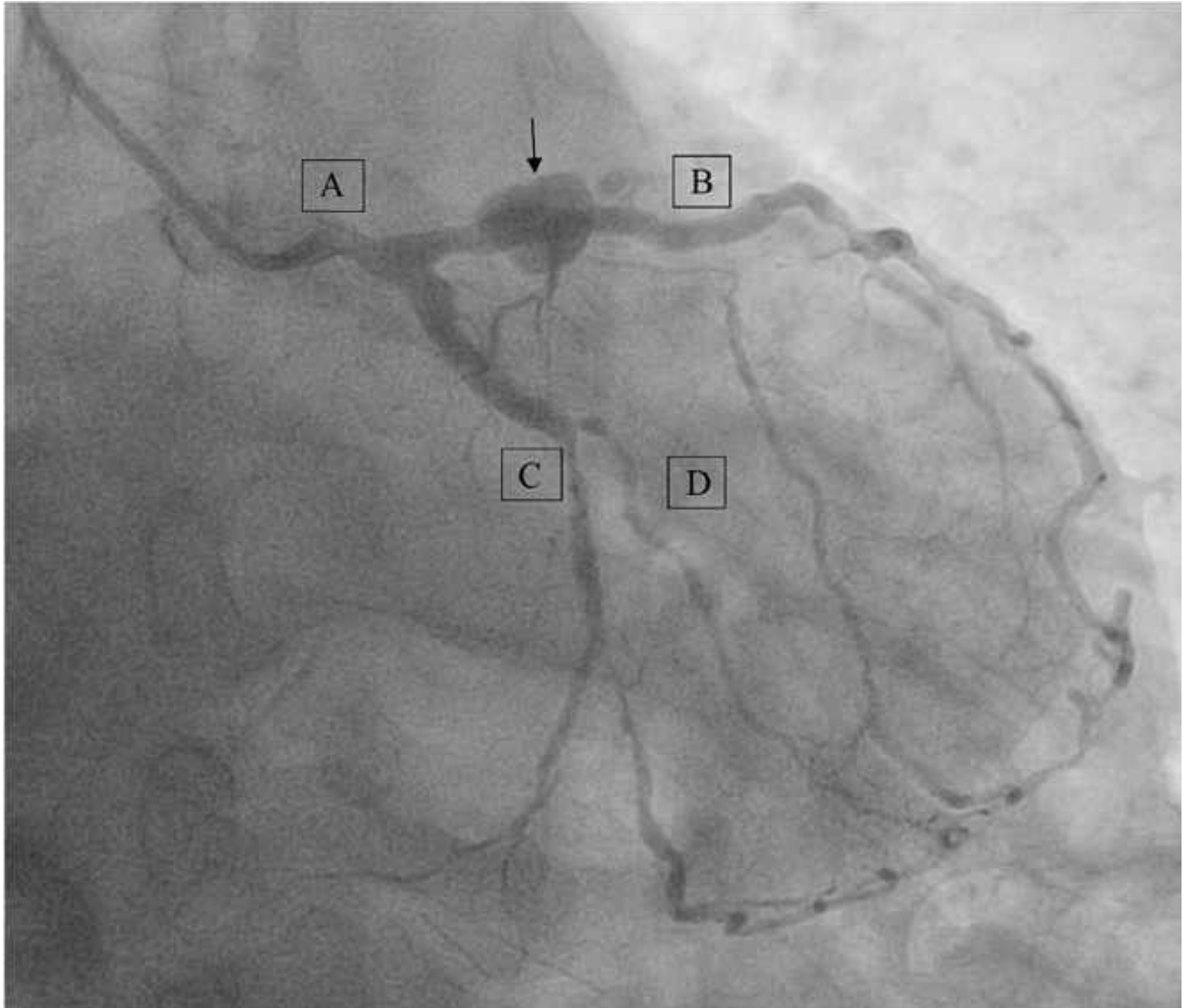


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Transluminal balloon coronary angioplasty with LCX and LAD stent implantation was performed with positive angiographic and clinical effects: distal artery filling without any signs of occlusion and

angina symptoms. Implanted stents are shown with arrows.

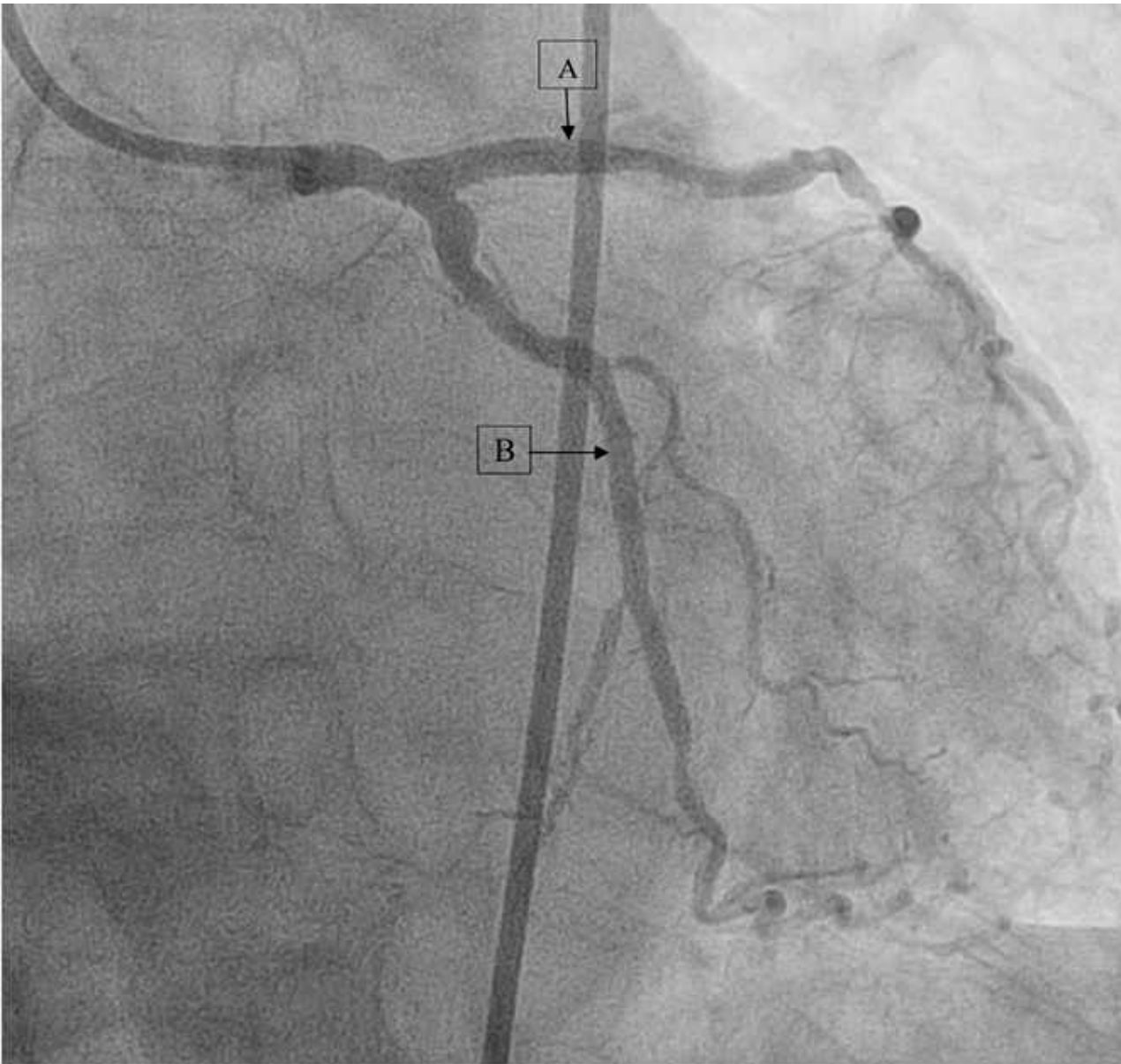
- (A) — *left main coronary artery (LMCA)*,
- (B) — *left anterior descending artery (LAD)*,
- (C) — *diagonal branch*.



**A 68-year-old** male with CAD, stable angina CCS class III presents with chest pain when climbing uphill and slow-pace walking for 100–200 m.

Coronary angiogram shows diffuse coronary atherosclerosis that is typical for T2D patients. 40% stenosis of LCA (A), 70% mid-LCX stenosis (B), proximal LAD widening (arrow), diffuse LMB atherosclerosis (D)

(A) — left main coronary artery (LMCA),  
(B) — left anterior descending artery (LAD),  
(C) — left circumflex branch (LCX),  
(D) — left marginal branch (LMB).



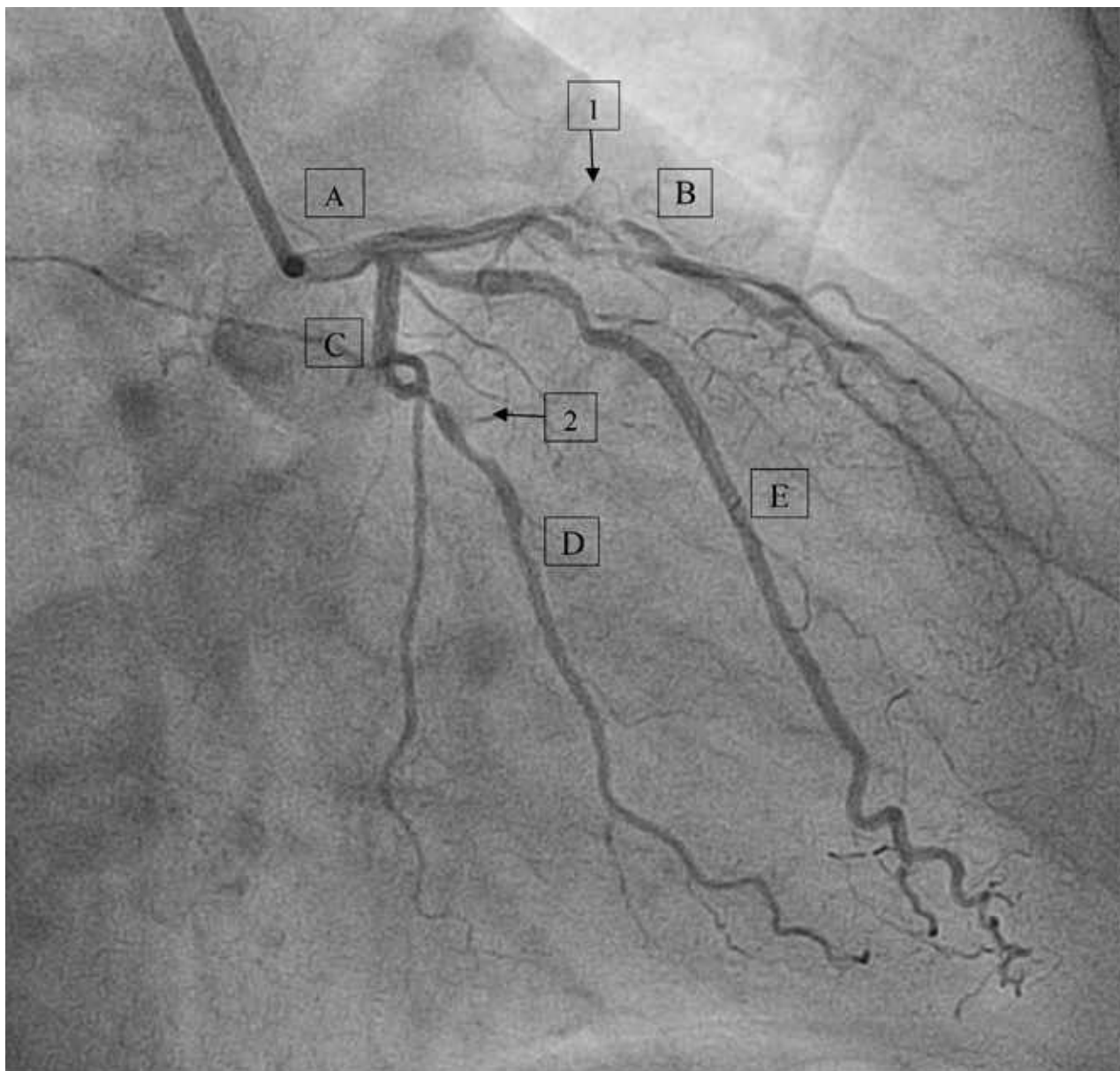
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Transluminal balloon coronary angioplasty with stent graft placement in the proximal LAD was performed with positive angiographic and clinical results (A). After the stent graft was placed, the LAD widening reduced. Then, balloon angioplasty with stent placement were performed (B) with positive angiographic (coronary artery filling with contrast,

the absence of filling deficits) and symptomatic effects.

Coronary angiogram shows the results of the procedure, with arrows showing the treated segments.

(A) — *left anterior descending artery (LAD)*,  
(B) — *left circumflex branch (LCX)*.

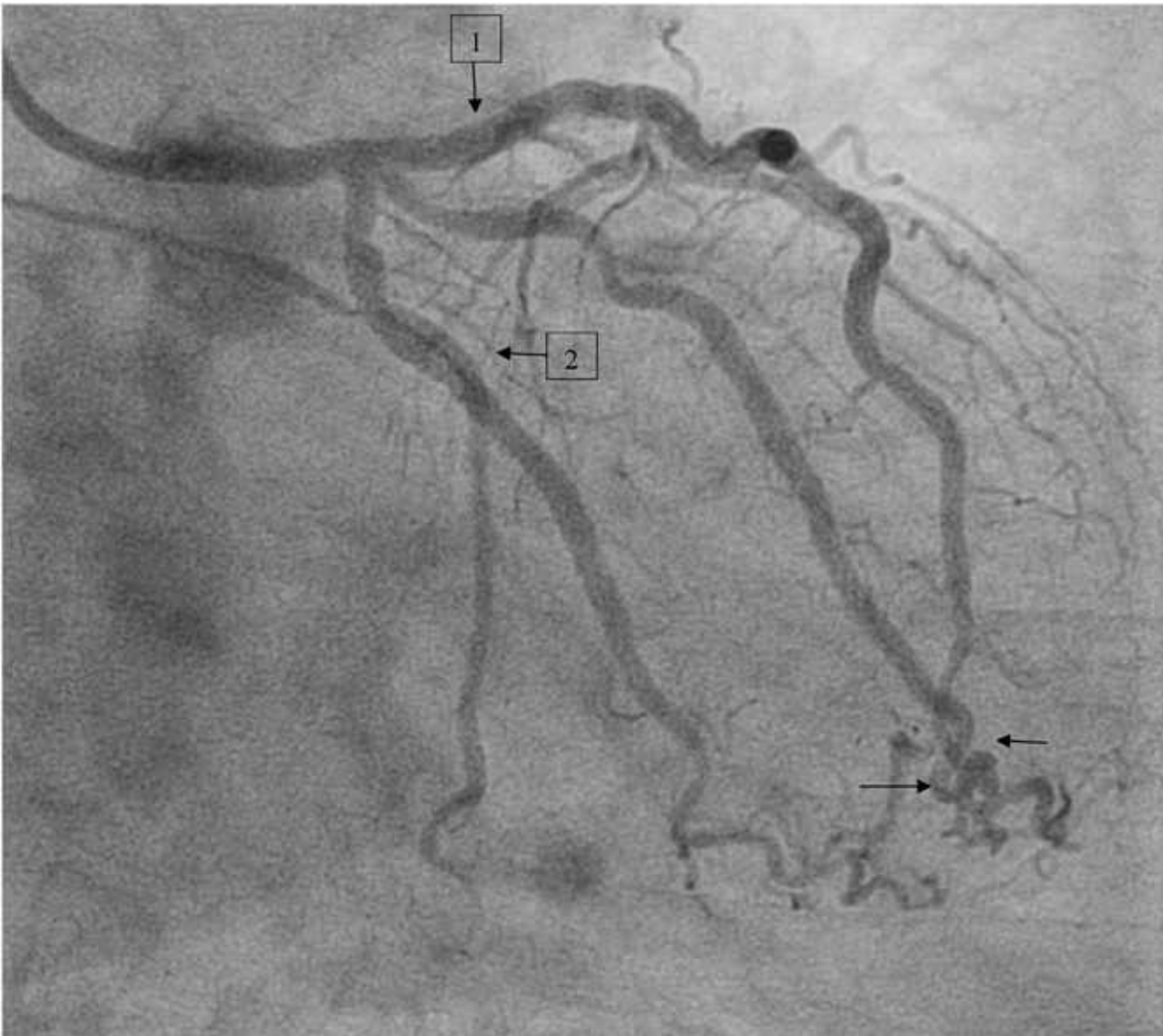


**A 66-year-old male** with CAD, stable angina CCS class III, and T1D presented complaining of substernal chest pains that irradiate to the left shoulder and arm and start with fast-paced walking for up to 50 m and with slow-pace walking for up to 100 m and stop after using 1–3 doses of nitroglycerin spray.

Coronary angiogram shows subtotal (99%) LAD stenosis (arrow 1) and diffuse atherosclerosis in the LMA with proximal and mid-segment 80% stenosis (arrow 2). In this case, endovascular strategy is preferred over CABG due to Syntax Score I<sup>1</sup>=11 and diffuse atherosclerosis.

(A) — *left main coronary artery (LMCA)*,  
 (B) — *left anterior descending artery (LAD)*,  
 (C) — *left circumflex artery (LCX)*,  
 (D) — *left marginal branch*,  
 (E) — *intermedial branch*.

<sup>1</sup> The Synergy between Percutaneous Coronary Intervention with Taxus and Cardiac Surgery (SYNTAX) score is an angiographic tool to grade the complexity and severity of coronary artery disease (CAD). The SYNTAX Score guides the individual treatment decision making between PCI and CABG



*Continued*

Transluminal balloon angioplasty with proximal LAD stenting (arrow 1) and LMB (arrow 2) was successfully performed with positive angiographic and clinical effects.

Repeat angiography shows that both stents are expanded, with no signs of stenosis or coronary dis-

section. TIMI grade 3 flow. Distal LAD and LMB twisting (arrows) are typical for patients with long-standing AH.



**A 60-year-old male** with CAD, stable angina CCS class II, and a history of of substernal chest pains that irradiate to the left shoulder and arm and start with fast-paced walking for up to 50 m and with slow-pace walking for up to 100 m and stop after using 1–3 doses of nitroglycerin spray.

Stress echocardiography showed areas of hypokinesia of the lateral left ventricular wall.

Coronary angiography revealed chronic LCX occlusion (arrow). For occlusion recanalization and better distal LCX visualization collateral arteries were filled

with contrast. That allowed to visualize the vessel lumens of RCA and LCA.

- (A) — *right coronary artery (RCA)*,
- (B) — *left main coronary artery (LMCA)*,
- (C) — *left anterior descending artery (LAD)*,
- (D) — *left circumflex artery (LCX)*.

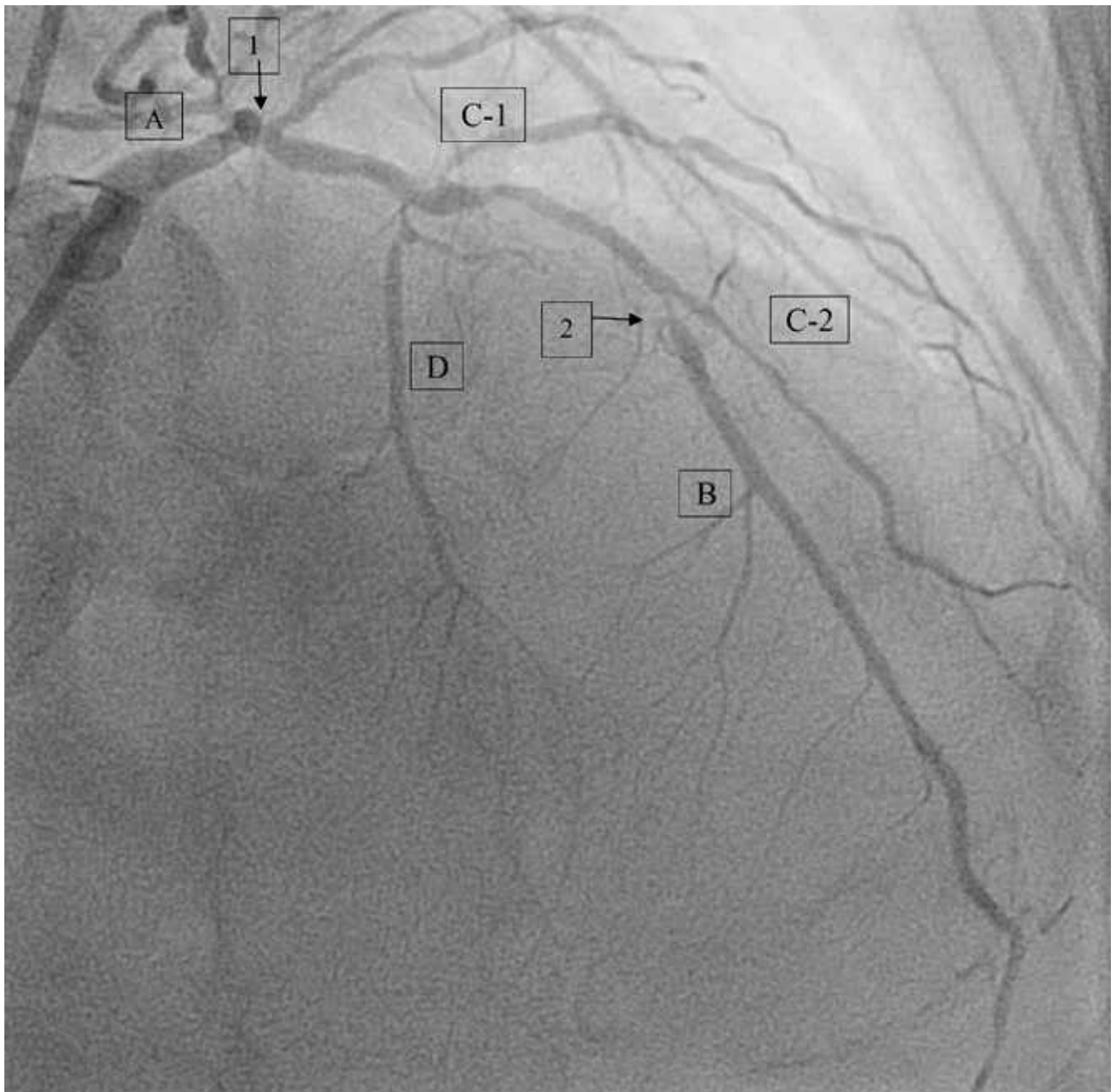


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Occlusion recanalization was performed and antegrade blood flow has fully recovered. Arrows show the area where the stent was placed. Coronary an-

giogram shows good microvascular filling, and the patients notes better excersize tolerance.



**An 80-year-old male** with CAD, stable angina CCS class III, and a history of substernal chest pain aggravated by exertion and cold.

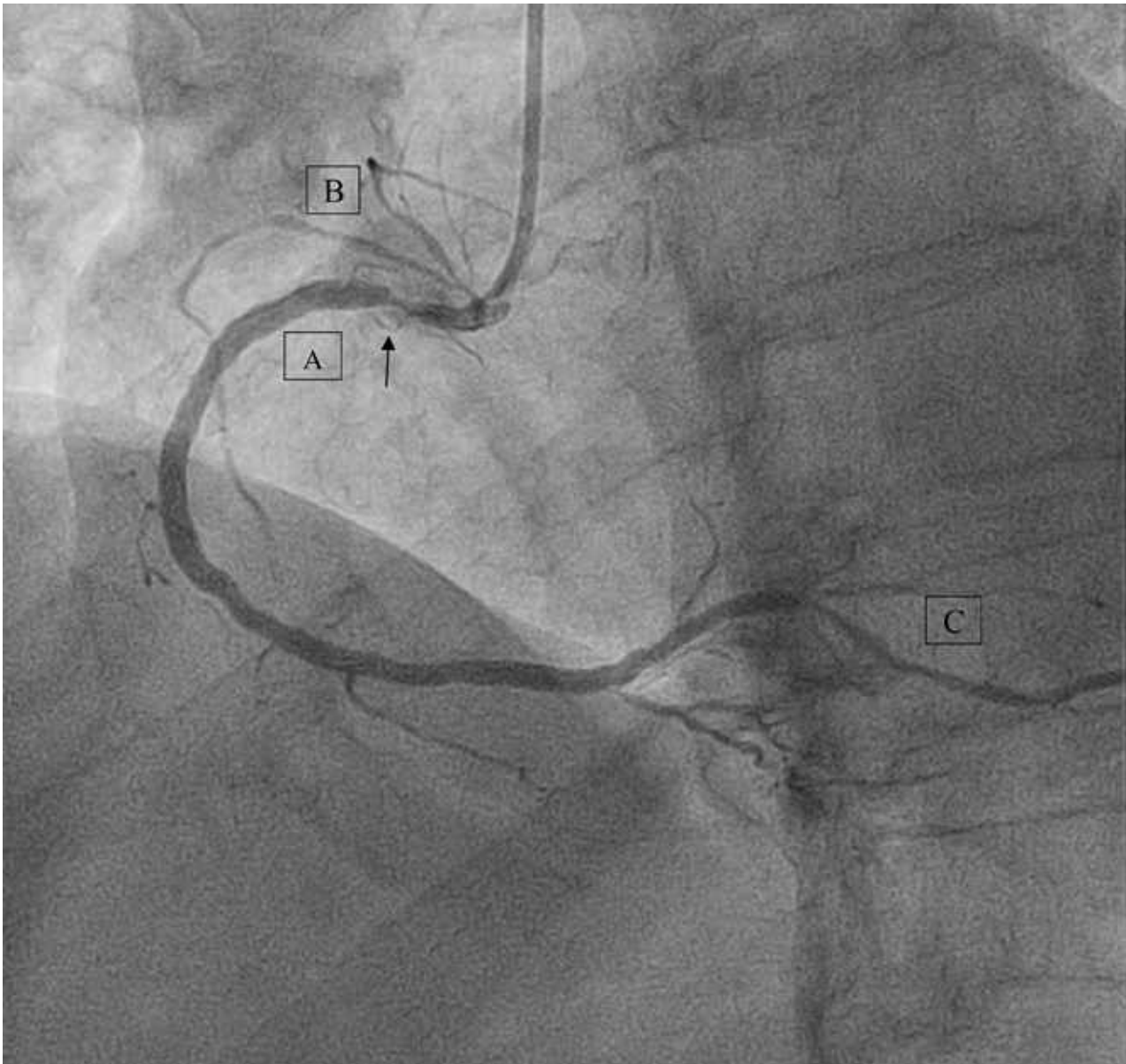
Coronary angiogram shows a 70% terminal LCA stenosis (arrow 1) and a 85% stenosis of LAD bifurcation (arrow 2). Diffuse atherosclerosis is characteristic of diabetic coronary involvement.

(A) — left main coronary artery (LMCA),

(B) — left anterior descending artery (LAD),

(C) — diagonal arteries

(D) — major septal branch.



*Continued*

RCA angiogram shows a 90% ostial stenosis (arrow) with distal diffuse atherosclerosis. Syntax Score I=17, which means that both direct and endovascular revascularization can be performed in this patient with similar prognosis. However, due to the absence

of significant twisting and calcifications endovascular revascularisation was a better choice.

(A) — right coronary artery (RCA),

(B) — The sinoatrial nodal artery

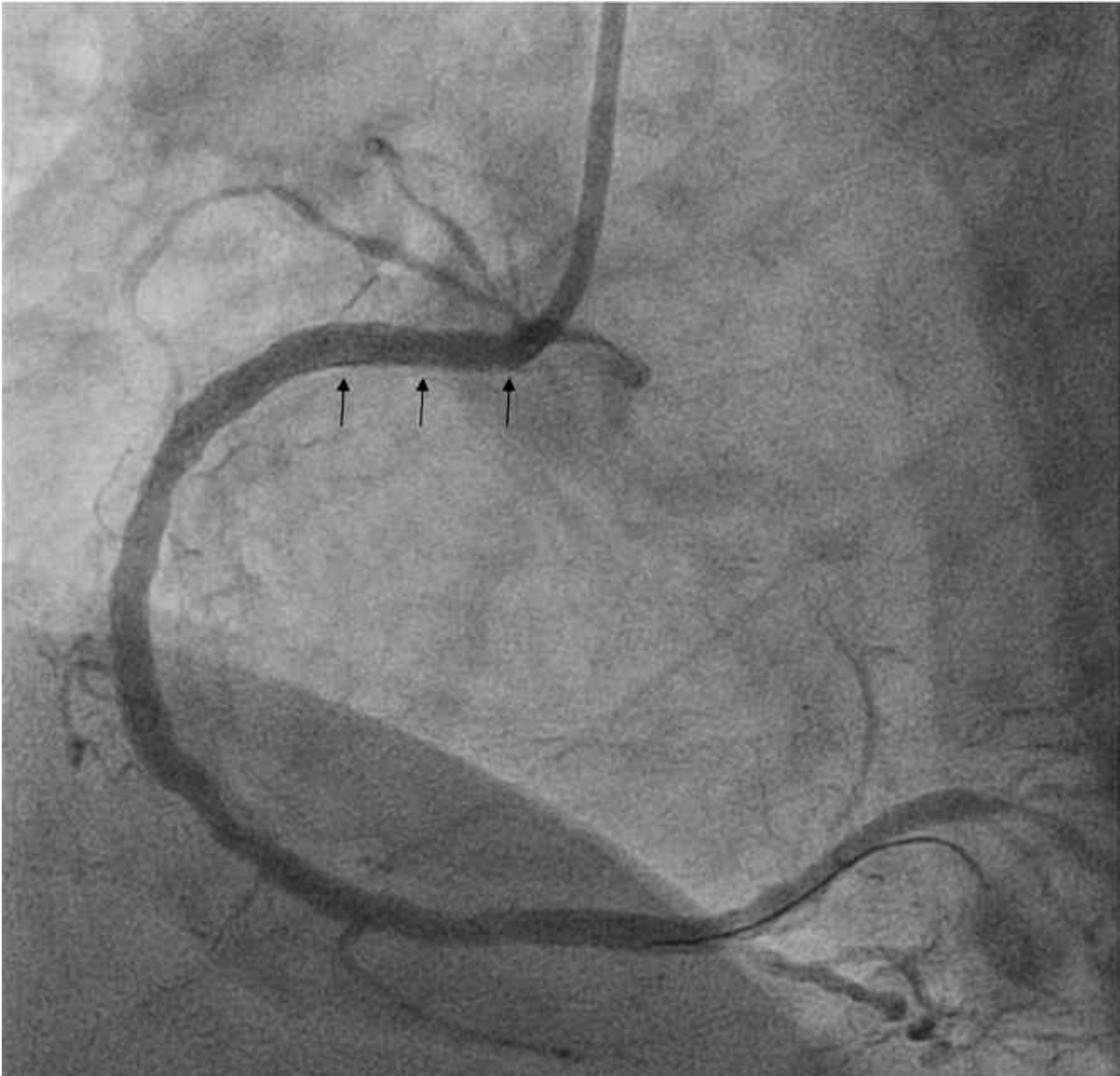
(C) — RCA posterolateral branch.



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LCA and RCA stenting was performed and LCA and LAD transluminal balloon angioplasty (arrows).

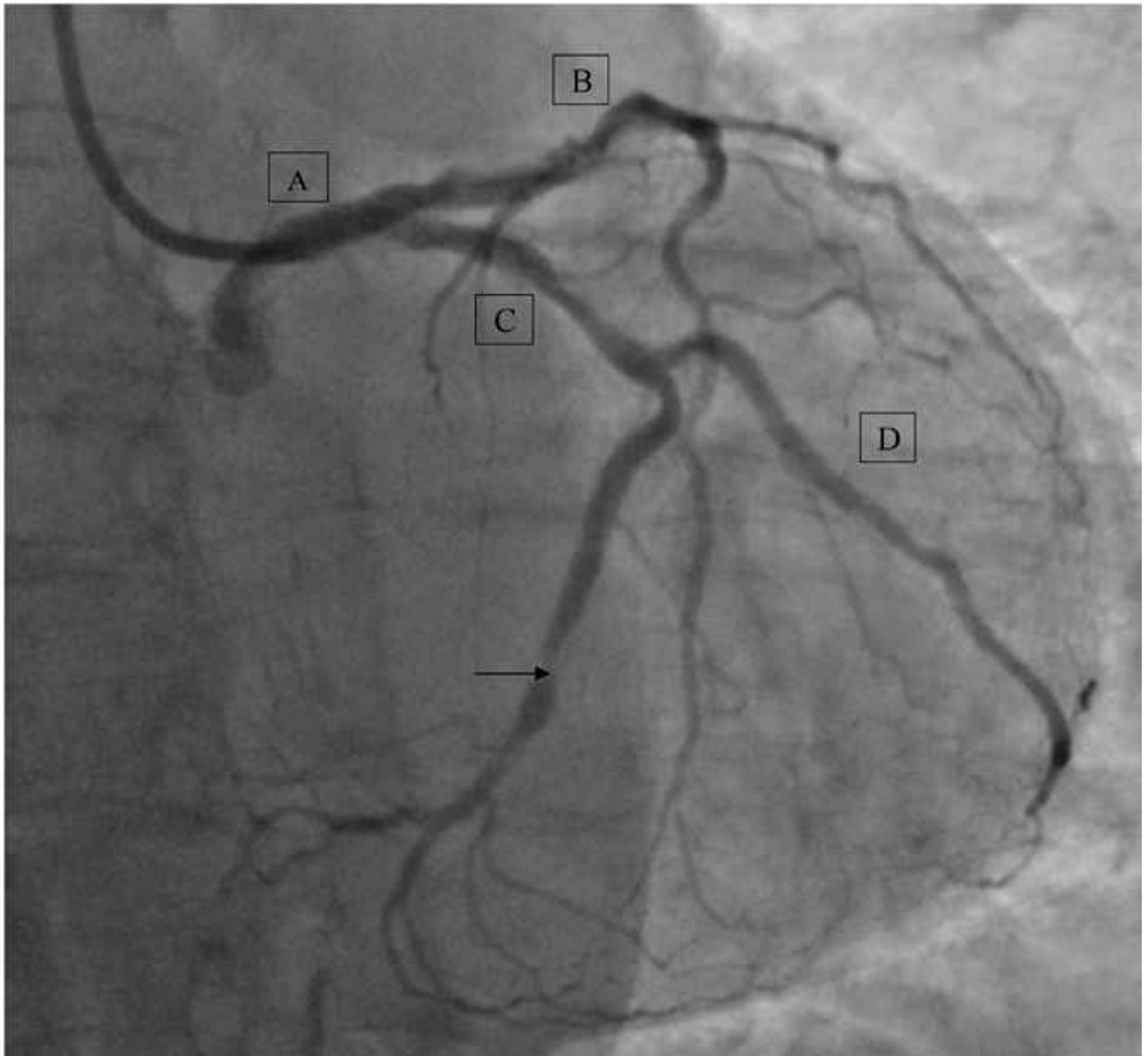
Coronary angiogram shows the final result with arrows pointing at the areas that were reconstructed. (A) — *pacemaker*



*Continued*

The final RCA angiogram. Stent was placed in the proximal RCA and minor part of aorta (2-3 mm) to secure the whole atherosclerotic plaque and RCA orifice (arrow).

The patient described a significant improvement of his quality of life. His exercise and everyday activity tolerance returned back to baseline.



**A 66-year-old patient** with CAD, stable angina CCS stage III, T2D presents with chest pain with mild excretion.

Coronary angiogram, right caudal view: a 90% stenosis of the mid-LCX (arrow).

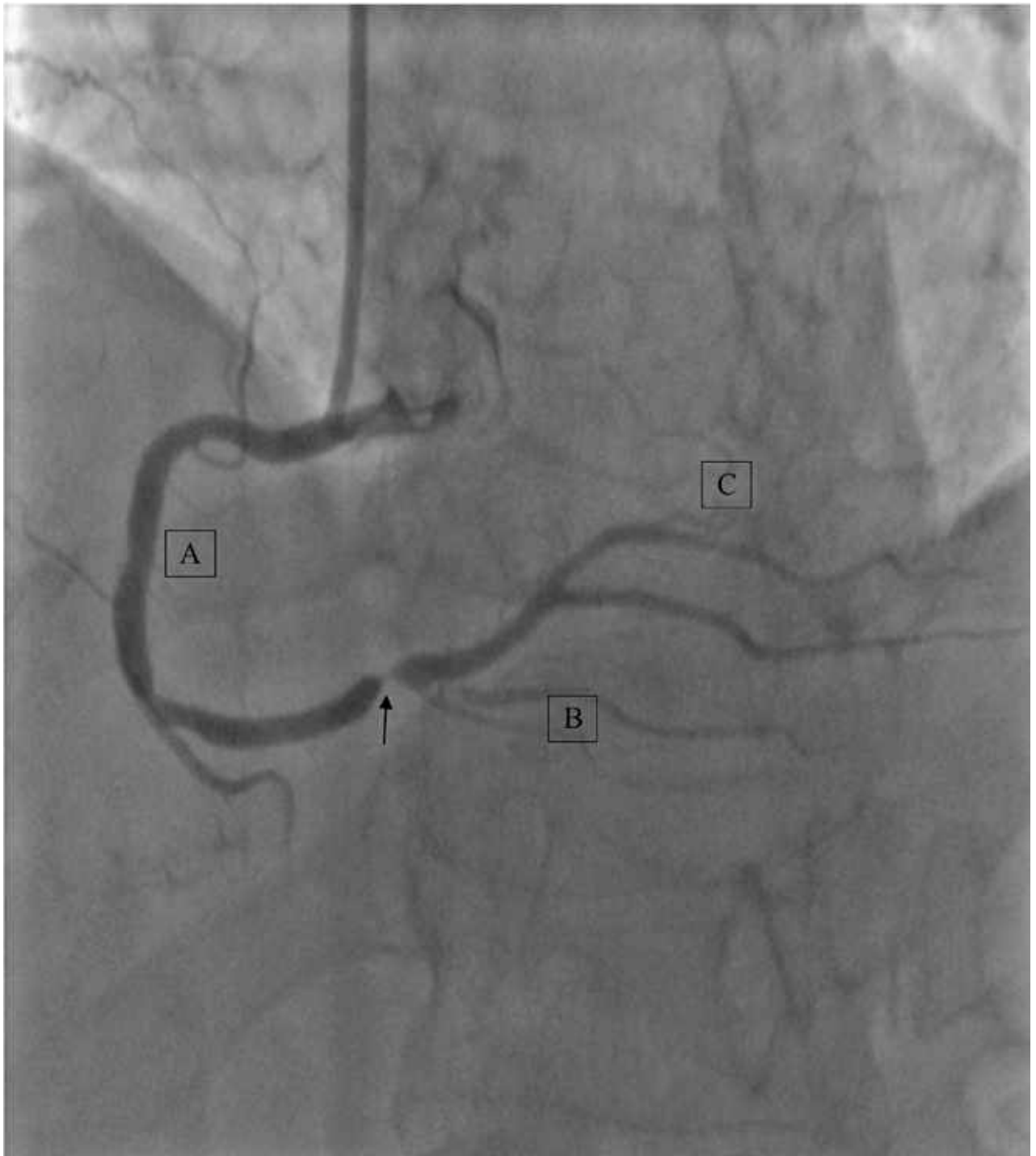
(A) — *left main coronary artery (LMCA)*,  
(B) — *left anterior descending artery (LAD)*,  
(C) — *obtuse marginal branch (OMB)*.



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Transluminal balloon coronary LCX angioplasty was performed with stent placement. The stent has fully expanded with no signs of dissection or stenosis. After the procedure angina has completely resolved.

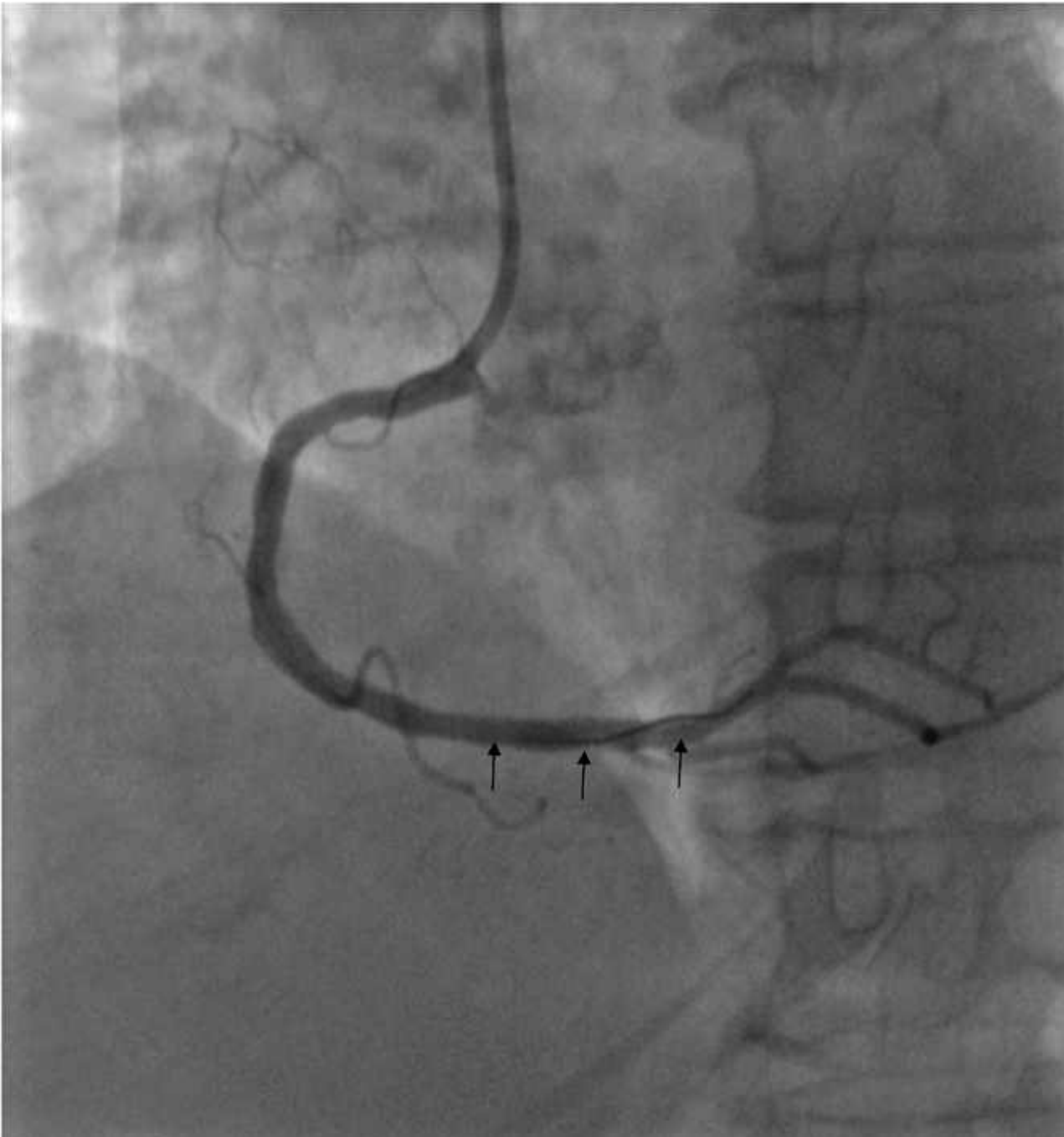
Coronary angiogram shows incomplete filling of microvascular structures with contrast that can be associated with microvascular changes due to diabetes (arrows).



**A 72-year-old male** with a history of CAD, stable angina CCS class II and T2D presented with chest tightness with walking for up to 200 m.

Stress echocardiography showed anterior and inferolateral wall hypokinesia. Coronary angiogram shows a 99% distal RCA stenosis (arrow).

(A) — *right coronary artery (RCA)*,  
(B) — *posterior descending artery (PDA)*,  
(C) — *right coronary artery (RCA) posterolateral branch*.

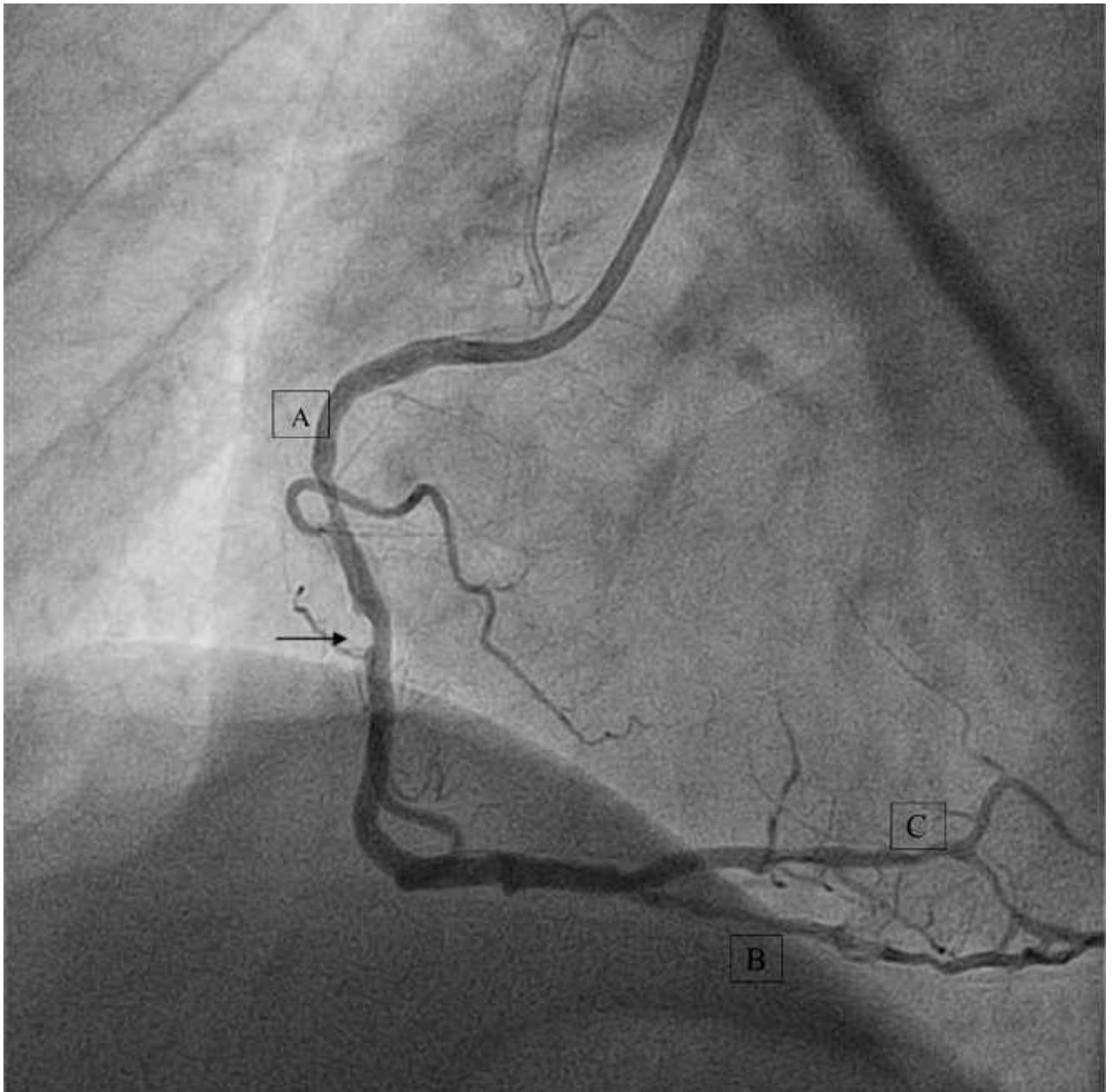


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Transluminal balloon angioplasty with drug-eluting stent placement was performed. Full stent expansion has resulted in positive angiographical and clinical outcomes (arrows) — flow obstruction has been re-

solved and there are no signs of complications or dissection.

After discharge the patient noted a complete resolution of chest pain even with intense exertion.

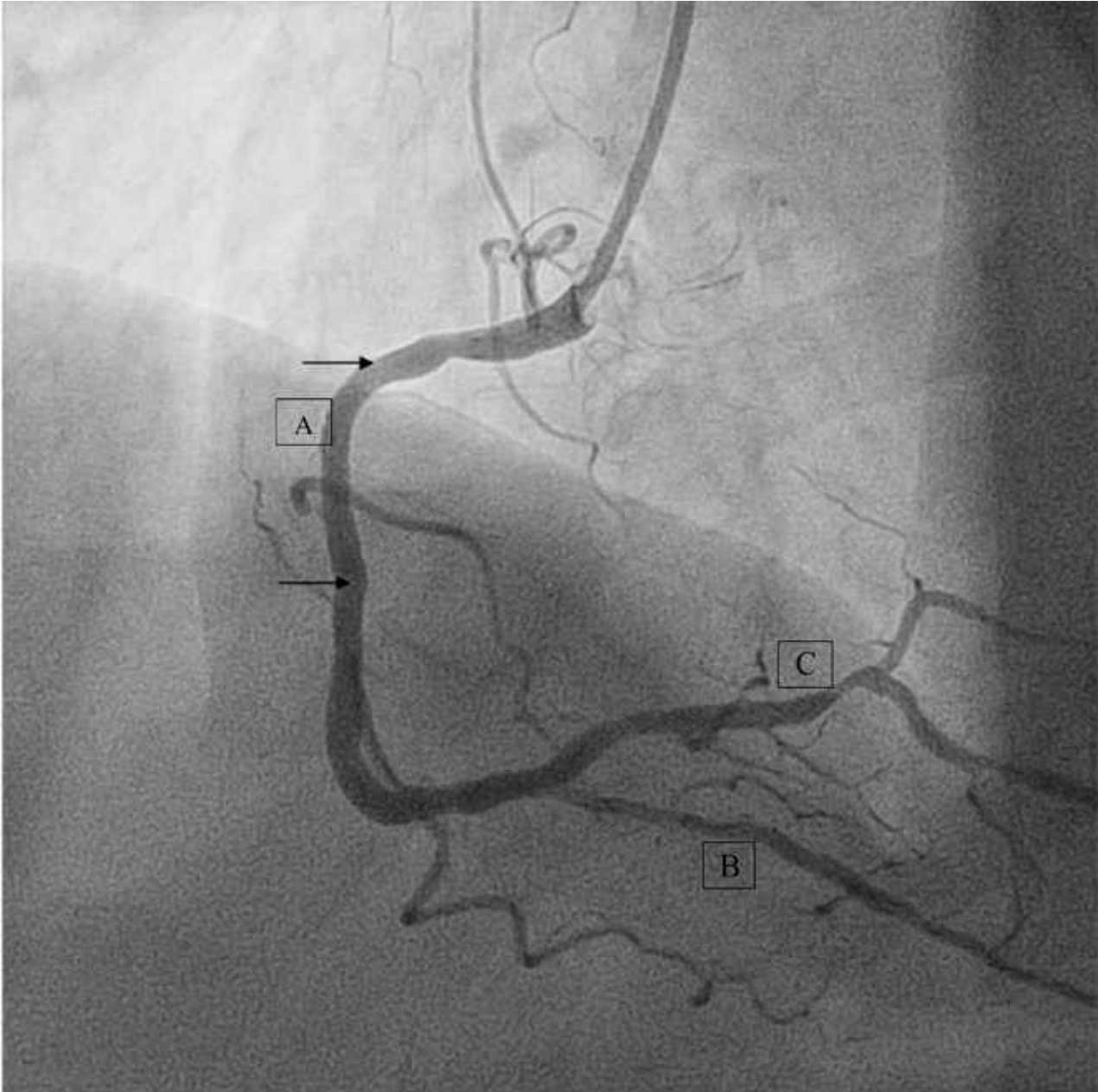


**A 45-year-old female** with a history of CA, stable angina CCS class II and chest pain after climbing 4 flights of stairs.

A treadmill test showed submaximal HR wasn't reached due to chest pain that stopped after 5 min of rest and ECG changes — ST depression in II, III, aVF for 2.5 mm.

Coronary angiogram shows local 75 % RCA atherosclerosis (arrow).

(A) — *right coronary artery (RCA)*,  
(B) — *posterior descending branch (PDA) and*  
(C) — *posterolateral branch without hemodynamically significant stenosis.*

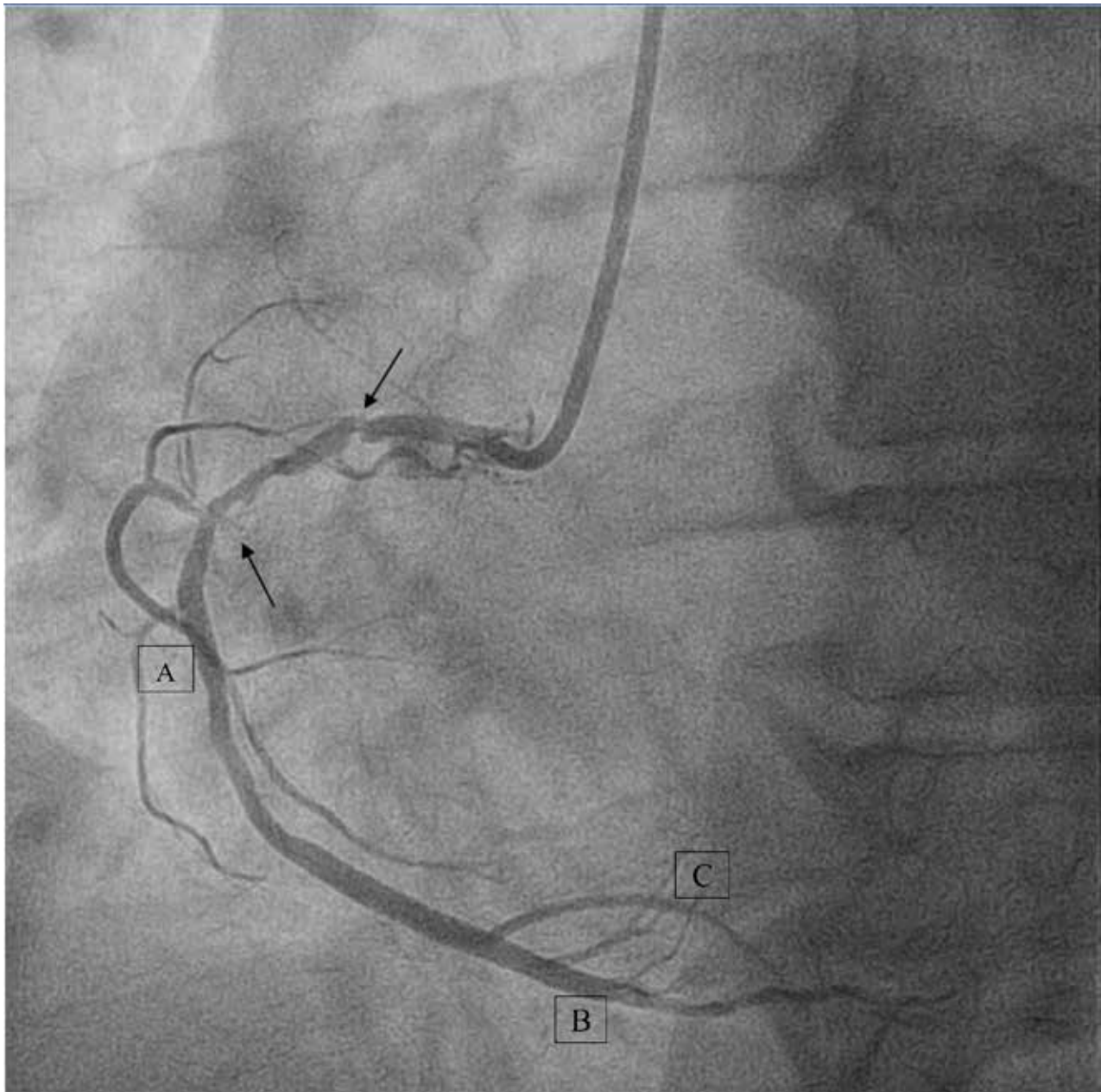


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Balloon angioplasty with RCA stent placement (arrow) was performed, the stent has fully expanded without any signs of stenosis, dissection, or lateral branches occlusion.

Echocardiography shows no areas of hypokinesis. The patient returned to her baseline activity level.

- (A) — right coronary artery (RCA),
- (B) — posterior descending artery,
- (C) — posterolateral branch (PLB).

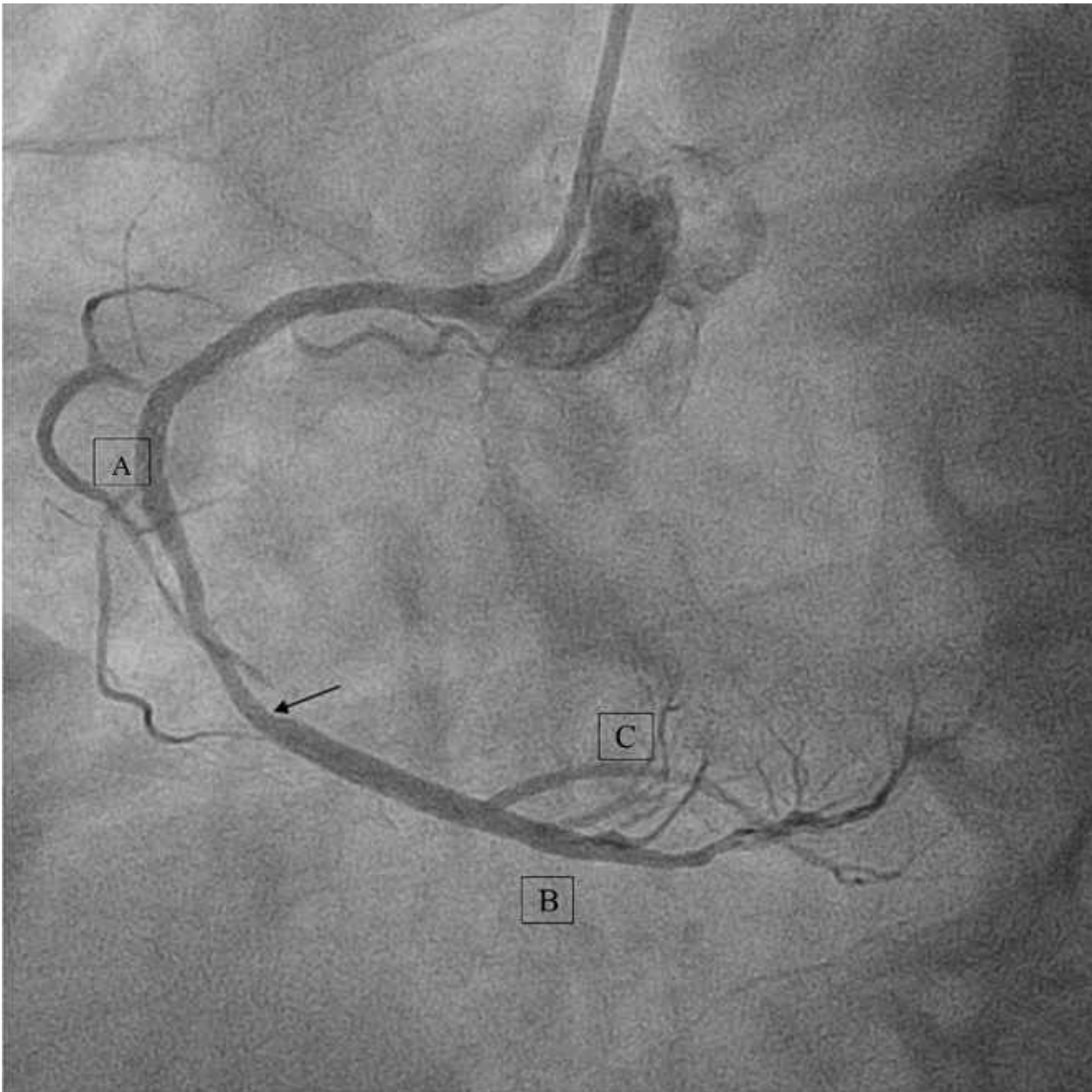


**A 48-year-old female** with T1D and familial hyperlipidemia.

Has a family history of MI in her parents at ages 50 and 54. Complains of decreased exercise tolerance over the last 6 months and chest pain with fast walking for up to 300 m and SOB when climbing stairs. Stress echocardiography showed LV inferior wall hypokinesia.

Coronary angiography showed a coronary tandem 75–80% lesion in the proximal RCA (arrows).

- (A) — *right coronary artery (RCA)*,
- (B) — *posterior descending artery*,
- (C) — *posterolateral branch (PLB)*.



*Continued*

RCA stenting was performed. Repeat angiogram showed a fully expanded stent, diameter of the stent fit vessel size, no dissections or perforations were seen.

Coronary angiogram shows a 30% mid-RCA stenosis that didn't require any intervention. The patient

will be taking a dual antithrombotic therapy and hypolipidemic therapy to achieve target lipid levels.

(A) — right coronary artery (RCA),

(B) — posterior descending artery,

(C) — posterolateral branch (PLB).



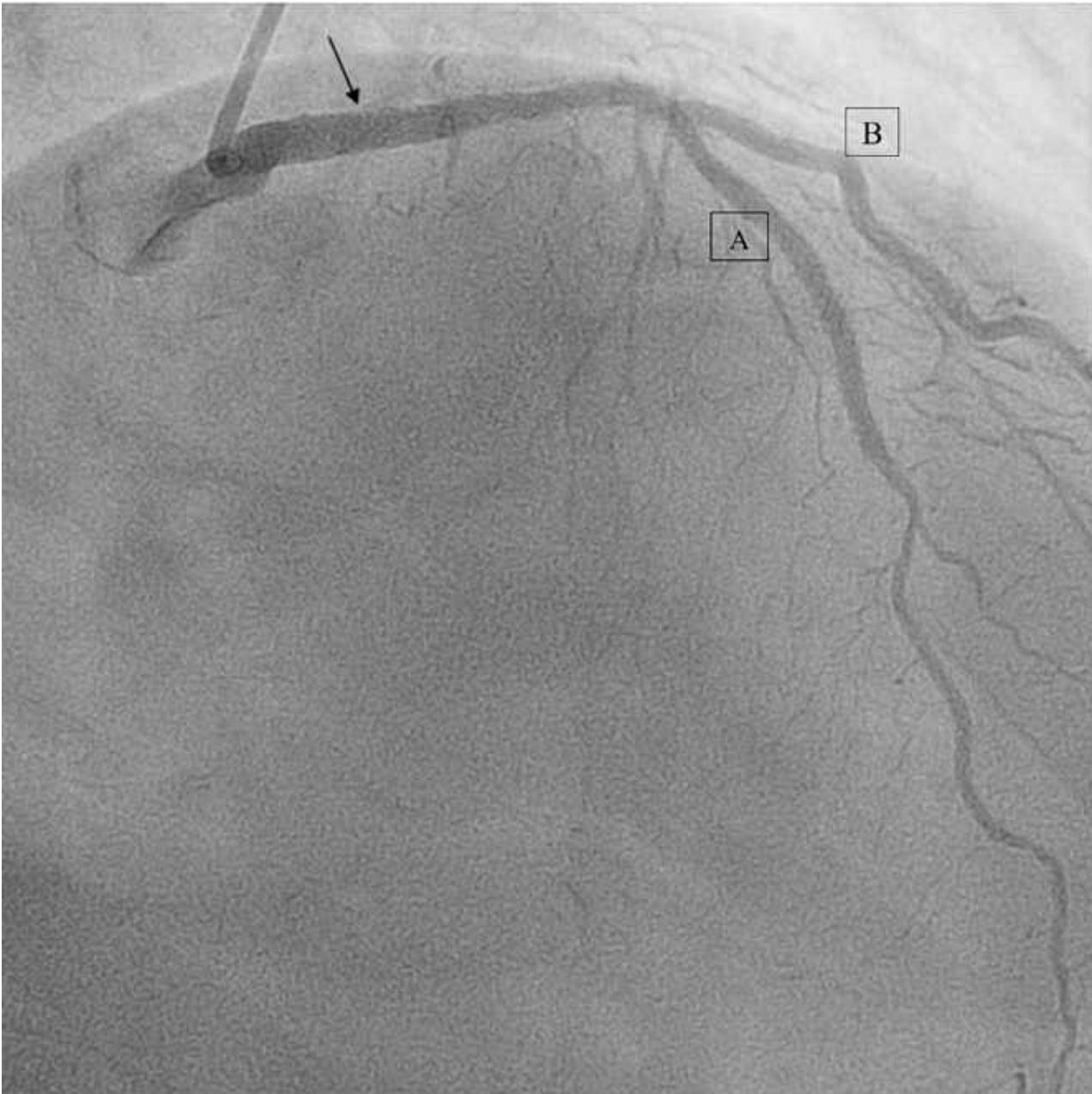
**A 78-year-old male** with CAD, CCS class II stable angina with typical chest pain with walking for up to 200 m.

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Coronary angiogram shows atypical anatomy. LAD starts directly from the left aortic sinus (A), LCX starts from the proximal RCA.

Proximal LAD atherosclerosis with calcifications (arrow).

(A) — *left anterior descending artery (LAD)*,  
(B) — *diagonal branch*.



*Continued*

A series of balloon angioplasty procedures with high-pressure catheters were performed with full vessel expansion that isn't always achieved in arterial lesions with calcifications.

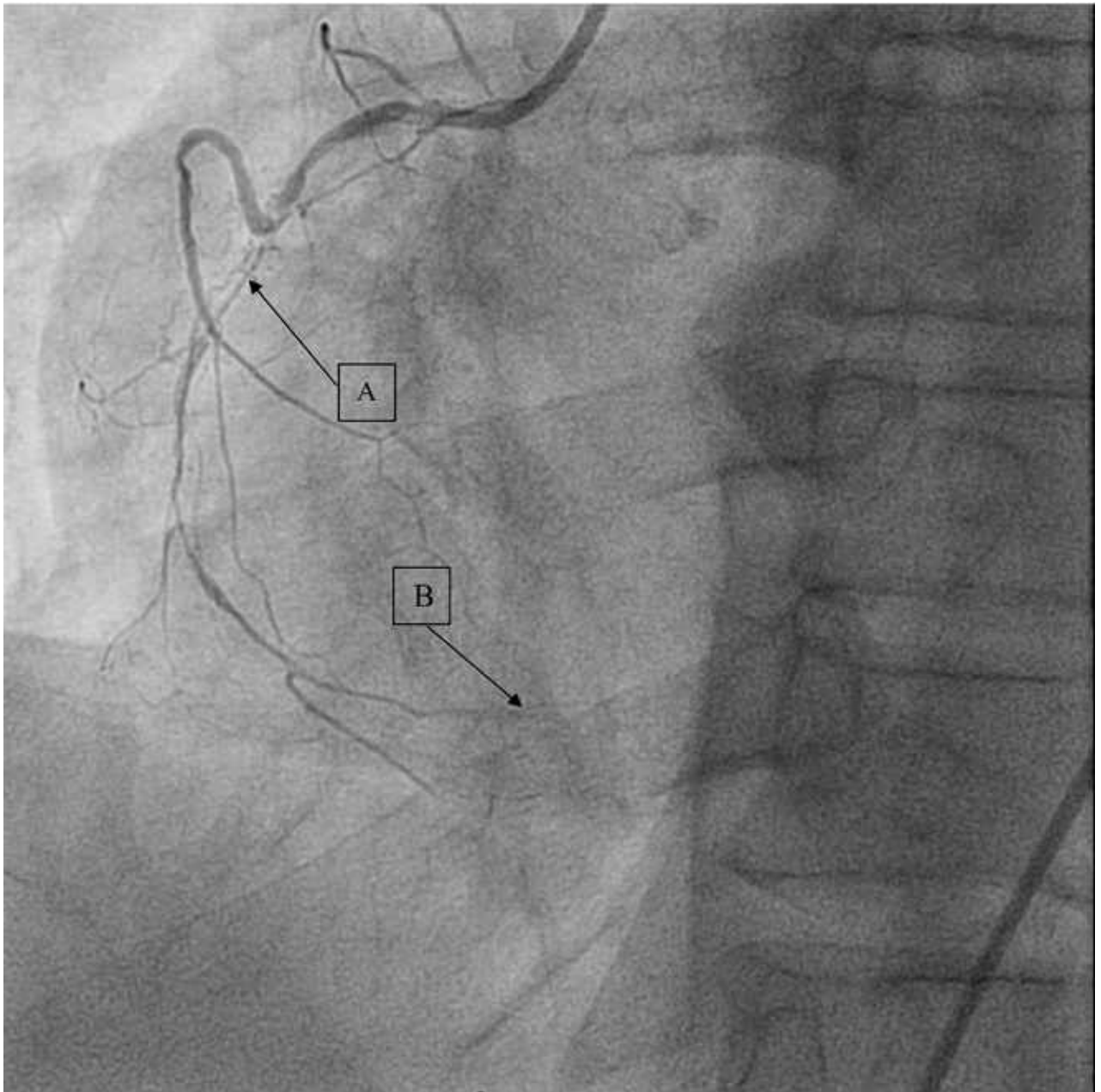
After the balloon catheter has fully expanded a stent was placed (arrow).

Repeat coronary angiogram shows a fully expanded stent without signs of stenosis or dissection.

At discharge the patient described no chest pain or any other angina symptoms while walking for more than 500m and climbing to the 5<sup>th</sup> floor. The patients also didn't have to stop while performing a 6-minute walk test.

(A) — *left anterior descending artery (LAD)*,

(B) — *diagonal branch*.



**A 68-year-old female** with unstable angina — early post-MI angina — complains of significant SOB with mild exertion. Echocardiography showed LV inferior wall hypokinesia and LVEF reduction to 38 %.

Coronary angiography showed diffuse RCA atherosclerosis with 99 % stenosis of proximal-to-distal segments (arrow A) and distal segment occlusion (arrow B).

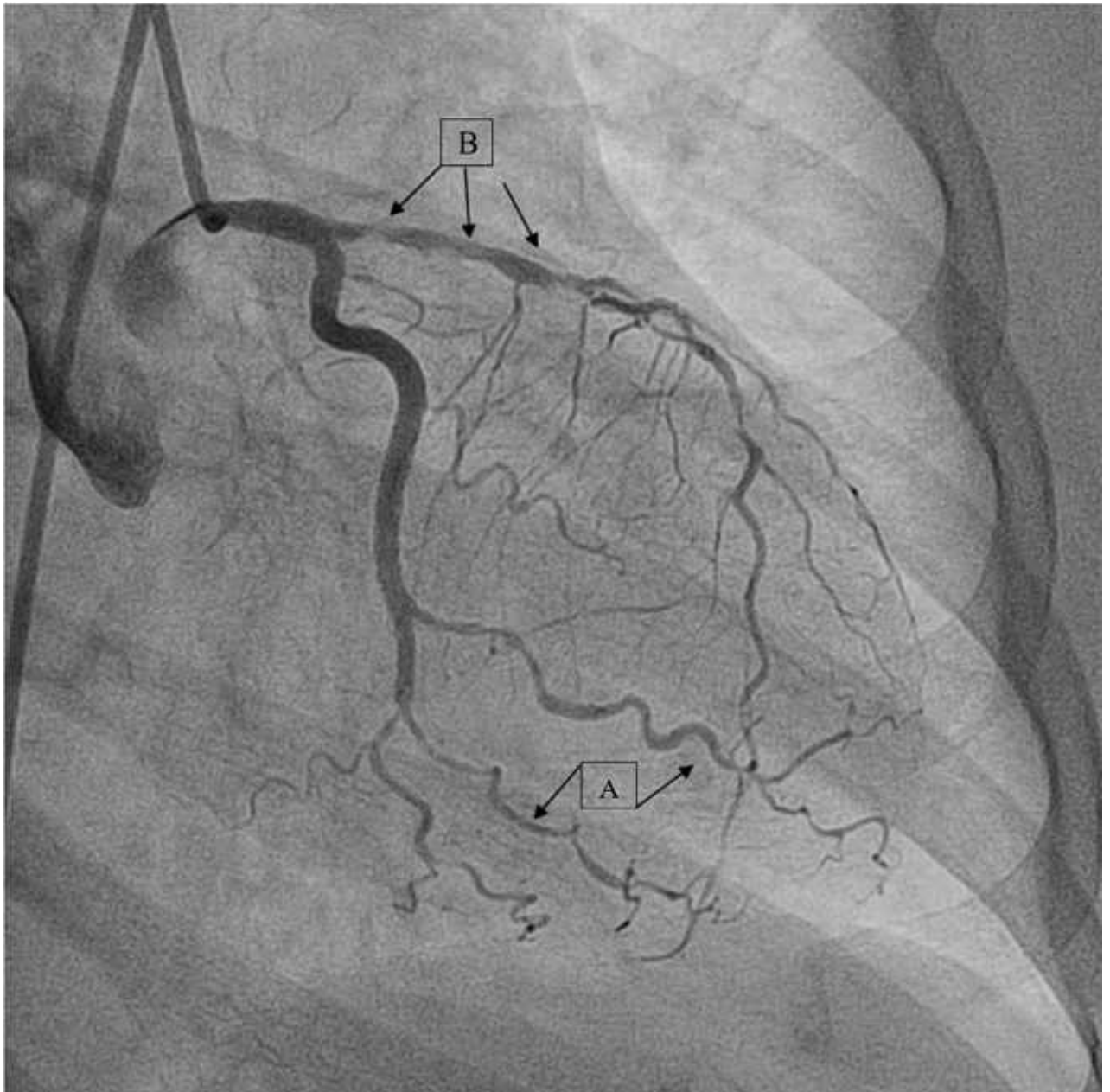


*Continued*

Coronary guidewire (arrow A) was navigated across distal-PIVA stenosis, balloon recanalization was performed with complete flow restoration and middle-to-proximal segment stent was placed (arrows). At 2-days follow-up the patient had no

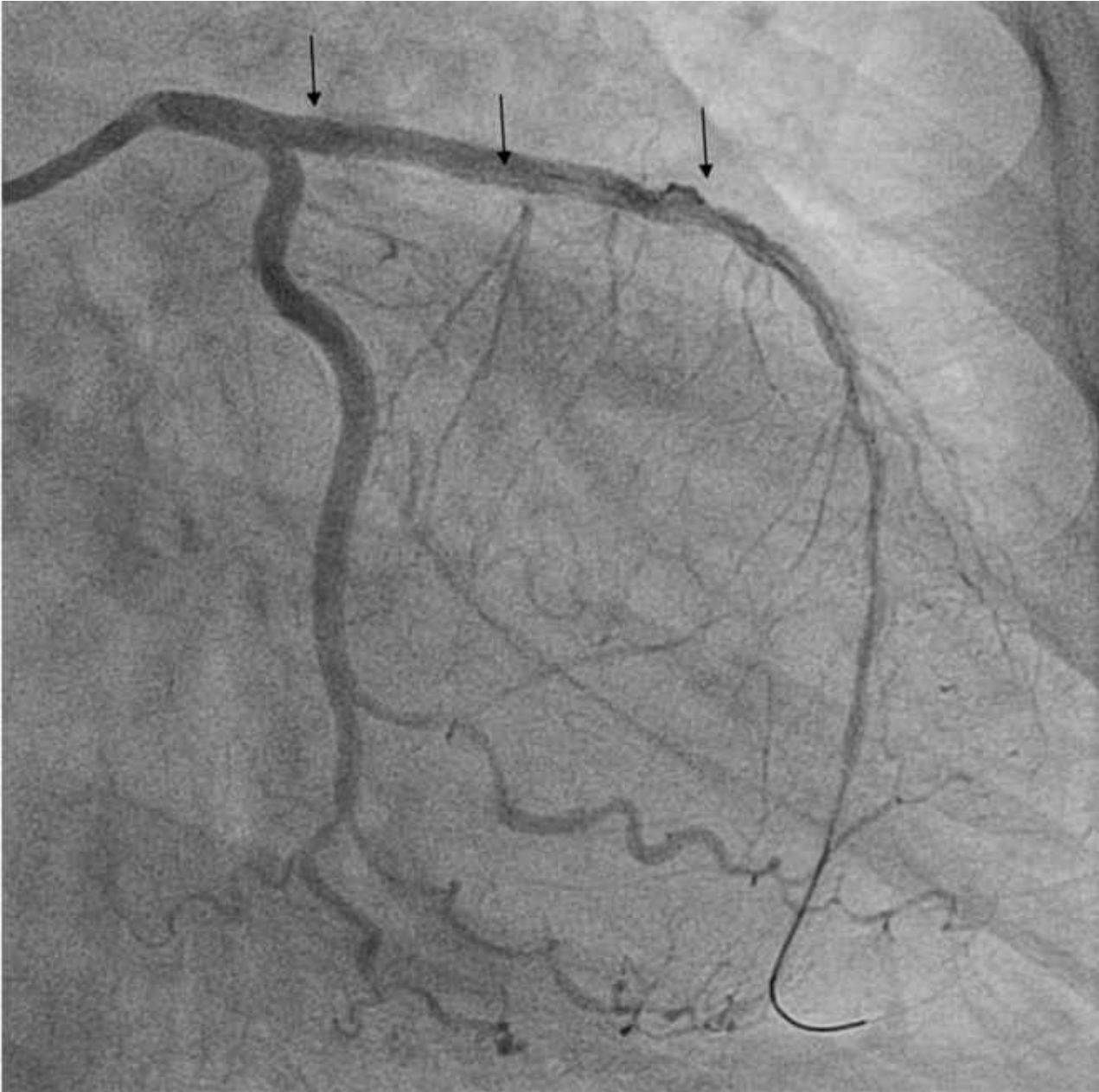
complaints, no chest pain or SOB when walking or climbing stairs.

At one-month follow-up an echocardiography showed increase in LVEF to 43% and reduction of LV inferior wall hypokinesia.



**A 76-year-old female** patient with a long-term history of AH (used to 130/80 mmHg, maximum 190/150 mmHg) complains of chest pain with exertion (walking for up to 200 m) that started a year ago.

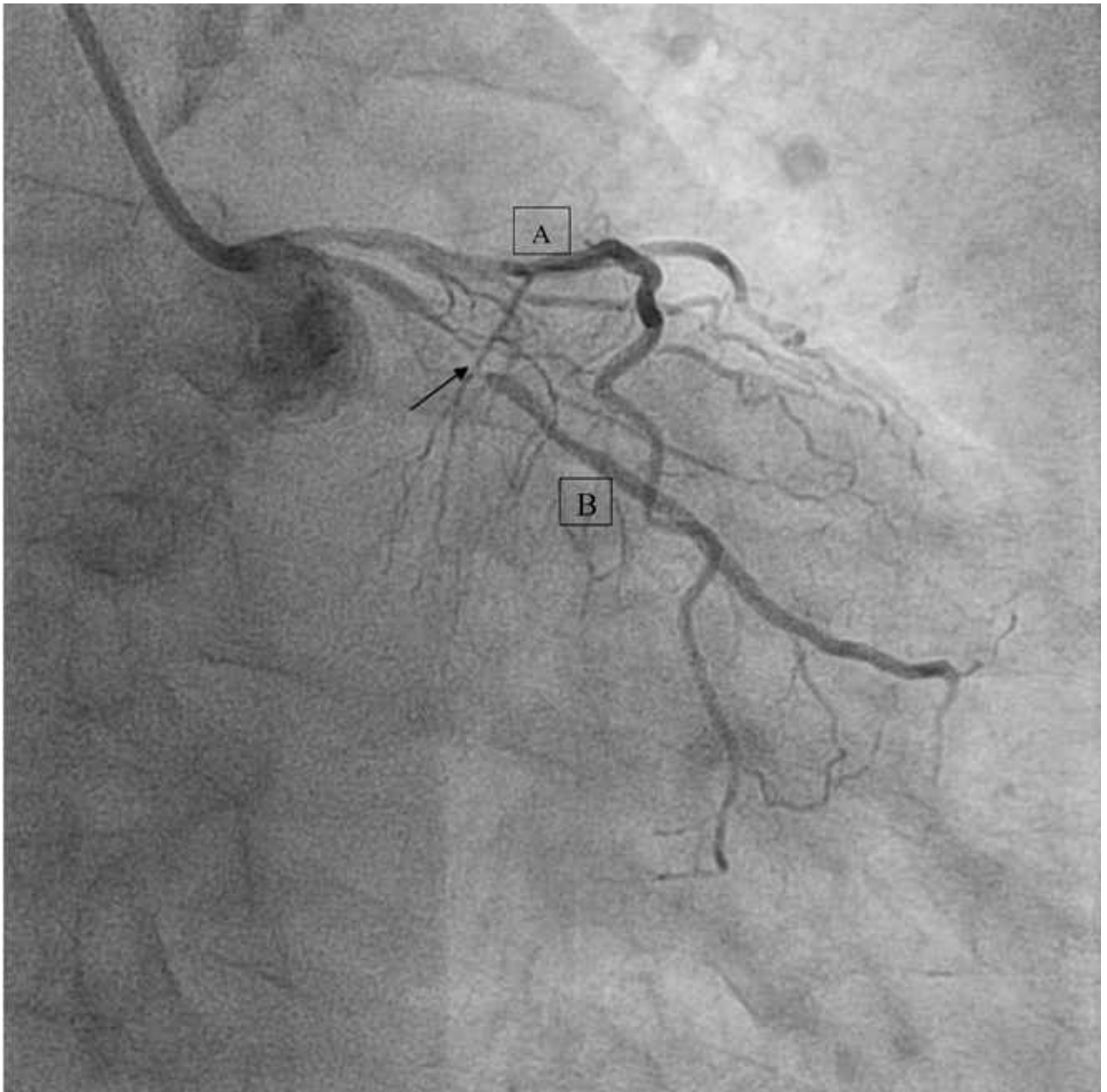
Coronary angiogram shows typical signs of AH: coronary artery coiling (A), diffuse LAD atherosclerosis (B) with up to 90 % proximal and mid-LAD stenosis.



*Continued*

The patient was treated with an LAD stent implantation (arrows). Repeat angiogram showed a fully expanded stent with no signs of dissection or perforation.

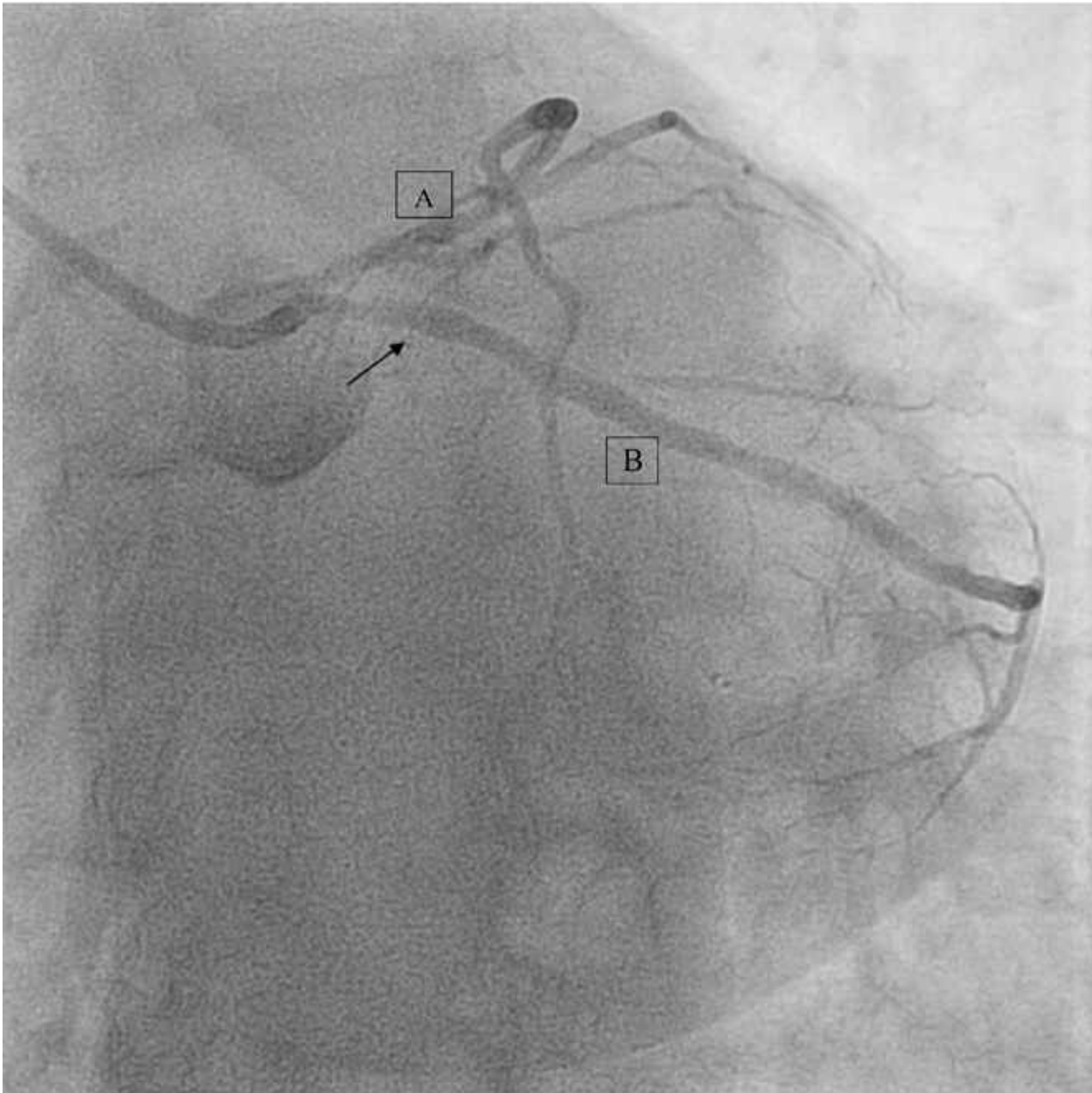
At discharge the patient had demonstrated improved exercise tolerance.



**An 86-year-old male** with no previous history of angina complains of 7-day history of chest pain while exercising that improves at rest. Over the last 2 days pain episodes developed more frequently, and the patient presented to the ER with signs of myocardial ischemia on ECG that improved with nitroglycerin.

Coronary angiogram shows a 99% proximal LCX stenosis (arrow) and the absence of hemodynamically significant narrowing of LAD.

(A) — *left anterior descending artery (LAD)*,  
(B) — *left circumflex artery (LCX)*.

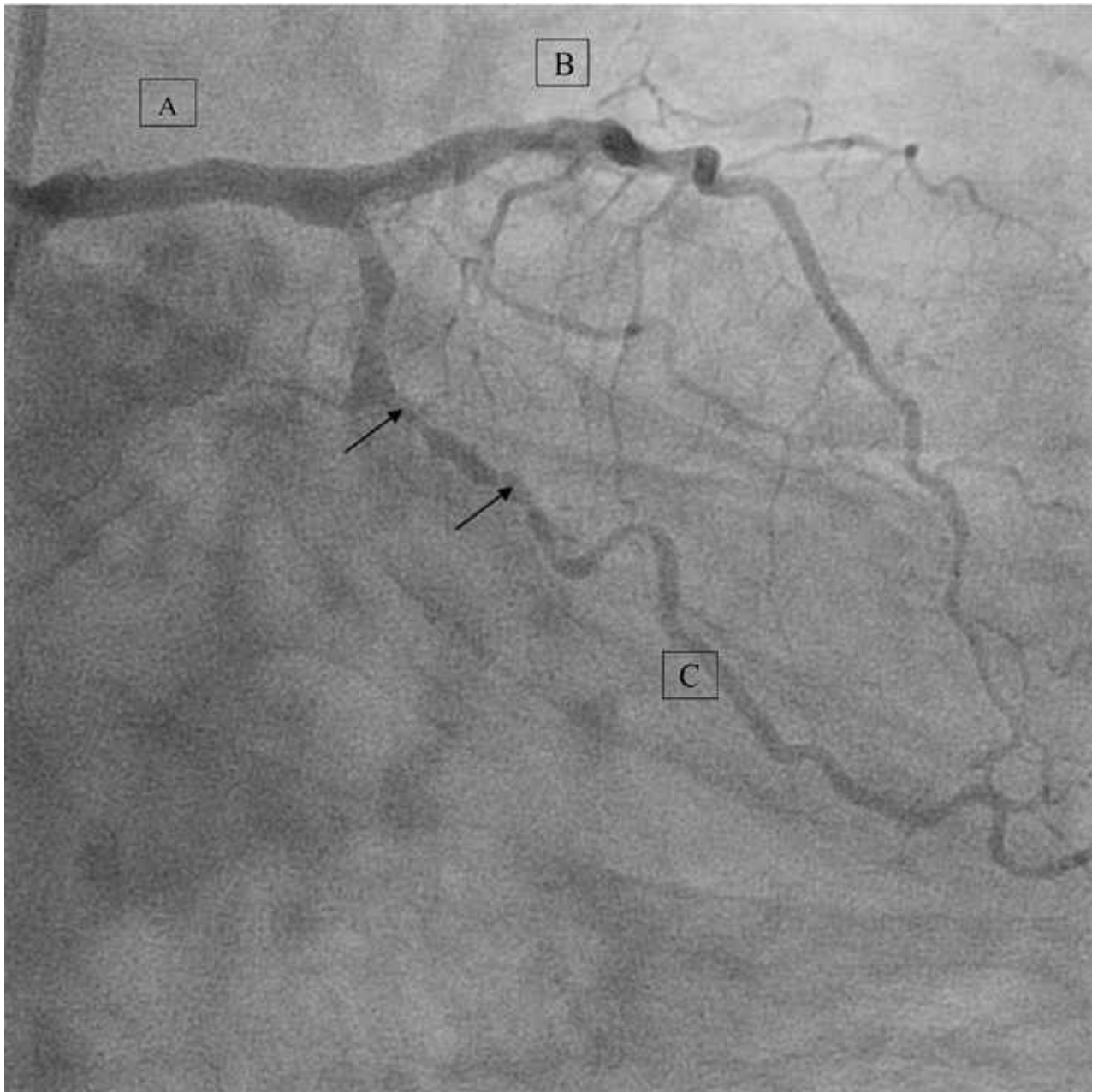


*Continued*

PCI with balloon angioplasty with LCX stent placement was performed. Repeat coronary angiogram showed a good blood flow and contrast filling in all coronary arteries with no signs of arterial dissection or perforation. In the post-operative period, the pa-

tient had no complains of chest pains as well as at 7-day follow-up.

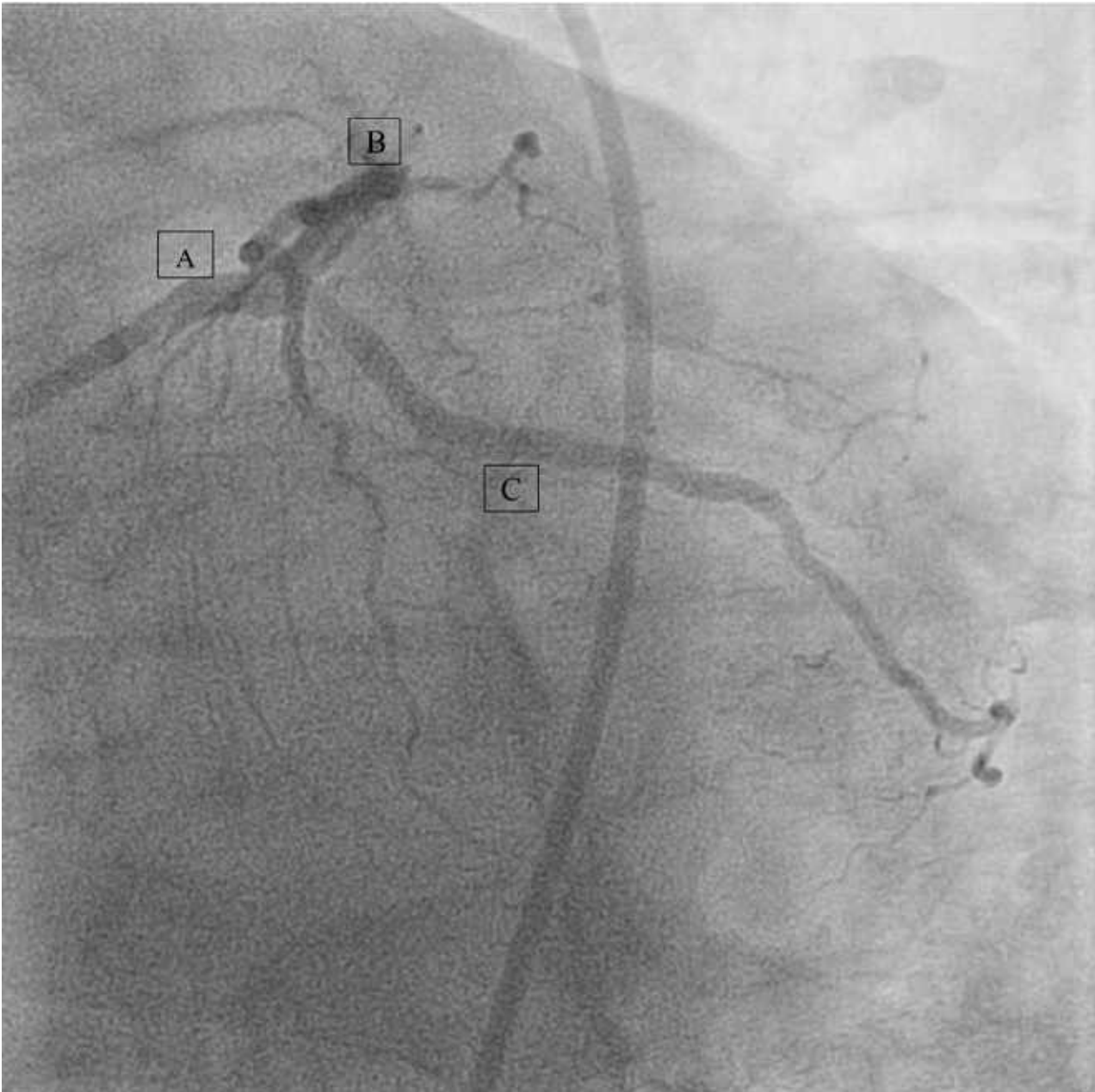
(A) — *left anterior descending artery (LAD)*,  
(B) — *left circumflex artery (LCX)*.



**A 76-year-old male** with a history of CAD, stable angina CCS class II and T2D presented with shoulder pain that radiated to the lower left side of the jaw and right arm when walking uphill or in the cold weather.

Coronary angiogram shows diffuse LCX atherosclerosis with OMB involvement and a 99% stenosis (arrows). Diffuse coronary artery atherosclerosis is a typical angiographic finding in T2D.

(A) — left main coronary artery (LMCA), left anterior descending artery (LAD),  
(B) — left circumflex artery (LCX).



*Continued*

PCI with stent placement from OMB to proximal LCX was successfully performed with complete recanalization and tissue re-flow. No signs of mural thrombosis, vessel dissection or perforation. The patient described complete resolution of chest pain.

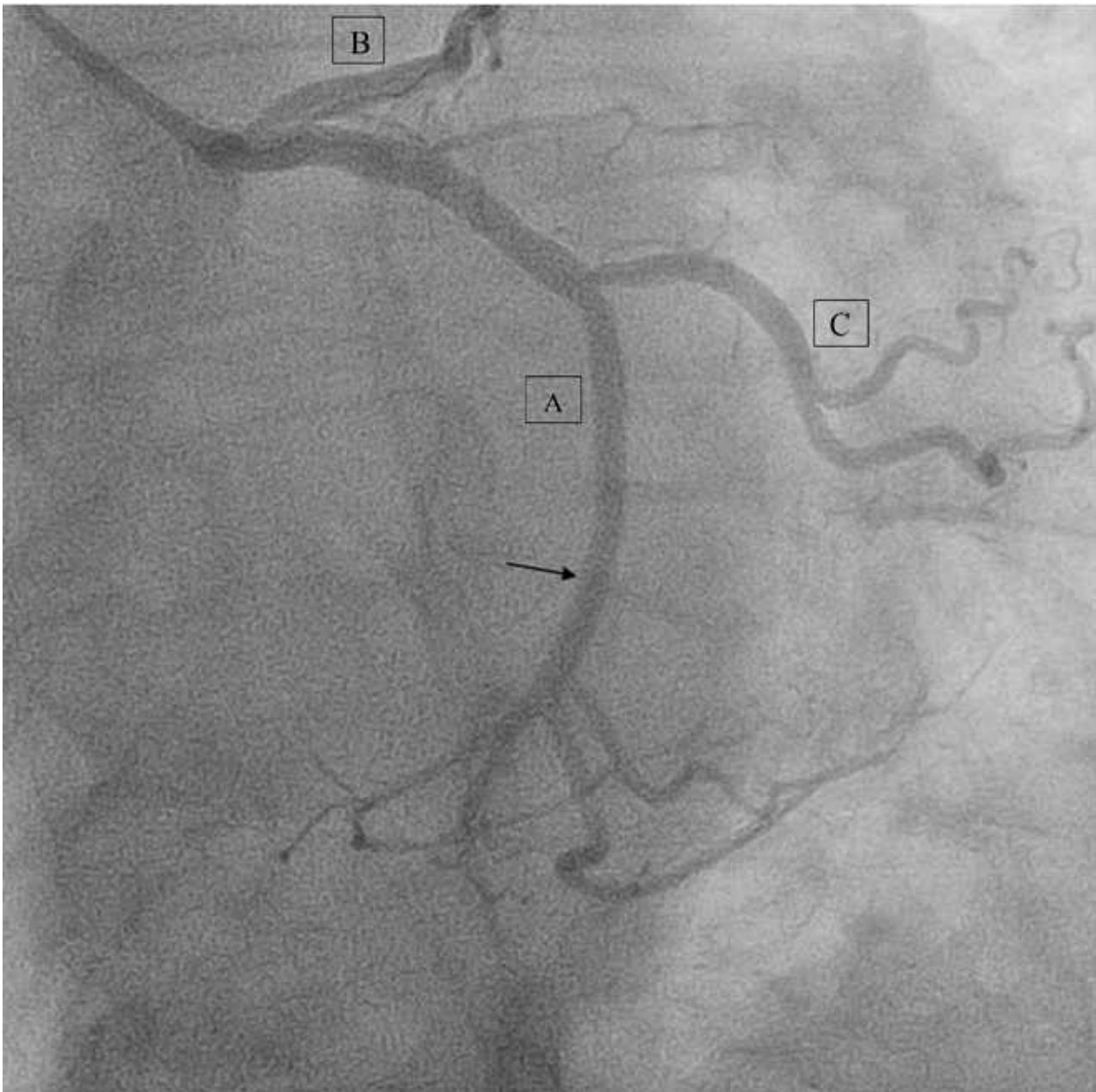
(A) — *left main coronary artery (LMCA)*,  
(B) — *anterior descending artery (LAD)*,  
(C) — *left circumflex artery (LCX)*.



A 56-year-old female with a history of LCX stent placement 3 months ago that resulted in complete resolution of chest pain.

The patient has AH with BP elevation up to 220/110 mmHg and adjusted to 130/80 mmHg. She presented with acute chest pain that irradiated to the neck, was provoked by minimal exercise, wasn't relieved by nitroglycerin and persisted throughout coronary angiography.

Coronary angiogram shows stent restenosis (arrow). LAD and OMB with normal blood flow.  
(A) — *left circumflex artery (LCX)*,  
(B) — *left anterior descending artery (LAD)*,  
(C) — *obtuse marginal artery (OMB)*.



*Continued*

Occlusion recanalization and stent implantation into the previously placed stent were performed with full blood flow restoration. No signs of distal thromboembolism or dissection were noted.

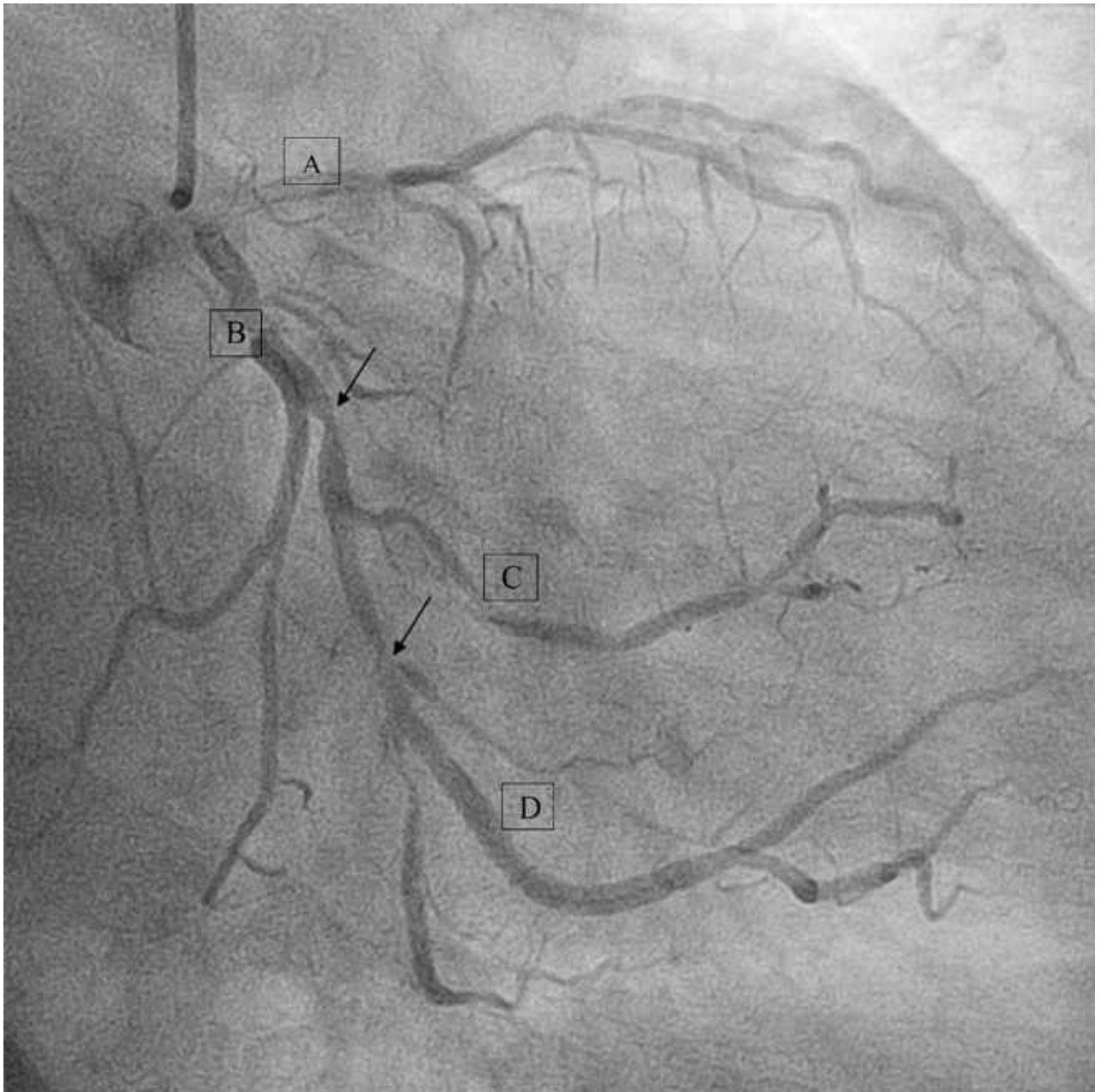
Angina chest pain completely resolved after the blood flow was restored. The patient had no angina

symptoms at discharge and echocardiography revealed no hypokinesis.

(A) — LCX,

(B) — LAD,

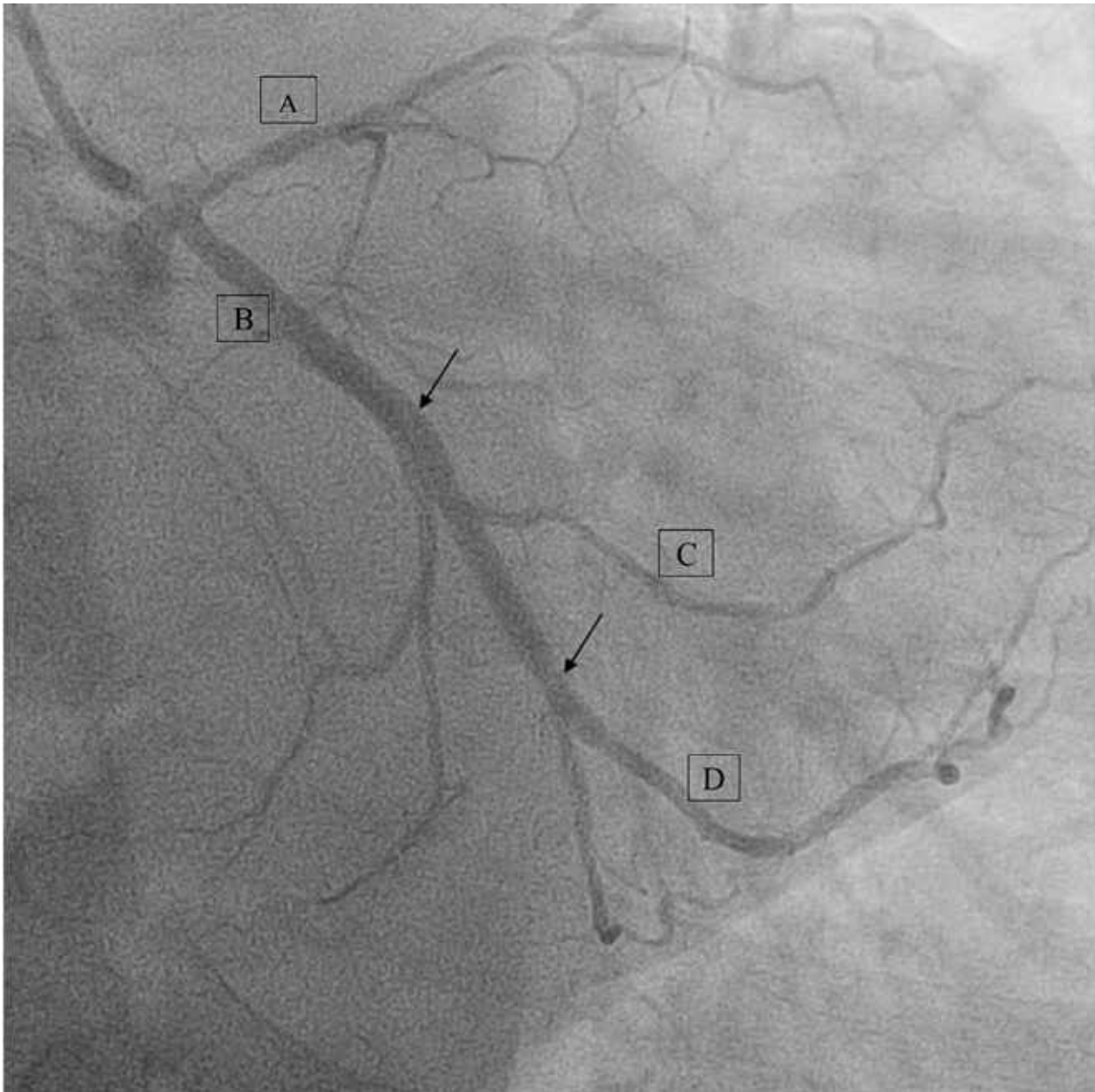
(C) — OMB (arrow pointing at the stent).



**A 63-year-old patient** with CAD, stable angina CCS class III, T2D and a history of anterior MI. Stress echocardiography reveals lateral LV wall hypokinesia.

Coronary angiogram shows a tandem 80% mid-LCX and 90% bifunctional stenosis at the beginning of PLB (arrows). SyntaxScore= 10 (low), endovascular revascularization is the preferred approach in this patient.

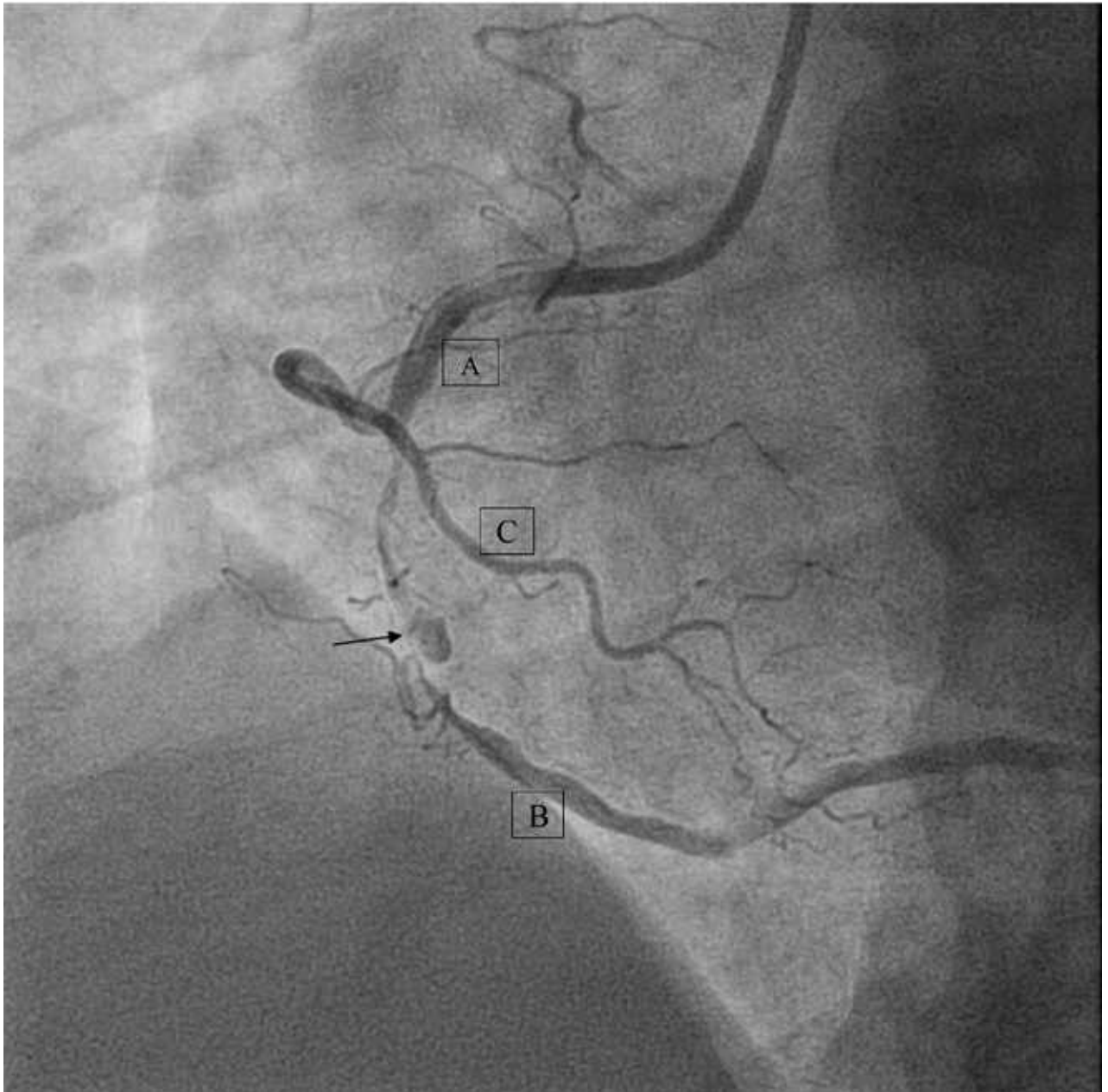
(A) — *left anterior descending artery (LAD)*,  
(B) — *circumflex artery (LCX)*,  
(C) — *obtuse marginal artery (OMB)*,  
(D) — *posterolateral branch (PLB)*.



*Continued*

2 drug-eluting tents were placed in the LCX and PLB. Side-branch dilation was performed afterwards (arrows). Coronary angiogram shows a fully restored blood flow, smooth margins without any signs of dissection or stent thrombosis. The patient described that chest pain had almost completely resolved.

(A)— *left anterior descending artery (LAD)*,  
(B)— *circumflex artery (LCX)*,  
(C)— *obtuse marginal artery (OMB)*,  
(D)— *posterolateral branch (PLB)*.

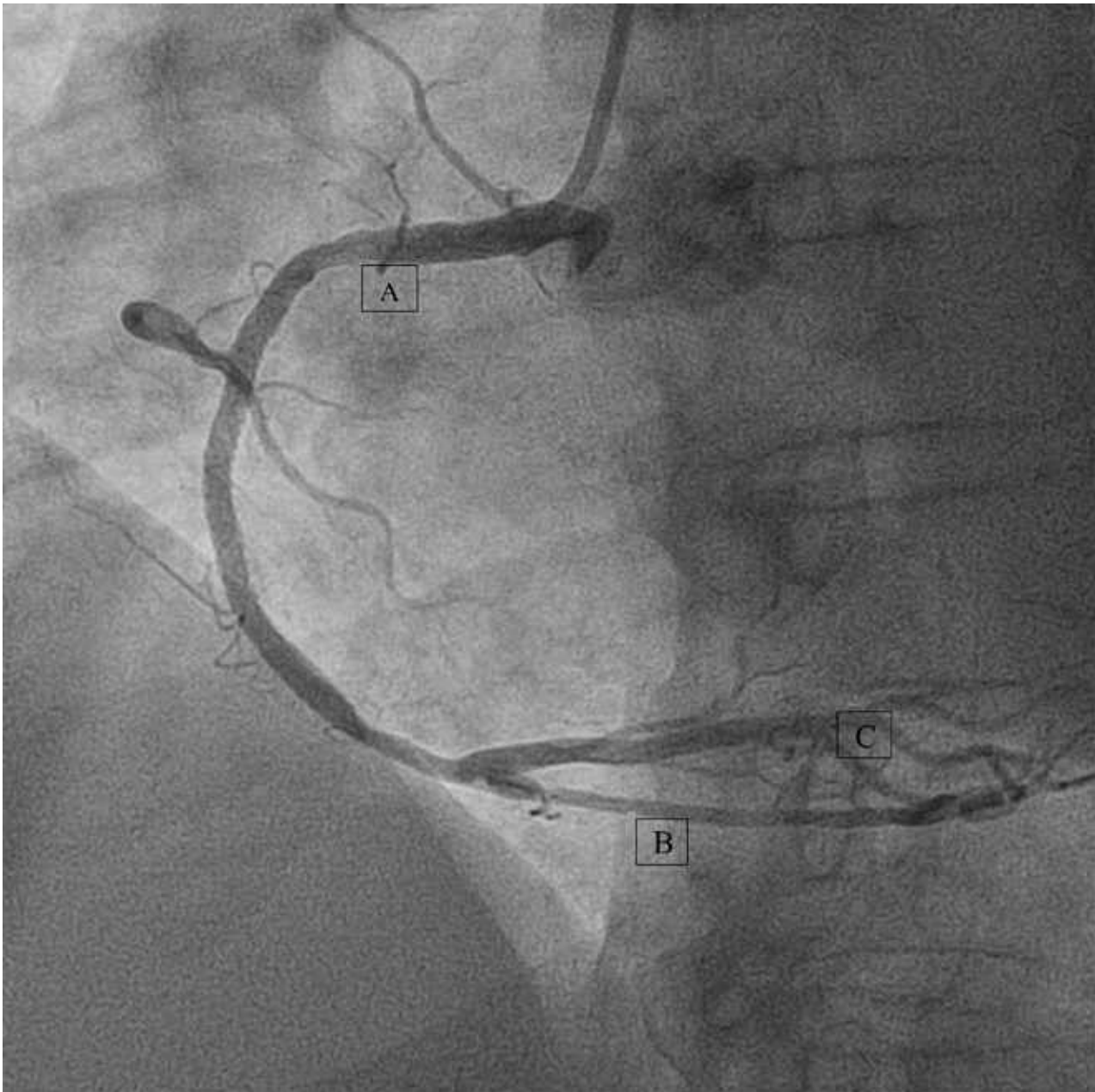


**A 35-year-old female** presents with unstable angina, chest pain during exercise. The patient has a 10-year history of smoking, familial hyperlipidemia and T1D.

Coronary angiogram shows a 90% mid-RCA stenosis caused by a massive atherosclerotic plaque with uneven margins and contrast seen under the plaque (arrow).

Endovascular correction was performed to restore blood flow via stent placement.

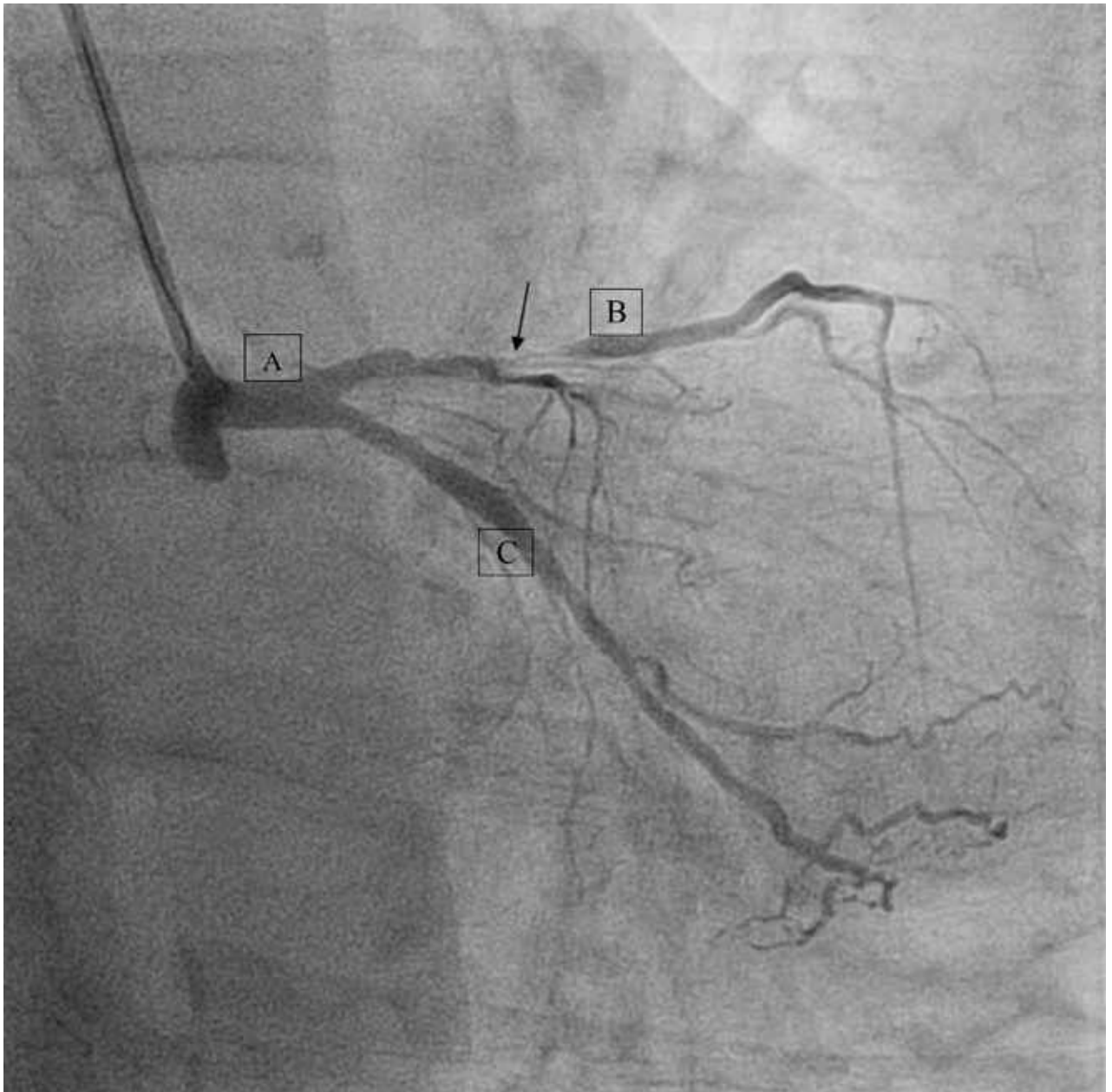
- (A) — proximal right coronary artery (RCA),
- (B) — distal right coronary artery (RCA),
- (C) — right ventricular branch.



*Continued*

Transluminal balloon angioplasty with RCA drug-eluting stent placement. Hyperlipidemia was managed with PCSK9 inhibitors, and the patient was advised on treatment cessation. The symptoms have completely resolved after the intervention.

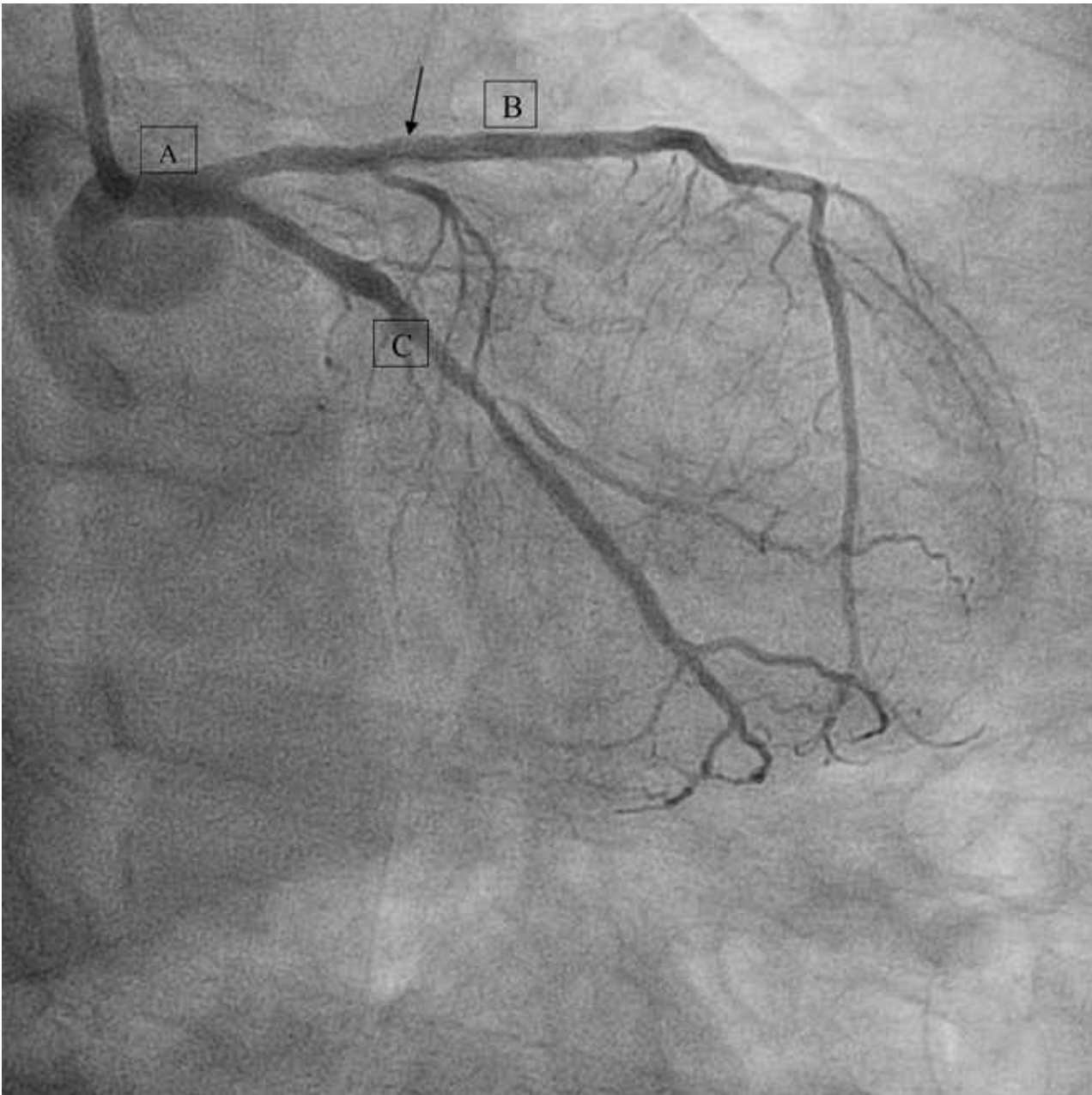
(A) — *right coronary artery (RCA)*,  
(B) — *posterior descending artery (PDA)*,  
(C) — *posterolateral branch (PLB)*.



**A 63-year-old patient** with CAD, stable angina CCS class III presents with chest pain when walking for up to 200 m that resolves at rest.

These symptoms are associated with LAD flow alteration. Coronary right caudal angiography shows proximal LAD 95% atherosclerosis (arrow).

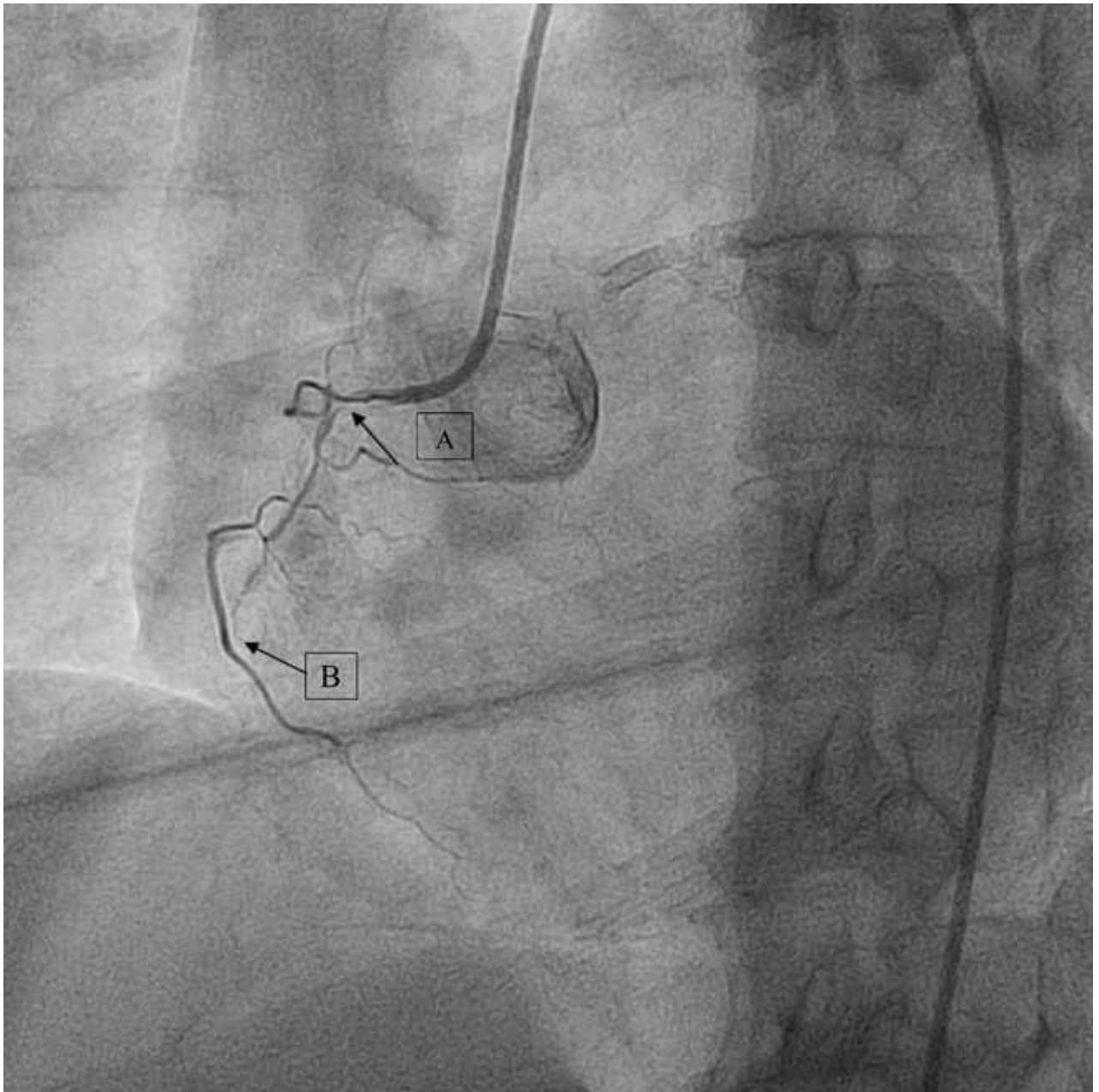
(A) — *left main coronary artery (LMCA)*,  
(B) — *left anterior descending artery (LAD)*,  
(C) — *circumflex artery (LCX)*.



*Continued*

Endovascular RCA revascularization with drug-eluting stent placement was performed. The stent has fully expanded (arrow) with no signs of dissection or thrombosis. Coronary angiogram shows optimal

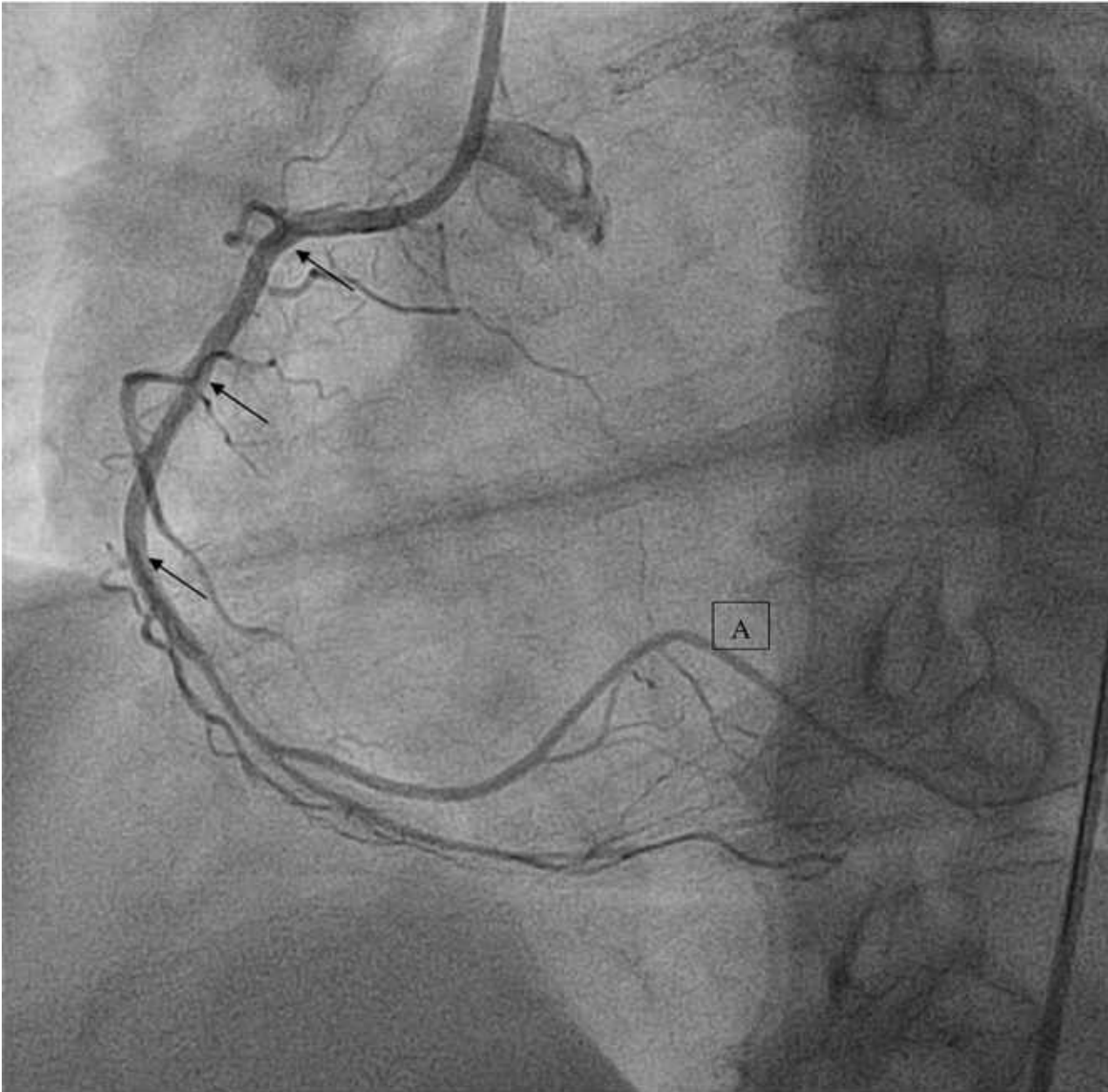
contrast filling of the LCA, TIMI 3, vessel margins are smooth.



**A 76-year-old male** with CAD, stable angina CCS class III, T1D, a history of MI in 2020 and LVEF 36 % complains of SOB, chest pain when walking for 150 m that resolve at rest.

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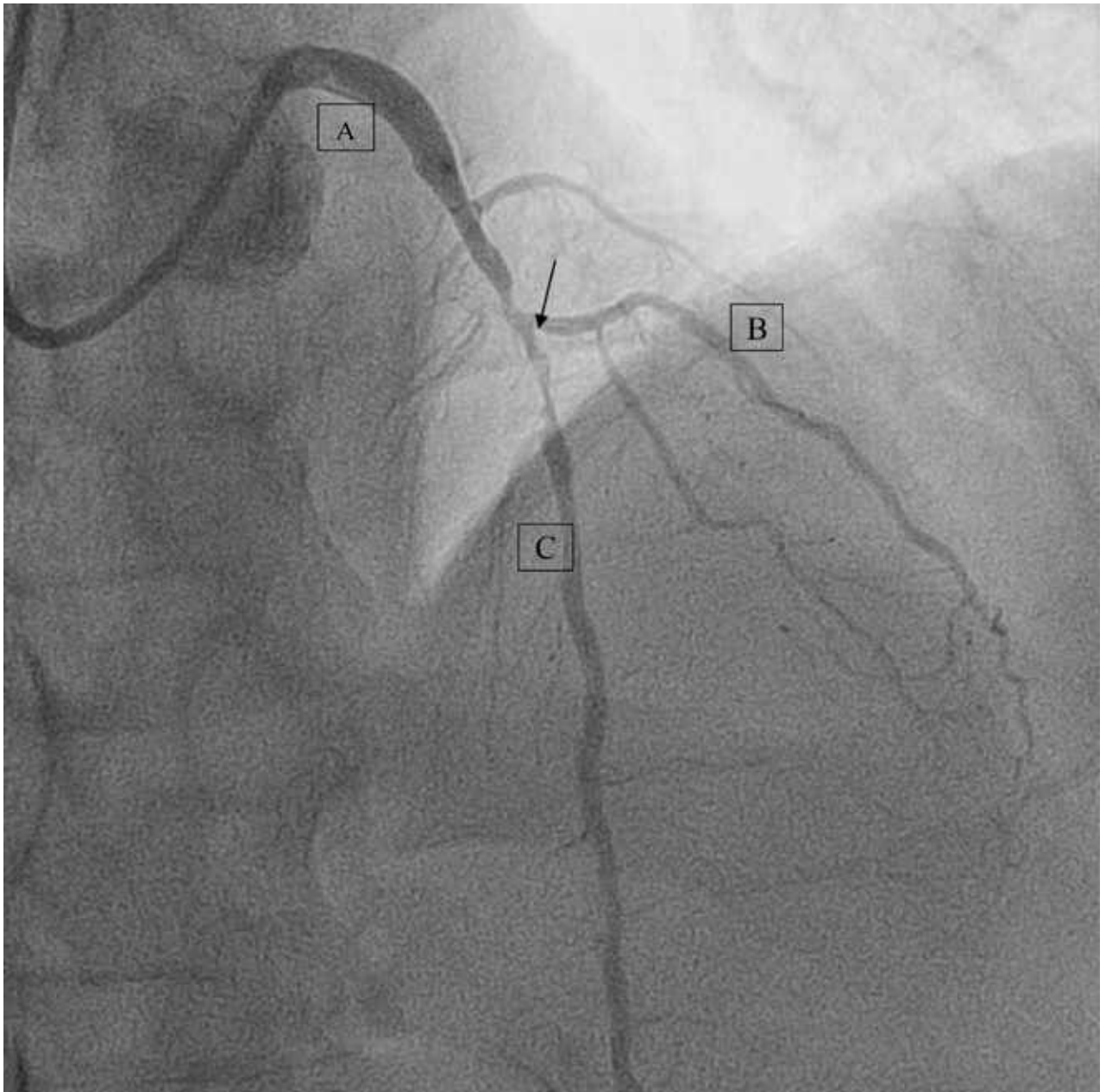
Coronary angiogram shows a 99% occlusion of proximal RCA (A) and chronic total mid-RCA occlusion (B).



*Continued*

Antegrade mechanical chronic RCA recanalization with stent placement in the mid- and proximal segments was performed (arrows). Repeat angiogram shows the restored blood flow in the RCA and PLB with smooth vessel margins.

The patient described the complete resolution of angina symptoms.



**A 65-year-old female** with a history of non-STEMI (ST depression in I, II, aVL, V1-V4) complains of severe chest pain irradiating to the scapular region and left lower jaw that started 1.5 hours prior to presentation.

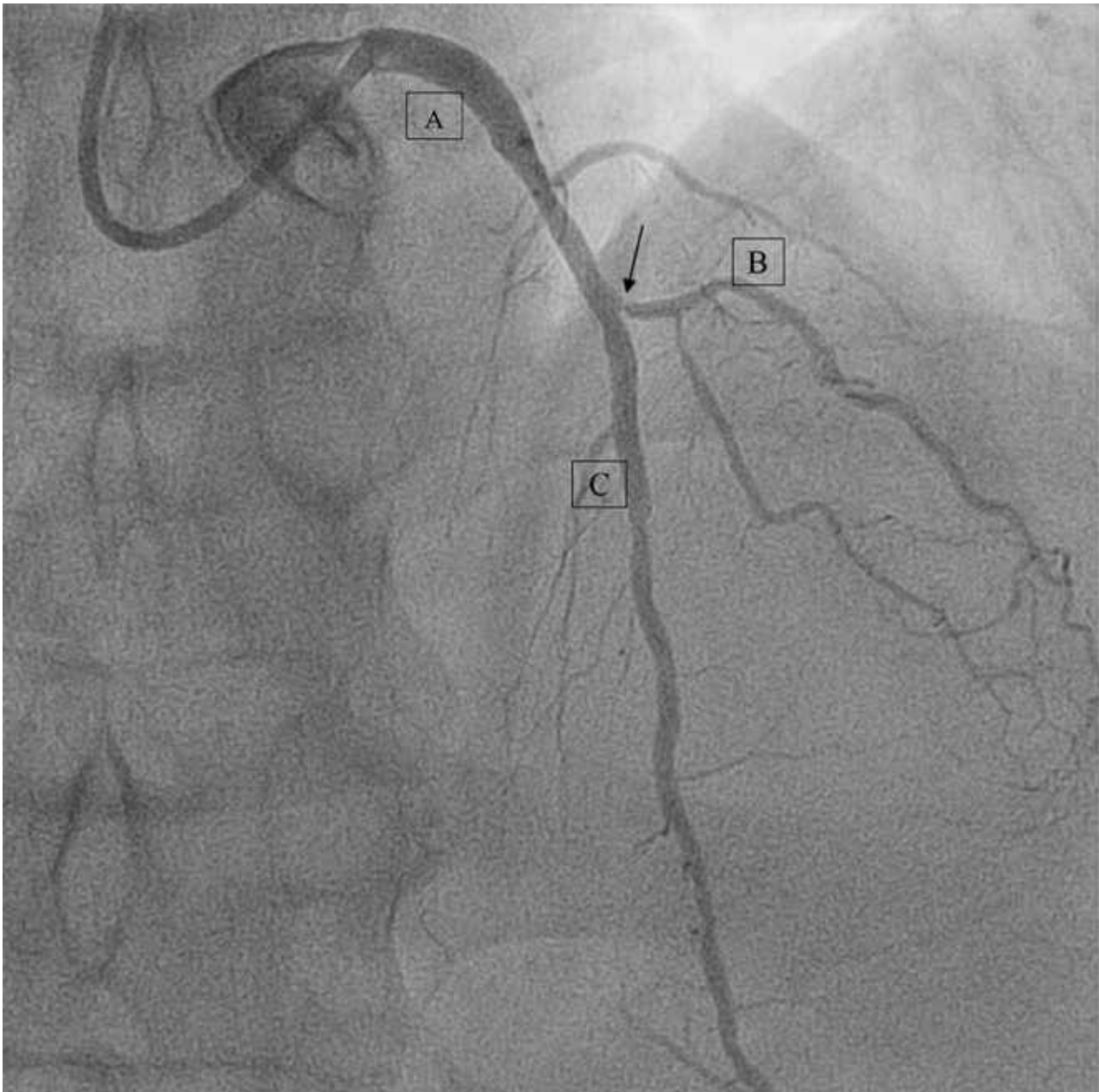
Coronary angiogram shows a 90% proximal LAD stenosis with uneven margins, lucency, and signs of

mural thrombosis (arrow). Endovascular correction was performed to restore the blood flow in the LAD.

(A) — *left main coronary artery (LMCA)*,

(B) — *diagonal branch (DB)*,

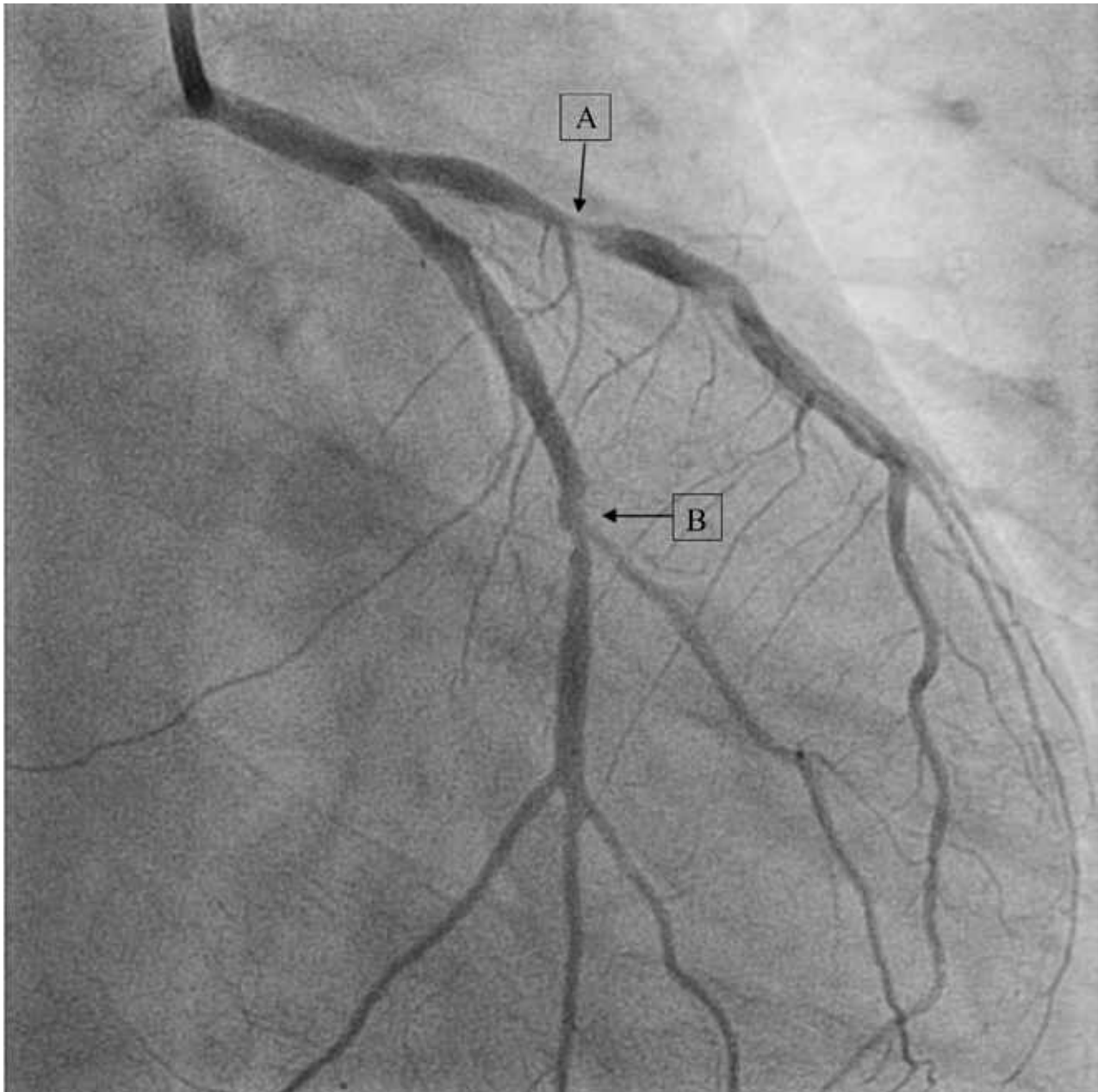
(C) — *left anterior descending artery (LAD)*.



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Endovascular revascularization was performed with LAD drug-eluting stent placement and SB ostium dilation (arrow). After the stent was placed chest pain has completely resolved and the patient was discharged.

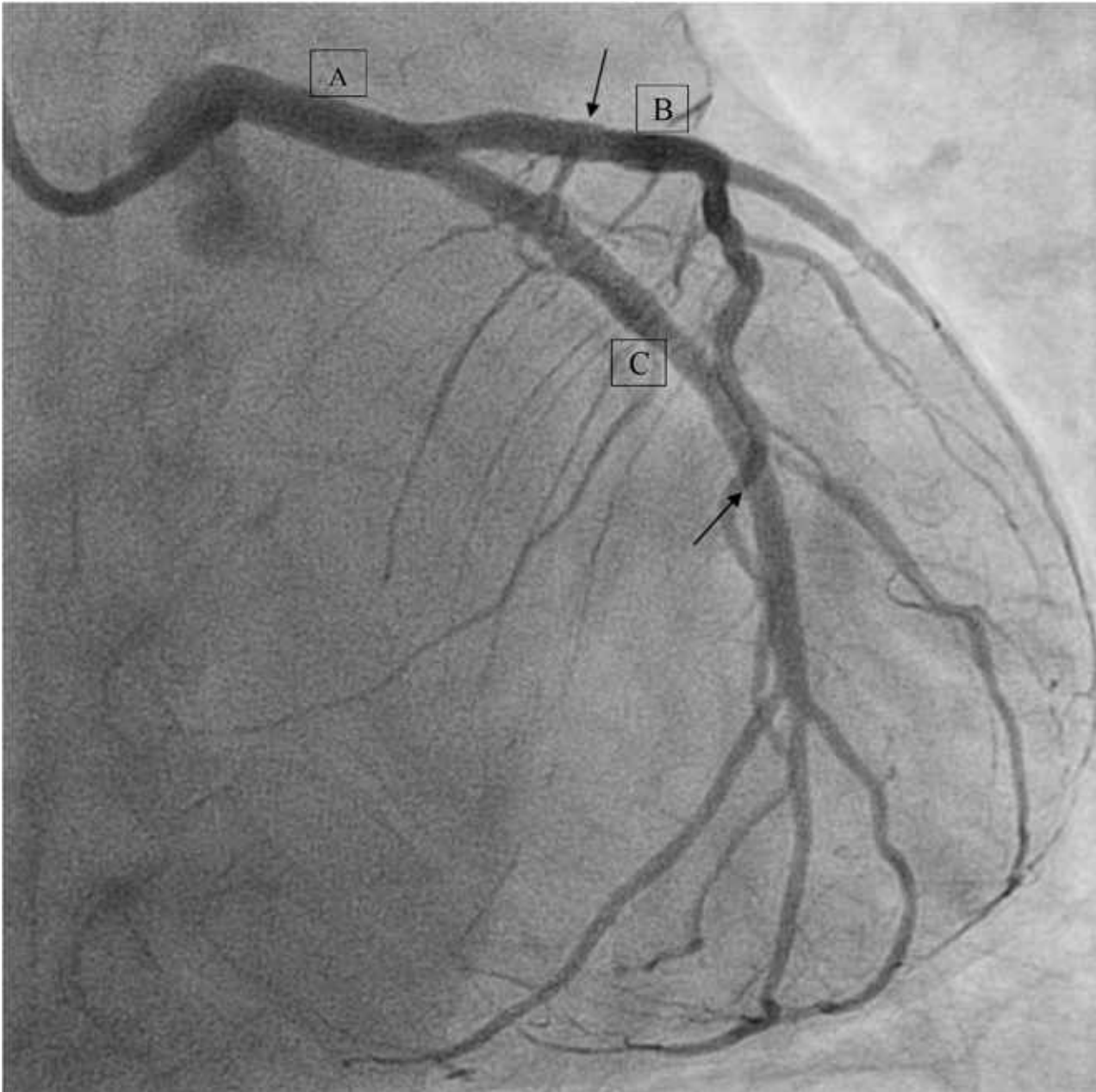
(A) — left main coronary artery (LMCA),  
(B) — side branch (SB),  
(C) — left anterior descending artery (LAD).



**A 65-year-old female** with CAD, stable angina CCS class III and T2D presents complaining of SOB during exercise (climbing stairs to the 2<sup>nd</sup> floor, fast-paced walking) and 25-year history of smoking.

Stress echocardiography showed anterior and later LV wall hypokinesia that wasn't associated with the development of classic angina chest pain. Patients with T2D and coronary atherosclerosis often present

with vague symptoms. Coronary angiogram shows a 90% proximal-LAD stenosis (A) and 80% LCX bifurcation stenosis (B).



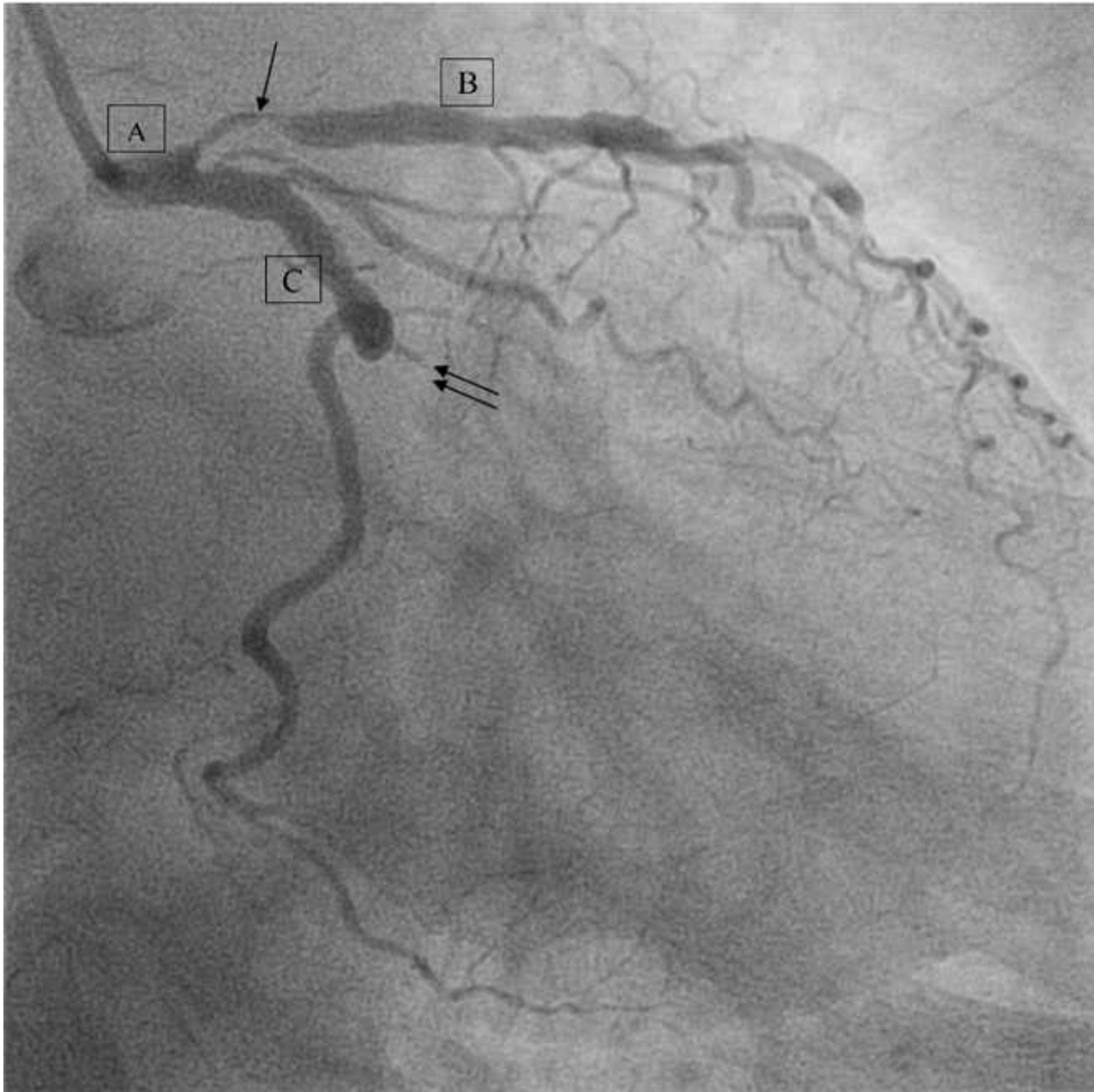
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A simultaneous LAD and LCX revascularisation with two drug-eluting stents implantation was performed (arrows). The patient was advised on lifestyle changes.

Coronary angiogram shows the final stenting result—a full blood flow restoration, smooth vessel margins in the area where the stent was placed, no

signs of arterial dissection. A simultaneous distal artery filling with contrast shows that stenting was successfully performed. The patient described the full resolution of SOB and chest pain.

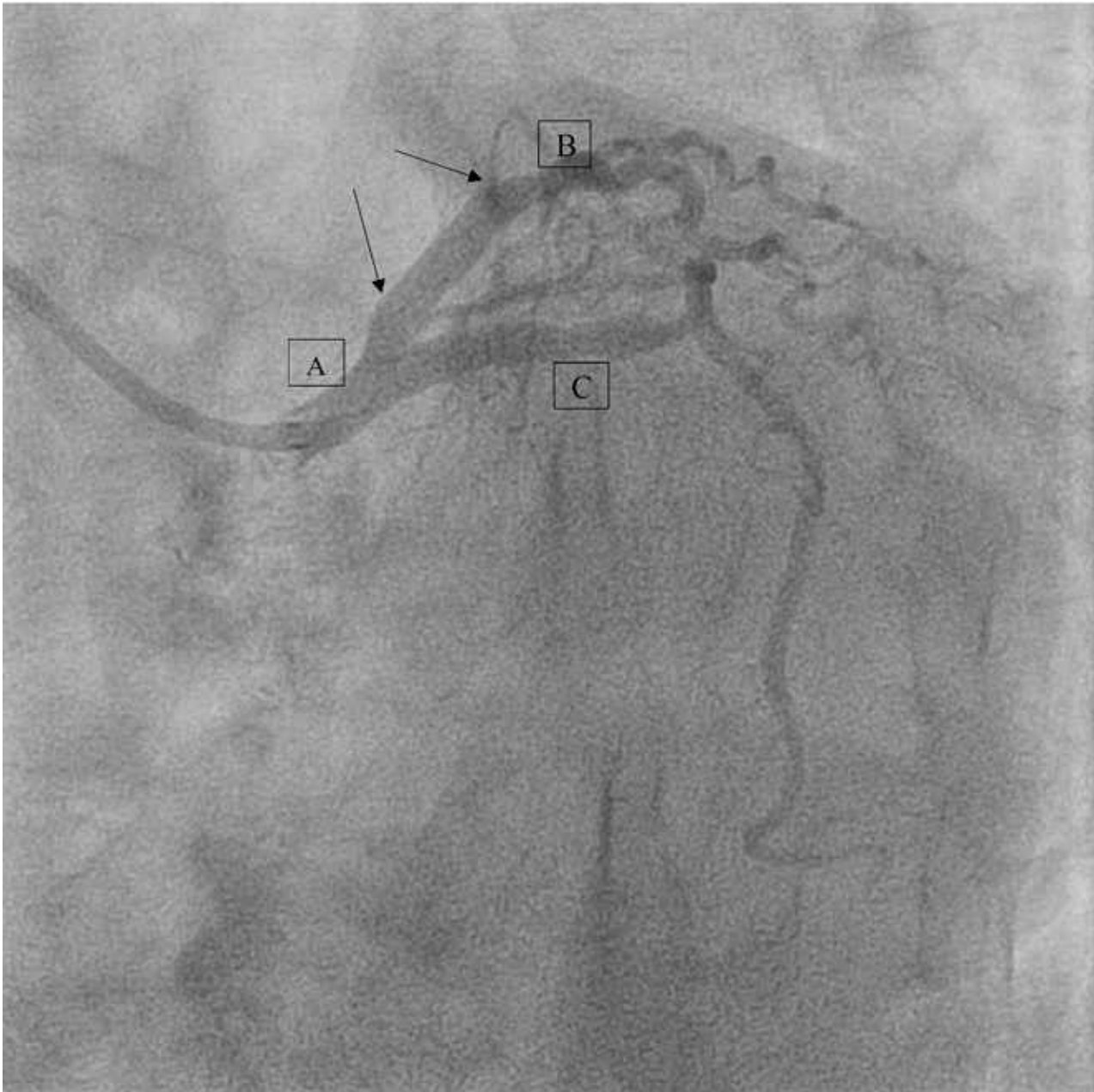
- (A)—left main coronary artery (LMCA),
- (B)—left anterior descending artery (LAD),
- (C)—circumflex artery (LCX).



**A 63-year-old male** with a history of CAD, stable angina CCS class III complains of chest pain during exercise that resolve at rest.

Coronary angiogram shows a 95% proximal LAD stenosis (one arrow) and chronic OMB occlusion (two arrows).

(A) — *left main coronary artery (LMCA)*,  
(B) — *left anterior descending artery (LAD)*,  
(C) — *circumflex artery (LCX)*.



*Continued*

Balloon angioplasty with LAD stenting was performed. Coronary angiogram shows a fully expanded coronary stent with no signs of stenosis, dissection, and occlusion of SB.

The patient described a full resolution of angina pain after the PCI and was able to return to baseline physical activity.

- (A) — *left main coronary artery (LMCA)*,
- (B) — *left anterior descending artery (LAD)*,
- (C) — *circumflex artery (LCX)*.



**CHAPTER 7**  
**CAROTID ANGIOPLASTY AND STENTING IN**  
**PATIENTS WITH DIABETES**

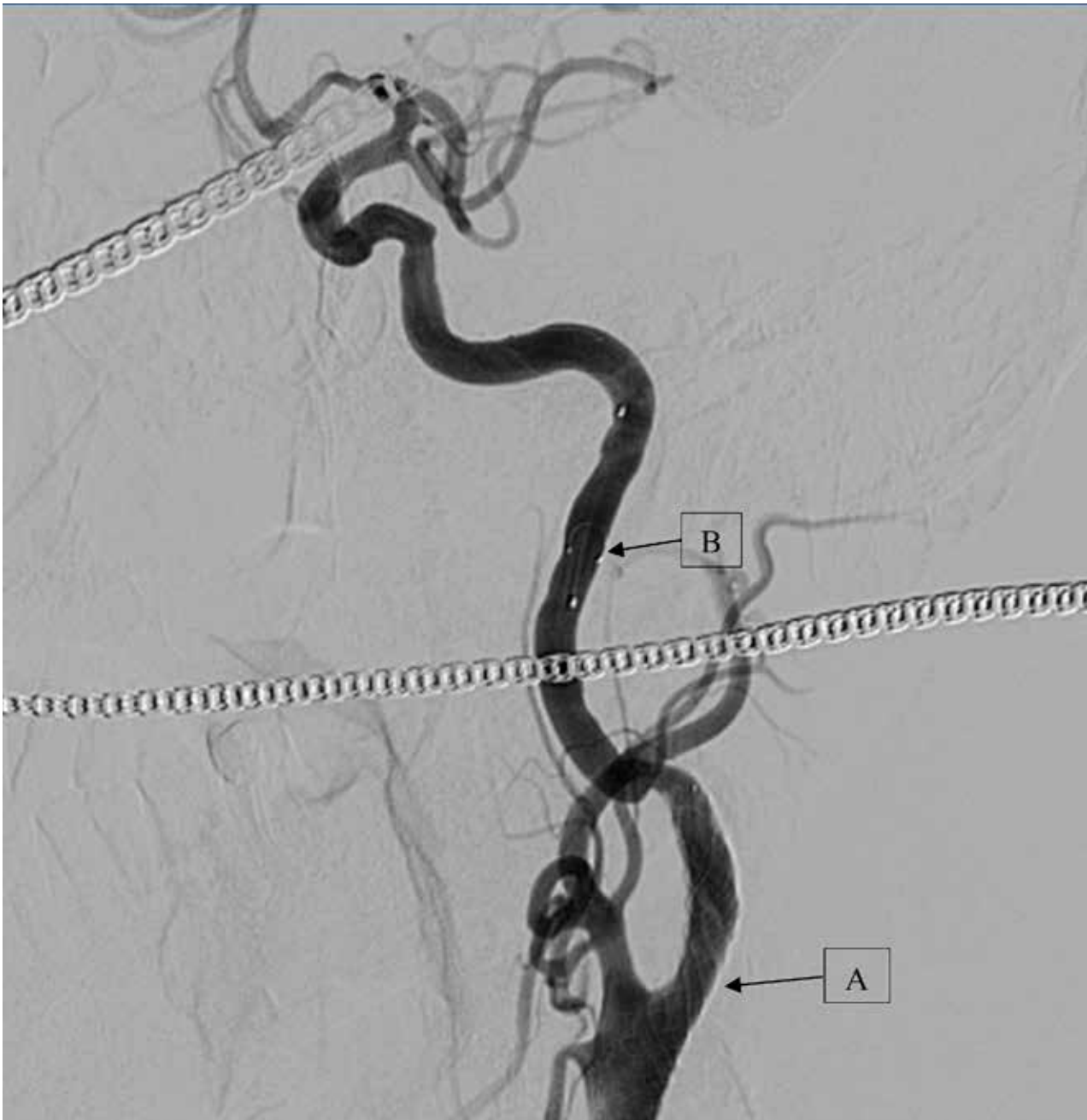


**A 73-year-old female** with a history of CAD, ischemic stroke in the left hemisphere 30 days prior to presentation.

LCA angiography shows a subtotal (99%) stenosis of the LCA with slow blood flow and contrast filling of the LICA.

LICA stenting was performed as a part of secondary stroke prevention and brain blood supply improvement.

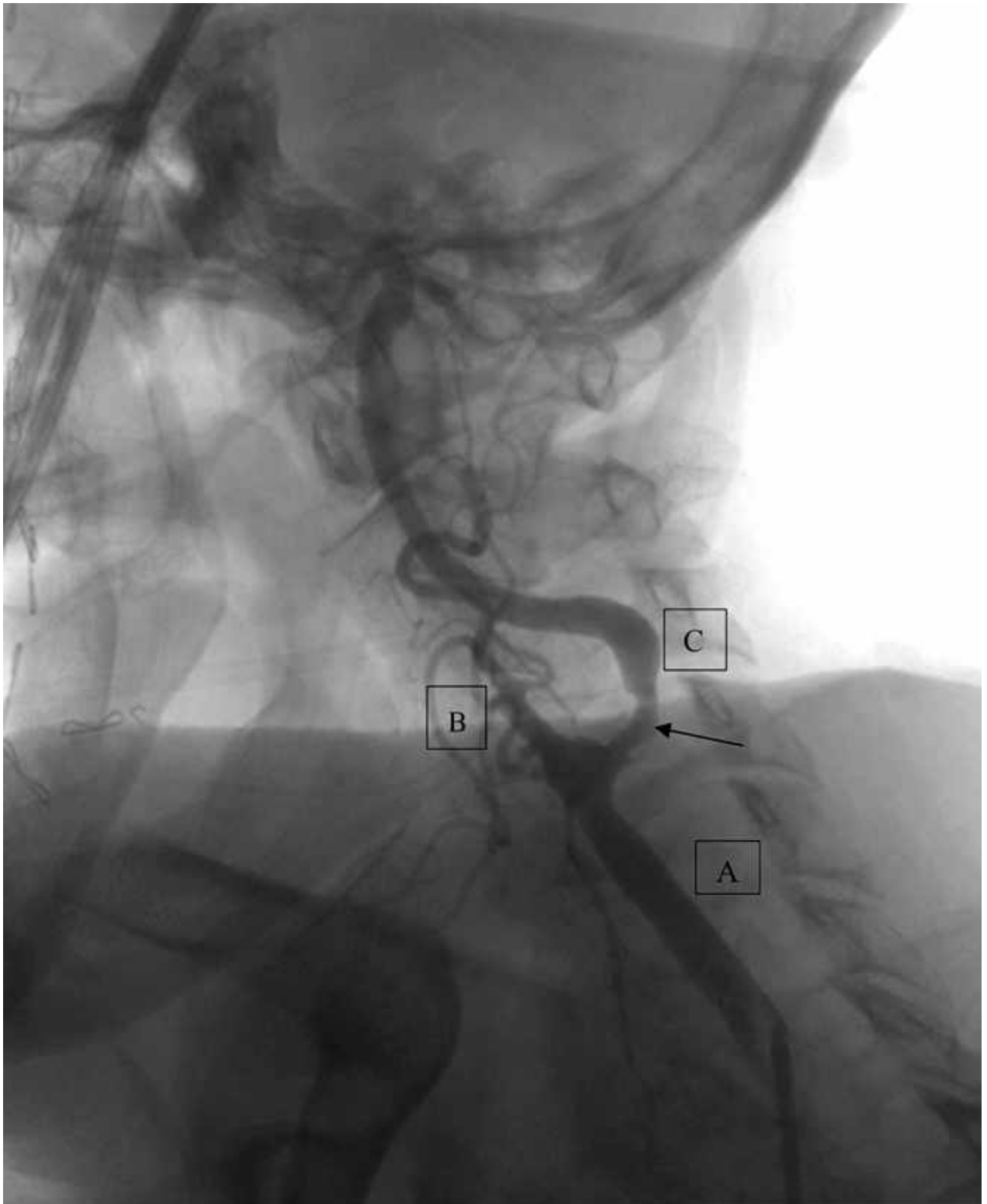
(A) — left common carotid artery (CCA),  
(B) — left internal carotid artery (ICA),  
(C) — left external carotid artery (ECA).



*Continued*

A double-layer stent (A) was placed; distal cerebral embolic protection system was used during the procedure (B).

Cerebral embolic protection system is a filter-based device that is placed distal to the stenosis and performed blood filtration during stent implantation. Post-procedural shows favorable CA dilation with full restoration of antegrade blood-flow.



**A 68-year-old female** with a history of ischemic stroke 1.5 years prior to presentation and TIA 4 months prior to presentation.

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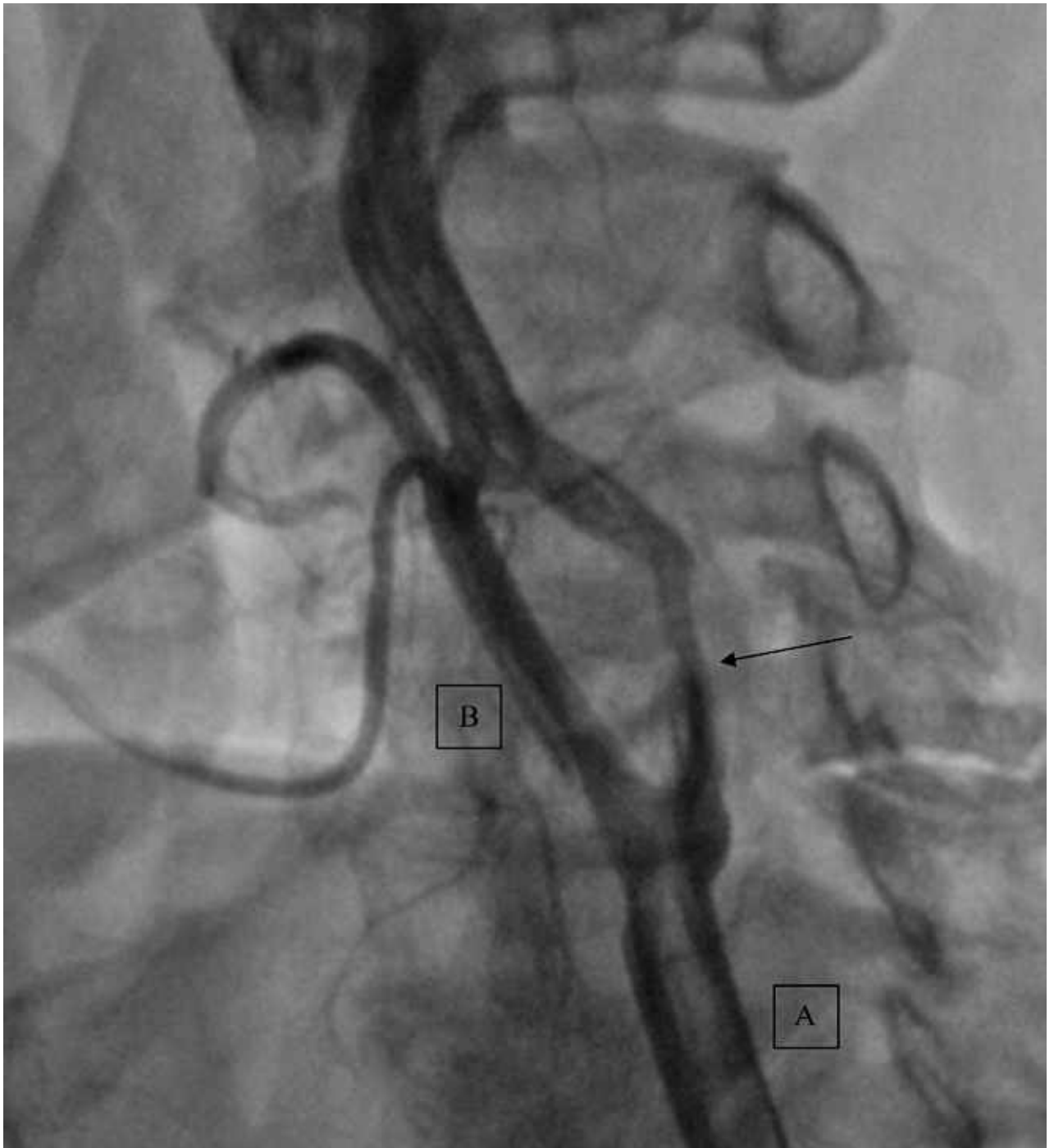
CA angiogram shows a CCA without stents (A), ECA (B) and ICA (C) pronounced twisting with 80% stenosis of the proximal ICA (arrow).



*Continued*

ICA and CCA stenting were performed (arrows). Stent has fully expanded with no signs of stenosis, dissection, and side branches occlusion. CA angiogram also shows a partial straightening of carotid arteries that leads to improved flood flow. ICA is

always stented using the cerebral protection system and the protection filter device is visualized on the current angiogram (A). This device provides cerebral embolic protection and is removed together with the atherosclerotic plaque at the end of the procedure.



**A 73-year-old patient** with a history of a transient loss of lateral vision 3 months prior to presentation.

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CA angiogram shows a 70 % ICA stenosis (arrow).  
There were no signs of stenosis in the CCA (A) and  
ECA (B).

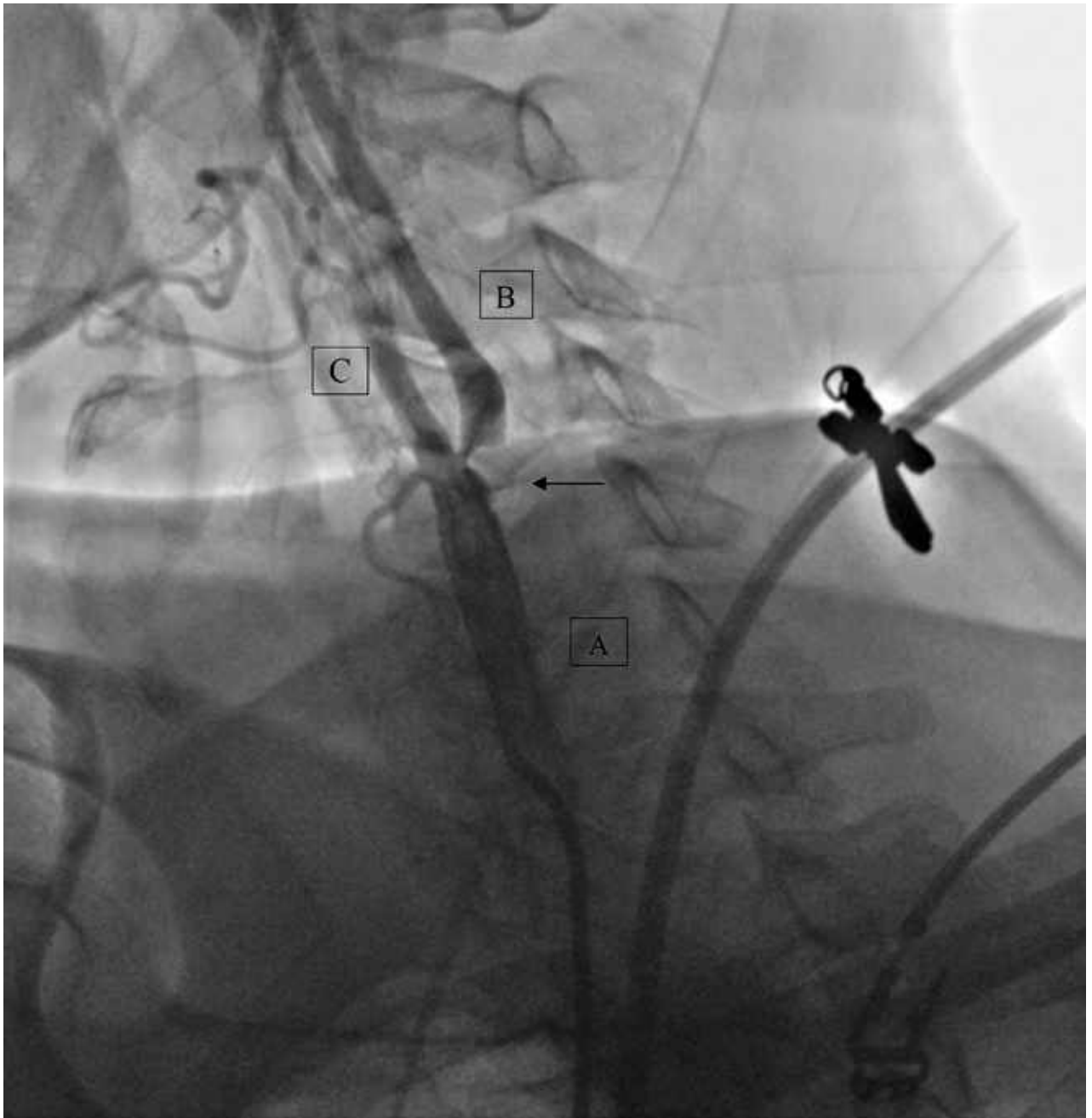


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ICA stenting (arrows) was performed with full restoration of antegrade blood flow. Self-expanding stents

that can adapt to vessel anatomy were implanted in the cerebral arteries.



**A 72-year male** with a history of CAD and T2D presented with fatigue, dizziness, ringing in his left ear, BP elevation to 150–160/100 mmHg.

These are not classical for symptomatic CAD but however requires CA visualization.

LCA angiogram showed a 90% eccentric LICA stenosis with smooth margins (arrow). The aim of en-

dovascular treatment would be the primary stroke prevention with artery stenting.

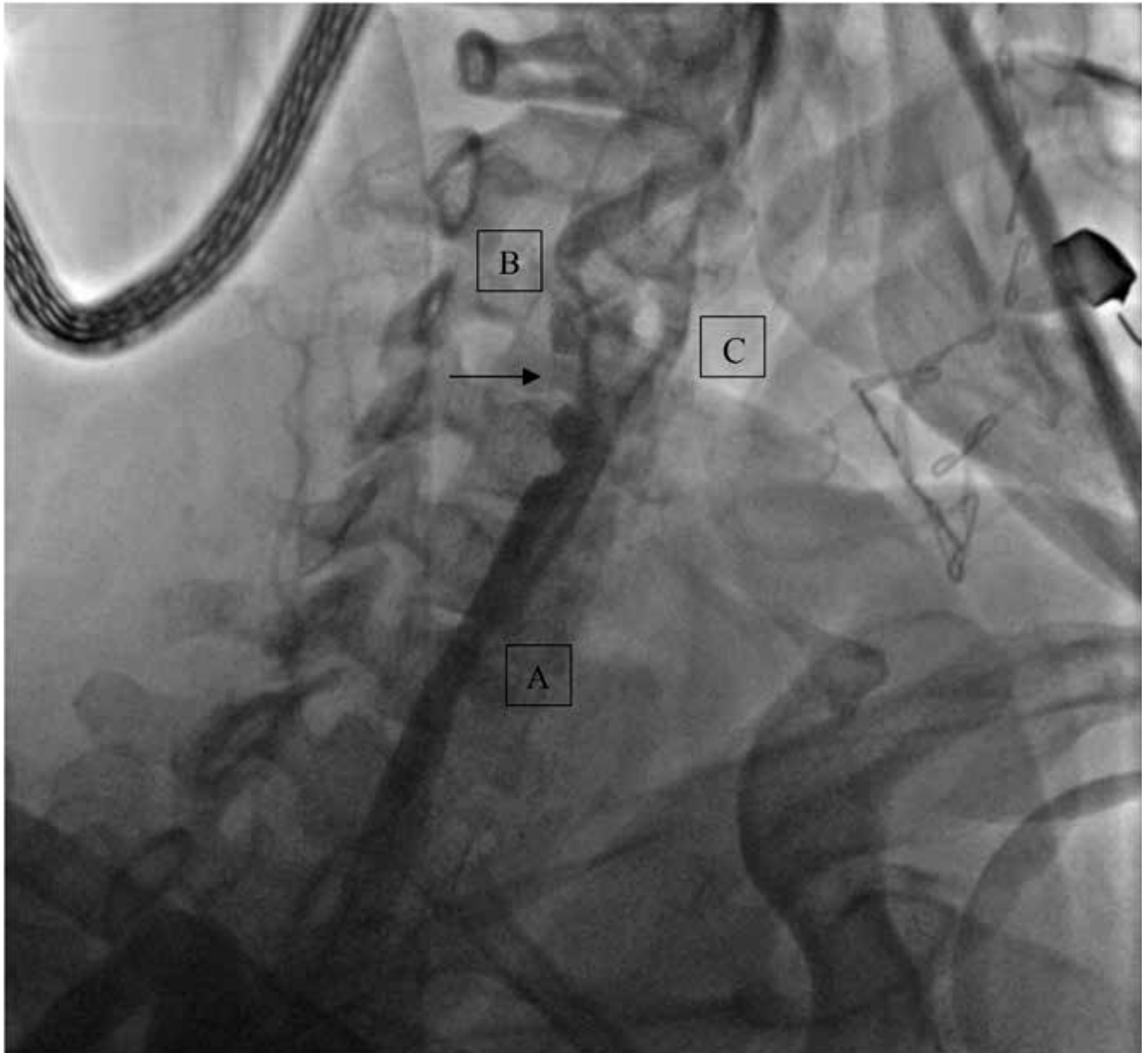
(A) — *common carotid artery (CCA)*,  
(B) — *internal carotid artery (ICA)*,  
(C) — *external carotid artery (ECA)*.



*Continued*

Left ICA stenting was performed (arrows) with double-layer stent placement and post-procedure DAT for 12 months.

Blood pressure stabilized in the post-operative period at 120–130/70–80 mmHg and dizziness resolved.



**A 67-year-old male** with a history of CAD, T2D, ischemic stroke in the right hemisphere presents with transient episodes of unconsciousness (the last episode of TIA occurred 2 weeks prior to presentation) and decreased memory.

---

CA angiogram shows a typical CAD in T2D and poorly controlled glycemia — severe artery stenosis with uneven margins that is typical for homogenous and embologenic plaques (arrow).

(A) — *common carotid artery (CCA)*,  
(B) — *internal carotid artery (ICA)*,  
(C) — *external carotid artery (ECA)*.

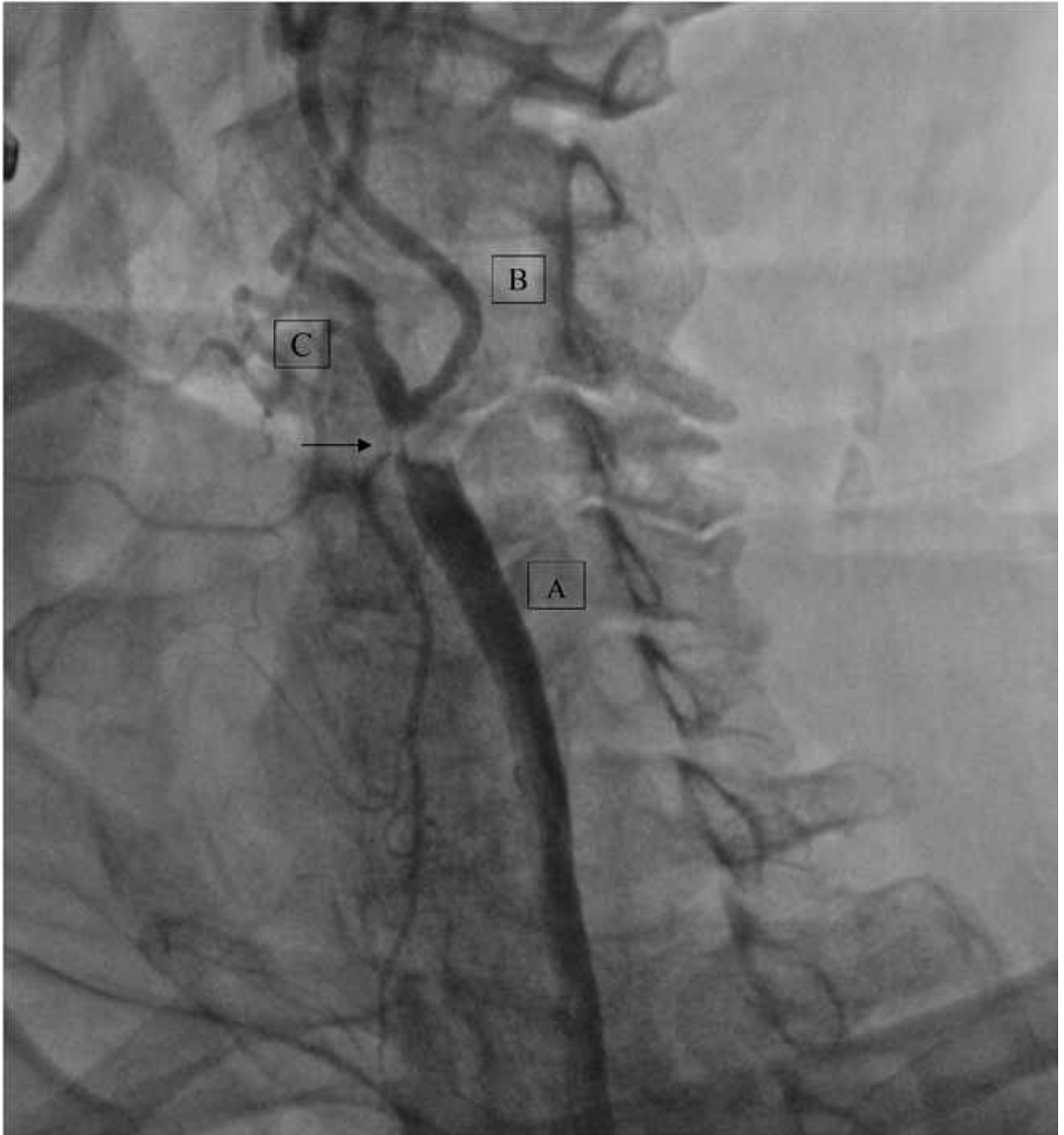


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Right ICA stenting was performed (arrows) using the distal cerebral protective system that is placed distal to the stenosis, filters cerebral blood flow and

prevents cerebral embolism. After the discharge the patient had no TIA episodes.



**A 67-year-old female** with a history of CAD, T1D, memory loss and decreased ability to concentrate her attention presents with dizziness, episodes of unconsciousness and elevated BP.

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CA angiogram shows left ICA subocclusion (arrow). (C) — *external carotid artery (ECA)*.  
(A) — *common carotid artery (CCA)*,  
(B) — *internal carotid artery (ICA)*,



*Continued*

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Left ICA stenting was performed to improve cerebral blood flow and prevent strokes (arrow). The patient described the full resolution of dizziness and episodes of unconsciousness and normal blood

pressure achieved with antihypertensive medications that she was taking prior to hospitalization.

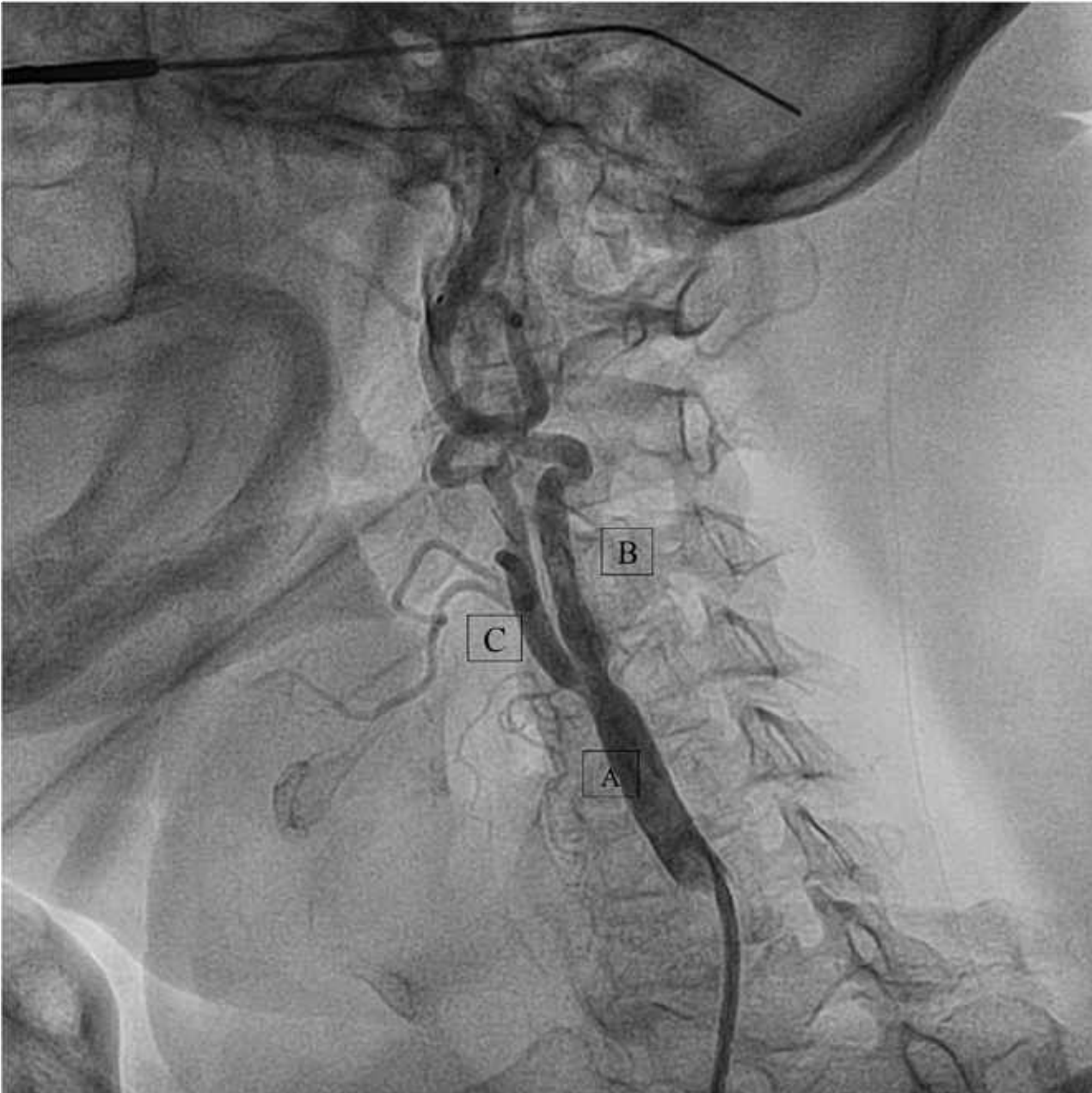


**A 76-year-old male** with a history of two episodes of TIA over the last 6 months (one of the episodes was associated with a transient loss of lateral vision and another with transient aphasia).

CA angiogram showed a 75% distal CCA (A) and ICA (B) stenosis with post-stenotic proximal ICA dilation.

Carotid US showed a 4 time increase in the blood flow velocity.

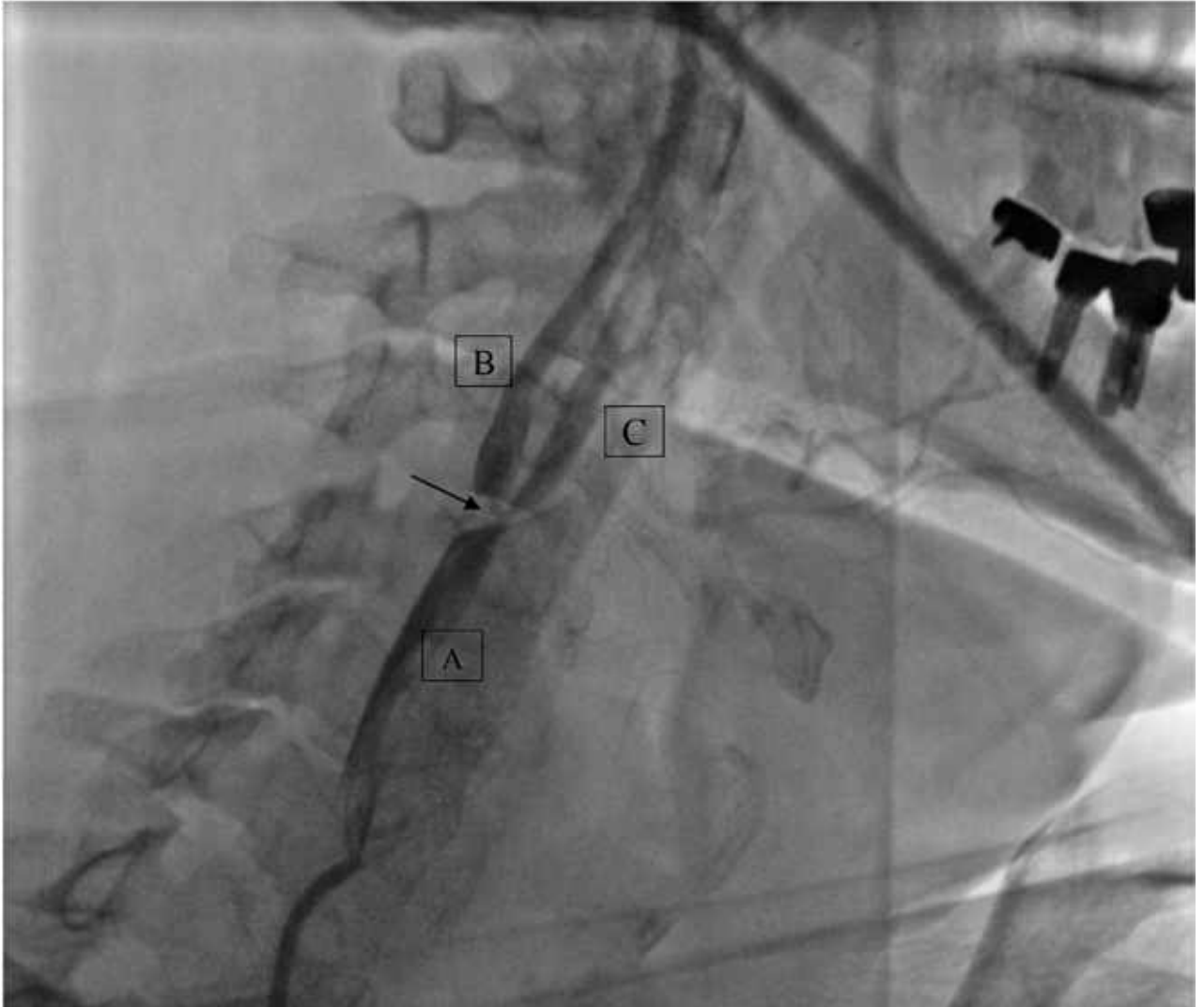
(A) — *common carotid artery (CCA)*,  
(B) — *internal carotid artery (ICA)*,  
(C) — *external carotid artery (ECA)*.



*Continued*

CCA and ICA stenting was performed using the double-layer carotid stent that prevents atherosclerotic plaque prolapse through the stent. At 1-year follow-up there were no repeat TIA.

(A) — *common carotid artery (CCA)*,  
(B) — *internal carotid artery (ICA)*,  
(C) — *external carotid artery (ECA)*.



**A 64-year-old female** with a history of CAD and a 90% eccentric CCA bifurcation and ICA and ECA ostial stenosis (arrow).

The patients report no history of stroke, TIA, amaurosis fugax in the last 6 months.

(A) — *common carotid artery (CCA)*,  
(B) — *internal carotid artery (ICA)*,  
(C) — *external carotid artery (ECA)*.



*Continued*

Carotid artery stenting was performed, and the stent covered all the area of atherosclerosis. At 12-month follow up there were no neurologic complications.

(A) — *common carotid artery (CCA)*,  
(B) — *internal carotid artery (ICA)*,  
(C) — *external carotid artery (ECA)*.

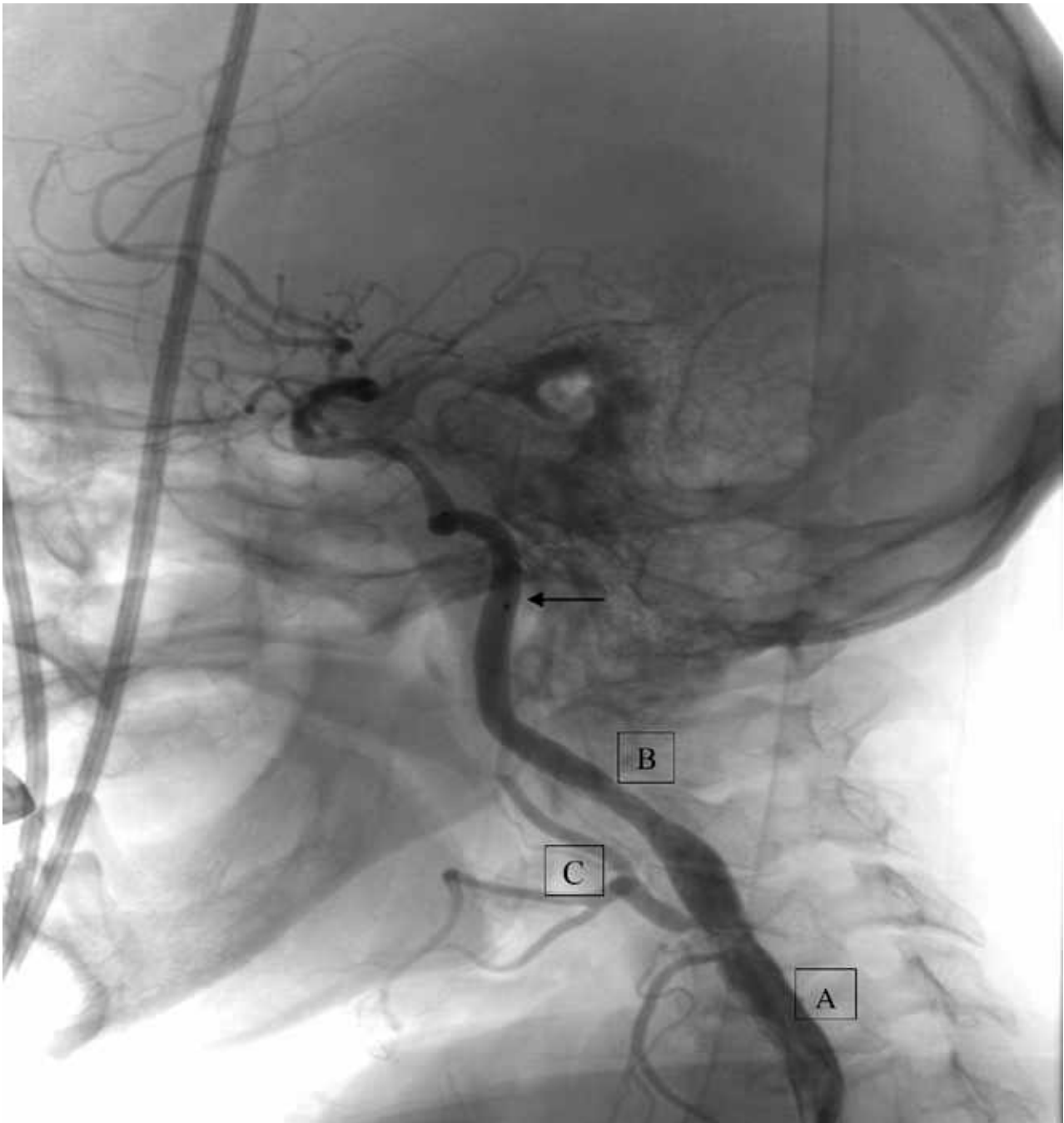


**A 78-year-old female** with a history of CAD and stroke 2 months prior to presentation.

LICA angiogram shows a complicated stenosis (arrow) caused by polymorphic atherosclerosis, ulcerated atherosclerotic plaque and contrast accumulation.

All these factors increase the risk of repeat stroke.

(A) — *common carotid artery (CCA)*,  
(B) — *internal carotid artery (ICA)*,  
(C) — *external carotid artery (ECA)*.



*Continued*

Left ICA stenting was performed with double-layer stent implantation to minimize the risks of repeat stroke. The distal cerebral protective system was placed in the left ICA, to cerebral blood flow and prevent embolism (arrow).

(A)— *common carotid artery (CCA)*,  
(B)— *internal carotid artery (ICA)*,  
(C)— *external carotid artery (ECA)*.



**An 83-year-old patient** with a history of CAD and stroke 3 weeks prior to presentation. CA angiogram showed a 2-cm spiral dissection in the left ICA (arrow).

This rare finding is associated with a high risk of repeat neurologic complications.

(A) — *common carotid artery (CCA)*,  
(B) — *internal carotid artery (ICA)*,  
(C) — *external carotid artery (ECA)*.



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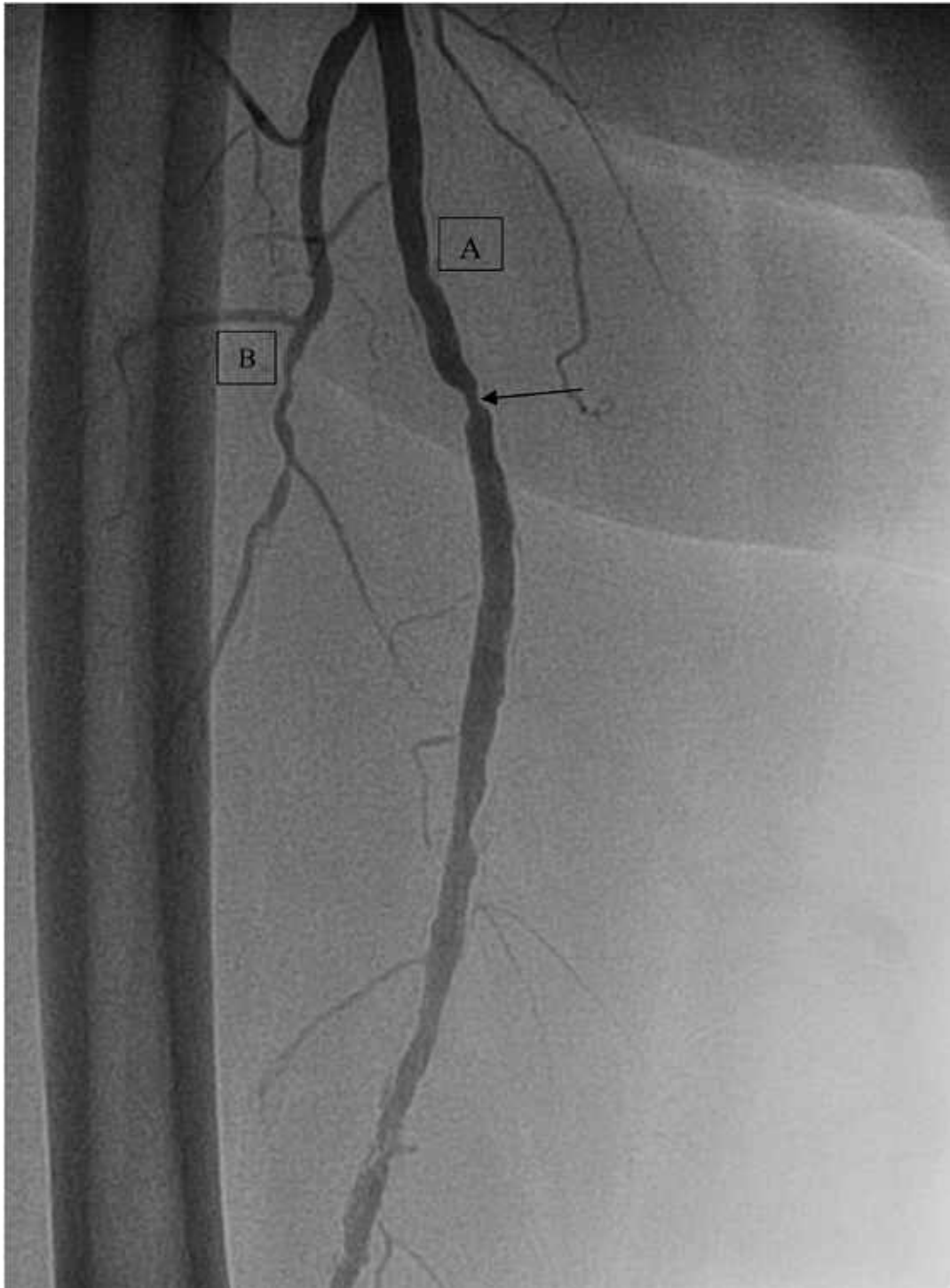
Left ICA stenting using the distal cerebral protective system was performed. To minimize the risk of post-operative neurologic complications the stent

specifically placed to cover the area of dissection and to tightly fix the floating intima (arrows).



Chapter 8

**PERIPHERAL ARTERY ANGIOPLASTY  
AND STENTING IN PATIENTS WITH DIABETES**

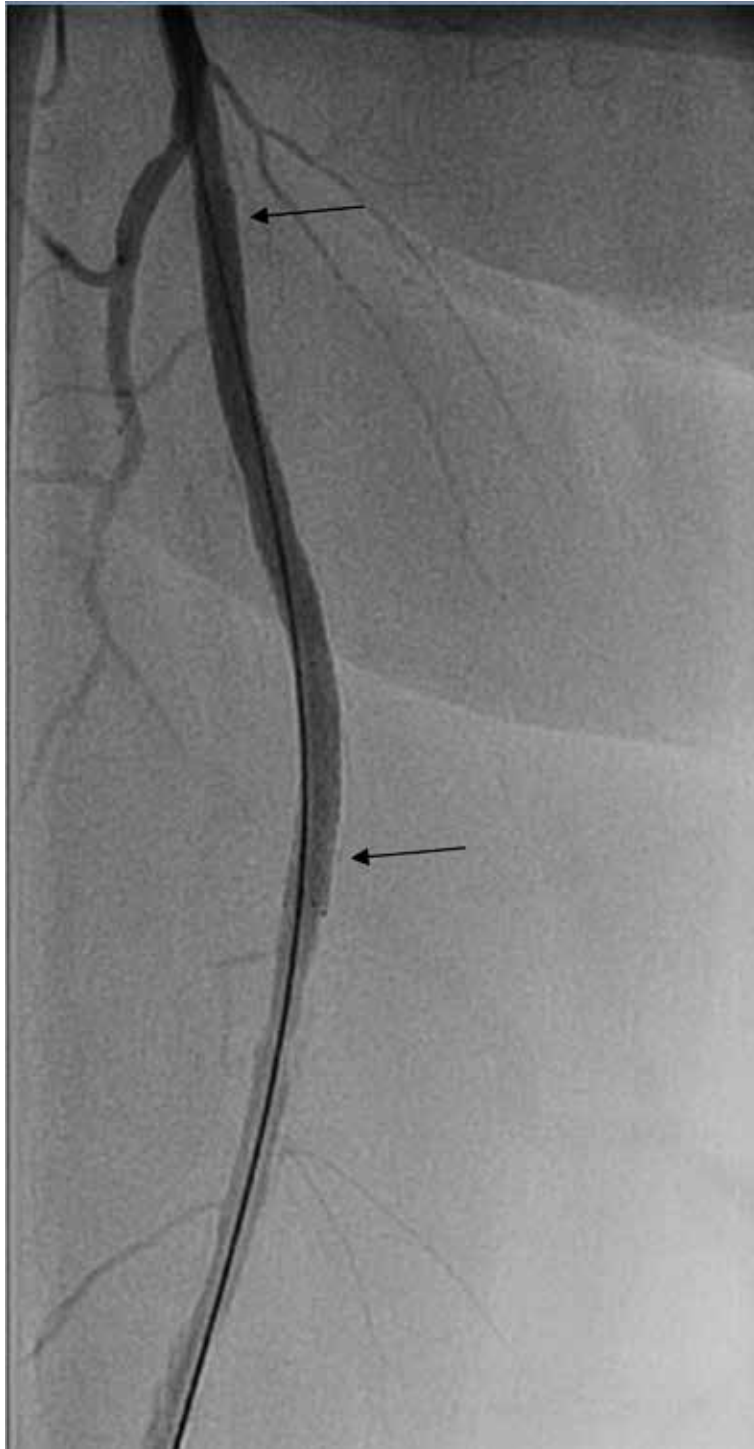


**A 73-year-old female** with a history of PAD, stage IIB chronic limb ischemia (according to the Fontaine classification modified by A.V. Pokrovsky) that significantly decreased the patient's quality of life.

The current angiogram shows an 80% proximal SFA stenosis (arrow) and a 50% mid-SFA stenosis.

To improve the patient's quality of life endovascular SFA revascularization was performed

(A) — *superficial femoral artery (SFA)*,  
(B) — *deep femoral artery (DFA)*.

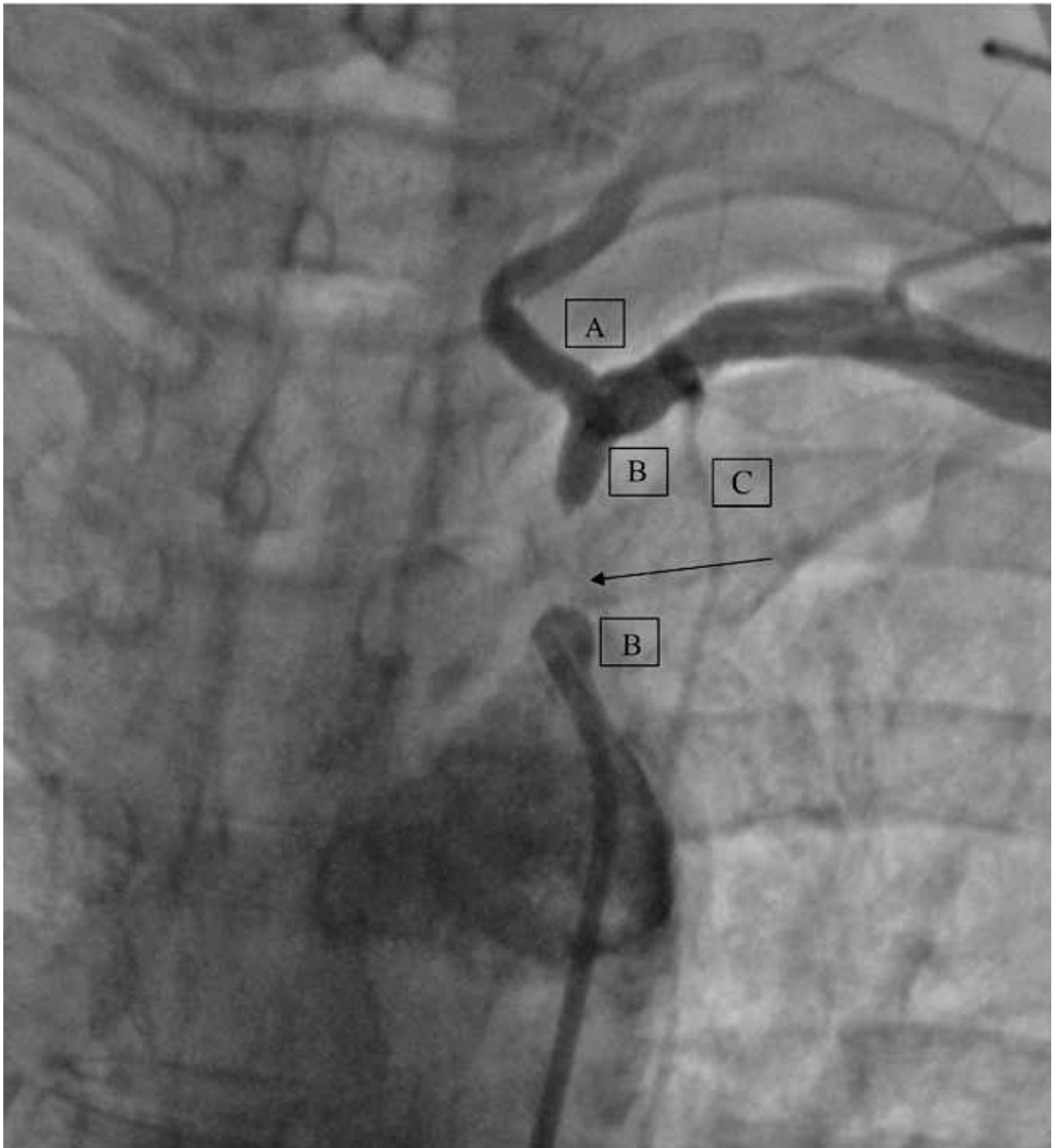


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Balloon angioplasty with right SFA was performed (arrows). The stent has fully expanded with complete blood flow restoration. The patient described the full

resolution of lower limb claudication and improved quality of life.



A 34-year-old male presented with a 50-mmHg blood pressure difference between arms first revealed at the annual check-up. The patient complains of numbness in the left arm and dizziness during activities that involve this arm.

Angiography revealed left subclavian artery occlusion (arrow) with the arm arteries filling from the vertebra-basilar vessels.  
(A) — vertebral artery,

(B) — subclavian artery,  
(C) — left internal mammary artery (LIMA).



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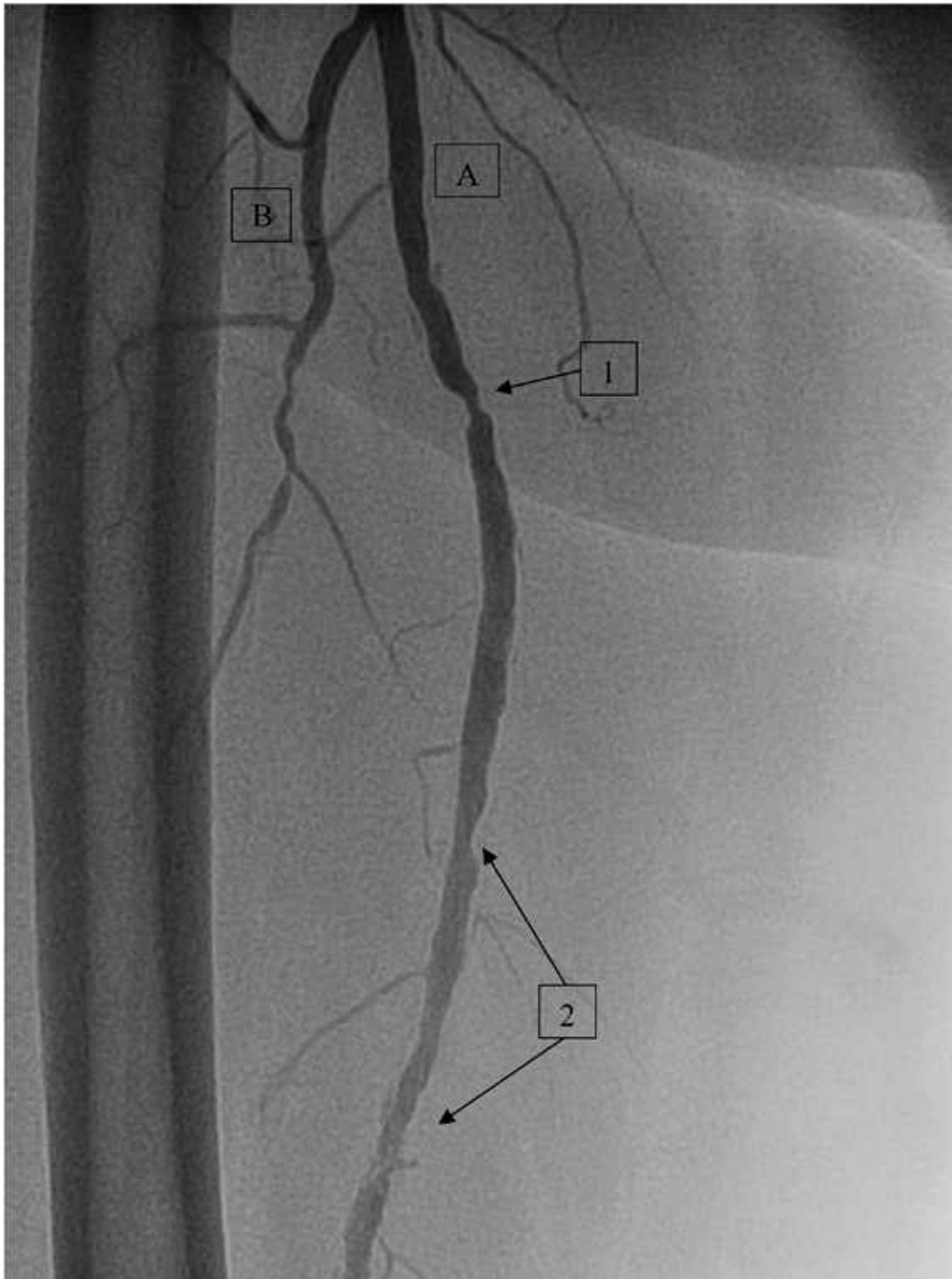
Subclavian artery recanalization with stent placement was performed with the complete restoration of antegrade blood flow (arrows). After the procedure no BP difference was noted, and the patient was discharged home 2 days later. At the outpatient fol-

low-up he described the completely normal left arm activity and no dizziness.

(A) — *vertebral artery,*

(B) — *subclavian artery,*

(C) — *left internal mammary artery (LIMA).*



**A 54-year-old patient** with a 30-year smoking history presented with decreased exercise tolerance due to numbness in the lower limbs over the last year, right calf pain during walking for 200 m over the last 1.5 months.

---

Angiography revealed an 85% right proximal SFA stenosis (arrow 1) and 50–60% mid-SFA stenosis (arrows 2).

(A) — *superficial femoral artery (SFA)*,  
(B) — *deep femoral artery (DFA)*.

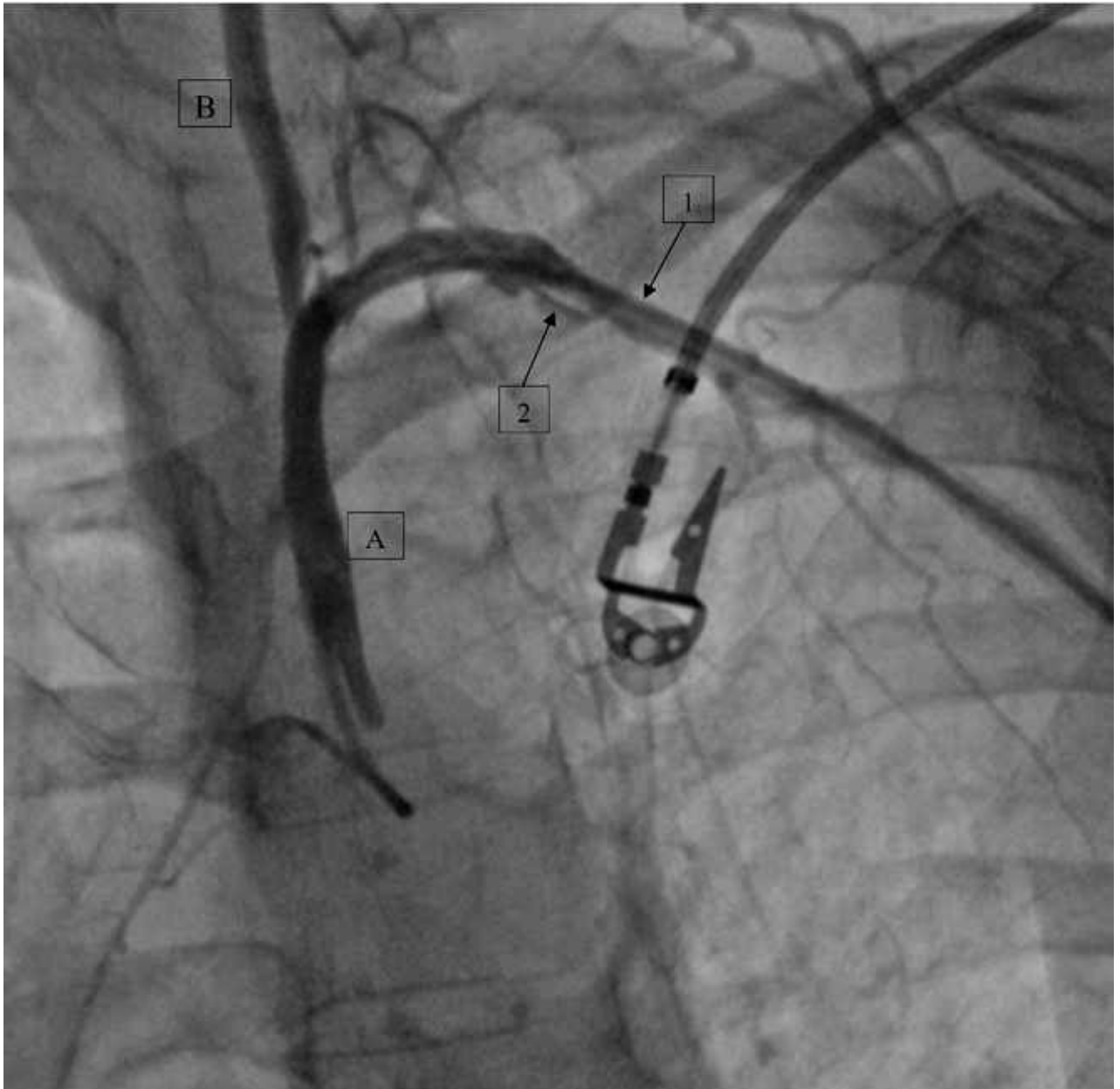


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Balloon angioplasty with right SFA stenting was performed with complete restoration of antegrade blood flow and no dissections. Post-procedure an-

giogram shows the implanted stent (arrows) and the guidewire.

(A) — *superficial femoral artery (SFA)*,  
(B) — *deep femoral artery (DFA)*.



**A 74-year-old female**

complains of dizziness and blurry vision when carrying a heavy bag in the left arm. CT angiography revealed a 95% left subclavian artery stenosis. The current angiogram shows the left subclavian artery after the balloon angioplasty; a guidewire (arrow 1)

and diffuse atherosclerosis (arrow 2) can be seen inside the artery.

(A) — left subclavian artery (LSA),

(B) — left vertebral artery (LVA).



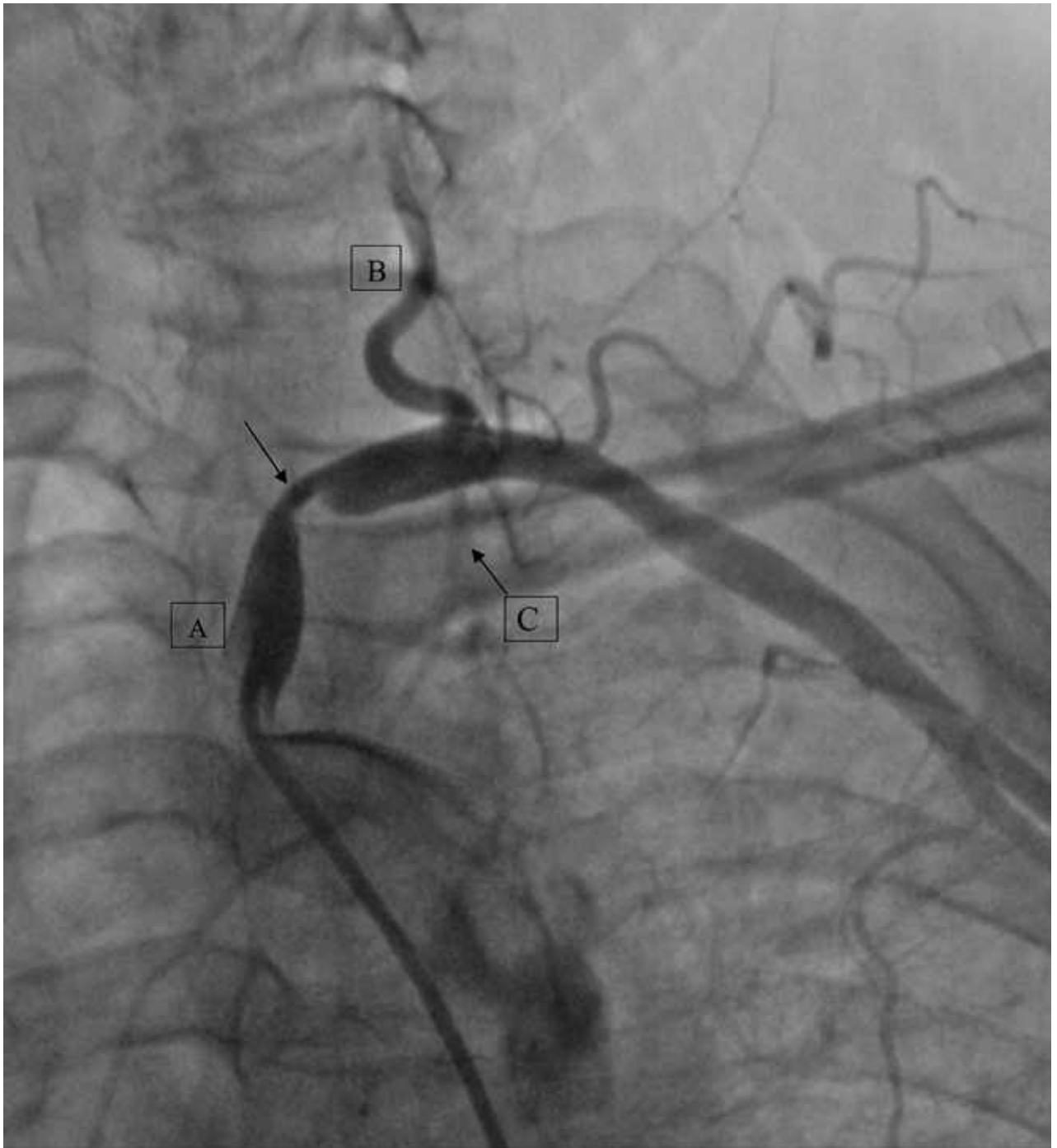
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The procedure was performed using the left radial access. The stent was placed from the LSA ostium through all the area of atherosclerosis (arrows). All the braces that originated from the area where the stent was placed were preserved without any signs of loss of compromised flow.

Two hours after the procedure the patient was allowed to walk. She complained of no pain when moving her left arm or carrying something.

(A) — left subclavian artery (LSA),

(B) — left vertebral artery (LVA).



**A 32-year-old athlete** presented after losing consciousness during dumbbell lifting in the gym.

BP on the right arm 120/80 mmHg and 70/50 mmHg on the left with weak left radial and ulnar pulse. Upper extremity CT angiography revealed a 90% proximal subclavian artery stenosis (arrow).

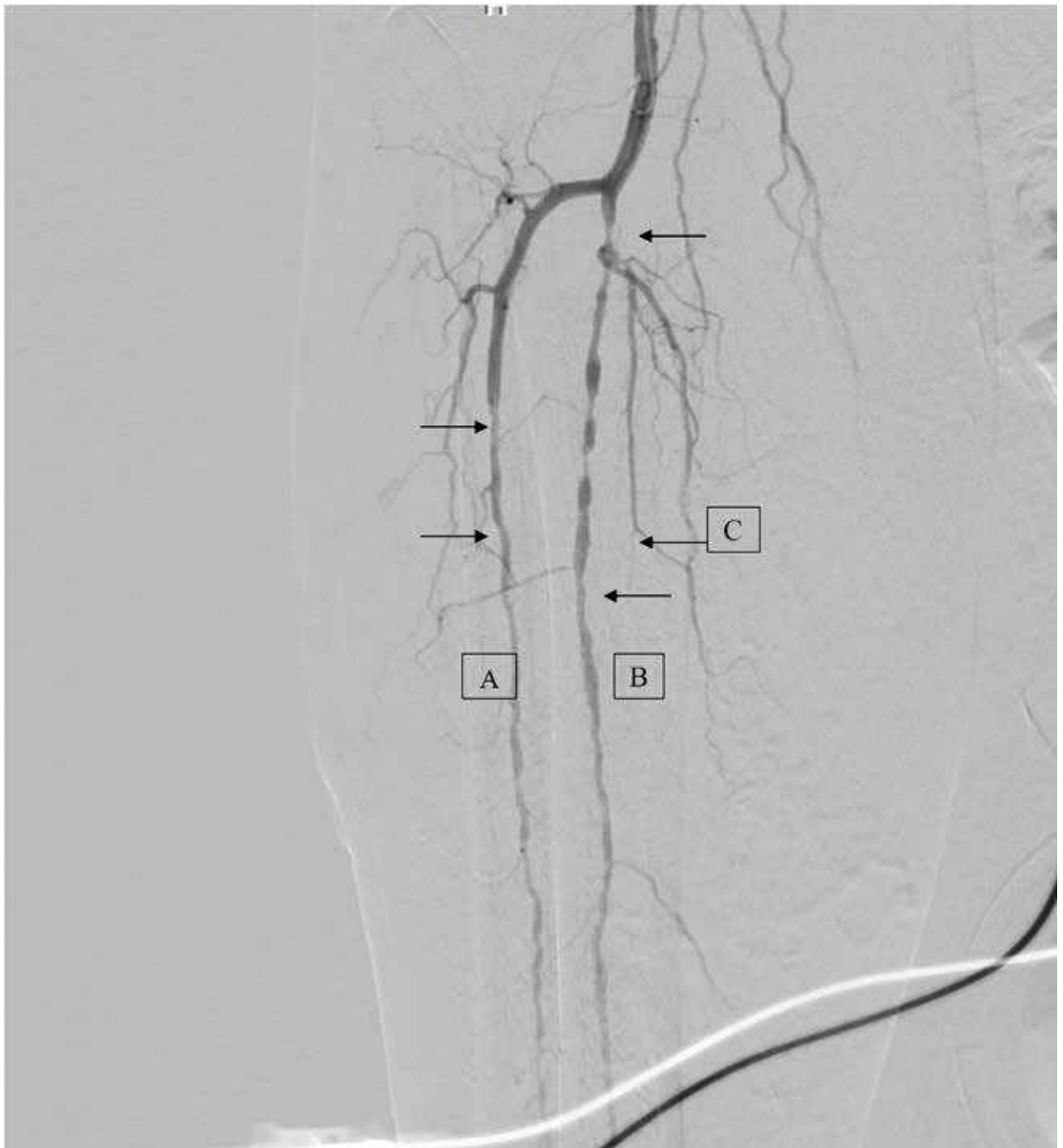
(A) — *left subclavian artery,*  
(B) — *left vertebral artery,*  
(C) — *left internal mammary artery (LIMA).*



*Continued*

Stenting was performed and antegrade blood flow was fully restored. Angiogram shows a guide wire catheter (A), guide wire (B), LIMA (C) and left vertebral artery (D). After the patient was discharged,

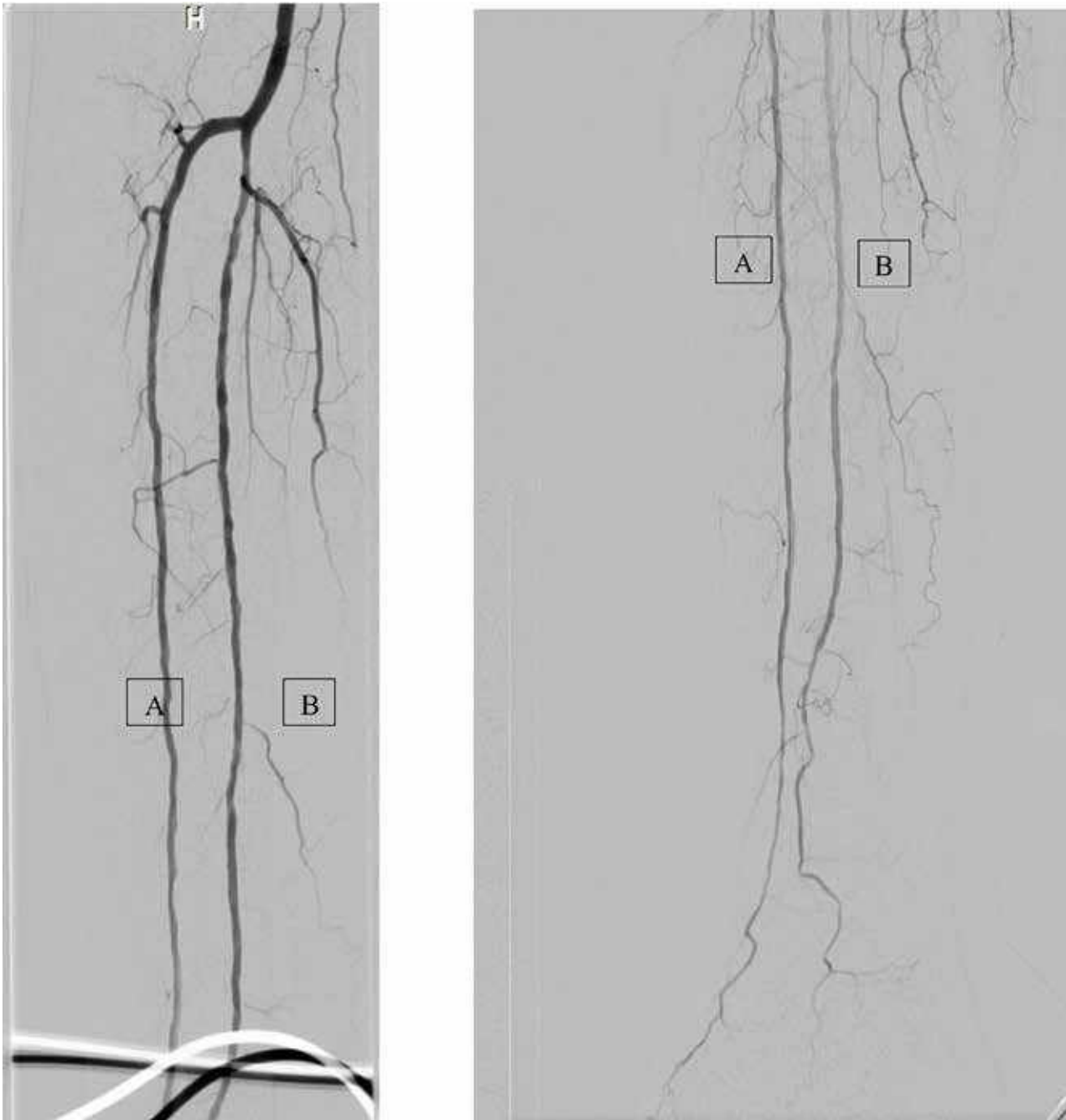
he returned to his baseline activity level; blood pressure became equal on both arms.



**A 78-year-old female** with stage III chronic limb ischemia (according to the Fontaine classification modified by A.V. Pokrovsky) and T2D presented with severe calf pain with mild exercise (slow-paced walking for up to 50 m).

Angiogram shows diffuse atherosclerosis of the anterior tibial artery (A) and fibular artery (B) with 95% stenosis and posterior tibial artery occlusion (C). Microvascular flow is also diminished that is a

typical finding in diabetic patients. Arrows show at the most significant lesions.



*Continued*

Anterior tibial artery (A) and fibular artery (B) transluminal balloon angioplasty was performed to improve blood flow in the ankle and foot arteries. Calf pain has completely resolved after the procedure and the patient became able to walk for up

to 1 km. Post-procedure angiograms show optimal filling with smooth arterial margins and no signs of arterial dissection.



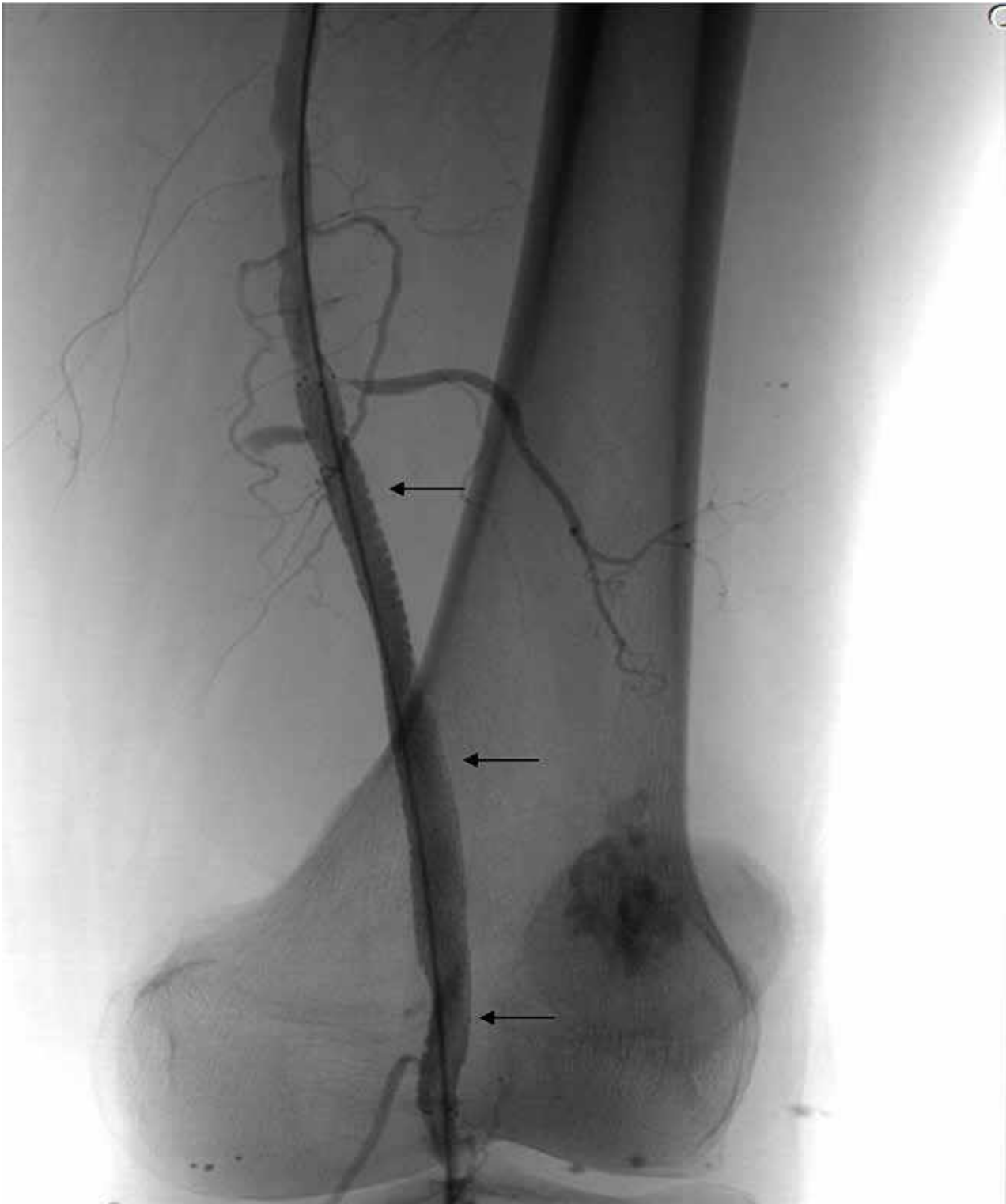
**A 66-year-old male** with stage III chronic limb ischemia (according to the Fontaine classification modified by A.V. Pokrovsky)

presents with severe foot and calf pain after walking for 100–150 m and ankle hair loss. Angiogram shows lower SFA occlusion (arrows). Postocclu-

sion SFA filling is provided by the collateral arteries from DFA.

(A) — *superficial femoral artery (SFA)*,

(B) — *popliteal artery (PA)*.



*Continued*

SFA recanalization with stent placement was performed. Post-procedure angiogram shows the im-

planted stent (arrows) with completely restored blood flow.



**A 65-year-old male** with stage III chronic limb ischemia (according to the Fontaine classification modified by A.V. Pokrovsky)

and T1D presents with claudication in the calf muscles and foot after fast-paced walking for up to 150 m that resolves with switching to slower pace. Angiogram shows diffuse mid-SFA atherosclerosis with 90% stenosis (arrows). Diffuse atherosclerotic

plaques with uneven margins are typical for patients with diabetes.

(A) — *superficial femoral artery (SFA)*.

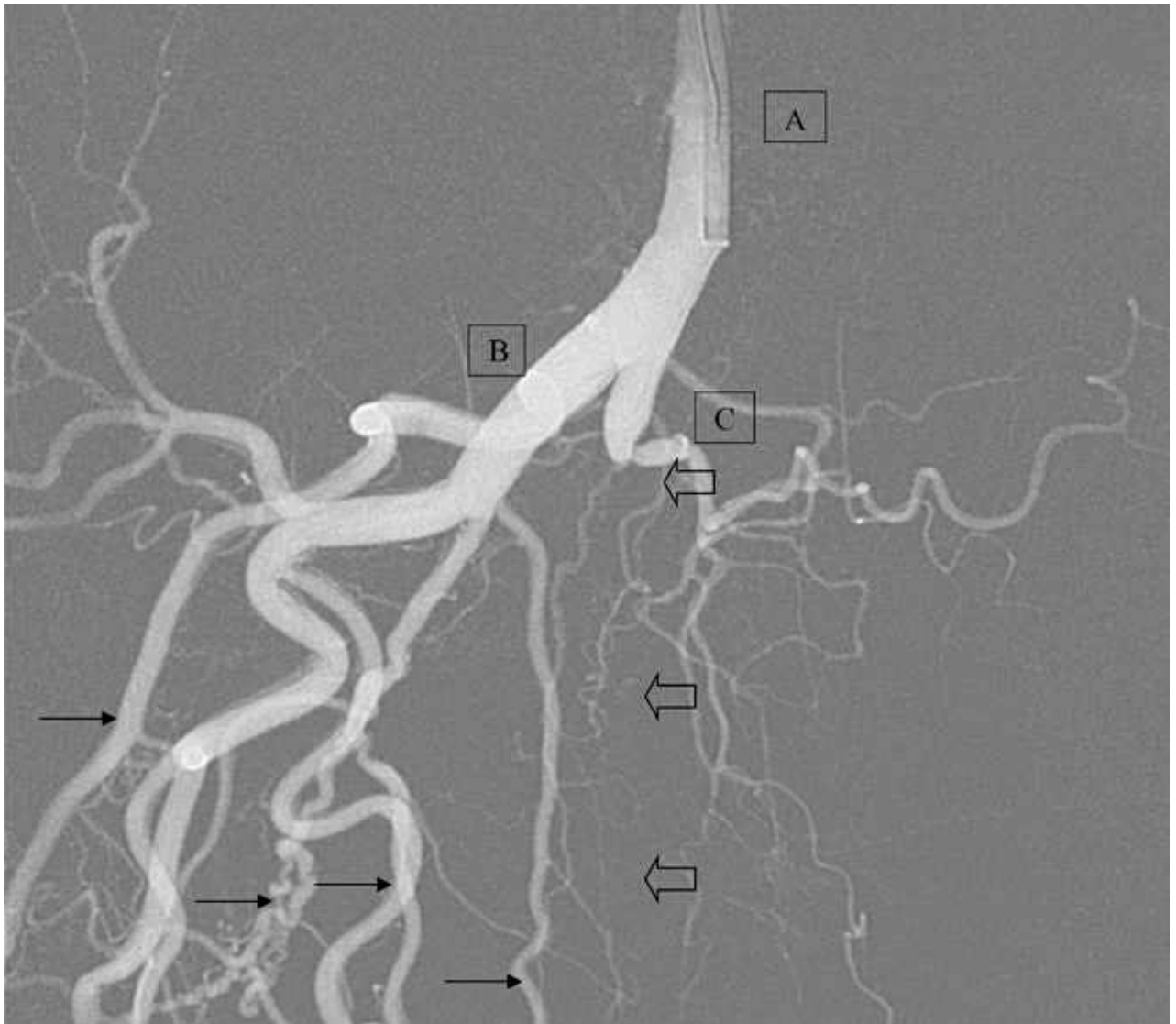


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Transluminal balloon angioplasty with stent placement was performed (arrows)  
Post-procedure angiogram shows complete restoration of antegrade blood flow with smooth arterial margins and no signs of dissection.

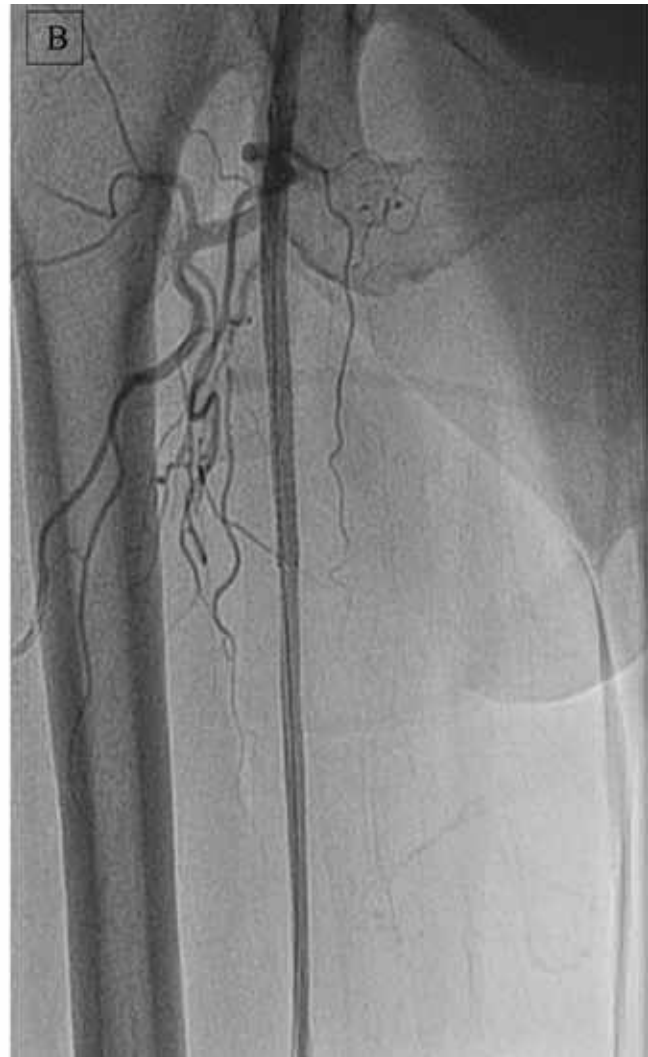
After endovascular treatment lower limb claudication has fully resolved.



**A 63-year-old male** with stage IV chronic limb ischemia (according to the Fontaine classification modified by A.V. Pokrovsky)

presents with severe right lower leg pain after walking and at rest. Angiogram shows proximal SFA occlusion (arrows). Distal SFA filling is provided by the collateral arteries from DFA.

(A) — *common femoral artery (CFA)*,  
(B) — *deep femoral artery (DFA)*,  
(C) — *superficial femoral artery (SFA)*.



*Continued*

Proximal SFA occlusion recanalization followed by transluminal balloon angioplasty was performed (A). Post-procedure angiogram shows residual 60% stenosis with dissection of the SFA (arrow). Stent

was later placed in the SFA to improve the long-term outcomes (B).

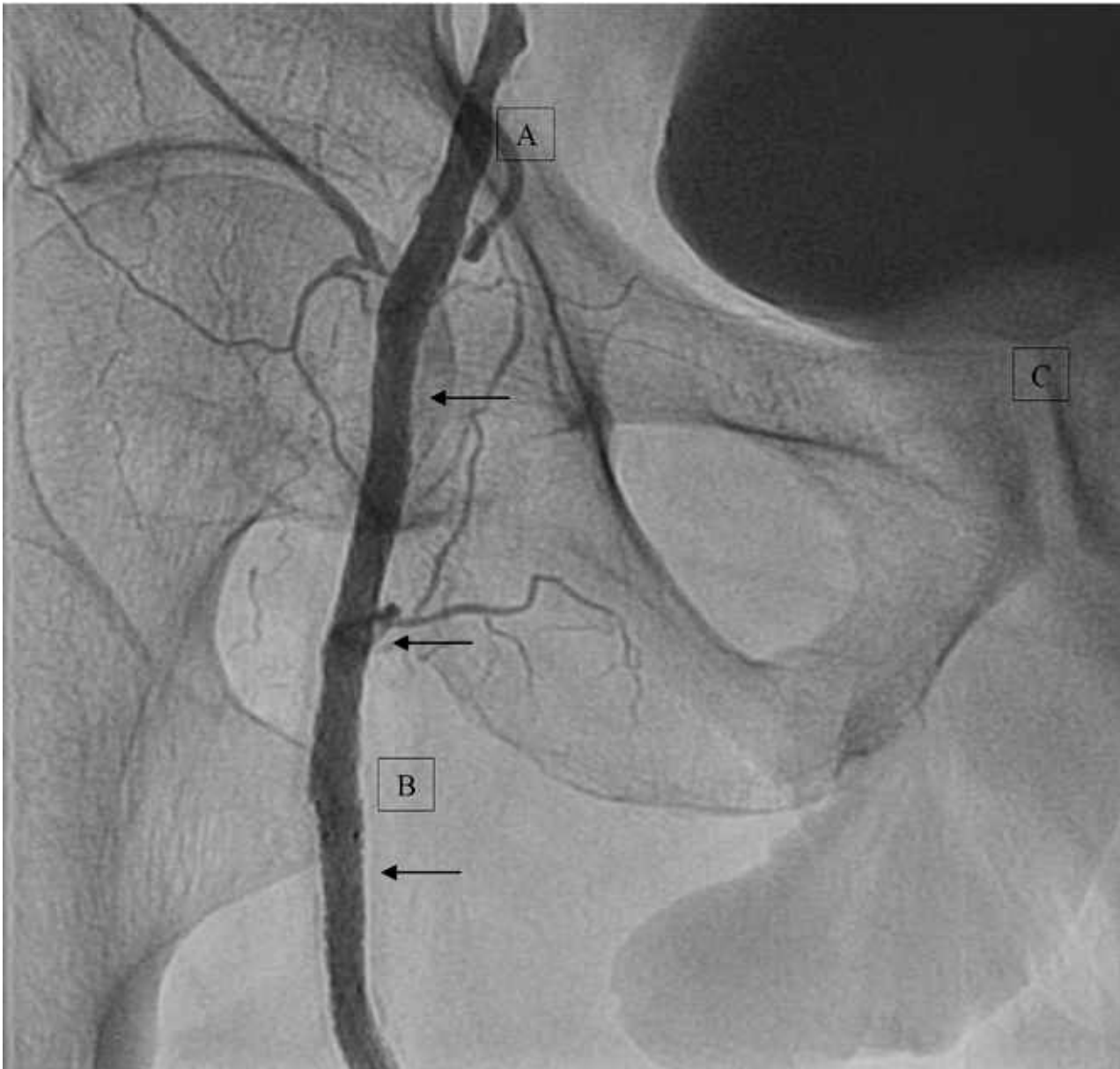


**A 72-year-old patient** with chronic lower limb ischemia presents with right lower leg pain at rest, lower leg coolness and weakness and a history of right calf hair loss.

Angiogram shows a total occlusion of right common femoral artery and complete absence of blood flow to the SFA (small arrows) and collateral flow from the DFA. Collateral blood flow is partially provided by the superficial iliac circumflex artery (large ar-

rows). Emergent revascularization was performed to preserve the lower extremity.

(A) — *external iliac artery (EIA)*,  
(B) — *common femoral artery (CFA)*,  
(C) — *iliac circumflex artery (ICA)*.



*Continued*

Occlusion recanalization followed by transluminal balloon angioplasty with stent placement was performed (arrows) with complete restoration of antegrade blood flow.

(A) — *common femoral artery (CFA)*,  
(B) — *superficial femoral artery (SFA)*,  
(C) — *bladder*.



**A 55-year-old male** with a history of T1D presents with pain and weakness in the calf muscles and feet during fast-paced walking or slow-paced walking for 150 m.

Angiogram shows diffuse atherosclerosis of the common iliac artery with external and internal iliac arteries involvement and up to 90% stenosis (arrows). Endovascular treatment was performed to increase pain-free walking distance and improve the patient's quality of life.

(A) — *common iliac artery (CIA)*,  
(B) — *external iliac artery (EIA)*,  
(C) — *internal iliac artery (IIA)*.



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Transluminal balloon angioplasty with stent placement was performed (arrows) with complete restoration of antegrade blood flow. After endovascular

treatment pain has completely resolved and pain-free walking distance increased to 2 km.

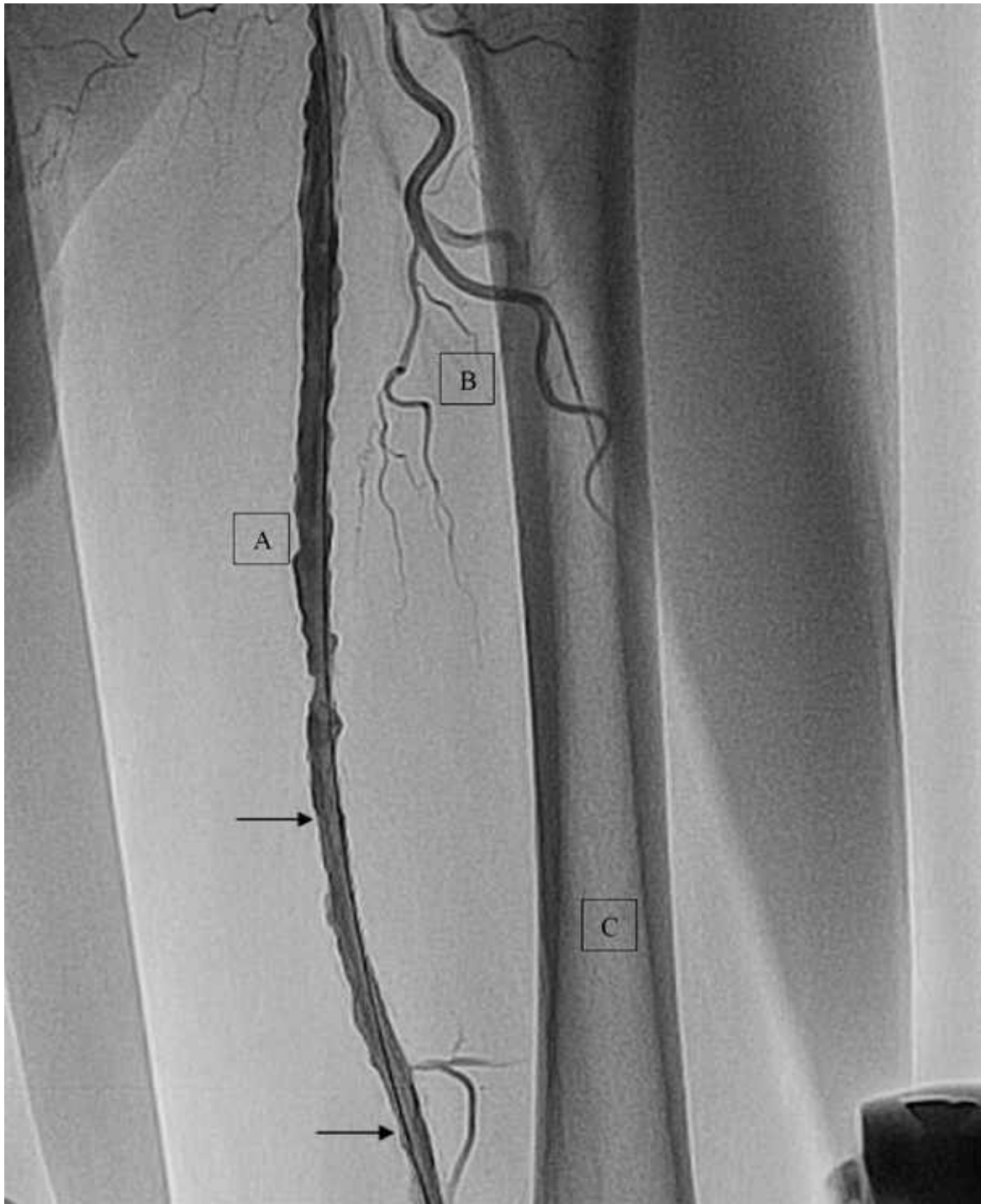


**A 76-year-old male** with stage III chronic limb ischemia (according to the Fontaine classification modified by A.V. Pokrovsky)

presents with left lower extremity pain when walking for up to 100 m. Has a 75–100 pack-year history of smoking. Angiogram shows diffuse calcified SFA

atherosclerosis with a 95% stenosis. Arrows show at the most significant areas of stenosis.

(A) — *superficial femoral artery (SFA)*,  
(B) — *femoral bone*.



*Continued*

SFA balloon angioplasty was performed with sufficient blood flow restoration and residual 30% stenosis (arrows) and no signs of dissection.

Patient was advised on smoking cessation. After discharge the pain-free walking distance increased to 1.5 km.

(A) — *superficial femoral artery (SFA)*,

(B) — *deep femoral artery (DFA)*,

(C) — *femoral bone*.



**A 56-year-old female** with T2D and chronic lower limb ischemia presents with calf muscle pain at rest and ischemic calf and ankle changes.

Arrows show ATA occlusion with distal ATA filling through collateral blood flow. However, ATA is affected by diffuse atherosclerosis that are typically seen in diabetic patients.

Blood flow in the (A) fibular artery (B)—PTA is preserved.

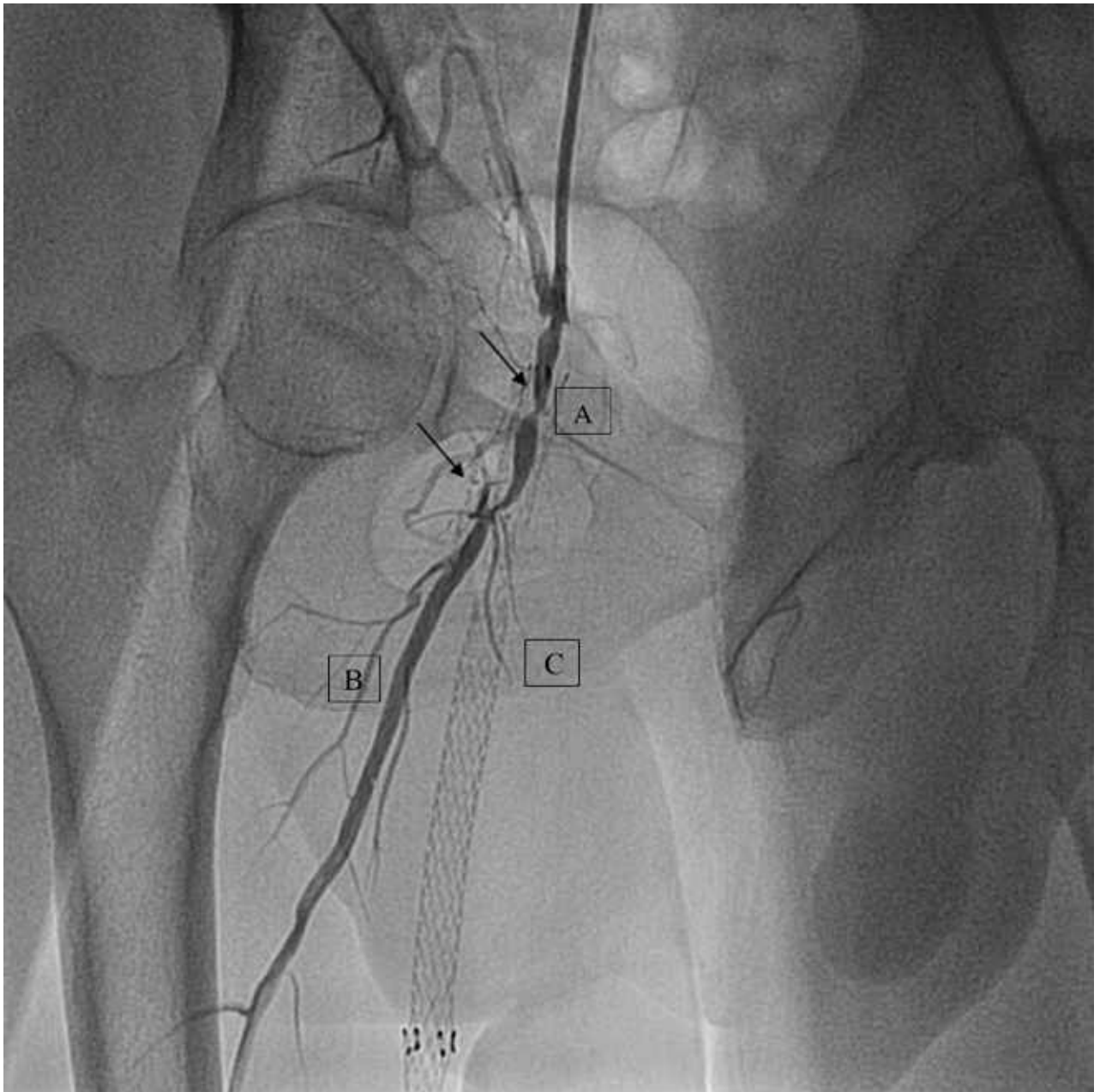


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Mechanical occlusion recanalization followed by anterior tibial artery balloon angioplasty with complete blood flow restoration and no signs of residual stenosis or dissection.

The patient was discharged home 5 days after the procedure. Her exercise activity improved, and ischemic ulcers have resolved.

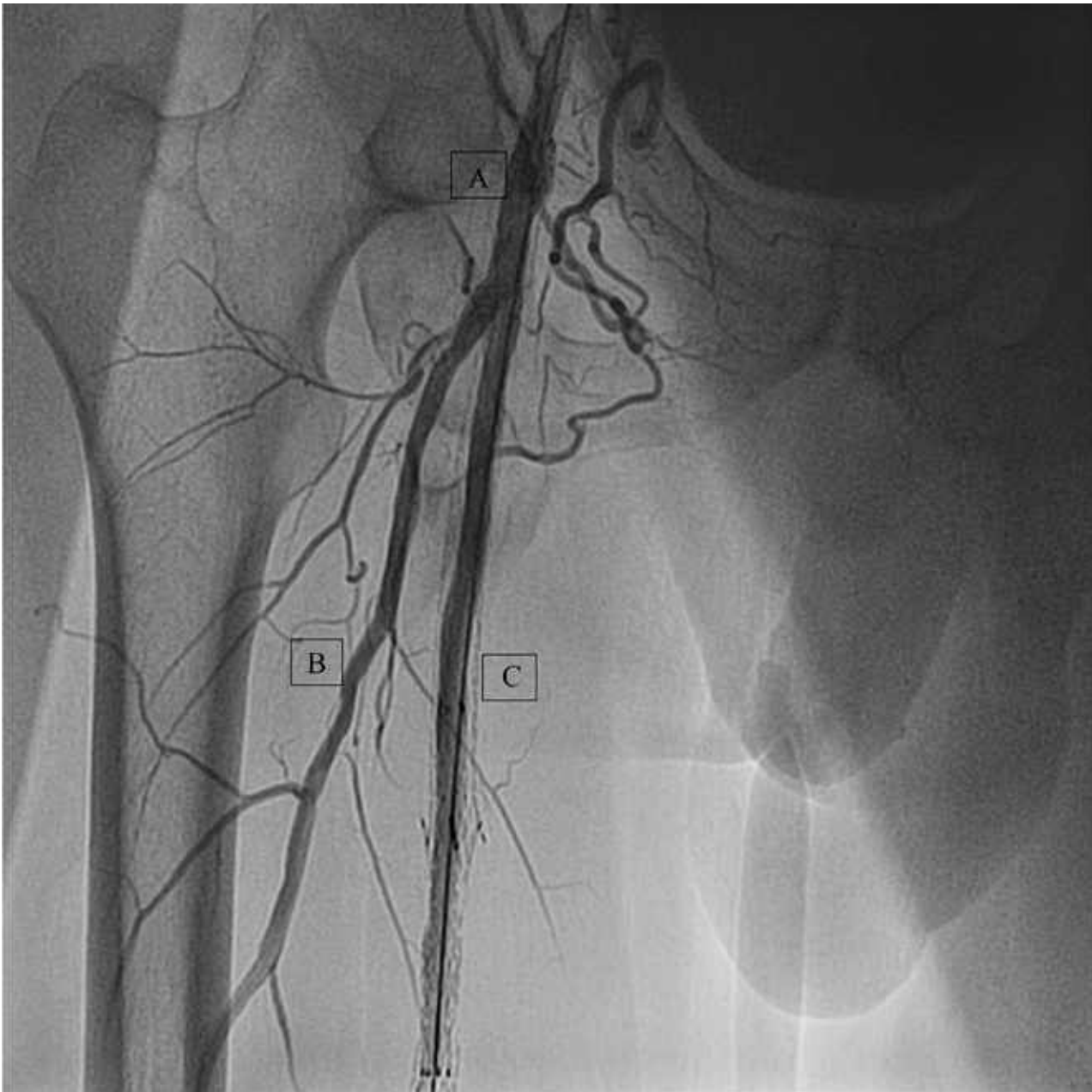
- (A) — anterior tibial artery (ATA),
- (B) — fibular artery (FA),
- (C) — posterior tibial artery (PTA).



**A 54-year-old male** with 2 implanted SFA stents stopped taking dual antithrombotic therapy 1 month after the procedure.

The patient presented with acute right lower extremity pain with minimal exercise and in rest. Angiogram shows SFA stent occlusion (C) and 85–90% proximal internal iliac artery stenosis (B).

(A) — *common iliac artery (CIA)*,  
(B) — *internal iliac artery (IIA)*,  
(C) — *superficial femoral artery (SFA)*.



*Continued*

Occlusion recanalization followed by superficial and deep femoral artery balloon angioplasty. Due to the insufficient results of angioplasty (residual stenosis >50%) repeat SFA stenting was performed.

The patient was repeatedly instructed on the importance of DAT after stenting. 24 hours after the

bandages were removed the patient was able to walk without feeling any pain.

(A) — *common femoral artery (CFA)*,

(B) — *deep femoral artery (DFA)*,

(C) — *superficial femoral artery (SFA)*.



**A 78-year-old male** with stage III chronic limb ischemia (according to the Fontaine classification modified by A.V. Pokrovsky) presents with right lower extremity pain with walking for up to 50 m and foot coolness.

Angiogram shows ATA filling through internal femoral artery collateral blood flow. Well-developed col-

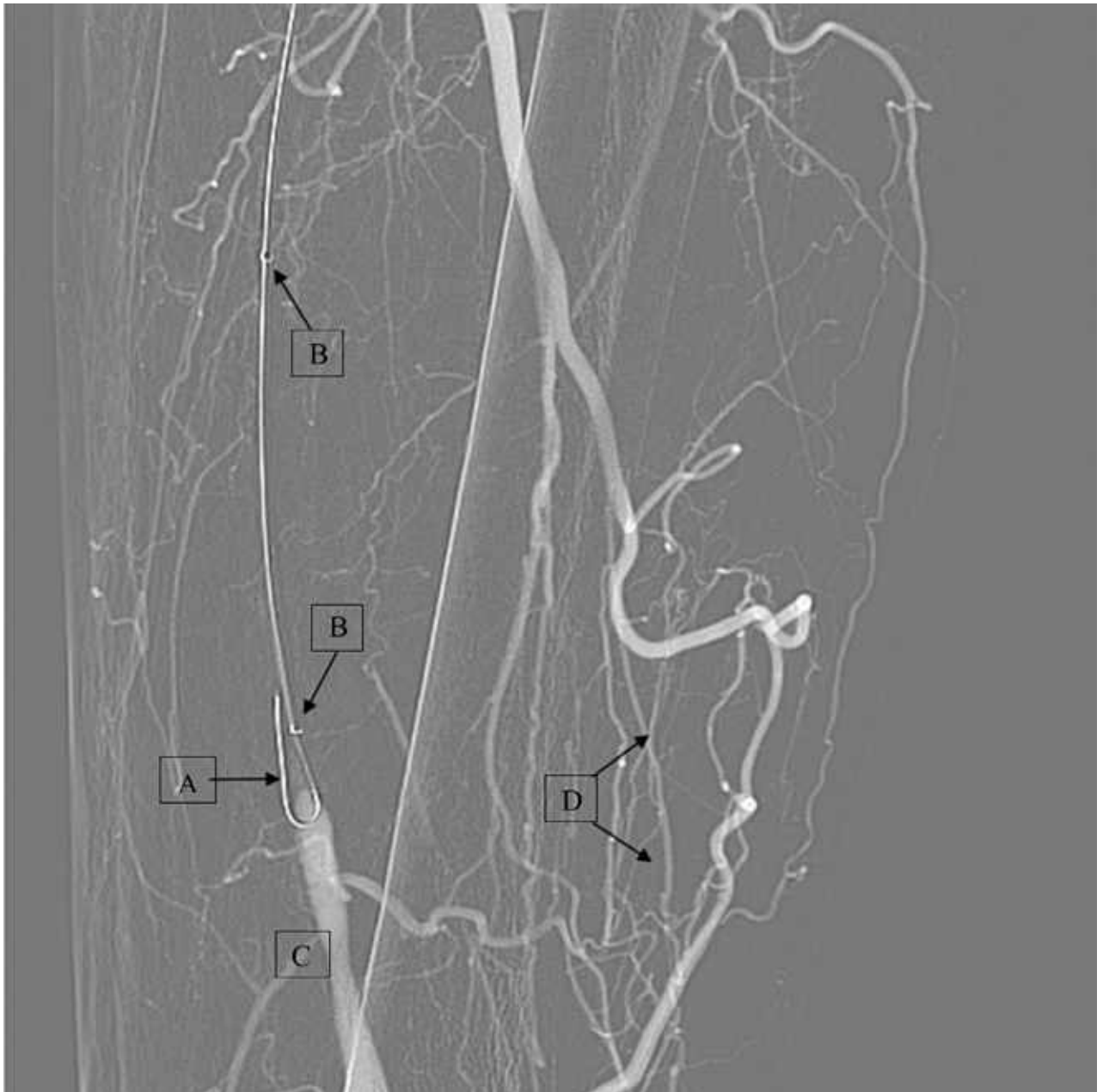
lateral circulation is a sign of chronic stenosis with gradual artery 'closing'.



*Continued*

First, occlusion recanalization with guidewire was performed followed by occlusion endovascular endarterectomy with balloon angioplasty (guidewire shown by the arrow). Post-procedure angiogram shows a complete resolution of blood flow without any signs of residual stenosis.

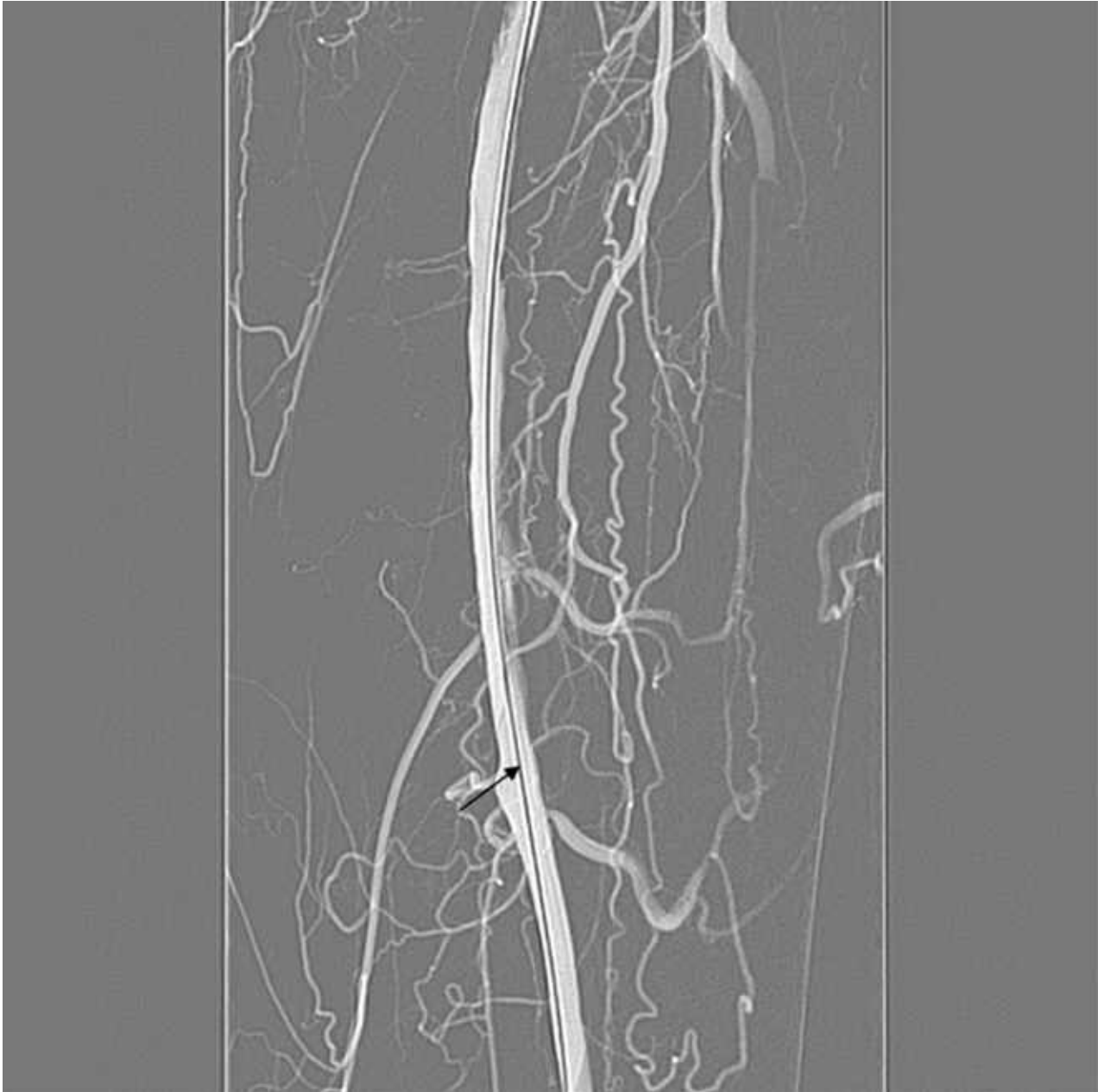
There were no complications in the early post-operative period. The patient returned to full normal physical activity and thermoregulation and sensitivity were completely restored.



**A 54-year-old female** with stage IIB chronic limb ischemia (according to the Fontaine classification modified by A.V. Pokrovsky) and 5.5-pack-year smoking history.

Angiogram shows left SFA occlusion recanalization with peripheral guidewire (arrow A) and balloon catheter (arrow B).

SFA (C) is filled through deep femoral artery collateral circulation (D).



*Continued*

Post-procedure angiogram shows complete restoration of ATA blood flow with a guide wire inside the vessel lumen (arrow).

The patient was advised on smoking cessation. After the procedure he returned to full activity with no pain in the lower extremity.



**A 65-year-old-patient** chronic limb ischemia and T1D presents with left lower extremity pain and numbness in the left foot toes. There were no ischemic ulcers in the left foot but, nevertheless, the patient was at high risk of limb amputation.

Angiogram shows left ATA occlusion (arrow 1) with weak blood flow in the internal femoral artery (arrow 2) that resulted in insufficient collateral circulation in the limb. Emergent endovascular treatment

was performed to restore blood flow to the superficial femoral artery.



*Continued*

Mechanical left ATA occlusion recanalization with subintimal recanalization was performed (poor microvascular filling in the area where the stent was placed — arrow).

Post-procedure angiogram shows a good arterial filling with even margins. Calf and foot are warm, non-painful, with improved sensitivity. The patient avoided limb amputation.



**A chronic 60-year-old smoker** with stage III chronic limb ischemia (according to the Fontaine classification modified by A.V. Pokrovsky)

presents with calf pain during slow-paced walking for 100 m that forces the patient to stop. Angiogram shows a more than 15 cm occlusion. Calf arteries are supplied through the collateral circulation (arrows) from internal femoral artery.

(A) — *deep femoral artery (DFA)*,  
(B) — *post-occlusion flow from in the superficial femoral artery.*



*Continued*

Mechanical recanalization of SFA occlusion with stent implantation was performed. Post-procedure angiogram shows a good flow in the side branches that is a sign of a successful intraluminal occlusion recanalization with complete restoration of ante-

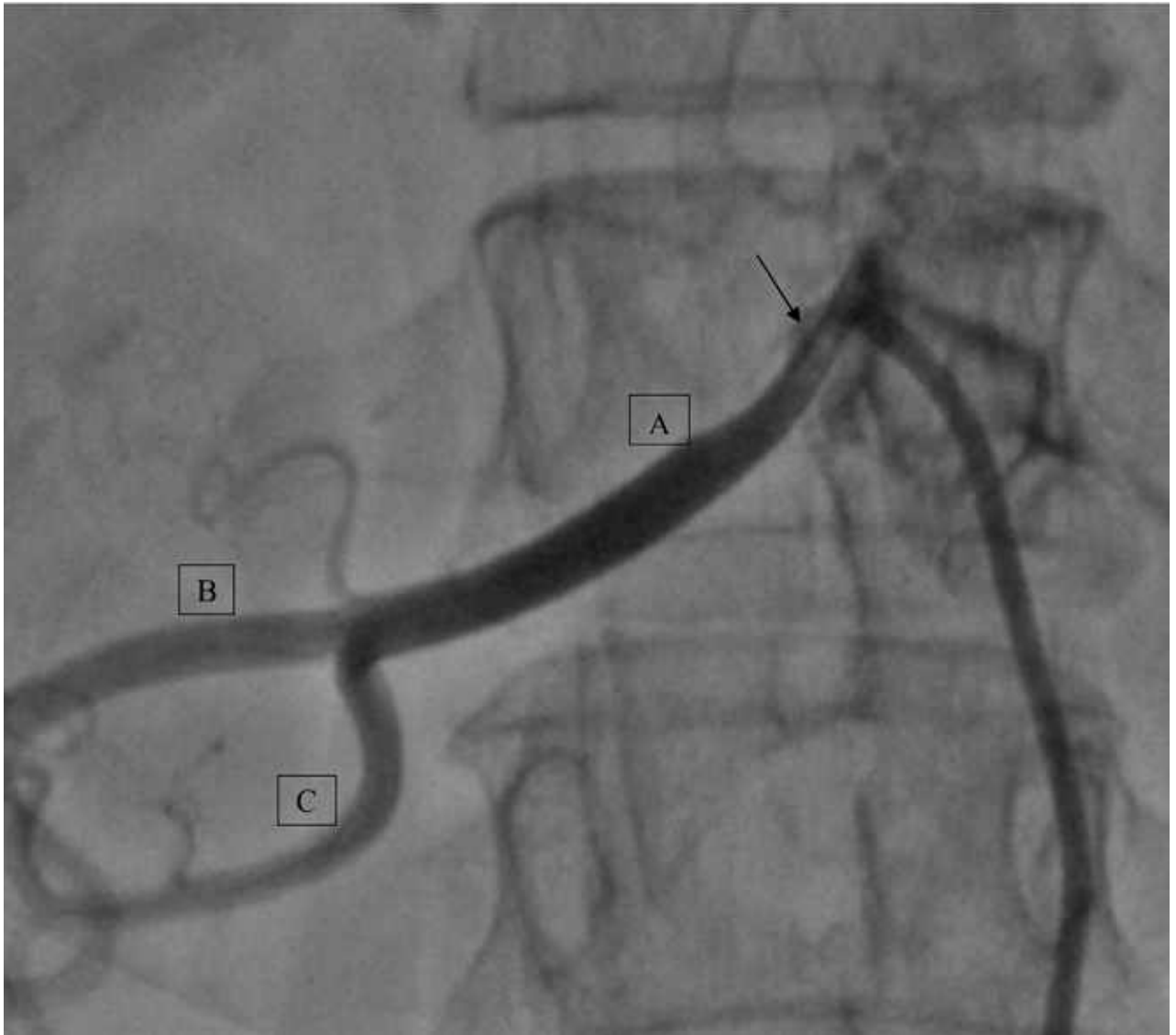
grade blood flow. The patient described a significant clinical improvement, and the pain-free walking distance has increased to up to 5 km.

(A) — *deep femoral artery (DFA)*,  
(B) — *superficial femoral artery (SFA)*.



Chapter 9

**RENAL ARTERY ANGIOPLASTY  
AND STENTING IN PATIENTS WITH DIABETES**

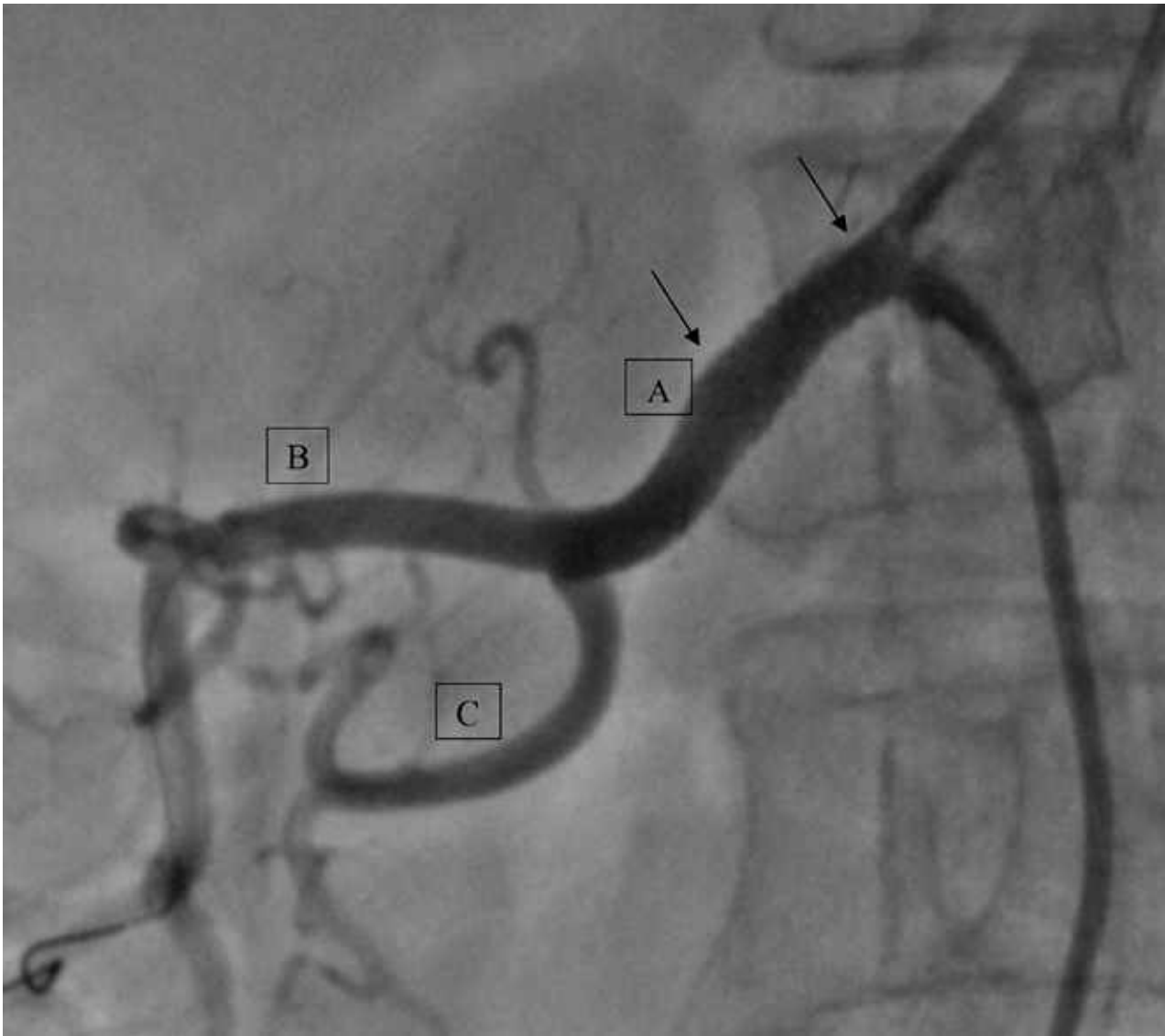


**A 63-year-old female** with a history of left nephrectomy presents with resistant AH.

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Angiogram shows a 70% complicated stenosis in the right renal artery ostium with intraluminal lucencies and uneven margins (arrow).

(A) *Common renal artery (CRA)*,  
(B) — *superior polar artery (SPA)*,  
(C) — *inferior polar artery (IPA)*.

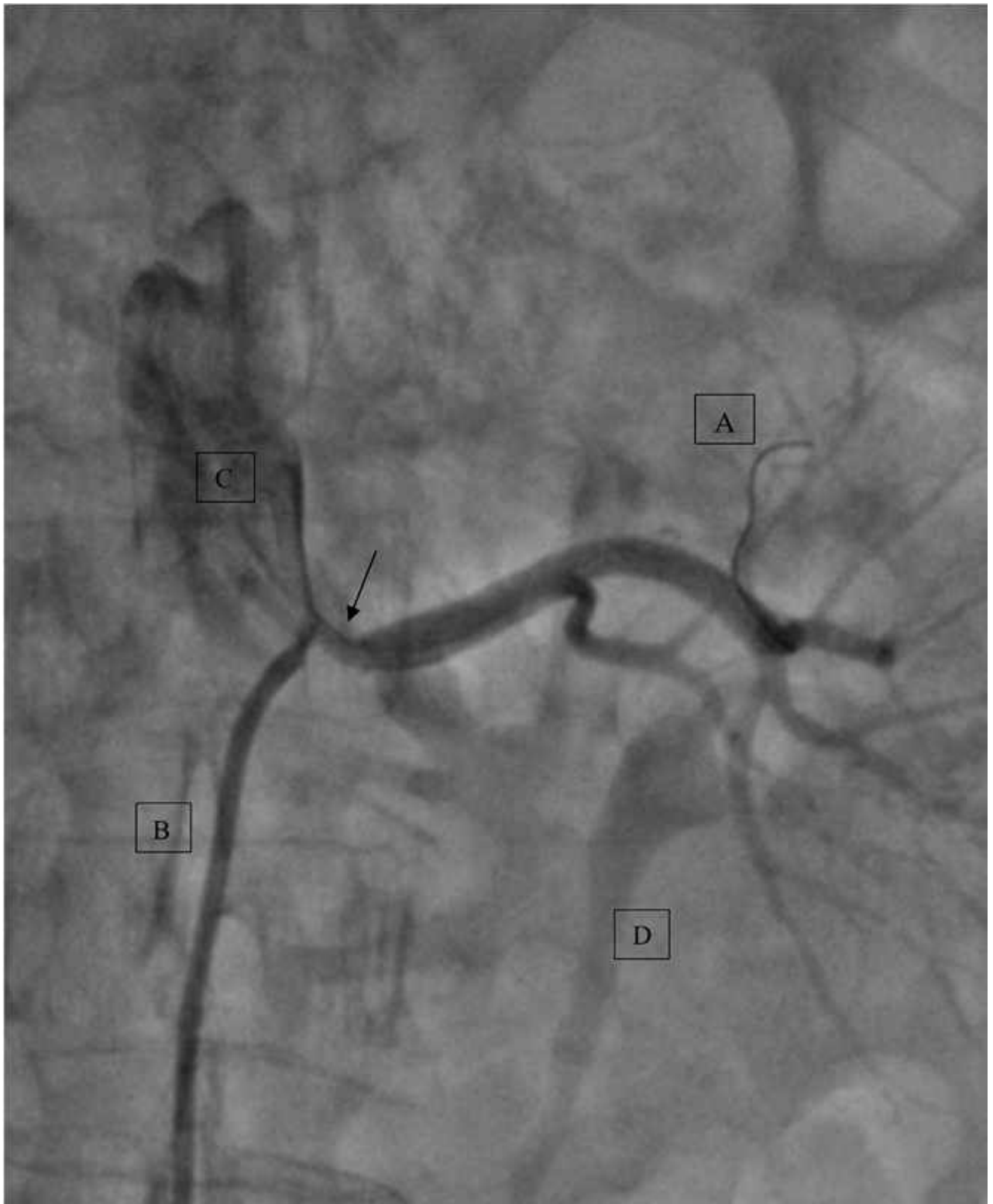


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Right renal artery stenting was performed (arrows) with complete restoration of blood flow. At 1-month follow-up the stenotic lumen is completely restored, kidney function is normal, BP control was achieved

by lower number and dosages of antihypertensive drugs.

- (A) *Common renal artery (CRA)*,
- (B) — *superior polar artery (SPA)*,
- (C) — *inferior polar artery (IPA)*.

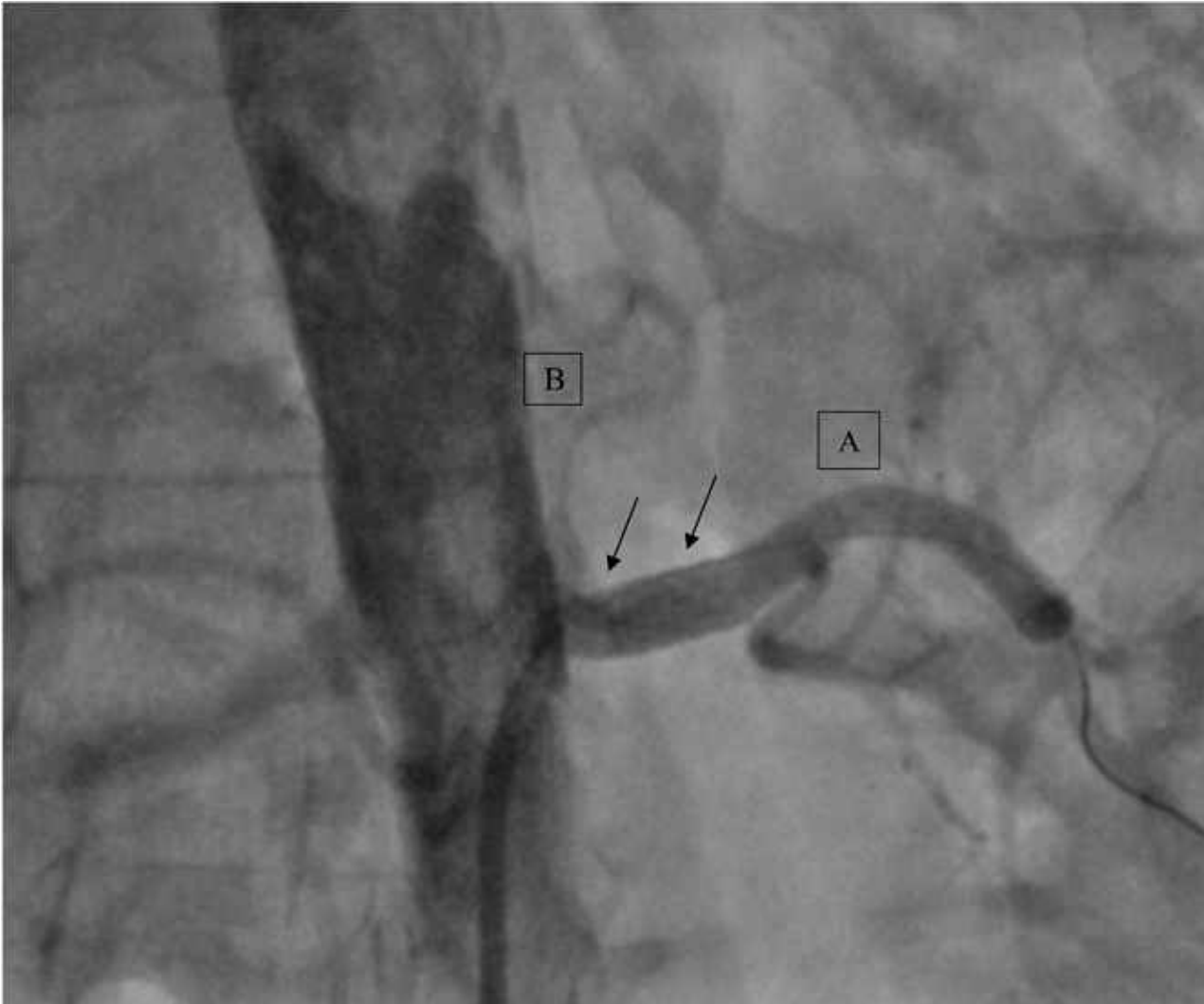


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**A 78-year-old female** with a long-term history of azotemia, chronic kidney disease, AH.

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Angiogram shows a 70% LRA ostial stenosis (arrow), a guide wire (B), contrast-filled abdominal aorta (C) and ureter (D).



*Continued*

Balloon angioplasty and LRA stenting was performed (arrows), stent has fully expanded with no signs of arterial dissection.

Post-procedure angiogram shows RRA (A) and abdominal aorta (B). Stent had to be partially placed

in the aorta to completely cover the atherosclerotic plaque, which is a mandatory condition for ostial stenosis stenting.



**A 36-year-old patient** with a history of AH with BP elevation up to 220/110 mmHg resistant to 4 antihypertensive medications (usual BP 140–150/90–100 mmHg)

---

presents with a 90 % LRA stenosis revealed by angiogram (arrow).

(A) renal artery,

(B) guide wire in the distal renal artery,

(C) — guide wire catheter.



*Continued*

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Balloon angioplasty with LRA stent placement was successfully performed (arrows). After the proce-

dure the BP decreased to 130/80 mmHg and antihypertensive therapy was adjusted



**A 78-year-old male** with a history of renal artery atherosclerosis and grade 2 CKD presents with ostial 80% left renal artery stenosis and a significant ostial

artery twisting (arrow). Renal artery starts from abdominal aorta posterolateral wall

(A) — *abdominal aorta*,  
(B) — *Left renal artery*.



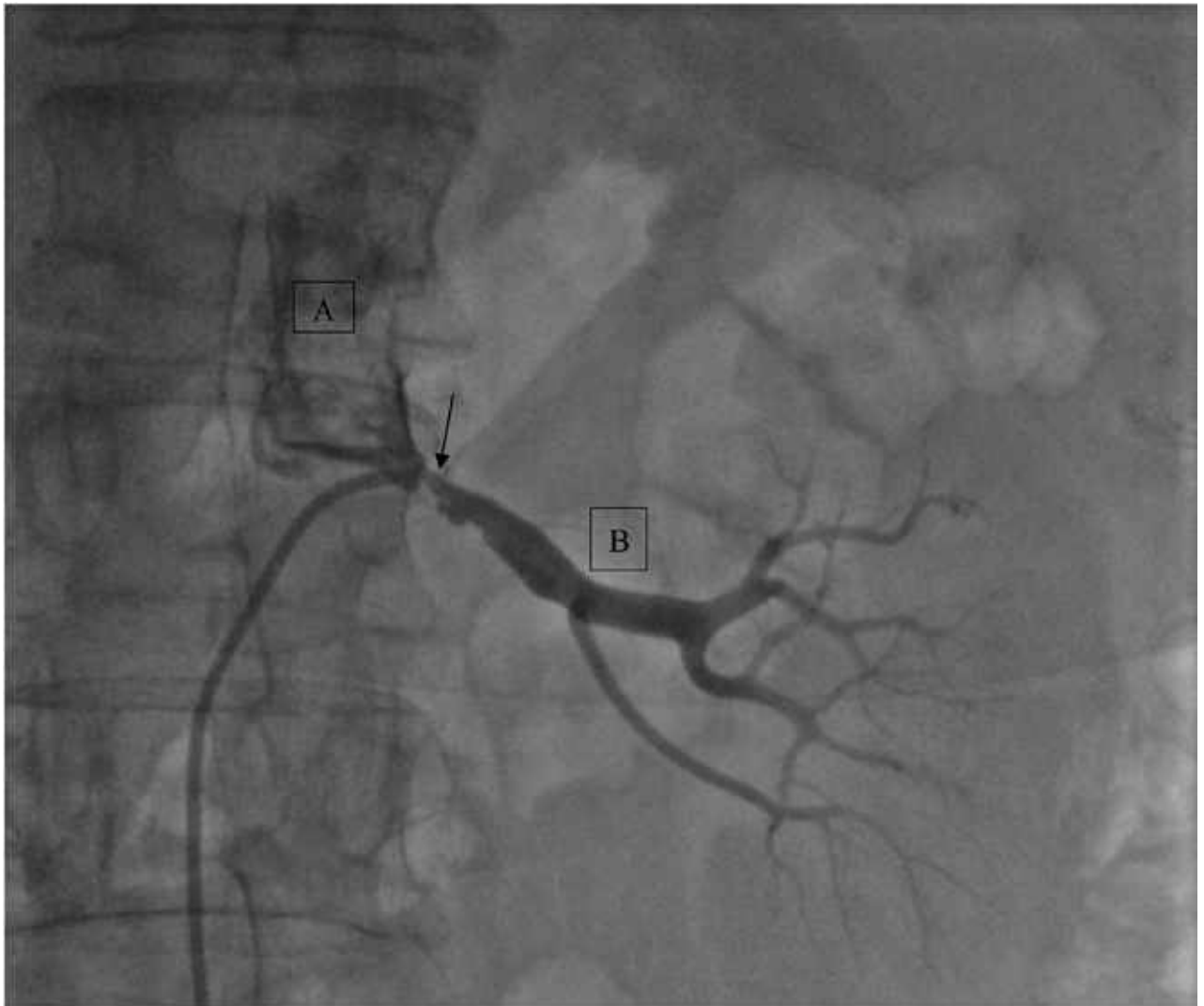
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Transluminal balloon angioplasty with LRA stenting and mild stent protrusion into the lumen of the aorta (recommended by the guidelines on stent placement

in ostial stenosis). This approach reduces the risk of ostial restenosis.

Post-procedure angiogram shows the area where the stent was placed (arrows).



**A 78-year-old female** with a history of renal artery atherosclerosis.

---

Grade 2 CKD, AH with BP elevation up to 210/110 mmHg presents with an 85% complicated stenosis with ulcerated margins (arrow).

(A) — *Abdominal aorta,*  
(B) — *Left renal artery.*



*Continued*

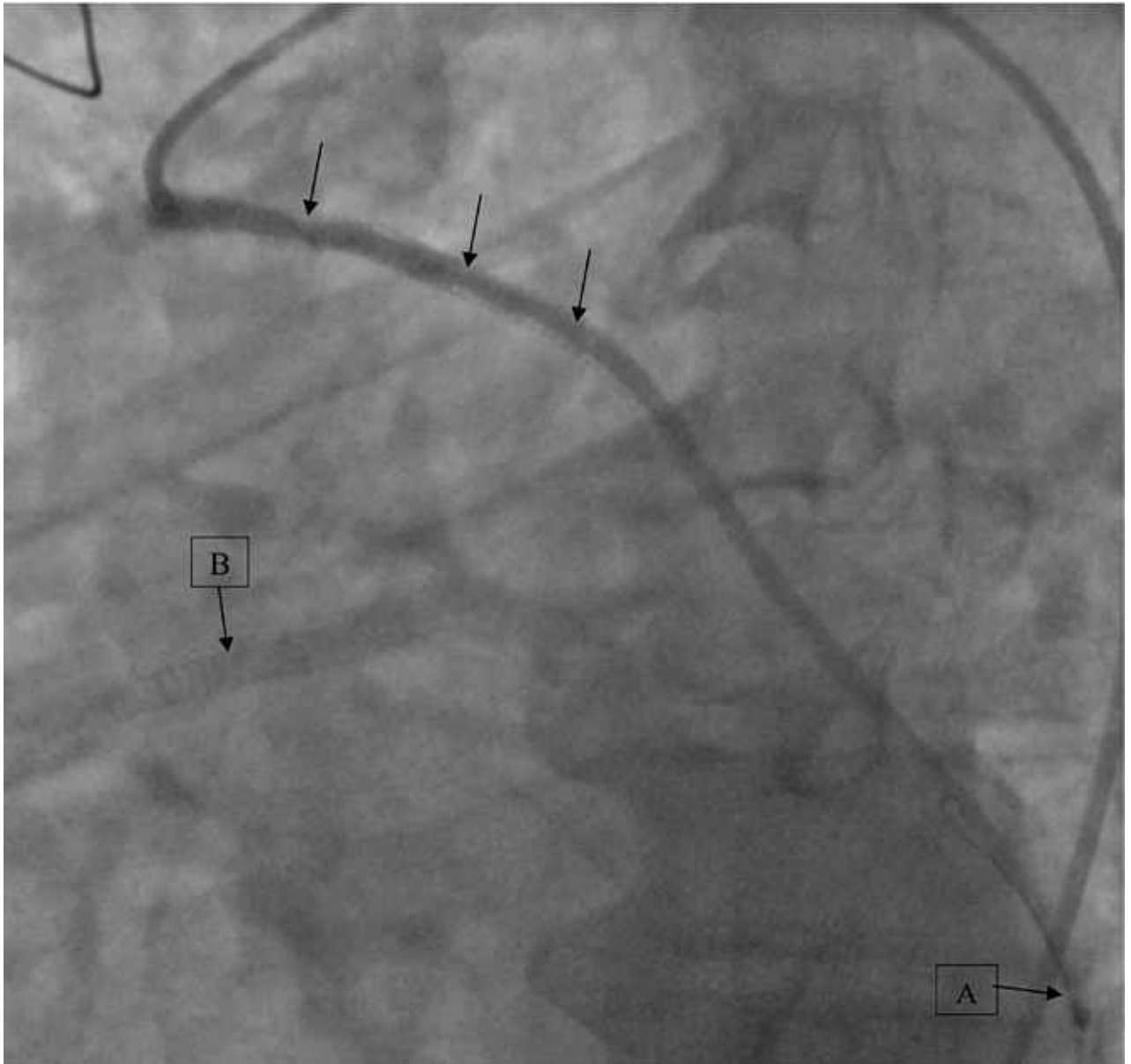
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LRA stenting was performed (arrow) with positive clinical outcomes (BP decreased to 160/90 mmHg and kidney function improved).



Chapter 10

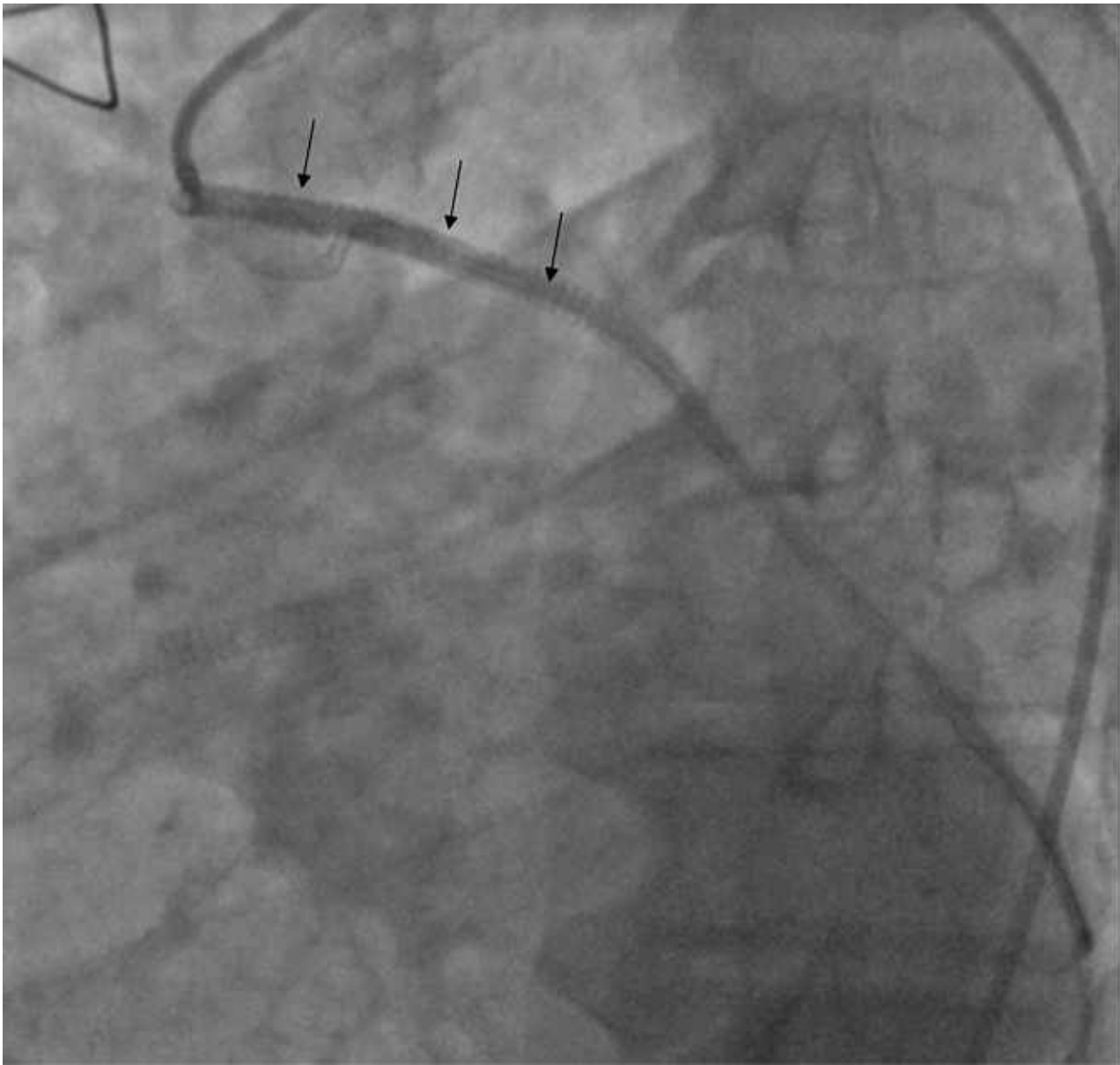
**CORONARY GRAFT ANGIOGRAPHY  
IN PATIENTS WITH DIABETES**



**A 76-year-old male** with a history of CABG 7 years ago (3 grafts — OMB, LAD, RCA) and RCA and OMB graft occlusion revealed by angiography 2 years ago.

Native RCA and OMB graft stenting was performed. In the last 6 months the patient started to complain of reduced exercise tolerance and typical angina pain when walking for up to 300 m.

Graft angiography showed a 70% tandem OMB restenosis (arrows). (B) stent in RCA



*Continued*

Repeat OMG graft stenting was performed (arrows) with full blood flow restoration (stent fully expanded, no signs of residual stenosis and dissection).

Balloon angioplasty with full balloon catheter expansion is the "gold standard" treatment for stent restenosis. It is followed by drug-eluting stent placement.

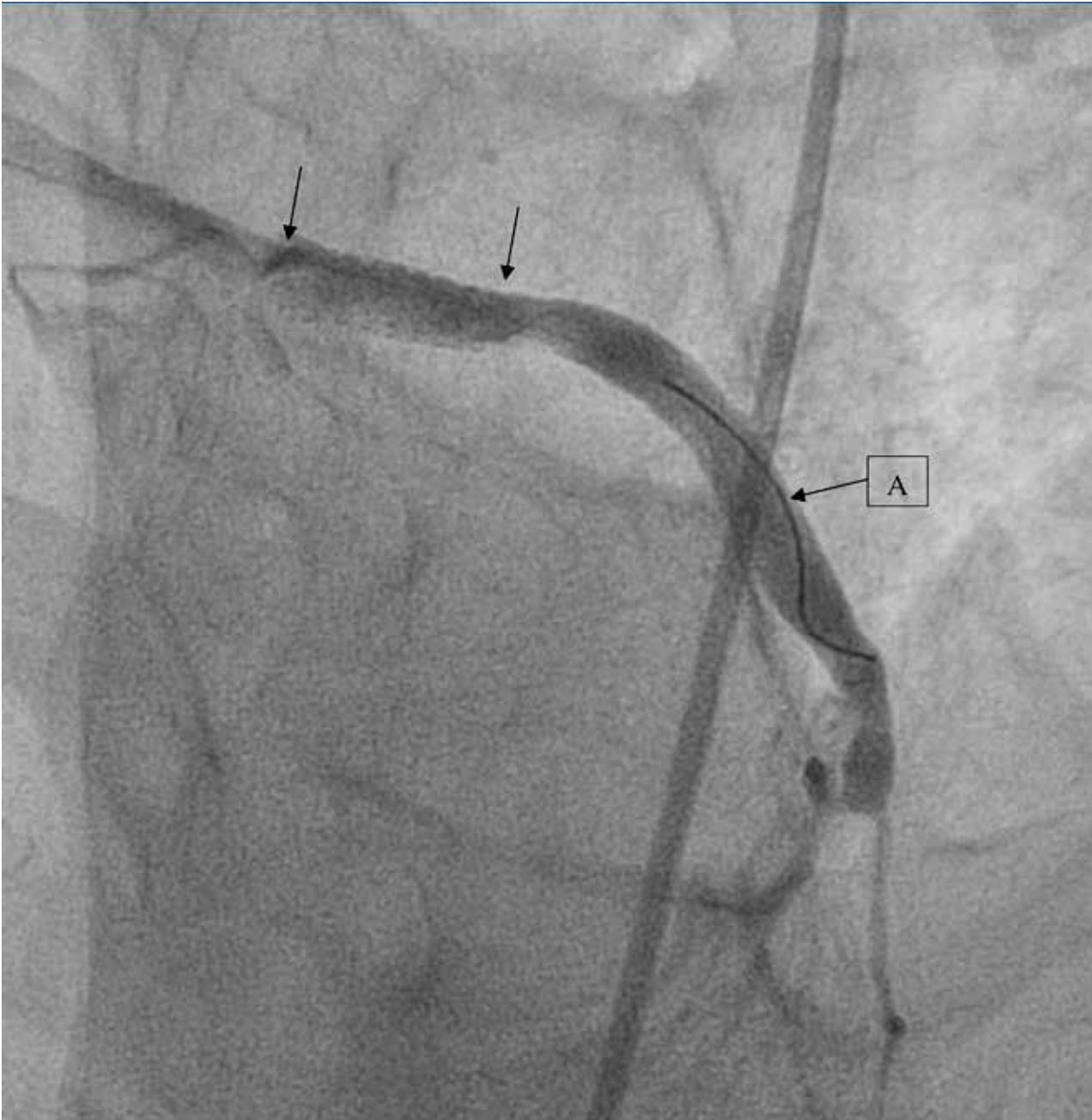


**An 80-year-old male** with a history of CABG 12 years ago presented with unstable angina symptoms.

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Graft angiogram shows an 85% diagonal branch venous graft stenosis (arrow)

(A) — *Diagonal branch graft,*  
(B) — *diagonal branch.*

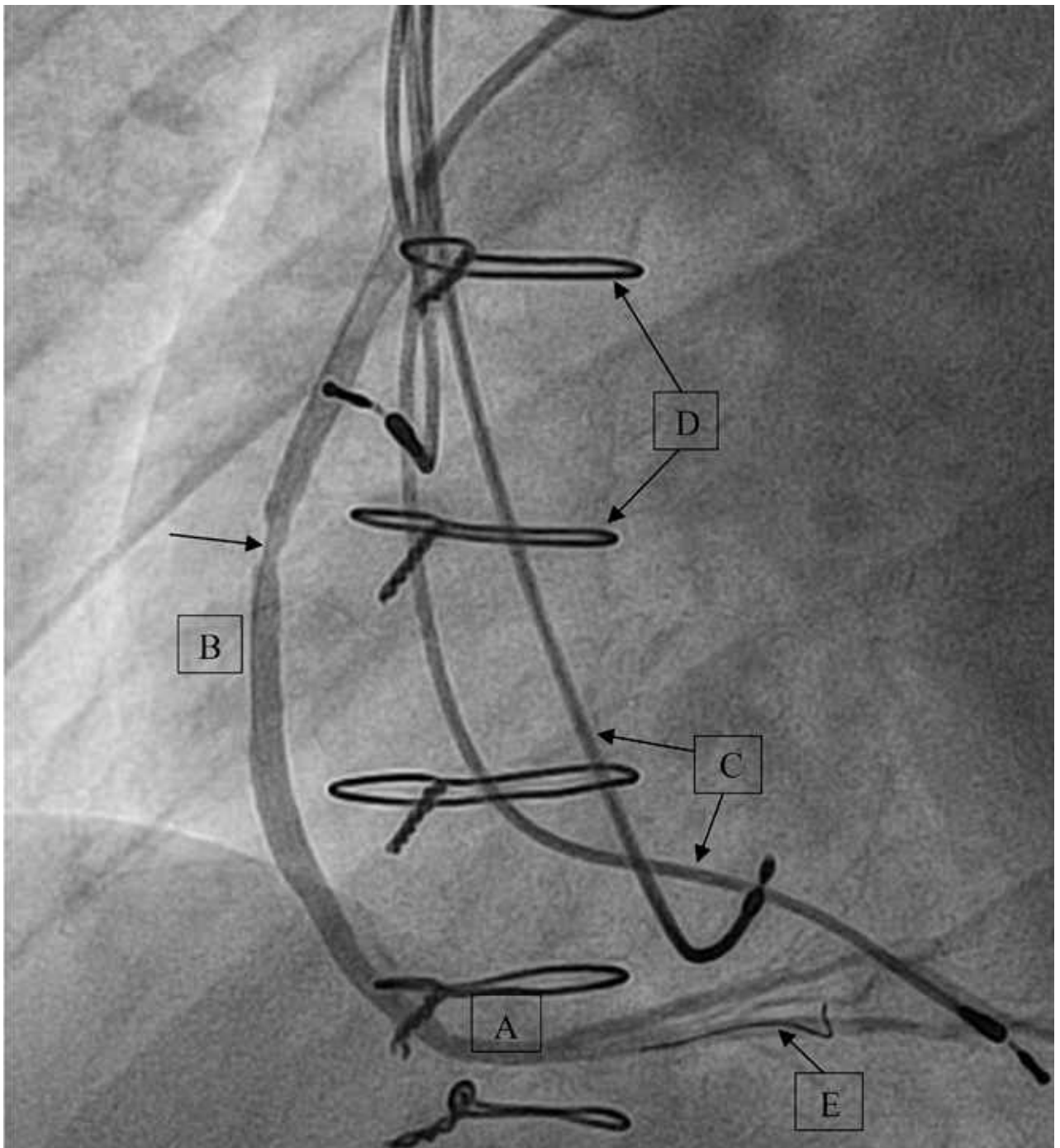


*Continued*

Venous graft stenting was performed (arrows) with complete stent expansion and no signs of residual stenosis, dissection, or thrombosis. Diagonal artery is intact.

The end of a coronary guide wire is visualized in the graft lumen (A).

The patient had no repeat angina pains after the procedure.



**A 76-year-old female** with a history of CABG 5 years ago and ICD placement 12 years ago, LVEF reduction to 42 % presents with SOB during walking uphill and chest pain in the cold weather.

Graft angiogram shows an 80 % stenosis (arrow).

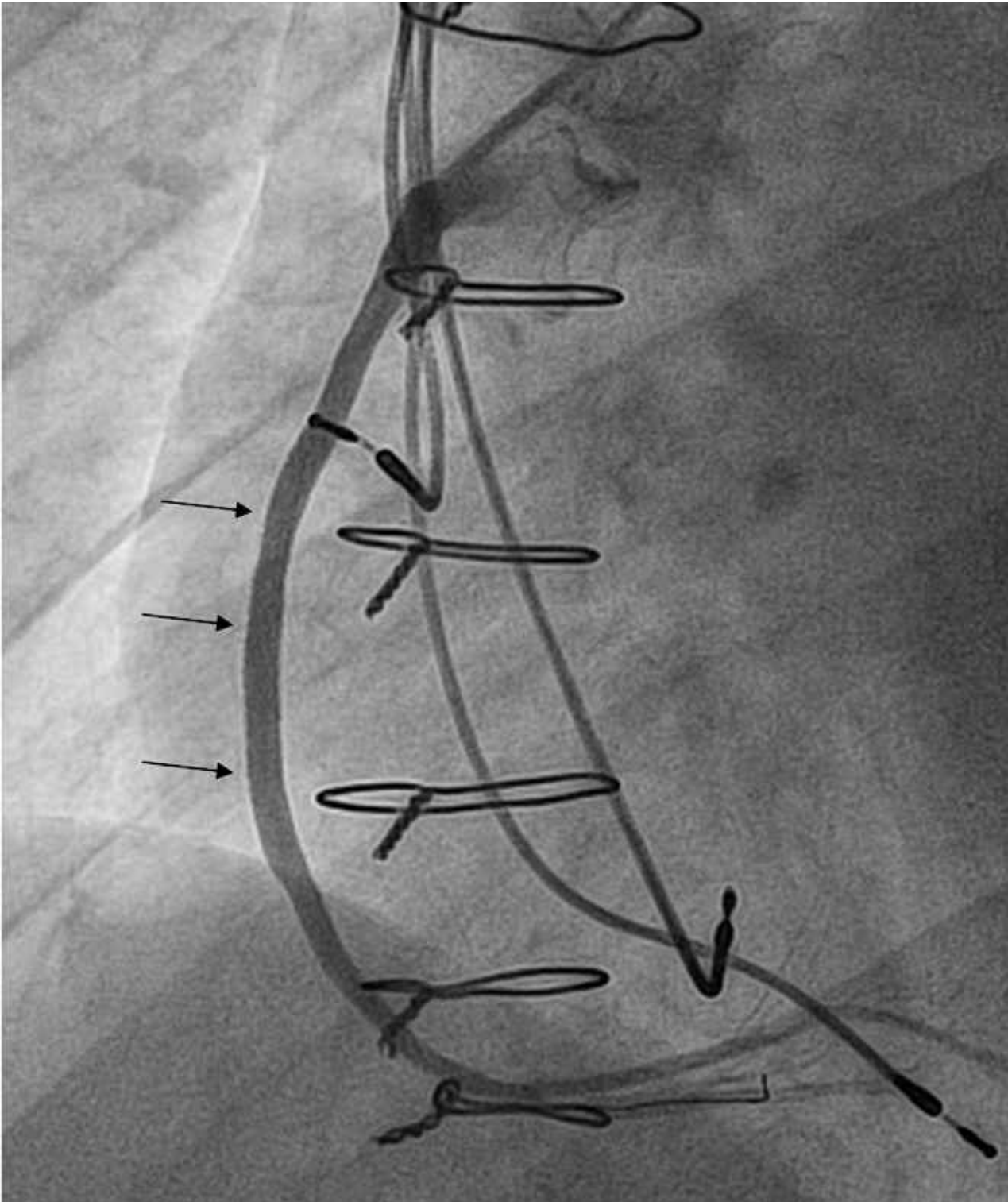
(A) Right coronary artery,

(B) Right coronary artery graft,

(C) ICD electrodes,

(D) — post-sternotomy wires,

(E) — Coronary guide wire in the distal-RCA.



*Continued*

Venous graft stenting was performed and resulted into full restoration of graft and arterial blood flow and no signs of residual stenosis or dissection.

No repeat episodes of chest pain or SOB.

ATLAS  
of Angiography in Patients with Diabetes

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