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Contents

Method for the Determination of the Consecution of Coronary Blood Flow Restoration in Patients with Acute Coronary Syndrome and Multivessel Coronary Disease

E.B. Shakhov[1], B.E. Shakhov[2], E.B. Petrova[2], E.G. Sharabrin[2]*

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Correct assessment of the priority of coronary blood flow restoration during PCI plays an important role in modern X-ray surgery. The treatment results from 38 patients with ST-segment elevation and non-ST-segment elevation ACS and multivessel coronary disease were analyzed. The scores based on which the completeness and sequence of coronary blood flow restoration were determined, were programmatically assigned to each affected coronary artery using specialized software. The software recommendation was compared with the treatment tactics proposed by three independent experts and "opinion" of the operating surgeon. The proportion of complete concordance between software recommendations and operating surgeon' suggestions in relation to priority of blood flow restoration for all three coronary arteries was 66.7%. The proportion of complete concordance in stenting tactics offered by the software and independent experts was 100%.

Keywords: *acute coronary syndrome, multivessel disease, staged revascularization, priority of coronary blood flow restoration, interventional tactics.*

Abbreviations

ACS – acute coronary syndrome
PCI – percutaneous coronary intervention
CHD – coronary heart disease
MI – myocardial infarction
STE-ACS – *ST*-segment elevation acute coronary syndrome
STD-ACS – *ST*-segment depression acute coronary syndrome
LAD – left anterior descending artery
CA – circumflex artery
RCA – right coronary artery
LMCA – left main coronary artery
TSCL – total score of coronary lesions

Relevance

Currently, coronary angiography reveals multivessel disease in 40–50% of patients with acute coronary syndrome (ACS) (1, 2). Priority restoration of symptom-related coronary artery in such complex coronary lesions is an indisputable fact (2). However, the tactics and the endovascular options for concomitant hemodynamically relevant coronary stenoses are increasingly discussed at greatest international medical conferences (3).

Leading European and American interventional cardiology centers show strong evidence of the efficacy of simultaneous complete myocardial revascularization using primary percutaneous coronary intervention (PCI). However, some reputable research teams of the Old and New Worlds continue to discuss the necessity of partial or staged interventions for multivessel coronary disease taking into account the severity of patients' condition, as well as the functional status and the viability of the myocardium in the ischemic area (4, 5).

In this aspect, numerous attempts to use rating scores for coronary lesions are made to determine the extent and tactics of intervention, but most of these rating scores are not adapted to ACS patients and intended only to facilitate the choice of interventional treatment option for CHD based on prognosis of the long-term major cardiac and cerebrovascular events (6).

Obviously, the development and introduction of new specialized rating scores to determine the priority of coronary blood flow restoration when the extent of PCI is planned after selective coronary angiography in ACS patients, is one of

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the most promising tasks in modern interventional cardiology.

Objective of the study. To evaluate effectiveness of the new specialized software – Sapphire 2015 – Right dominance and Sapphire 2015 – Left dominance for determining priority of coronary blood flow restoration when the extent of PCI is planned after selective coronary angiography in ACS patients.

Material and methods

The treatment results from 38 ACS patients admitted to the City Clinical Hospital #5 in Nizhniy Novgorod within the period from December 13, 2015 to April 29, 2016, were analyzed. Our study included 17 (44.7%) women and 21 (55.3%) men with electrocardiographic and clinical patterns of *ST*-segment elevation and *ST*-segment depression acute coronary syndrome (STE-ACS and STD-ACS, respectively). In the majority of cases, symptom-related acute ischemia was diagnosed in the anterior and posterior walls of the left ventricle (Table 1).

Clinical patterns of coronary heart disease until hospitalization for ACS varied in the examined patients. Fourteen (36.8%) patients experienced progressive angina and 9 (23.7%) patients had new-onset angina within 1 month prior to acute myocardial ischemia. Fifteen (39.5%) patients had stable angina within 12 months prior to ACS. Twelve (31.6%) patients had prior myocardial infarctions (MI). Non-*Q*-wave MI and Q-wave MI were observed in 9 (23.7%) and 5 (13.2%) cases, respectively. The majority of the examined patients had 1 prior MI (Fig. 1).

The primary inclusion criteria in our study were as follows: ACS with obvious electrocardiographic evidence of *ST*-segment elevation or depression (J-point >2 cm above or below the isoelectric line in 2 or more precordial leads), high risk of fatal and non-fatal cardiac events, multivessel (complex) atherosclerotic lesions of coronary arteries. Selective coronary angiography revealed at least one hemodynamically relevant lesion (stenoses >60–70%) in the left anterior descending artery (LAD), circumflex artery (CA), and right coronary artery (RCA) in all examined patients. The patients with left main coronary artery (LMCA) disease and chronic total occlusions of major coronary arteries and their large branches which were diagnosed in 5 (13.2%) and 7 (18.4%) patients, respectively, were analyzed thoroughly. The severity of coronary artery disease was calculated using the SYNTAX Score calculator (version 2.11). Mean SYNTAX Score in STE-ACS patients was 25.4 ± 11.5. Mean SYNTAX Score in STD-ACS patients was 31.3 ± 19.3.

Urgent endovascular correction for complex multivessel atherosclerotic coronary lesions

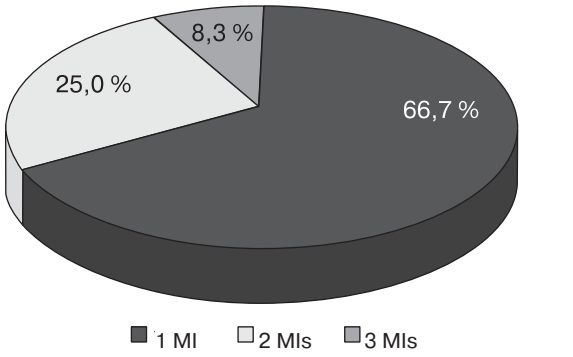

Figure 1. Patient distribution by the number of prior MI episodes.

Table 1. Characteristics of ACS patients

Clinical features in ACS patients	Number of patients, %
Clinical types of ACS:	
ST-segment elevation ACS	26 (68.4%)
non-*ST*-segment elevation ACS	12 (31.6%)
Localization of symptom-related ischemia:	
Anterior wall of the left ventricle	16 (42.1%)
Anterior lateral wall of the left ventricle	2 (5.3%)
Posterior wall of the left ventricle	14 (36.8%)
Posterior lateral wall of the left ventricle	4 (10.5%)
Lateral wall of the left ventricle	2 (5.3%)
Risk stratification for in-hospital mortality and probability of myocardial infarction:	
TIMI risk score for STE-ACS (⩾8, high risk)	26 (68.4%)
GRACE risk score for STD-ACS (⩾140, high risk)	12 (31.6%)
Stratification for surgical risk and PCI complexity:	
Syntax Score (>33, high risk)	13 (34.2%)

was performed after selective coronary angiography in STE-ACS patients as part of emergency invasive treatment strategy. Mean "door-to-balloon" time in our study was 71.5 ± 10.8 minutes.

The STD-ACS patients at high risk underwent radiosurgery within the first 24 hours after admission as part of early invasive strategy.

Complete and partial endovascular myocardial revascularizations after PCI were achieved in 12 (31.6%) and 23 (60.5%) patients, respectively. Staged complete coronary blood flow restoration during one hospitalization was performed in one case. Emergency coronary artery bypass grafting after selective coronary angiography was performed in 2 cases.

The priority of coronary blood flow restoration when planning the extent of PCI, was guided by the specialized software Sapphire 2015 – Right dominance and Sapphire 2015 – Left dominance (application for registration of PC software #2016615658 dated May 04, 2016 and #2016614449 dated May 04, 2016) developed in the X-ray Diagnostics Department of the Medical Advanced Training Faculty of the Nizhniy Novgorod State Medical Academy).

The program code was based on detailed analysis of coronary hemodynamics proposed by Professor Yu. S. Petrosyan and D.G. Iosseliani in 1976 (7). Based on the proposed algorithm for calculation of the total score of coronary lesions (TSCL), scores for each affected artery were programmatically correlated with the value for all coronary arteries.

Given the relationship between electrocardiographic criteria for acute myocardial ischemia and localization of symptom-related lesion in one of the coronary arteries, the staff of the X-ray Diagnostics Department of the of the Medical Advanced Training Faculty of the Nizhniy Novgorod State Medical Academy, based on retrospective analysis of 400 case histories of ACS patients developed additional adjustment factors to assess the completeness and priority of the coronary blood flow restoration. For instance, the software assigned score 2.8 and score 1.4 to the symptom-related coronary lesion at right-dominant coronary blood flow in case of STE-ACS and STD-ACS, respectively. The value "–1" was assigned to the coronary chronic total occlusion regardless of the clinical type of ACS. The coronary territories were considered to be the left anterior descending artery and its major branches (LAD), circumflex artery and its major branches

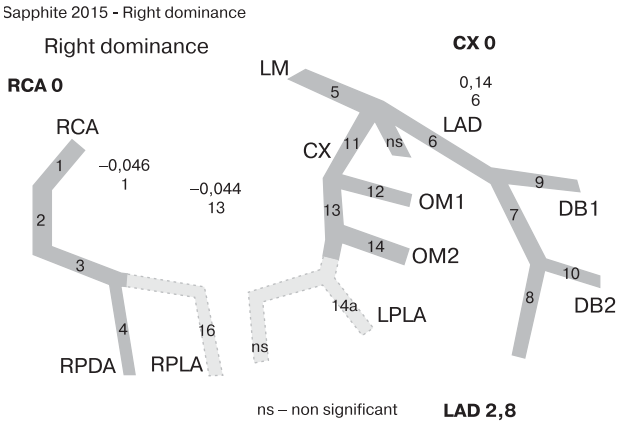

Figure 2. Example of calculating the completeness and sequence of endovascular correction for three-vessel atherosclerotic coronary lesion in a patient with STE-ACS using the Sapphire 2015 – Right dominance software.

(CA), right coronary artery and its major branches (RCA).

For easy and fast analysis of coronary lesions in ACS patients, the developed software assesses three hemodynamically significant grades of stenosis: grade 2 – 50–75% stenosis; grade 3 – 76–99% stenosis; grade 4 – 100% stenosis (occlusion).

Depending on the stenosis grade, localization of atherosclerotic lesion, and symptom-related ischemia, the software assigned a certain score to each affected coronary artery based on which the interventional surgeon was asked to make a choice concerning the completeness and sequence of LAD, CA, and RCA restoration. For example, the complete myocardial revascularization was considered to be optional, if the total score of coronary lesions programmatically calculated for one of the three major coronary arteries varied from 0 to 0.576 or was negative (Fig. 2).

Time spent for SYNTAX Score calculator (version 2.11) and Sapphire 2015 – Right dominance/Sapphire 2015 – Left dominance was compared to assess how quickly the intervention tactics in ACS patients can be virtually determined.

The simulated algorithm of endovascular correction was retrospectively compared with the intervention tactics selected by the operating surgeon, as well as with the revascularization strategy decided by three independent experts. In our study, the advisory decision was considered as the reference only if opinions of all three experts concerning the intervention tactics in the study population were identical. The quality of coronary intervention performed by the operating surgeon was indirectly

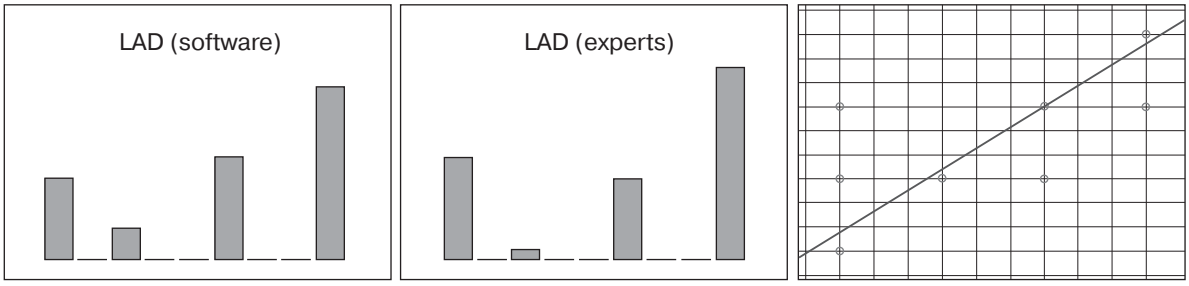

Figure 3. Correlation analysis of the LAD restoration tactics suggested by the software and three independent experts.

evaluated based on the patients' survival in the early postoperative period (up to Day 20 after intervention).

Statistical analysis of the obtained results was performed using the licensed Statistica 10.0. The results are presented as M ± sd, where M – mean, sd – standard deviation. The non-parametric Spearman's rank correlation coefficient (R) and Mann–Whitney U-test for comparison of two independent variables were used to analyze the results (8). P values of <0.01 were considered as statistically significant.

Results

When the opinions proposed by the software and three independent experts concerning the extent of myocardial revascularization and priority of stenting of three coronary arteries (LAD, CA, and RCA) were analyzed, we established that the proportions of complete and partial concordances of the proposed endovascular tactics were 71.1% and 26.3%, respectively; the proportion of complete discordance was 2.6% (Table 2).

The correlation analysis of sequence of LAD blood flow restoration proposed by the software and three independent experts showed that the proportion of complete concordance between opinions offered by natural and artificial intelligence was 86.8% (R = 0.934; $p < 0.01$). Thus, in the software and experts' opinion, LAD blood flow should be primarily restored in 44.7% and 50.0% of ACS patients, respectively (Fig. 3).

In relation to priority of CA restoration, the software and human tactics were identical in 73.6% of cases (R = 0.690; $p < 0.01$). For example, in the software and experts' opinion, CA blood flow should be primarily restored in 18.4% and 15.8% of patients, respectively (Table 3).

The proportion of complete concordance of opinions proposed by the software and experts with respect to priority of RCA blood flow restoration was 81.6% (R = 0.919; $p < 0.01$). Thus, in the software and experts' opinion, RCA blood flow should be primarily restored in 36.8% and 31.6% of patients, respectively (Table 3).

When the opinions proposed by the software and operating surgeon concerning the extent of myocardial revascularization and stenting priority for three coronary arteries (LAD, CA, and RCA) were analyzed, we established that the proportions of complete and partial concordances of the proposed endovascular

Table 2. Concordance and discordance of endovascular tactics suggested by the software and three independent experts

Complete concordance of stenting priority for three coronary arteries, patients (%)	Partial concordance of stenting priority for three coronary arteries, patients (%)	Complete discordance of stenting priority for three coronary arteries, patients (%)
27 (71.1%)	10 (26.3%)	1 (2.6%)

Table 3. Opinions suggested by the software and three independent experts in relation to the priority of coronary blood flow restoration

	Software opinion, patients (%)	Experts opinion, patients (%)
Priority LAD restoration	17 (44.7%)	19 (50.0%)
Priority CA restoration	7 (18.4%)	6 (15.8%)
Priority RCA restoration	14 (36.8%)	12 (31.6%)

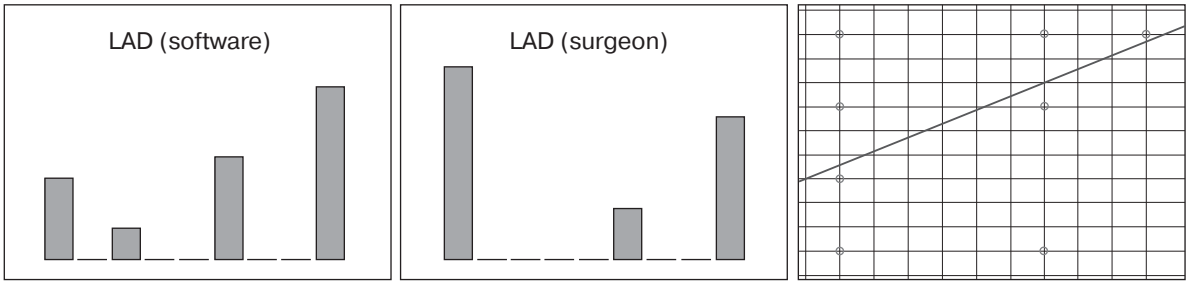

Figure 4. Correlation analysis of the LAD restoration tactics suggested by the software and operating surgeon.

tactics were 34.2% and 57.9%, respectively; the proportion of complete discordance was 7.9% (Table 4).

The correlation analysis of sequence of LAD blood flow restoration proposed by the software and operating surgeon showed that the proportion of complete concordance between opinions offered by natural and artificial intelligence was 65.8% ($R = 0.769$; $p < 0.01$). Thus, in the software and operating surgeon's opinion, LAD should be primarily restored in 44.7% and 36.8% of ACS patients, respectively (Fig. 4).

In relation to sequence of CA restoration, the software and human tactics were identical in 63.2% of cases ($R = 0.646$; $p < 0.01$). Particularly, in the software and operating surgeon's opinion, CA blood flow should be primarily restored in 18.4% and 21.1% of ACS patients, respectively.

The proportion of complete concordance of opinions proposed by the software and endovascular surgeon with respect to priority of RCA blood flow restoration was 52.6% ($R = 0.815$; $p < 0.01$). Thus, in the software and operating surgeon's opinion, RCA blood flow should be primarily restored in 36.8% of patients (Table 5).

We obtained very interesting results when compared time spent for planning intervention via SYNTAX Score calculator (version 2.11) and Sapphire 2015 – Right dominance/ Sapphire 2015 – Left dominance. Thus, mean time for SYNTAX Score calculation was 201 ± ± 104 seconds. Mean time for intervention tactics to be determined using our software was significantly reduced to 65±39 seconds ($Z = 6.804$; $p < 0.01$).

On Day 20, the survival of patients included in our study was 76.3%. Nine (23.7%) patients died in the early postoperative period due to progressive left ventricular failure caused by extension of myocardial damage area. Seven patients (18.4%) among them had baseline electrocardiographic pattern of ST-segment elevation mainly in the anterior chest leads. The evidence of STD-ACS in the posterior wall of the left ventricle was observed in two died patients at the first medical contact.

Three (7.9%) patients died on the operating table due to sudden cardiac arrest. Four (10.5%) patients died on Day 3. One patient died on Day 7 after intervention.

It is important to note that 3 (7.9%) patients with STE-ACS had prior myocardial infarctions: two patients had a history of 2 MIs and one

Table 4. Concordance and discordance of endovascular tactics suggested by the software and operating surgeon

Complete concordance of stenting priority for three coronary arteries, patients (%)	Partial concordance of stenting priority for three coronary arteries, patients (%)	Complete discordance of stenting priority for three coronary arteries, patients (%)
13 (34.2%)	22 (57.9%)	3 (7.9%)

Table 5. Opinions suggested by the software and operating surgeon in relation to the priority of coronary restoration

	Software opinion, patients (%)	Surgeon's opinion, patients (%)
Priority LAD restoration	17 (44.7%)	14 (36.8%)
Priority CA restoration	7 (18.4%)	8 (21.1%)
Priority RCA restoration	14 (36.8%)	14 (36.8%)

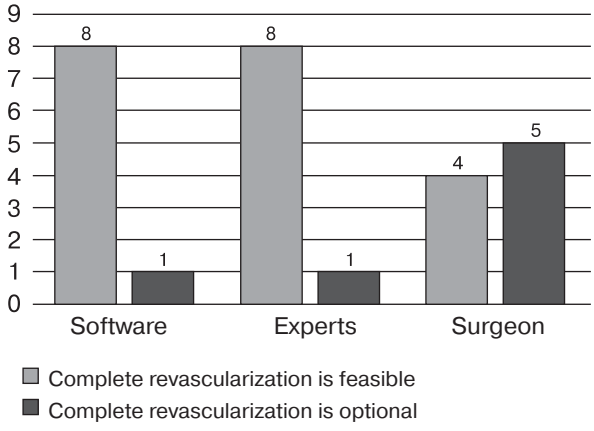

Figure 5. Analysis of extent of myocardial revascularization in patients died by Day 20 (the absolute number of studied patients is indicated).

patient had 1 prior MI. Two patients with STD-ACS had a history of 1 and 3 MIs, respectively. Four (10.5%) patients who died by Day 20 had no myocardial infarction in history. The coronary blood flow was completely restored in 4 died patients, whereas the expert resolution and software opinion showed the feasibility of complete myocardial revascularization in 8 cases (Fig. 5).

Discussion

Having analyzed the obtained results, we noticed a statistically significant relationship between the options proposed by the software, independent experts, and operating surgeon concerning the extent of myocardial revascularization and sequence of stenting of three coronary arteries. However, the proportion of complete concordance in tactics of endovascular intervention was slightly higher in the "software-independent experts" pair. Obviously, this may be explained by higher theoretical and practical experience of experts whose opinion was considered as the reference (Table 6).

In this regard, the artificial intelligence when used to assist in choosing the tactics of endovascular correction for multivessel coronary disease may improve the quality of surgeon-dependent endovascular intervention. In particular, mean time to determine intervention tactics using our software was significantly lower (65 ± 39 seconds, $Z = 6.804$; $p < 0.01$) compared to SYNTAX Score calculator; it is explained by priority analysis of hemodynamical rather than morphological component of the relevant coronary stenosis (6, 7).

Quite high in-hospital mortality in studied patients with ACS was extremely important to us. As many as 9 (23.7%) examined patients died on Day 20 after intervention. This situation was analyzed by Kaul P., Ezekowitz J.A., Armstrong P.W. et al. (2013) in the retrospective analysis of the progressive heart failure in patients with acute myocardial ischemia (9).

The authors demonstrate the direct relationship between previous myocardial infarctions and fatal worsening of myocardial dysfunction during ACS treatment (9). Nevertheless, in our study, only a half of died patients had a history of MIs. However, additional 4 patients with STE-ACS without prior myocardial infarctions died by Day 20 after partial restoration of coronary hemodynamics.

This fact is probably explained by the meta-analysis of several randomized studies performed by El-Hayek G.E., Gershlick A.H., Hong M.K. et al. in 2015 (10). In the investigators' opinion, currently there is conclusive evidence of increased incidence of major cardiac events in the early and long-term periods after partial myocardial revascularization compared to a complete one in patients with STE-ACS (10). Therefore, opinions by the software and three independent experts on feasibility of complete coronary restoration in 8 out of 9 died patients were reasonably concordant.

Table 6. Sequence of coronary blood flow restoration: proportion of complete concordance between the software and human opinions

	Software			R	p
	LAD	CA	RCA		
Experts					
LAD	86.8%	–	–	0.934	$p < 0.01$
CA	–	73.6%	–	0.690	$p < 0.01$
RCA	–	–	81.6%	0.919	$p < 0.01$
Operating surgeon					
LAD	65.8%	–	–	0.769	$p < 0.01$
CA	–	63.2%	–	0.646	$p < 0.01$
RCA	–	–	52.6%	0.815	$p < 0.01$

In several studies, the followers of staged myocardial revascularization demonstrated that the incidence of fatal and non-fatal cardiovascular events in the intra – and postoperative periods of STE-ACS treatment depended primarily on the correct priority of blood flow restoration rather than the number of completely restored coronary arteries (11).

In our study, there was insignificant correlation between the opinions proposed by the software and operating surgeon on the priority of blood flow restoration in the LAD ($R = 0.736$; $p = 0.023$) and CA ($R = 0.694$; $p = 0.037$). The software and operating surgeon had exactly the same opinion in relation to priority of blood flow restoration for all three coronary arteries in 66.7% of cases. However, the stenting tactics for multivessel coronary disease proposed by the software and three independent experts was 100% identical.

Therefore, the high mortality in the early postoperative period in our patients with multivessel disease could be associated with tactical errors related to completeness of revascularization and priority of blood flow restoration in three coronary arteries.

Conclusions

It is reasonable to take into consideration the results obtained from Sapphire 2015 – Right dominance and Sapphire 2015 – Left dominance when determining the priority of coronary blood flow restoration in ACS patients with multivessel coronary disease.

The recommendations given by Sapphire 2015 – Right dominance and Sapphire 2015 – Left dominance concerning the extent of myocardial revascularization and priority of coronary blood flow restoration significantly correlate with the experts' opinion on the tactics of the upcoming intervention.

Sapphire 2015 – Right dominance and Sapphire 2015 – Left dominance take significantly less time compared to the SYNTAX Score calculator to determine the intervention tactics; therefore, coronary lesions can be analyzed concomitantly with PCI planning after selective coronary angiography.

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Clinical Presentation of a Successful Transcatheter Aortic Valve Replacement Via the Right Subclavian Artery

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Recently, transcatheter aortic valve implantation has become a method of choice in patients at high surgical risk. Transfemoral approach is considered to be preferable for this intervention. However, with the increased number of transcatheter interventions in the clinical practice, we have been faced with the increased proportion of patients who are not eligible for the femoral access. Various alternative methods of delivering the aortic valve endograft can be used in such cases. This article describes a clinical presentation of a successful implantation of a self-expanding aortic valve bioprosthesis via the right subclavian artery.

Keywords: *aortic stenosis, transcatheter aortic valve replacement, subclavian access.*

Introduction

The transcatheter aortic valve (AV) replacement is currently recognized as an alternative treatment option for critical aortic stenosis in patients at high surgical risk (1, 2, 3). Being minimally invasive, the transfemoral approach is the most widely used for transcatheter AV implantation (TAVI) as confirmed by many studies, registries and meta-analyses (4–12). However, it is not always possible to perform TAVI via the transfemoral access for various reasons (small size, severe tortuosity, advanced atherosclerosis and/or calcinosis of the iliofemoral vascular segment, etc.) (13, 14). In order to prevent complications related to vascular access and system delivery, the alternative TAVI approaches (transapical, transaxillary, transaortic, via the subclavian, iliac, and carotid arteries) can be used in such cases; they are described in detail in the literature and are commonly used worldwide (15–18). At present, a variety of AV endografts and methods of bioprosthesis delivery allow us to perform TAVI in almost 99% of patients with aortic stenosis (19). The clinical case of successful implantation of CoreValve prosthesis via the right subclavian artery (ScA) is presented below, since the use of conventional femoral access was limited due to type III chronic aortic dissection in a female patient.

Female patient P., 65 y.o., was admitted to the clinic complaining of the pressing retrosternal pain and shortness of breath on exertion. Coronary angiography revealed a 50% stenosis in the middle third of the left anterior descending artery and a 60% ostial stenosis of the right coronary artery. According to echocardiography (EchoCG) data, the following was detected: left ventricular ejection fraction – 65%, local contractility was not impaired, left ventricular myocardial hypertrophy, AV annulus – 2.2–2.3 cm, V_{max} – 5.5 m/sec, AV peak gradient – 120 mmHg, AV mean gradient – 66 mmHg, AV area – 0.63 cm^2, grade 2 AV insufficiency, grade 2 mitral regurgitation, systolic pressure in the pulmonary artery – 40 mmHg (Fig. 1). Multispiral computed tomography (MSCT) of the aorta: severe calcification of the AV from the fibrous annulus to the orifice of the right and left coronary arteries (10 mm and 12 mm, respectively), the size of the AV fibrous annulus is 33 × 30 mm. Aneurysmal dilatation is observed with the signs of intimal dissection at the level of the aortic arch; the maximum diameter at this level constitutes 34 mm; the diameters of the false and true lumens are 11 mm and 23 mm, respectively. (Fig. 2). Medical history: left-sided mastectomy followed by chemoradiotherapy.

Based on the clinical, laboratory and instrumental data the following diagnosis was established: Severe

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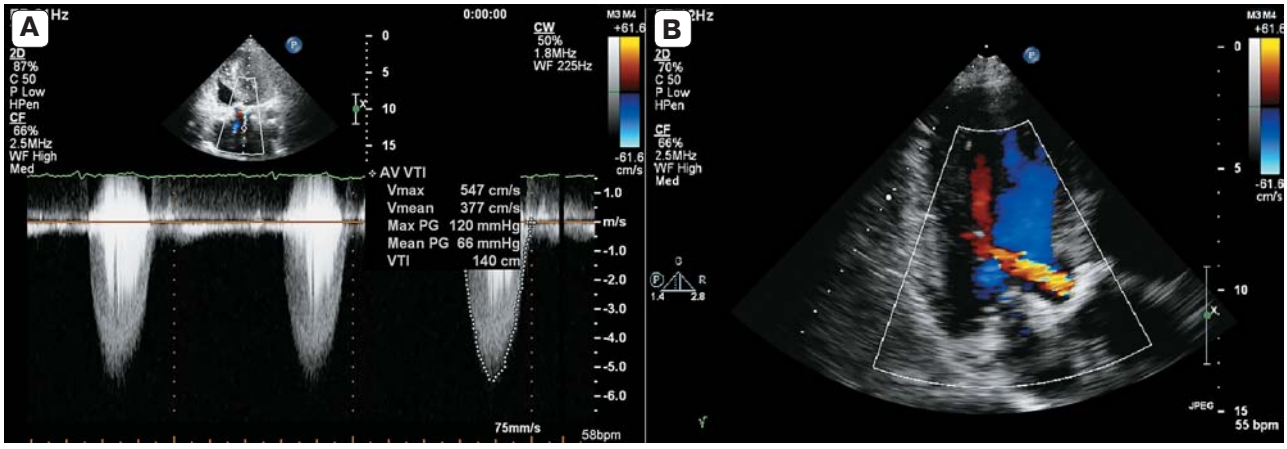

Figure 1. Preoperative transthoracic EchoCG. A – Data of the continuous wave Doppler. B – Color-guided Doppler assessment of the AV – grade 2 aortic regurgitation.

degenerative stenosis of the aortic orifice. CHD: coronary atherosclerosis. Grade 3 arterial hypertension, risk 4. Functional class 2 by NYHA classification of heart failure. Dissection of the aortic arch. Type 2 diabetes mellitus, compensation. Grade 3 alimentary-constitutive obesity (body mass index – 42 kg/m^2). Left-sided mastectomy (1989) followed by chemoradiotherapy.

On April 06, 2015, the patient underwent TAVI via the right ScA. Under the endotracheal anesthesia, the right ScA was approached and 18F sheath was inserted. 6F sheath was percutaneously inserted into the left common femoral artery through which a diagnostic catheter was placed into the aortic root. Angiography of the aortic root was performed to determine a projection of implantation. Through the sheath inserted into the right ScA, a balloon catheter was positioned in the native AV on the super stiff guidewire followed by the ballooning of the AV. The next step included delivery and implantation of Corevalve No.29 bioprosthesis in the AV position (Fig. 3). The control angiography revealed that coronary arteries were patent, obturative function of the aortic valve was adequate. The catheters, guidewires and sheaths were removed. The patient was transferred from the ICU to the Cardiac Surgical Department 20 hours after the surgery. The postoperative period was unremarkable. On Day 6 after the surgery the control EchoCG revealed: AV peak gradient – 21 mmHg, AV mean gradient – 12 mmHg, the opening area of the prosthetic cusps – 2.2 cm^2. The patient was discharged from the hospital on Day 7 after the intervention.

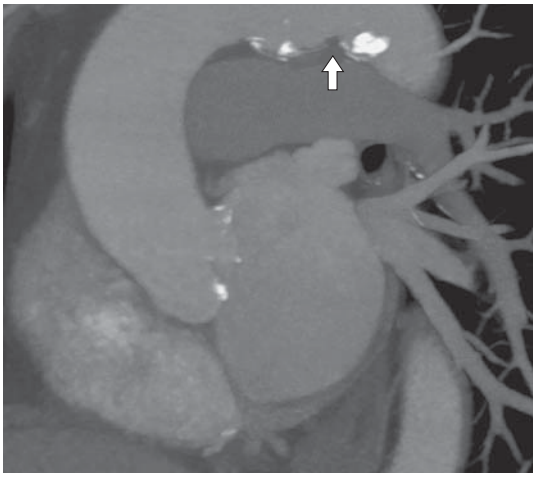

Figure 2. Multispiral CT-aortography shows calcified AV cusps and intimal dissection of the aortic arch.

Discussion

Currently, the apical approach is the most common alternative to transfemoral approach as applied to implantation of the balloon-expandable prosthesis (7–11, 20). In our case, we abandoned the transapical implantation because the patient had a history of left-sided mastectomy followed by chemoradiotherapy and there was a high risk of the left ventricular damage with the apical access due to post-radiation fibrotic changes of the chest tissues. As mentioned above, the patient underwent AV replacement with a self-expandable CoreValve bioprosthesis which could only be implanted retrogradly. Some investigators reported that this approach is non-inferior to the transfemoral access in relation to the rates of immediate interventional success, access-related complications and achievement of endpoints, and is superior in some parameters (incidence of contrast-induced nephropathy and bleeding at the access site) (21).

The anatomical conditions making conduction of TAVI via the ScA possible are as follows: artery diameter ⩾ 6 mm, the absence of severe tortuosity and calcinosis in the arteries. Unlike

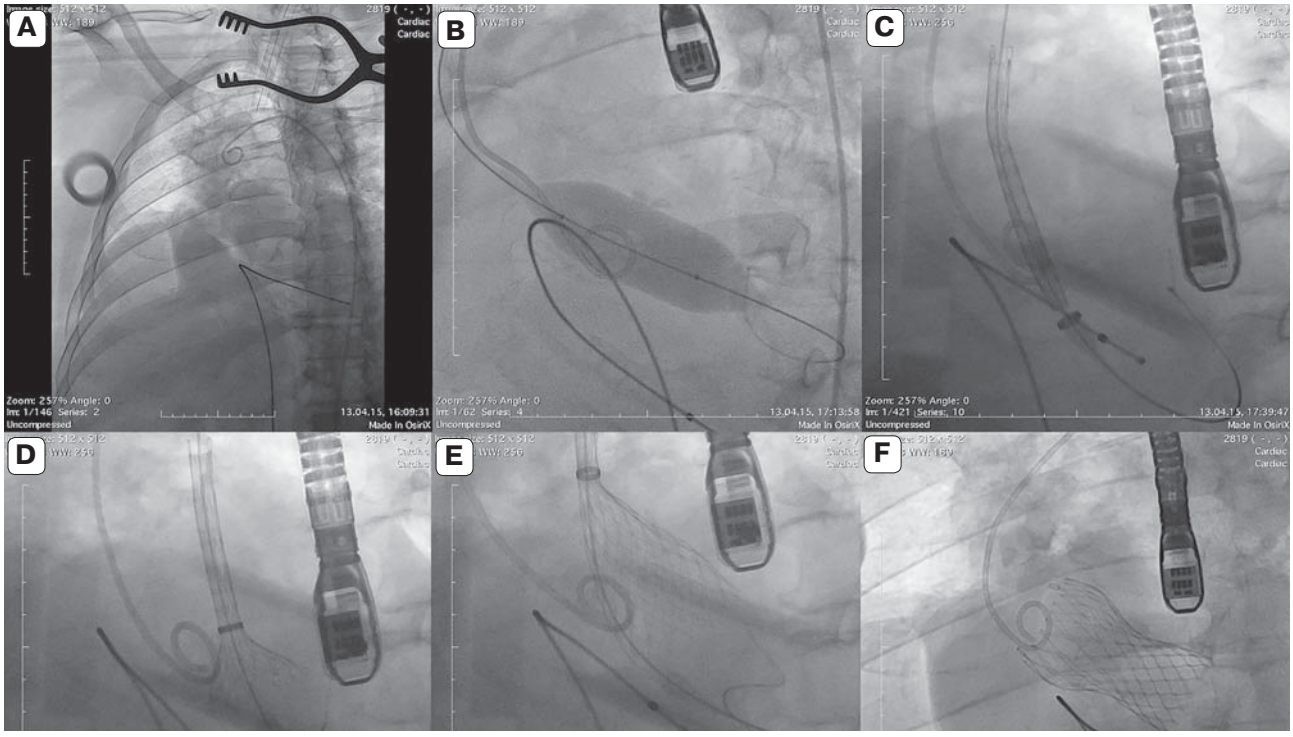

Figure 3. Steps of trans-subclavian CoreValve prosthesis implantation. A – The pigtail catheter is placed into the aortic root; the lead for pacing is positioned in the right ventricle. B – AV balloon angioplasty*. C – Folded bioprosthesis is positioned in the AV. D – Intraventricular part of the prosthesis is deployed. E – The middle part of the nitinol cage is expanded; the prosthetic cusps are functioning.* F – The final appearance after complete CoreValve deployment.
*– these steps are performed using high-frequency pacing (mean BP – 50 mmHg)

the iliofemoral vascular segment, pathological tortuosity and total calcinosis are not typical for axillary and subclavian arteries. Of note, this approach allows us to perform TAVI even in patients with a functioning mammary coronary bypass, if ScA diameter is > 7 mm (22). In our case we used the right ScA because the use of the left ScA would have involved the delivery of the valve through a compromised dissected portion of the aorta and there would be no advantages as compared to the transfemoral access.

When highlighting the technical aspects of the intervention, it should be noted that acute angle of the ScA originating from the brachiocephalic artery (BCA) did not present any particular difficulties when inseting the 18F sheath 18F. In this case the patient's anatomical features allowed us to use a conventional 40-cm sheath; however,in cases of "inconvenient" anatomical features we use 30-cm graduated sheaths that allow us to control the depth of insertion more accurately and thus provide a higher precision of implantation. Some investigators note that the relatively short distance between the place of vascular access and the aortic root makes it possible to control the prosthesis deployment more thoroughly; however, there was no expected reduction in permanent pacing due to the smaller probability of a "low implantation" (23).

The disadvantages of subclavian approach include the "complexity" of the anatomical area as compared to the groin area and an obligatory need for endotracheal anesthesia that can adversely impact the outcomes of treatment and prolong hospitalization in case of concomitant pulmonary pathology. When planning an intervention involving the right ScA, the severity of atherosclerotic lesions of the brachiocephalic arteries (including intracranial ones) should be evaluated in detail to determine the risk of possible neurological complications associated with blood flow restriction in the BCA basin when the sheath is located in the vasculature.

Conclusion

Transfemoral approach is the method of choice for routine practice because of easier access to the femoral artery from the technical point of view, convenience of manipulations in this area and the possibility to use local anesthesia. However, if concomitant pathology of aorto-femoral segment exists, it is not possible to use the transfemoral approach, and the use of ScA is a reliable and safe alternative

option which allows us to perform transcatheter AV implantation in these cases.

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Diagnosis and Endovascular Treatment of a Splenic Artery Aneurysm

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High resolution capacities of modern non-invasive imaging techniques have significantly simplified the diagnostics of visceral aneurysms. Splenic artery aneurysms are potentially life-threatening in case of rupture. This fact requires timely preventative surgical treatment which should be offered if the aneurysm exceeds 20 mm in diameter. Currently, the endovascular treatment options are increasingly used for treatment of splenic artery aneurysms. The authors present a clinical case of successful endovascular embolization of a splenic artery aneurysm.

Keywords: *aneurysm, splenic artery embolization, endovascular treatment.*

In surgical and therapeutic clinical practice, the aneurysms of the unpaired visceral arteries are relatively rare. However, the relevance of the topic is doubtless due to the difficulties in early diagnostics of this pathology and a high risk of lethal complications. Possible clinical scenarios associated with visceral aneurysms include acute and/or chronic abdominal ischemia. If collateral blood flow is adequate, the disease is quite frequently asymptomatic and is diagnosed incidentally when a patient is examined for other diseases, or at autopsy.

Centuries-long observational experience demonstrates that among all of the unpaired visceral arteries, the splenic artery (SA) is the most susceptible to aneurysmal degeneration of the vascular wall. According to modern data, SA aneurysms account for 60% of all aneurysms of the unpaired visceral arteries, followed by hepatic artery aneurysms (20–40%), superior mesenteric artery aneurysms (5%) and aneurysms with more rare localizations. The incidence of SA lesions ranges from 0.098% per 195,000 autopsies to 10.4% (targeted autopsies in the older populations). SA aneurysms are detected in 4 : 1 ratio with prevalence of female patients aged up to 51 y.o. Currently, the most common cause of SA aneurysm formation, as opposed to other visceral arteries, is fibromuscular dysplasia; other less frequent causes are portal hypertension, pregnancy, atherosclerosis, inflammation of the hepatobiliary zone (pancreatitis, cholecystitis), mycotic nature, and hypertension (1, 2).

The aneurysms of the unpaired visceral arteries were reported for the first time in the middle of the 16th century. The famous French physician and physiologist J.F. Fernel (1555) noted that aneurysms can form in many arteries – both external (arteries of the limbs and neck) and internal ones (arteries of the chest, spleen, and mesenterium) (3). Later, the French surgeon Beaussier (1770) published the first detailed pathological description of SA aneurysm (4). In 1786 the Italian physician J. Nenci observed the rupture of a large (the size of a fist), true SA aneurysm that resulted in the patient's sudden death (5). Over the next two centuries more than 2000 cases of SA aneurysms were described in the literature which significantly promoted thorough understanding and systematic investigation of this pathology.

Surgical treatment of the visceral artery aneurysms became feasible in the late 19th – early 20th century due to the progress of general surgery and anesthesiology as well as to the experiments in the collateral circulation of the abdomen, which shed the light on the peculiarities of the abdominal collateral blood flow. In 1905, the German surgeon V. Winckler reported for the first time a successful SA

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ligation and splenectomy used for treatment of SA aneurysm (6). Surgical treatment methods remained the only option until 70 s of the last century, when alternative methods of treatment were developed as a result of the medical scientific revolution in the mid-20th century. The first positive long-term results of endovascular embolization and laparoscopic ligation for SA aneurysm were reported by P. Probst et al. (1978) (7) and M. Hashizume et al. (1993) (8), respectively.

To date, there is a recognized opinion that SA aneurysms exceeding 2–3 cm require surgical intervention due to a high risk of fatal complications. SA aneurysm ruptures constitute up to 10% of untreated cases; the mortality rate of aneurysm rupture ranges from 25 to 50% and reaches 75% in pregnant women (with 95% mortality for the fetus). Rupture is mainly accompanied with intra-abdominal bleeding (gastrointestinal hemorrhages in 13%), including recurrent bleeding (1). Currently, the endovascular treatment methods are the most commonly used for this pathology and their successful rate after primary and repeated interventions ranges from 60 to 88% and from 75 to 100%, respectively (9).

The following clinical case is provided as an example:

Female patient R., 57 y.o. (born on July 07, 1956) had a long-standing gallstone disease. In March 2014, she underwent laparoscopic cholecystectomy for chronic calculous cholecystitis complicated by perivascular infiltrate. After the discharge moderate pain in the upper parts of the abdomen, nausea, belching, unformed stool persisted which caused an outpatient examination in May 2014. As a part of examination, computed tomography (CT) was performed on May 29, 2014 and SA aneurysm was diagnosed.

The patient was referred to the Department of Vascular Surgery of Vishnevsky 3rd Central Military Clinical Hospital for further examination. On June 06, 2014, selective angiography of the visceral arteries was performed. The angiography revealed tortuous hypertrophied SA up to 8 mm in diameter with abnormally increased blood flow velocity and spherical saccular aneurysm of the distal third of the SA exceeding 4 cm in diameter (Fig. 1). After the indications for surgical treatment were established, on June 16, 2014, the embolization of the splenic artery was performed. The middle segment of the SA and aneurysmal cavity were partially embolized using 3 COOK coils 35-10-3, 35-20-10 mm. During the control angiography, the residual blood flow through the artery was preserved by more than 75% (Fig. 2, A). Then the artery at the border of its proximal and middle segments was totally occluded using 12 mm AMPLAZ occluder. Control angiography was performed after the intervention: the splenic artery is visualized up to the proximal third (Fig. 2, B). On June 18, 2014 abdominal CT was conducted to control the efficacy of intervention in the postoperative period. This examination detected no abnormal density areas in the spleen, pancreas, or liver. Aneurysm up to 26 mm in diameter was revealed in the splenic artery

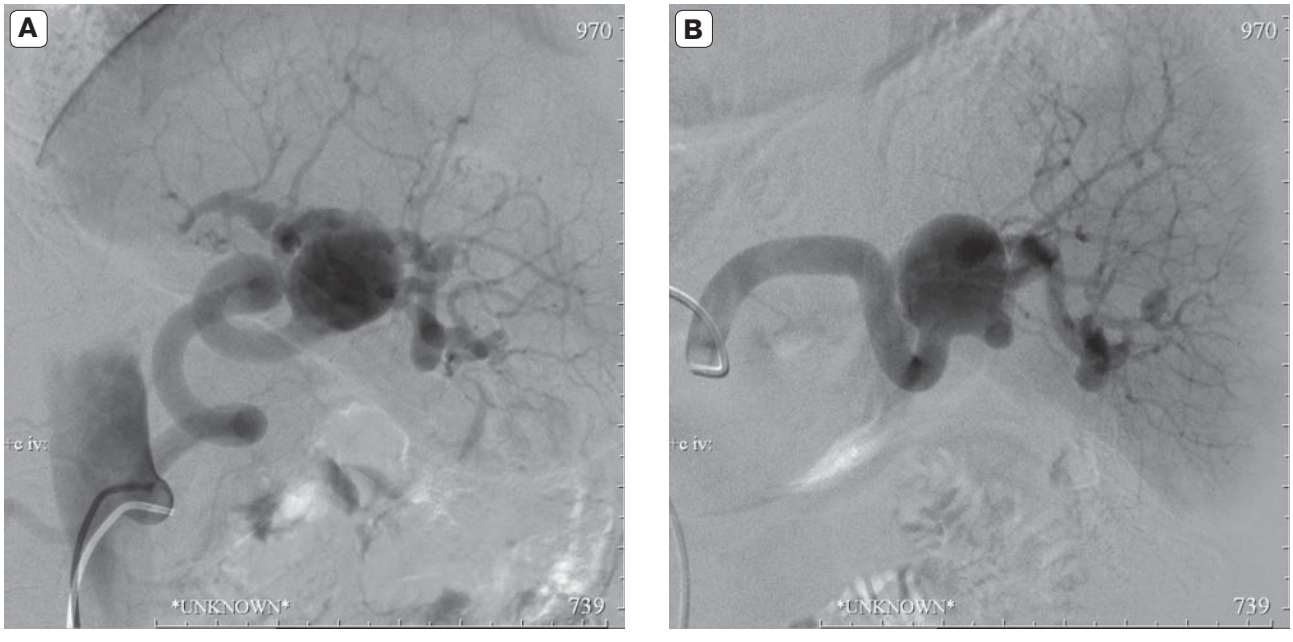

Figure 1. Selective angiography of the splenic artery performed on June 06, 2014. A, B – tortuous and hypertrophied SA up to 8 mm in diameter and saccular aneurysm of the distal segment of the SA measured up to 4 cm.

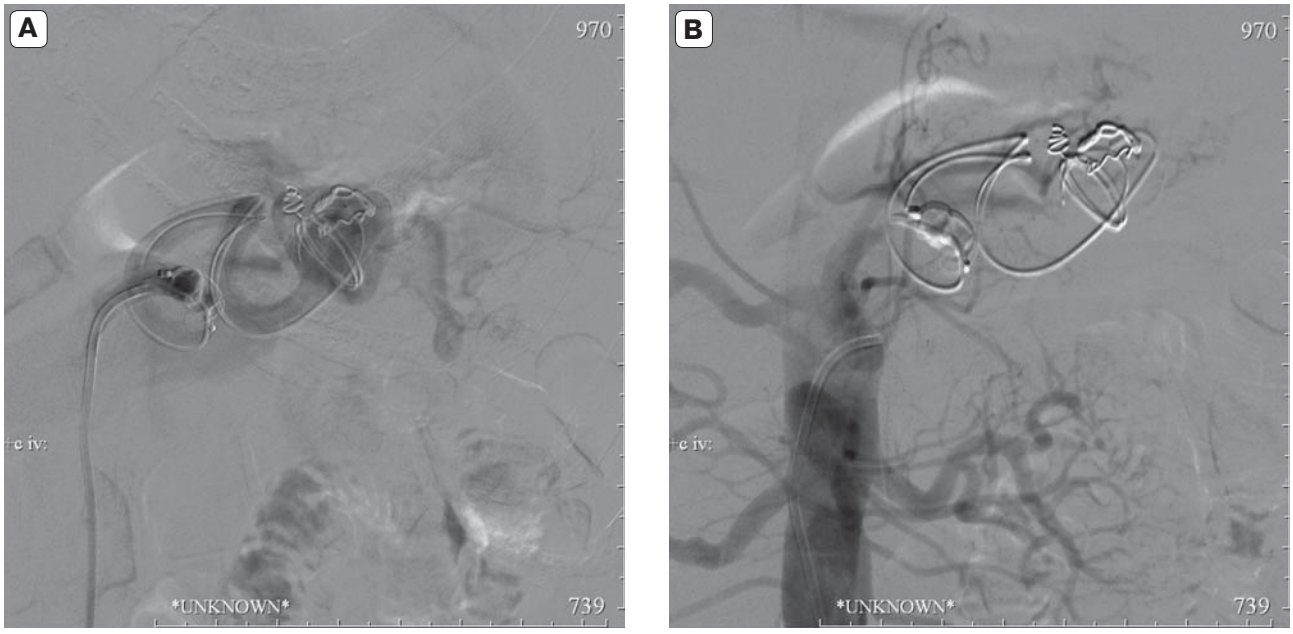

Figure 2. Embolization of the splenic artery dated June 16, 2014. A – residual blood flow in the artery > 75% after partial embolization; B – artery is visualized up to the proximal segment of the SA, there is no distal blood flow.

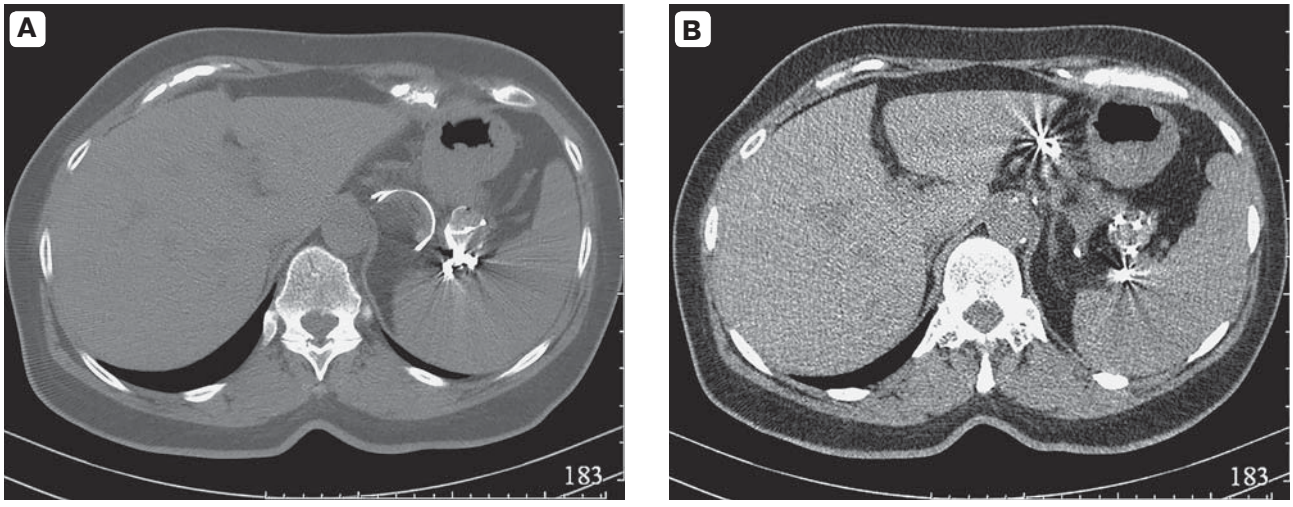

Figure 3. Abdominal computed tomography dated June 18, 2014. A, B – aneurysm of the splenic artery up to 26 mm in diameter with multiple lumpy calcifications and metal coils in the aneurysmal cavity and the SA.

at the level of the splenic hilum. Numerous lumpy calcifications were visualized in the aneurysm structure. A metal "chord" was detected in the splenic artery and the aneurysm (Fig. 3). The clinical remission of chronic gastrointestinal disorders was achieved with appropriate medical therapy. The patient was discharged in a satisfactory condition.

Further she was followed-up for post-cholecystectomy syndrome and occasionally noted an unformed stool in case of diet violation. In October 2015, during the scheduled hospitalization at Vishnevsky 3rd Central Military Clinical Hospital she had no complaints of abdominal pain and dyspepsia. The results of clinical and biochemical blood count and of urinalysis were within the normal range. Non-enhanced and contrast-enhanced CT performed on October 05, 2015, detected no abnormal density areas in the spleen, pancreas, or liver. The signs of growth of the previously embolized SA aneurism up to 28 × 27 mm were detected (Fig. 4). Thus, selective angiography of the visceral arteries was performed on October 07, 2015. It was determined that the tortuous SA was occluded in the proximal segment. Distal portions of the artery, aneurysmatic lumen with previously implanted coils and, partially, proximal part of the SA were fragmentarily filled retrogradely via two afferent vessels (Fig. 5, A). Three COOK coils 35-8-5 mm were sequentially implanted at the border of the proximal and middle segments of a large SA afferent vessel resulting in significant reduction of the blood flow in the distal segment of the SA with preservation of blood flow

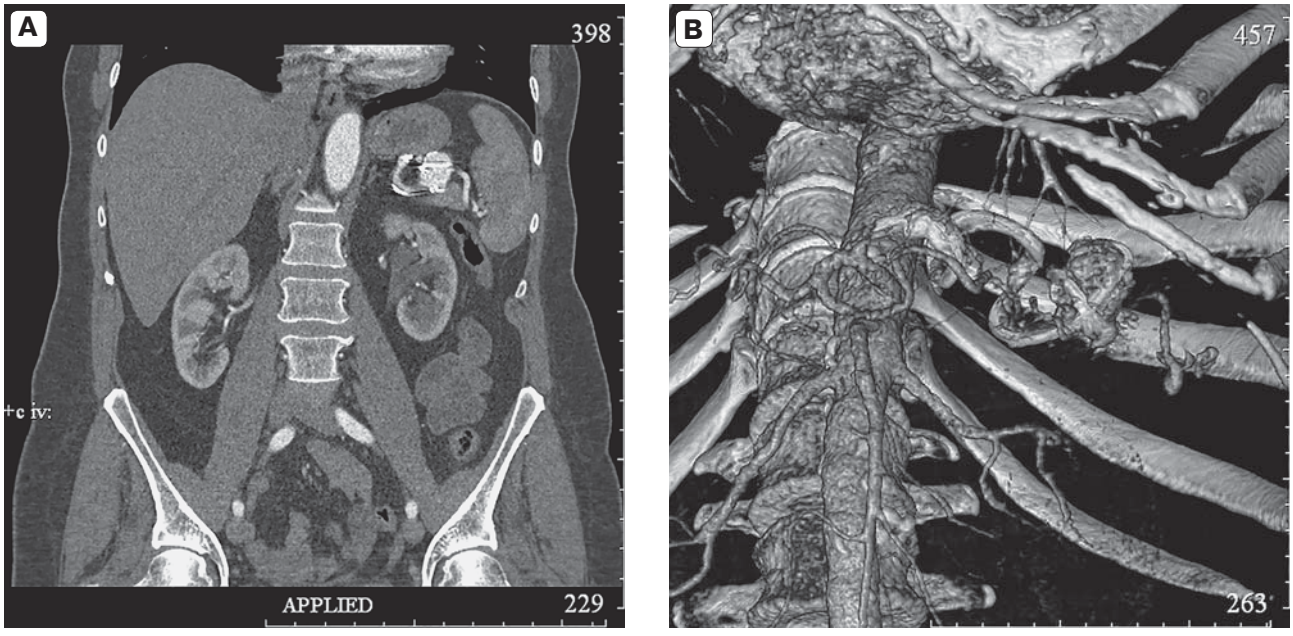

Figure 4. CT-angiography dated October 05, 2015. A, B – status after embolization of the SA aneurysm with evidence of growth up to 28 × 27 mm and retrograde blood flow.

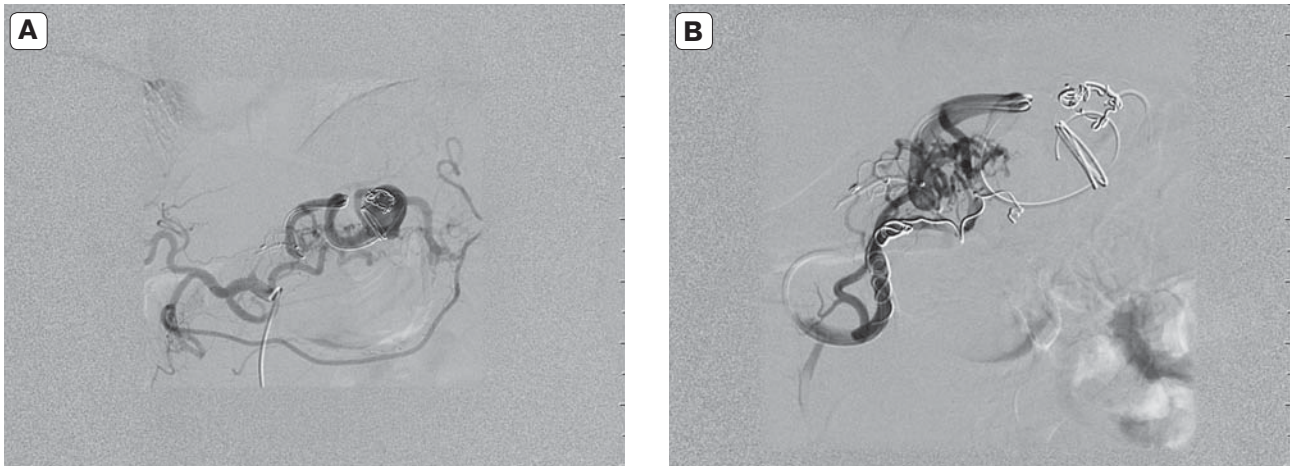

Figure 5. Selective angiography of the celiac trunk branches (a) and embolization of a collateral of the splenic artery (b) dated October 07, 2015. A – collaterals of the splenic artery; B – embolization of the large afferent vessel of the SA aneurism.

through the pancreatic branches not filling the aneurysmal cavity (Fig. 5, B).

In February 2016 she was admitted to Vishnevsky 3rd Central Military Clinical Hospital for the next step of the endovascular treatment – embolization of the splenic artery collateral vessels. According to angiography data, on February 16, 2016, the tortuous branches of the splenic and the pancreatoduodenal arteries with multiple afferent vessels of the partially thrombosed aneurysm of the distal segment of the SA were detected (Fig. 6); the major afferent vessels were sequentially embolized with 3 COOK coils 35-5-5 mm (Fig. 7, A–C). At control angiography, the celiac trunk, common hepatic and gastroduodenal arteries with preserved pancreatic branches, the distal part of the SA cannot be visualized, the aneurysm was totally embolized (Fig. 7, C, D). The postoperative period was unremarkable. The patient was discharged in a satisfactory condition. In February-May 2016, she had no complaints. CT-angiography (June 06, 2016) revealed that the SA aneurysm was reduced to 20 × 17 mm. There were no abnormal density areas in the spleen, pancreas, or liver.

Therefore, the application of non-invasive imaging techniques such as CT and MRI, along with angiography, significantly facilitates the diagnosis of the visceral arteries abnormalities. This examination is necessary to plan the extent of interventions on the visceral arteries, to determine the causes of the abdominal pain syndrome, in particular, to rule out vascular

Figure 6. Selective angiography of the celiac trunk branches dated February 16, 2016. A, B – SA collaterals with retrograde filling of the aneurism.

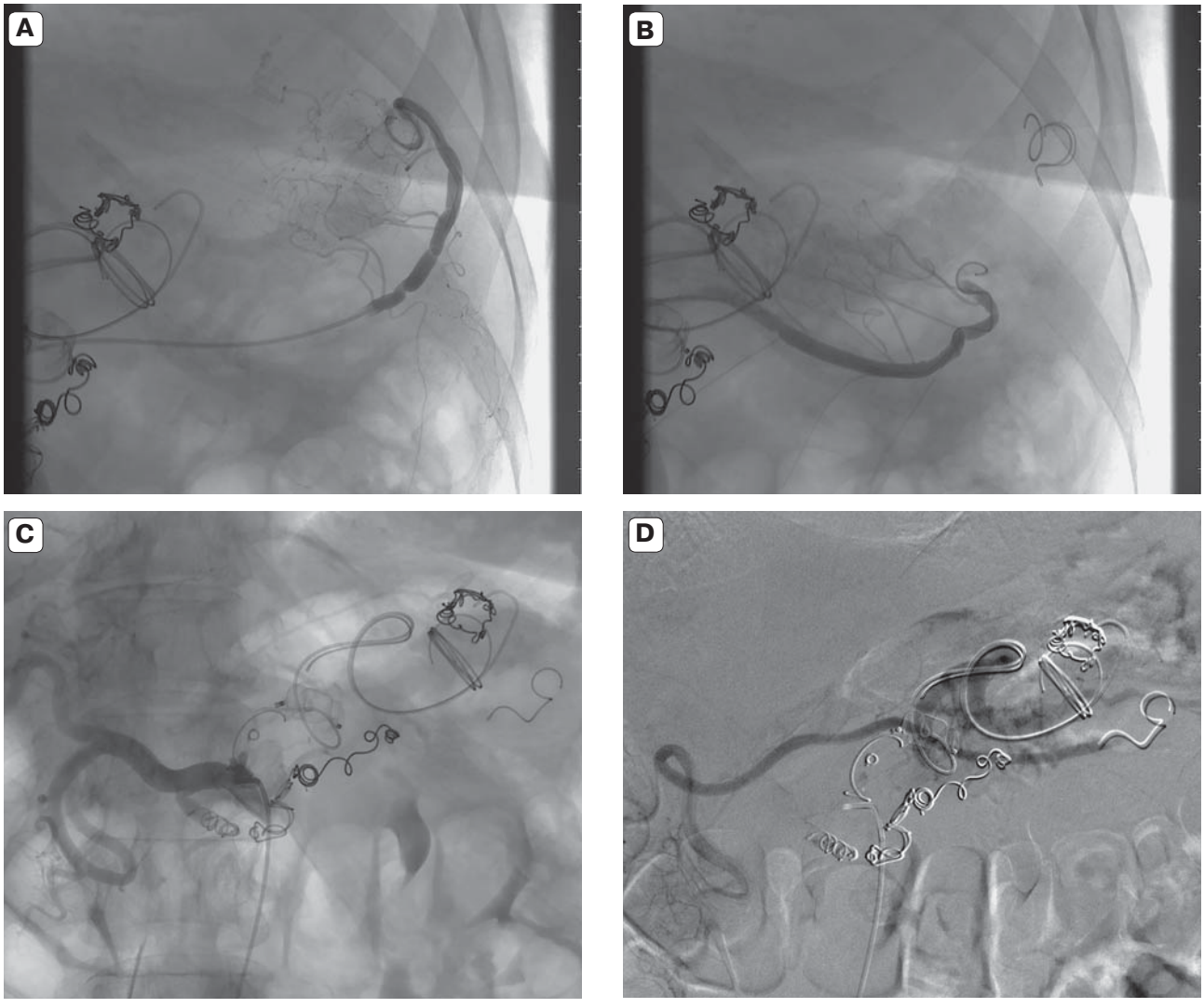

Figure 7. Embolization of collaterals of the splenic artery dated February 16, 2016. A, B, C – sequential embolization of three afferent vessels of the SA aneurysm; C, D – distal part of the SA is not visualized.

pathology, as well as to monitor and control the hemodynamic efficacy of surgical correction over time. Currently, the endovascular technique is a minimally invasive and highly effective method used for treatment of aneurysms of the visceral branches of the aorta and as an alternative option for the surgical revascularization, especially in patients at high risk of cardiovascular complications.

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Coronary Artery Bypass Grafting (CABG) Combined with Endarterectomy and Stent Retrieval in Patients after Percutaneous Coronary Interventions

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Despite the increasing number of patients undergoing percutaneous coronary interventions (PCIs), in-stent restenosis remains the major limiting factor for this procedure. In this situation, interventional techniques are often ineffective and long-term results remain unsatisfactory. Therefore, the interest in surgical treatment methods for patients with a history of PCI is increasing. The experience of coronary artery bypass grafting with endarterectomy and stent retrieval from the coronary arteries is presented.

Key words: *percutaneous coronary intervention, endarterectomy, diffuse coronary artery disease, coronary artery bypass grafting.*

Introduction. Despite the increasing number of patients undergoing percutaneous coronary interventions (PCIs), in-stent restenosis remains the major limiting factor for this procedure. There are controversies regarding the treatment of this complication. Interventional techniques in this situation are often ineffective and long-term results remain unsatisfactory. Therefore, the interest in surgical treatment methods for patients with a history of PCI including coronary endarterectomy with stent retrieval is increasing.

Materials and methods. From 2009 until 2014, twelve patients with earlier implanted stents underwent coronary endarterectomy. Clinical anatomical status as well as surgical treatment outcomes were assessed in these 12 subjects.

Results. All patients had diffuse coronary artery disease. Procedure was successful without any major complications in all cases. One case of angina which recurred due to three occluded autovenous grafts in 4 months after the intervention has been registered. Angiography in 3 years detected one occluded autovenous graft in in each of 7 patients in total. EchoCG revealed slightly increased left ventricular ejection fraction; no new areas with impaired local contractility were registered.

Conclusion. Coronary endarterectomy with stent retrieval is a safe and effective treatment method used in patients with in-stent restenoses and diffuse coronary artery disease.

Introduction

When medical therapy is inadequate, percutaneous coronary intervention (PCI) and coronary artery bypass grafting (CABG) are the main treatment methods for the coronary heart disease (CHD). The increase in the number of currently performed PCIs is mostly associated with minimal invasiveness of the procedure and relatively low risk of complications. With improvement of techniques and development of new stent types the range of patients who undergo endovascular coronary interventions expands. Angioplasty is attempted more often for treatment of diffuse, multiple, bifurcation and distal lesions of the coronary arteries. However, extension of indications for PCI is limited by a number of factors, the main of which are still the long-term complications related to PCI, i.e. in-stent restenosis, development of atherosclerotic lesion proximal and distal to the implanted stent, as well as thrombosis of the recanalized coronary artery (1). The drug-eluting stents preventing the neointimal proliferation were developed to solve this problem. However, conducted studies

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demonstrated that despite these efforts the incidence of in-stent restenoses remains rather high (2, 3, 4, 5).

As a rule, the following endovascular methods of correction are primarily used for in-stent restenosis: repeated balloon angioplasty (6), directional coronary atherectomy (7, 8), rotational atherectomy (9, 10), and additional stenting (11, 12). However, the interventional techniques are often ineffective and the long-term outcomes remain unsatisfactory. In the meantime, CABG has demonstrated better immediate and long-term outcomes in restenosis treatment as compared to interventional techniques (13). Therefore, the number of patients with a history of PICs referred for the coronary bypass surgery has been increasing over the recent years.

The formation of distal anastomoses during CABG in this group of patients is very often associated with technical difficulties caused by distal location of the implanted stent or by a diffuse lesion of the arterial wall. In these cases, coronary endarterectomy (EAE) with retrieval of the previously implanted stent is required (14–16), but this intervention is associated with the increased perioperative risk of MI according to some authors (17, 18). Solution of this problem is the most topical for a group of patients with post-PCI recurrent angina. The present article analyzed the results of CABG surgeries accompanied by endarterectomy and retrieval of the stent from the coronary arteries.

Materials and methods

160 CABG surgeries were performed in patients with post-PCI recurrent angina at the Cardiovascular Surgery Department of A.L. Myasnikov Institute of Clinical Cardiology from 2009 to 2014. 12 of them underwent coronary endarterectomy with retrieval of the previously implanted stent because the conventional anastomosis could not be formed for the above reasons. The preoperative clinical anatomical characteristics and the results of the surgeries in these 12 patients have been evaluated. Clinical characteristic of the patients is presented in Table 1.

Mean age of the patients was 62.6 ± 9.6 years old; they were predominantly males (92%). Functional class 3 of angina according to Canadian Cardiovascular Society classification was reported in most cases. Two patients had significantly decreased EF; in the remaining cases global LV contractility was satisfactory (mean pre-operative EF constituted 50.3 ± 3.2%).

The time from the last PCI ranged from 3 to 48 months. Recanalization of the earlier implanted stent via ballooning (1 case) and repeated stenting (3 cases) were previously attempted in 4 cases. The degree of in-stent restenosis varied from 30% to 100%. Most patients (75%) had multivessel PCI. Mean number of stented arteries was 1.8 ± 0.8. Eight patients (66.7%) had multiple stents (2 or more) implanted in one coronary artery.

All patients underwent conventional CABG using cardiopulmonary bypass under moderate hypothermia. Hypothermic crystalloid cardioplegia was delivered antegradly via the aortic root. The choice of tactics and the extent of revascularization was based on the angiographic data and intraoperative inspection of the arteries. All surgeries were performed using microsurgical equipment and surgical microscope. In 4 patients endarterectomy was performed in the right coronary artery (RCA) followed by arterial repair with autogenous vein. The repair of the left anterior descending artery (LAD) using the autovenous patch followed by end-to-side anastomosis with the left internal thoracic artery (LITA) was performed in 3 patients due to extended (45 mm and more) anastomosis.

The angina recurrence, cardiac mortality and LV contractility were assessed using EchoCG data. Three-year results were obtained from 7 patients who underwent control coronaroshuntography (CSG).

Results

Diffuse coronary artery disease with significant distal lesions was intraoperatively observed in all 12 cases. Coronary artery lesions with hemodynamically significant narrowing of the proximal, middle and distal segments were considered diffuse. Coronary endarterectomy with retrieval of the previously implanted stents was performed in all cases. In-stent stenosis >70% in combination with significant distal lesion which did not allow us to form conventional anastomosis (atherosclerotic lesion of the arterial wall, luminal diameter <1.5 mm) was considered as indication for EAE.

The arteriotomy was performed distal to the implanted stent. In the majority of cases EAE was conducted using the indirect technique. In 4 cases it was necessary to extend arteriotomy incision in the distal direction and to perform

Table 1. Clinical characteristics of the patients

	Age	Gender	FC	Number of affected vessels	EF, %	In-stent restenosis, %	Time from the past PCI, months	Number of PCIs	Number of implanted stents
1	60	M	3	3	40	95% – RCA, 100% – LAD	5	1	RCA 1; LAD 1;
2	77	M	3	3	38	95% – RCA	4	1	RCA 3
3	64	M	3	3	35	LAD –70%	36	1	LAD 1; CA 1
4	71	M	4	4	49	100% – LAD; 100% –RCA	48	5	RCA 2; LAD 2
5	74	F	3	4	41	LAD – 70% RCA – 30% OMB – 70%	4	3	LAD 1; RCA 4; OMB 1
6	66	M	4	4	60	LAD – 100% RCA – 60% OMB – 60%	8	4	LAD 2; RCA 1; OMB 1
7	47	M	3	4	60	LAD – 100%	3	1	LAD 2
8	52	M	3	4	60	LAD – 90% OMB – 100% and 95%	12	1	LAD 3; CA 1; RCA 1
9	59	M	3	4	40	LAD – 100%	11	1	LAD 2
10	72	M	4	5	60	LAD – 70% RCA – 80%	7	3	LAD 1; RCA 1
11	59	M	3	4	60	LAD – 100%	39	1	LAD 1
12	52	M	3	3	60	LAD – 90% CA – 100%	7	1	LAD 1; CA 1

FC – functional class of angina; EF – ejection fraction of the left ventricle; PCI - percutaneous coronary intervention; LAD – left anterior descending artery; RCA – right coronary artery; OMB – obtuse marginal branch; CA – circumflex artery.

direct EAE (plaque separation). The affected arterial wall was separated together with the stent. Coronary artery bypass grafts were formed using Prolene 8-0 suture.

The left internal thoracic artery (LITA) was used for LAD revascularization in all patients. Endarterectomy of the LAD followed by creating its anastomosis with LITA was performed in 9 patients. The method of arterial repair depended on the length of arteriotomy. In 3 cases, when direct EAE was performed due to extended anastomosis (up to 120 mm) and distal location, the artery was repaired using the autovenous patch followed by creating end-to-side LITA anastomosis (Fig. 1). LAD was repaired using the LITA wall in the remaining patients. One patient had endarterectomy with stent retrieval from 2 arteries: RCA (bypassed with the autogenous vein) and LAD (bypassed with LITA). EAE with stent retrieval from the RCA only followed by revascularization with autovenous conduit was performed in 3 patients (Fig. 2). The drug-eluting and bare metal stents were removed in 6 and 6 patients, respectively. The intraoperative data are presented in Table 2.

No lethal outcomes, myocardial infarction, heart failure requiring inotropic or mechanical support, and infectious complications were observed during the perioperative and in-hospital periods. In one case repeated sternotomy with additional hemostasis due to a bleeding was performed in the immediate postoperative period.

In the early postoperative period all patients who underwent endarterectomy were prescribed heparin (target activated partial thromboplastin time (APTT) was 2-fold higher than the normal value) and were subsequently switched to administration of indirect anticoagulants (warfarin with target international normalized ratio (INR) – 2–3) for 6 months after the surgery in combination with antiplatelet therapy.

Hospitalization lasted for 15 ± 3 days (prolongation of hospitalization stay was associated with the necessity to adjust dosages of indirect anticoagulants). On Day 8 after the surgery coronaroshuntography (CSG) was performed to monitor the patency of the grafts. The grafts were patent in all cases. There was no evidence of heart failure, angina or arrhythmias at the time of discharge.

During the follow-up one angina recurrence was reported in 4 months after the surgery; the patient underwent CSG which detected

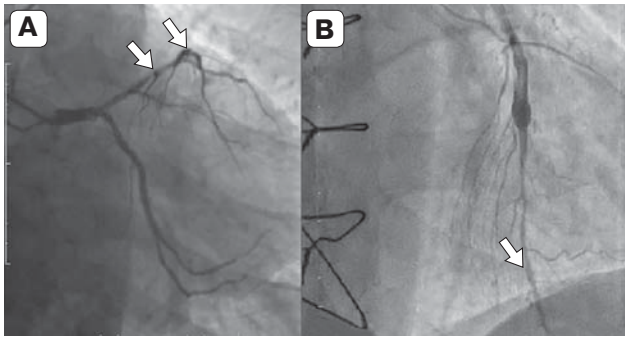

Figure 1. A – Preoperative coronary angiography (arrows indicate the stents previously implanted in the LAD), the distal portion of the LAD is not visualized. B – Coronaroshuntography performed in the same patient 3 years after endarterectomy with removal of 2 coronary stents from the LAD, repair of the coronarotomy section with the autovenous patch followed by its revascularization with LITA. LAD (arrow) is adequately filled through the LITA.

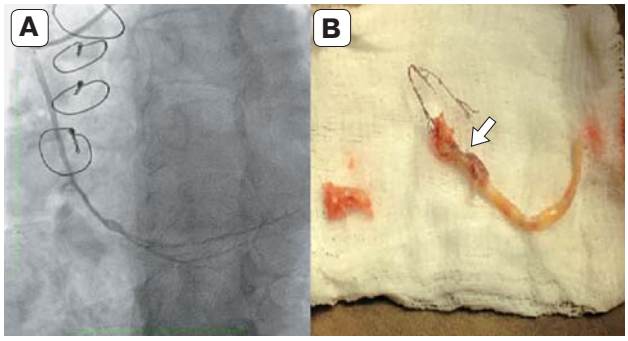

Figure 2. A – LAD coronaroshuntography performed 3 years after endarterectomy with stent removal from the cross area; the posterior descending artery is filled through the autovenous graft. B – gross specimen of the removed atherosclerotic plaque with the stent (arrow) from the cross area of the LAD.

3 occluded autovenous grafts; thereat, they were recanalized and stented.

Control CSG in 3 years after the surgery performed in 7 patients with cardialgia revealed one occluded venous graft to the RCA (endarterectomy with stent retrieval). No patients had angina recurrence at this time point. According to EchoCG data, during the 3-year follow-up, mean EF increased (from 50.3 ± 3.2% to 57.5 ± 1.7%), no new areas of impaired local contractility were detected.

Discussion

Restenosis in the coronary stents and stented arteries remains one of the most important unsolved problems in CHD patients, especially in case of diffuse and distal coronary artery disease. In this situation, repeated stenting of the affected coronary artery or rotational atherectomy are the most common treatment strategies. However, most often it is a temporary measure allowing to delay surgery. Risk factors for unsatisfactory outcomes of the CABG performed after PCI include diabetes mellitus, the number of affected arteries, type and location of the lesion, and incomplete revascularization after the PCI. Repeated stenting of the artery often results in formation of severe stenoses located both inside the previously implanted stent (neointimal hyperplasia) (19) and distal to the implanted stents (20); it affects the receiving vessels, causes technical difficulties when forming distal anastomoses and adversely impacts the outcomes. Therefore, the patients with a history of multiple coronary stenting represent a population with negative prognosis for graft functioning, and the need for coronary endarterectomy is often the cause of refusal from the surgery.

Table 2. Intraoperative data

	Number of grafted arteries	Length of the arteriotomy in EAE, mm	Time of the CB, min	Time of the MI, min	EF in 1 week after thesurgery, %
1	4	47	105	80	60
2	4	25	102	60	40
3	2	20	112	52	60
4	4	30	107	50	60
5	4	50	90	59	55
6	4	20	115	73	60
7	4	25	67	45	60
8	4	50	91	66	65
9	3	120	70	63	55
10	5	30	101	57	60
11	4	20	100	67	60
12	3	20	111	70	60

EAE – endarterectomy; CB – cardiopulmonary bypass; MI – myocardial ischemia; EF – ejection fraction of the left ventricle.

Despite the scepticism and certain distrust to the coronary endarterectomy technique caused by high mortality rate reported in the first publications, the accumulating experience proves that this method does not significantly differ in the incidence of postoperative complications and is justified in patients with severe coronary artery disease (21–23). Sometimes, when CABG is performed after multiple coronary stenting, the vessels look like all-metal frame. Moreover, endarterectomy from such vessel is always a forced measure in order to make formation of anastomosis possible (24). In such cases the efficacy of performed surgery largely depends on the surgeon's experience.

The number of reports on endarterectomy with stent retrieval is limited. This approach is used worldwide for coronary vessels of small diameter at the distal segment in combination with atherosclerotic lesions of implanted stents at the proximal and middle segments. Fukui T. et al. reports that LAD endarterectomy with stent retrieval followed by its revascularization with LITA is an effective and safe method of restenosis treatment (15).

According to different authors there are several types of LAD repair. Demirsoy E. et al., Santini F. et al. report on the successful LAD reconstruction using the saphenous vein graft in combination with end-to-side mammary coronary graft to the venous patch (25). Other authors consider that using a combination of tissues with different elasticity (coronary artery, venous patch, LITA) is the principal disadvantage of this technique. Lesser elasticity of the venous patch may result in blood flow turbulence. Excessive venous patch and turbulence in this area may adversely affect the blood flow parameters and result in coronary artery thrombosis (26). Shimokawa T. et al. report that arterial repair after coronary endarterectomy using only arterial patch improves re-endothelialisation. They determined that LAD diameter after reconstruction becomes equal to LITA diameter within one year after the surgery; moreover, physiological remodelling takes place in the LAD and its properties become similar to LITA ones resulting in prolonged lifespan of the graft (27).

In our study we have used several techniques of arterial repair after endarterectomy. It depended on location of the artery and the length of the arteriotomy. Both extended LITA-coronary anastomoses and anastomoses using autovenous patches remained patent throughout the follow-up period which is likely related to a pedicled LITA used as a conduit. Therefore, the use of complex LAD repair in our study did not affect the graft patency in the long-term follow-up.

In patients who underwent EAE with stent retrieval special attention should be paid to anticoagulant and antiplatelet therapy during the postoperative period. In order to prevent early vascular thrombosis various authors recommend the intake of indirect anticoagulants for up to 6 months in patients (maintaining INR within the range from 2 to 3) as well as continuous administration of antiplatelet agents (15). We followed the above algorithm of antithrombotic therapy for prevention of coronary thrombosis. All patients who underwent endarterectomy were prescribed heparin in the early postoperative period and subsequently switched to warfarin on Day 5–7 after the surgery. According to our data, this anticoagulation regimen is adequate to prevent early thrombotic occlusion of the grafts and does not cause uncontrolled postoperative bleedings.

Conclusion

Thus, coronary endarterectomy with stent retrieval is a safe and effective technique used for treatment of patients with in-stent restenoses and diffuse coronary artery disease. This method can be used when it is impossible to create anastomosis due to previously implanted stent. The pedicled LITA used as the conduit is the most optimal option when conducting LAD endarterectomy with stent retrieval.

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Endovascular Correction of Pelvic Arterial Injury

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Endovascular surgery methods were used in 14 patients (13 men and 1 woman aged from 15 to 57 y.o.) with pelvic arterial injuries. Selective embolization was performed in 12 patients using PVA particles (9 cases) and embolic coils (3 cases). Embolization was effective and no recurrent bleeding was observed in all cases. Stent-grafts were implanted in 2 patients with developing false aneurysm with complete exclusion of the aneurysm from the blood flow. Endovascular treatment options are minimally invasive alternatives to reconstructive vascular surgeries.

Keywords: *arterial injury, pelvic fractures, endovascular surgery, embolization, stent-graft.*

Abbreviations

AG – angiography
IIA – internal iliac artery
DFA – deep femoral artery
EIA – external iliac artery
CIA – common iliac artery
PFs – pelvic fractures

Study objective. to evaluate the efficacy of endovascular surgery for pelvic arterial injury.

Background. The subjects with pelvic arterial injury often also have multiple internal injuries, fractures and are in a severe condition. The most sparing and effective treatment options should be used in these patients.

Material and methods. Fourteen patients with pelvic arterial injuries underwent endovascular interventions: embolization (12 patients) and stent-grafting (2 patients).

Results. Embolization was effective in all patients and no recurrent bleeding was observed; stent-grafts allowed to exclude the developing false aneurysms from the blood flow. Two lethal outcomes were not associated with embolization, but were caused by severe combined trauma and internal injuries.

Conclusions. The minimal invasive endovascular treatment options allow us to effectively manage the bleeding in extremely severely injured subjects, exclude false aneurysms from the blood flow, and avoid vascular reconstructive surgeries.

Introduction

Endovascular treatment options are used in patients with vascular injuries, i.e. embolization is applied for bleeding and stent-grafting is used for the injury of the main arteries and development of false aneurysms (FAs).

The mortality of some subjects with pelvic fractures (PFs) is not associated with fractures but is caused by vascular injuries, since 40% of PFs patients experience intrapelvic or intra-abdominal bleeding (1). If the iliac arteries or medium and small sized arteries are injured, the 30-day mortality rates constitute 57% and 24%, respectively (2).

Smith W. et al. consider that (3) the majority of PFs-related fatal outcomes is caused by bleeding (74.4%) and multiple organ failure (17.9%). The death during the first 24 hours is more likely caused by bleeding and blood loss, and the death after 24 hours is associated with multiple organ failure.

Bleeding is the primary cause of death in PFs patients. Therefore, the increase of survival rate depends on the early management of bleeding.

Materials and methods

During the period from 1994 to 2015 endovascular interventions were performed in 14 subjects with pelvic arterial injuries. They included 13 men and 1 woman aged from 15 to 57 y.o. The modes of injury were as follows: fall from a height – 4 cases, pedestrian accident – 2 cases (knocked down by a car – 1 subject, falling between the platform and the

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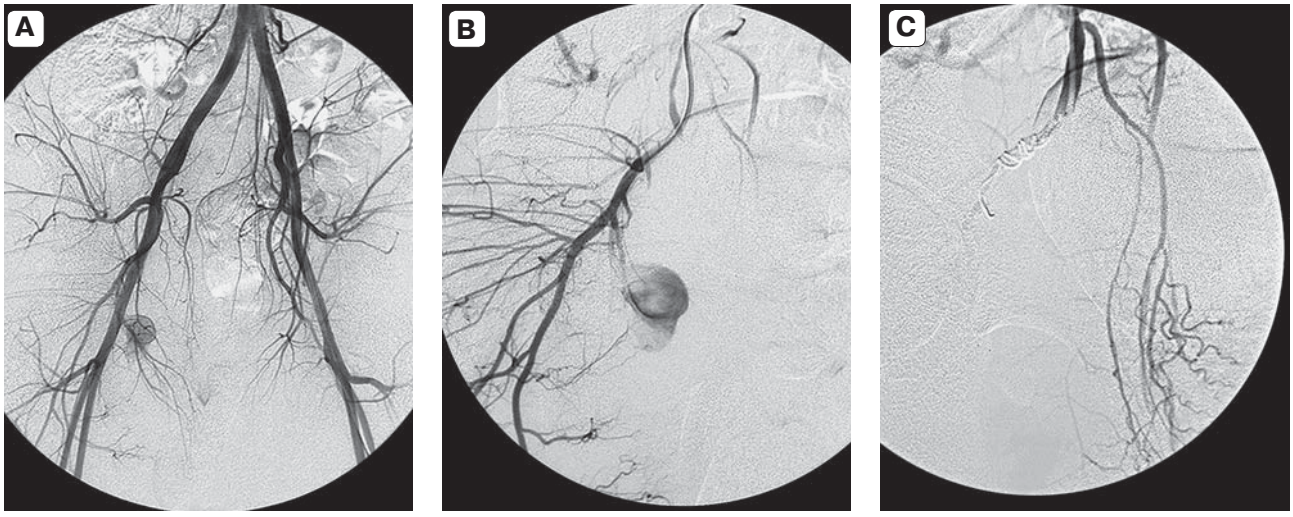

Figure 1. Angiography in the patient aged of 15 y.o. after a knife wound. A, B – false aneurism of a branch of the internal iliac artery. C – the false aneurysm is not visualized after the coil embolization.

train – 1 subject); stab wounds – 5 cases; gunshot wound – 1 case; osteosynthesis-induced injury – 2 cases (1 patient had a femoral fracture due to falling, another subject was pressed by a slab on the construction site resulting in rupture of the symphysis pubis and left sacroiliac joint, fracture of the left lateral mass of the sacrum). Two out of 5 patients with stab wounds of the gluteal region also had penetrating thoracoabdominal injuries. Eight subjects had bone fractures including PFs.

Results

Angiography (AG) detected contrast media extravasation in 8 patients, and the presence of cavity and beginning of FA development in 6 patients. Branches of the internal iliac artery (IIA) were injured in 11 subjects (unilateral injuries in 10 subjects and bilateral injuries in 1 subject); two subjects had the injury of deep femoral artery (DFA), and 1 patient had ruptured CIA bifurcation involving the external (EIA) and internal iliac arteries.

Embolization was performed in 12 patients in accordance with the identified source of bleeding: unilateral embolization in 11 cases and bilateral embolization in 1 case. The catheter was selectively placed into the afferent vessel in all cases. The arteries were embolized using 300, 350–500 μm COOK PVA particles (9 cases) and COOK coils (3 cases including 1 case when haemostatic sponge was additionally used). The embolization was effective in all patients (Fig.1, A–C). No recurrent bleeding was observed. There were 2 deaths caused by the severity of the patients state as a result of injured vital organs.

Stent-grafts were implanted in 2 patients with developed FAs.

Wallgraft 12 × 50 mm (Boston Scientific) (Fig. 2, A, B) with sequential balloon dilatation of the proximal and distal ends of the stent-graft was implanted in a patient with CIA bifurcation FA involving IIA and EIA. Control AG revealed a minor opacification of the aneurysmal cavity. On Day 6, US Doppler revealed no blood flow in the FA which also was confirmed by the contrast-enhanced CT. The hematoma size decreased by more than 3-fold.

Bleeding from the postoperative wound was observed in a patient who underwent left hip nailing. AG revealed multichamber FA of the left DFA sized 69 × 27 × 26 mm. Wallgraft 8 × 20 mm (Boston Scientific) was implanted in the DFA which made it possible to completely exclude FA from the blood flow.

In both cases the patients were discharged in a satisfactory condition.

Discussion

In some cases endovascular surgery is an alternative to conventional reconstructive vascular surgeries for vessel injuries including pelvic vascular injuries. Two investigators teams (4.5) reported the US National Trauma Data Bank findings and detected a clear tendency towards the increasing use of embolization and stenting for the vascular injury.

Branco B.C. et al. (4) noted the increase in the use of endovascular methods for vascular trauma from 0.3 to 9% of all cases within the period from 2002 to 2010 (9 years) in the United States. In subjects with blunt trauma this

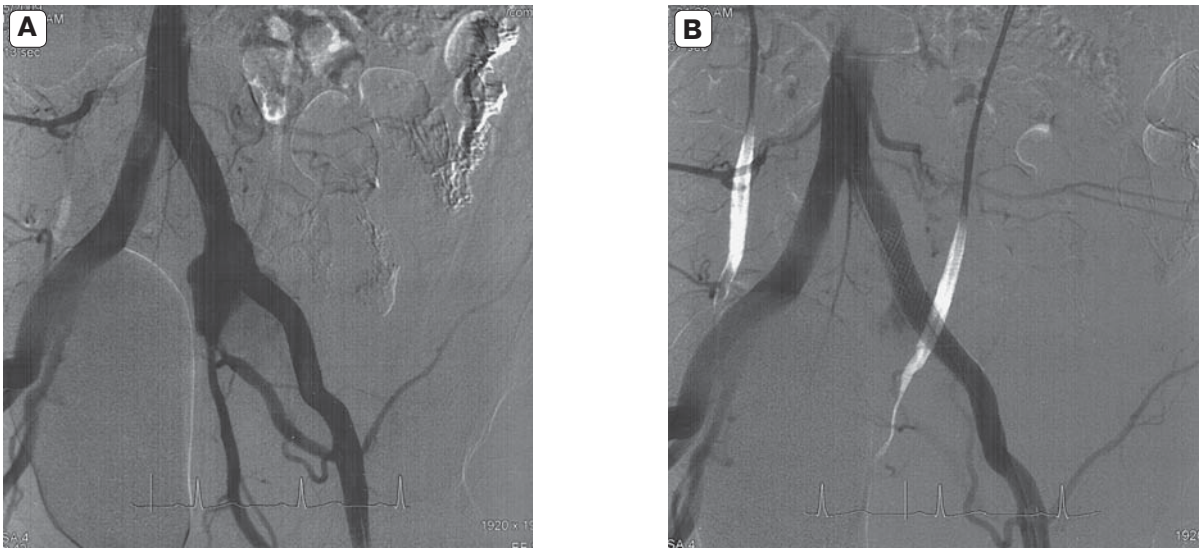

Figure 2. A – false aneurysm of the bifurcation of the common, external and internal iliac arteries; B – exclusion of the false aneurysm from the blood flow using stent-grafting.

parameter increased from 0.4 to 13.2%. This parameter increased from 8 to 40.3%, from 0.5 to 21.9%, and from 0.4 to 20.4% for the injuries of the IIA, thoracic aorta, and CIA + EIA, respectively. Over the same period the proportion of open surgeries decreased from 49.1 to 45.6%, especially for blunt trauma (from 42.9 to 35.8%). Lower in-hospital mortality rate was observed for endovascular methods as compared to open surgeries (12.9 vs 22.4%), as well as the incidence of sepsis.

The retrospective analysis performed by Lauerman M.H. et al. (5) demonstrated that stenting was used in 11.3 and 6.3% of patients with blunt trauma of the iliac arteries with or without PFs, respectively, and in 1.8% of subjects with penetrating arterial wounds.

IIA branches are the most common sources of bleeding, but other sources of bleeding and bilateral or unilateral injuries of 2–3 arteries are possible (6–8). Multiple sources of bleeding can be detected in 93% of the patients (9). In our series of observations the following vessels were injured: IIA branches (11 cases), CIA bifurcation (1 case), and DFA (2 cases); bilateral vascular damage was observed only in 1 patient.

The signs of bleeding detected by AG are as follows: contrast media extravasation, appearance of the cavity, no opacification of the artery, irregular arterial wall and stagnated opacified blood.

PVA particles and coils are most commonly used for embolization. The degree of selective catheterization and the type of embolic agent depend on the type of vascular damage and its accessibility. The efficacy of embolization is high (90–100%) (6, 10–14).

In order to prevent complications, unilateral selective embolization should be performed, if possible (15, 16). Frequently, complications after embolization are associated with bilateral and/or nonselective embolization.

Matityahu A. et al. (15) analyzed the complication rate in 98 patients who underwent embolization. The complication rate was 11%: gluteal muscle necrosis, failed wound closure, infection. All patients who had complications underwent bilateral embolization; non-selective embolization was performed in 81% of complications. Suzuki T. et al. (16) performed embolization in 165 subjects. Necrosis of the gluteal muscles and the skin after bilateral embolization developed in 12 patients. Trauma can not be excluded as a risk factor for necrosis, but bilateral embolization has played a significant role as well.

However, in some cases non-selective and/or bilateral embolization is required to be performed. Bilateral IIA embolization allows us to effectively manage unspecified bleeding in PFs (17). If there is no appropriate response to superselective embolization and AG revealed multiple sources of bleeding, bilateral embolization should be performed as well (9).

The continuous or newly occurred hemorrhages are the indications for re-embolization (9, 11, 18, 19). Bleeding may originate from the same or from another source as well. Gourlay D. et al. (18) performed AG in 556 PFs patients, 42 of them (7.5%) required repeated AG due to suspected reoccurrence of bleeding. Repeated

AG identified new sources of bleeding (68%), hemorrhages from the previously embolized area (18%), and both (14%). Fang J.F. et al. (19) embolized 140 patients, and in 26 cases (18.6%) re-embolization after primary super-selective embolization was required.

Mortality in patients with vascular injury after PFs is primarily associated with the baseline severity of the subjects condition and to a lesser extent with complications after embolization and continuous bleeding. In our study 12 patients had no recurrent hemorrhages, complications after embolization, and 2 lethal outcomes were not related to embolization.

Stent grafts are used in trauma of the main vessels (20-24) including iatrogenic damage.

Lagana D. et al. (20) implanted stent-grafts in 13 patients. EIA was ruptured in 11 patients, and CIA – in 2 subjects (6 traumatic ruptures and 7 iatrogenic ruptures). Technical success was achieved in all cases. Mean follow-up was 22.3 months, the patency of stent-grafts was 92.3%.

Trellopoulos G. et al. (21) used endovascular treatment options in 18 patients (half of them had pelvic arterial injuries). Stent-grafting and embolization was successfully performed in 12 and 4 patients, respectively. Three (17%) patients died. At Month 6 and Month 12 no complications related to stent-grafting were observed in 71.4% and 65.6% of the patients, respectively, and the patency rates of the stent-grafts were 91.7% and 81.8%, respectively.

Fernandez J.D. et al. (22) described ruptures of the iliac arteries caused by endovascular stent grafting of the aorta in 17 patients (18 arteries). Implantation of the stent-grafts made it possible to manage 17 ruptures in 16 patients.

Canaud L. et al. (23) implanted various types of stent-grafts in 7 patients with damaged CIA (6 cases) or aorta (1 case) after a lumbar spine surgery. The rupture was closed in all cases.

E.P. Kokhan et al. (24) implanted Jostent-graft to close a fistula between the EIA and the iliac vein which developed after a gunshot wound.

In both cases stent-grafts allowed to completely exclude the false aneurysms from the blood flow.

Conclusion

The arterial injury after pelvic fractures or stab wounds accompanied by bleeding and instable hemodynamics is a severe condition with high mortality rate. The main source of bleeding is IIA branches, but 2–3 arteries may be damaged. Embolization can stop the bleeding. Selective embolization should be used, if possible, otherwise, IIA embolization should be applied, and the benefits from embolization and the possibility of complications should be assessed. In case of the injured main arteries, the stent-grafting is a perspective treatment option allowing us to exclude the source of bleeding (the false aneurysm) from the blood flow. The minimally invasive endovascular methods allow us to stop the bleeding in extremely severely injured subjects and, in some cases, can be used as an alternative to reconstructive vascular surgery.

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Complications During and at Various Follow-up After Inferior Vena Cava Filters Implantation. Indications for inferior Vena Cava Filters Retrieval (Literature Review)

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Inferior vena cava filters are widely used for prevention of pulmonary embolism, their high efficacy has been demonstrated worldwide. Many types of inferior vena cava filters have been developed, and all types of them cause complications. Complications can vary: local complications at the puncture site, malposition of the inferior vena cava filter, failed deployment, dislocation, perforation of the inferior vena cava wall and adjacent organs, fracture of the inferior vena cava filter and its parts, inclination of the filter by more than 15° to the long axis of the inferior vena cava, invasion of the filter parts into the inferior vena cava wall, thrombosis of the filter and inferior vena cava, recurrent thromboembolism, microbial colonization of the inferior vena cava filter.

The objective of this review was to demonstrate the current status of the issue: the desire to use this highly effective method and to avoid related complications. In the recent years, the inferior vena cava filters which can then be removed from the inferior vena cava have become widely used. Literature data show that the removal of inferior vena cava filters as soon as they are no longer needed is optimal.

Keywords: *inferior vena cava filter, complications, inferior vena cava filter retrieval.*

According to the summary statistics of Angel L.F. et al. (1), based on 37 publications involving 6834 patients, inferior vena cava (IVC) filters are effective prevention option for pulmonary embolism (PE). The incidence of PE after IVC filter implantation constituted 1.7%.

Complications are observed for all types of IVC filters and may be associated with implantation of IVC filter; they may occur while IVC filter is in the inferior vena cava or when it is removed. The retrievable IVC filters protect against PE and allow us to avoid IVC filter-related complications (2).

According to the British Society of Interventional Radiology (BSIR) registry, implantation of IVC filter is a low-risk procedure; the number of major complications constituted < 0.5% (3).

1. Local complications related to implantation of the IVC filter. The incidence of hematomas at the puncture site ranges from 1% to 4.1% (4–6). Implantation of the IVC filters via transfemoral access is preferred by 84% of physicians (7).

2. Malposition. Rosenthal D. et al. (4) implanted 94 IVC filters under the US control, and in 3 cases (3.2%) the IVC filters were placed in the right iliac vein which required these to be removed and re-implanted.

3. Failed deployment, torsion of the IVC filter pedicles during implantation. Smouse H.B. et al. (8) reported 2 cases (1.6%) of failed deployment of a Crux IVC filter. Kohi M.P. et al. (9) described torsion of the ALN IVC filter legs immediately after its deployment; IVC filter was retrieved.

4. IVC filter dislocation. Wang W. et al. (10) registered that a Celect IVC filter was displaced by more than 2 cm in the IVC (mean 2.43 ± 0.12 cm) in 21 out of 534 patients (3.9%) including 12 and 9 patients with cranial and caudal displacements, respectively. Hoffer E.K. et al. (11) revealed the migration of a Gunther Tulip IVC filter by more than 2 cm in 12.5% of the cases (in 53 out of 369 patients). The dislocation of inclined IVC filters (2.2%) was observed more often if the filter was implanted in the IVC for more than 50 days (12). IVC filter migration was observed in 1.3–6% of the patients (5.13–15).

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The dislocated IVC filter can end up in the renal vein (16), right atrium (7), right ventricle (17, 18) and cause their perforation.

Wu A. et al. (19) gathered literature data on 38 cases of IVC filter dislocation after the "blind" placement of the central venous catheter via the J-wire. 18 IVC filters dislocated to the heart and the central venous structures.

5. Perforation of the IVC wall and various organs. Jia Z. et al. (20) analyzed 88 clinical trials and 112 clinical observations covering the period from 1970 to 2014, summarizing the data obtained from 9002 patients who were implanted 15 various types of IVC filters. Perforation was reported in 1699 out of 9002 patients (19%) including 322 cases out of 1699 subjects (19%) with involvement of different organs or structures. Some patients (8%) had symptoms related to perforation (the most commonly, pain); perforation was asymptomatic in 45% of patients and 47% of patients had unknown symptoms. Major complications were observed in 83 patients (5%). 63 patients required surgical retrieval of the IVC filter, 11 subjects needed endovascular stenting or embolization; permanent IVC filters were removed using endovascular approach in 4 subjects; 4 patients underwent percutaneous nephrostomy or ureteral stenting. 2 lethal outcomes were reported in 2 observations. In total, 12 patients required removal of the IVC filter or any other interventions to eliminate the complications caused by perforation.

Analysis of CT results obtained from the patients and performed for reasons often unrelated to the IVC filter, determined a very high incidence of the IVC wall perforation.

According to Lee J.K. et al. (21), IVC wall was penetrated in 87.6% of the cases: significant perforation was observed in 57.8% of the cases; asymptomatic vertebral erosion and aortic wall perforation occurred in 4.4% of the cases. The risk of perforation was higher if the IVC filter stayed over 20 days and the IVC diameter was < 24.2 mm.

Wood E.A. et al. (22) collected the data on 391 IVC wall perforations after 3311 IVC filter implantations (12%). The adjacent organs were involved in 117 patients, and the most commonly affected organs were aorta (43 cases) and small intestine (36 cases).

Olorunsola O.G. et al. (23) on the CT scans determined IVC wall penetration with at least one IVC pedicle in 17% of the cases within 1–447 days after implantation. The rate of perforation increased over time. Hoffer E.K. et al. (11) found asymptomatic perforation in 53 out of 122 patients (43.4%) who had CT scans performed within 757 days (on average).

Durack J.C. et al. (24) on CT scans detected the IVC wall perforation by at least one structure of the IVC filter in 86% of patients. After Day 71 erforation was always observed often as a progressive process.

Zhou D. et al. (25) performed CT in 265 patients within the time period from 0 to 1592 days after Celect inverior vena cava filter implantation. The rates of perforation were 39% and 80% on Day 30 and Day 90, respectively. Mean number of structures perforating the IVC wall constituted 1.8 and 2.1 on Day 30 and Day 90, respectively. Perforation in the various structures and organs occurred in 35 of 265 patients (13.2%): duodenum (22 cases), aorta (9 cases), lumbar muscles (4 cases), vertebral bodies (3 cases), pancreas (2 cases), adrenal gland, liver, right kidney, lymph node and diaphragm (1 case each) (10 patients had penetrations in 2 structures or organs). The majority of perforations was asymptomatic.

Bos A. et al. (26) performed CT scanning in 193 patients after Celect IVC filter implantation. IVC wall was perforated by more than 3 mm in 55 patients (28.5%). The time of the IVC filter stay in the IVC exceeding 100 days was associated with perforation. Age, gender, history of PE did not affect the perforation rate. CT scanning demonstrated low rate of local complications after the perforation. However, McLoney E.D. et al. (27) noted a higher rate of perforation in women (45.5%) as compared to men (30.8%) and cancer patients (29.9%).

Malgor R.D. et al. (28) analyzed 21 duodenal perforations caused by the IVC filter. Abdominal pain and bleeding were observed in 11 and 5 patients, respectively. IVC filters were removed via laparotomy.

Since several organs may be simultaneously perforated, Georg Y. et al. (29) described a case when all 6 IVC filter pedicles perforated the IVC and surrounding structures: vertebra, transverse colon, aorta, duodenum, psoas muscles.

6. Fracture and displacement of the filter parts. The fracture of the IVC filter parts can be caused by the metal fatigue (30).

Vijay K. et al. (31) detected the IVC filter fracture (Recovery, G2, and G2 Express) in 63 out of 548 patients (12%) with rate increasing over time. Distal embolization with parts of the fractured IVC filter constituted 13%.

Nicholson W. et al. (32) detected the fracture of at least one IVC filter pedicle in 13 out of

80 patients (16%). At least 1 element of the Bard Recovery IVC filter was chipped and resulted in embolism in 7 out of 28 patients including 5 patients in whom at least 1 part fragment ended up in the heart. Three patients developed life-threatening ventricular tachycardia and/or cardiac tamponade with 1 fatal outcome. Bard G2 IVC filter was fractured in 6 out of 52 patients; asymptomatic embolization of the internal organ arteries with IVC filter fragments was detected in 2 patients.

Dinglasan L.A. et al. (32) reported 3 patients in whom chipped fragments of the IVC filter were incorporated in the right ventricle, IVC wall, and the extravascular space. Oh J.C. et al. (34) detected the fractured IVC filter in 12.5% of the cases on the CT scan.

An T. et al. (35) examined 684 patients with G2 IVC filters. 16 IVC filter pedicles (1.9%) were fractured in 13 patients within 5.5–76.5 months. The displaced IVC filter fragments were detected in the pulmonary artery (4 cases), right ventricle (2 cases), pericardium, iliac vein, and kidney (1 case each). The broken off parts remained near the IVC filter in 4 patients; the displaced IVC filter parts could not be detected in 3 patients. The displacement of the IVC filter parts was asymptomatic.

Tam M.D. et al (36) detected 26 fractured IVC filter pedicles in 20 out of 363 patients. The chipped fragments migrated in the pulmonary arteries in 8 cases, in the iliac or femoral veins in 7 cases and to the, right ventricle and renal vein in 1 case each. In 7 observations to the broken fragments, in one case they behind close to the IVC filter.

Kalayakunta J.K. et al. (37) described a case of pericardiac tamponade caused by embolism with the broken element. Other authors also described the fracture and of the IVC filter parts (7, 11, 27, 30, 38).

7. Inclination of the filter by more than 15 degrees along the long axis of the IVC exceeding 15° can cause problems during the IVC filter removal by making the retrieval more complex (39) and may result in expansion of the IVC filter top into the IVC wall. The success of IVC filter removal directly depends on the filter inclination (40). The significant IVC filter inclination can be observed in 8.9 24% of the cases (41, 42).

8. Expansion of the IVC filter parts into the IVC wall. If the IVC filter is inclined and its top is pressed into the IVC wall, intimal hyperplasia develops resulting in incorporation of the top which makes it difficult for the removal. OptEase IVC filter is recommended to be placed in the IVC for a relatively short time prior to its removal due to intensive contact between the IVC filter side parts and the IVC wall and its invasion (43). Endothelial adhesion and invasion of the IVC filter parts are observed in 4.9%-51.1% of the cases (12, 15, 21).

8. IVC filter/IVC thrombosis. IVC thrombosis after the IVC filter implantation was noted in 1–7.2% of the cases (5, 8, 12–15, 39, 44), and it is often asymptomatic.

V.I. Prokubovsky et al. (45): reported that IVC filter was not retrieved due to thrombosis (8/68 patients) and embolism (8/68 patients). I.I. Zatevakhin et al. (46) reported the IVC embolism in 9.3% of the cases, chronic IVC occlusion – in 13.9%, total IVC occlusion with IVC syndrome was diagnosed in 24.1% of the patients with thrombotic lesions below the level of the renal veins confluence. Oh J.C. et al. (46) observed IVC stenosis in 4.7% of the cases.

9. PE after the IVC filter implantation. Sarosiek S. et al. (47) registered 25 cases of PE in 952 patients when the filter was present in the IVC. Smoot R.L. et al. (48) diagnosed PE in 3% of the patients when the filter was placed in the IVC and in 1% of the patients after the IVC filter retrieval. Hoffer E.K. et al. (11) detected new or recurrent PE in 3.3% of the patients. The incidence of PE constituted 1.5–12.7% (5, 8, 12, 13, 26). I.I. Zatevakhin et al. (46) observed a repeated PE in the long-term period in 5.2% of the cases (out of 266 patients).

10. The incidence of repeated or newly diagnosed deep vein thrombosis of the lower extremities and the pelvis was 3.8–55% (5, 6, 8, 11, 12, 15, 44, 48). According to Janjua M. et al. (14), new deep vein thrombosis was registered in 4.2% of the cases and new thrombosis + PE – in 0.7% of the cases. According to the British Society of Interventional Radiology registry, new deep vein thrombosis of the lower extremities and/or IVC was observed in 88 out of 1434 patients (3).

11. Infection and microbial colonization. Rottensteich A. et al. (49) provided data confirming the presence of infection in the IVC filter in 3 patients. Ferraro F. et al. (15) implanted 68 IVC filters; microbial colonization with no clinical signs of infection was detected in 1% of the cases.

The number of complications increases with a prolonged presence of the filter in the IVC.

Janjua M. et al. (14) detected complications in 12 out of 144 patients (8.3%), half of the complications developed beyond Month 3.

Ho K.M. et al. (12) consider that invasion of the filter into the IVC wall (4.9%), IVC thrombosis (4.0%), and displacement of the inclined IVC filter (2.2%) were more frequently observed if the filter stayed for more than 50 days.

The possibility of complications necessitates the use of retrievable IVS filters.

According to the summary statistics of Angel L.F. et al. (1), the rate of IVC filter retrieval is relatively low (34%), often the retrievable IVS filters become permanent. In the USA, the rate of IVC filter removal ranges from 11% to 70% (50).

The American Association for the Surgery of Trauma encourages to increase the IVC filter retrieval rate which constitutes 22%; after the registry of the patients was established, the retrieval rate increased from 15.5% to 31.5% (51).

Different authors report various timing in filter removal time framework, different number of attempts and various rate of successful removals.

Mission J.F. et al (52) planned to remove the retrievable IVC filter after implantation only in 30.4% of the cases. The factors affecting the removal rate are as follows: a history of cancer, the necessity of the further intake of anticoagulants. There were no contraindications for IVC filter removal in 21.6% of the patients who were not further planned for IVC filter retrieval. The attempts to remove the IVC filters in 62 patients were unsuccessful in 25.8% of the cases.

Lagana D. et al. (40) retrieved 26 out of 201 IVC filters within the period from 180 to 1155 days. The indications for retrieval included: no contraindications for anticoagulation therapy, no PE and blood clots in the iliac veins and IVC. From the technical point of view, IVC filter removal is more difficult than its implantation, the rate of failed removal is directly proportional to the IVC filter inclination.

Siracuse J.J. et al. (53) implanted 605 retrievable IVC filters and removed 25% of them. The predictors for failed retrieval were: age over 80 y.o., acute bleeding, cancer, history of PE and/or venous thromboembolism.

Geisbüsch P. et al. (54) removed IVC filters in 53% of the patients. The retrieval rate was lower in patients older than 80 y.o. and in subjects with malignancies. The attempts to retrieve the IVC filter failed (7%) when the filter was implanted in the IVC for over 90 days.

Oh J.C. et al. (34) removed IVC filters in 89.1% of the patients, the attempts to retrieve them in other patients were unsuccessful because the top or the pedicles of the filter were incorporated into the IVC wall. The authors consider that perforation is not a contraindication for IVC filter removal.

Avgerinos E.D. et al. (39) implanted retrievable IVC filters in 401 patients; the attempt to remove filters was made in 259 patients and 237 IVC filters were retrieved (59.1%). Eleven IVC filters (4.2%) were left due to filter thrombosis, and the attempts to retrieve the filter were unsuccessful in 11 patients (4.2%). It was difficult to remove 38 IVC filters. The predictors of failed removal attempts included prolonged duration of the IVC filter stay (96.9 ± 111.9 versus 29.5 ± 25,1 days in case of successful retrieval) and embedment in the IVC wall. The predictors for difficult removal were prolonged tine when the filter is in the IVC (51.1 ± 69.8 days versus 29.1 ± 24.5 days), IVC filter inclination, and embedment of the filter to the IVC wall. The retrieval can be difficult or it can fail if the duration of filter staying in the IVC exceeds 50 and 90 days, respectively, and when the top of the IVC filter is embedded in the IVC wall. The inclination of the IVC filter increases the difficulty of retrieval but not the failure rate.

Durack J.C. et al. (24) attempted to remove the IVC filters in 24% of the cases (12/50) and these attempts were successful in 92% of the cases (11/12). The authors recommend to remove IVC filters as soon as possible after indications for their implantation no longer exist.

Lee M.J. et al. (55) have successfully retrieved the IVC filters in 576 out of 628 patients (92%), mean time from the IVC filter implantation to removal was 90 days. Mean time to successful removal was 85 days, and the mean time in unsuccessful attempts was 145 days.

Peterson E.A. et al. (50) attempted to remove IVC filters in 165 out of 275 patients (60%), and the attempts were successful in 146 patients.

Bass A.R. et al. (56) retrieved IVC filters in 40% of the patients in 5.1 months on average; complications related to removal were observed in 11% of the cases and the attempts to remove the IVC filters failed in 10% of the cases%.

According to the British Society of Interventional Radiology registry, the attempts to remove IVC filters were made in 78% of the cases for retrievable IVC filters; the rate of technical success was 83% and higher if the time of the filter stay in the IVC did not exceed 9 weeks (3).

IVC filter can be removed after prolonged staying in the IVC, so Hull J.E. et al. (38) retrieved 12 IVC filters with a mean duration of stay of 1021 days (119–1242 ± 134); however, the IVC filter pedicles were fractured in 8 cases during the removal.

According to Vijay K. et al. (31), the rates of successful removal of non-fractured IVC filters and IVC filters with chipped parts were 98.4% and 53.4%, respectively. Veerapong J. et al. (57) were able to remove IVC filter dislocated into the right ventricle via trans-jugular access.

In difficult cases, additional equipment and techniques are used for IVC filter retrieval. Thus, Ryu R.K. et al. (41) used additional techniques in 5.4% of the cases in Celect IVC filters and in 18.3% of the cases in Option IVC filters.

Staropoulos S.W. et al. (58) using endobronchial forceps removed 109 out of 114 IVC filters (96%) with the top inclined and embedded in the IVC wall. IVC filters were staying in the IVC, on average, for 465 days (31–2976 days). There were three minor and one major complications without sequelae.

Van Ha T.G. et al. (43) removed OptEase IVC filter without complications in 3 patients using rigid endobronchial forceps and loop-snares.

The difficulties arise when broken IVC filters are retrieved. Dinglasan L.A. et al. (33) removed 148 IVC filters 15 of which were broken. The main part of the IVC filters (in all cases) and their fragments (in 12 cases) were removed using endobronchial forceps and loops. A small defect in the IVC was detected in 5 of 15 cases.

Kuo W.T. et al. (59) developed a method for removal of embedded IVC filter using 308-nm xenon chloride excimer laser for circular ablation of fibrous tissues, separation of the IVC filter from the IVC wall; then, IVC filter was removed. The indications for IVC filter removal were symptomatic filter-related IVC thrombosis, chronic IVC occlusion, pain caused by retroperitoneal or intestinal perforation. This method was successful in 98 out of 100 patients with 8 different types of IVC filters present in the IVC from 37 to 6,663 days.

Conclusion

IVC filter is an effective option to prevent PE, however, all types of IVC filters cause complications. The most common complications are IVC wall perforation with filter structures, IVC filter dislocation, and fracture of the IVC filter parts. The application of IVC filters which can be removed as soon as they are no longer needed is optimal. The majority of complications can be prevented if IVC filter is retrieved during the early period.

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4th Annual International Course "Modern Trends in the Treatment of STEMI – from Guidelines to Daily Practice" (MOSCOW-STEMI)

The 4th Annual International Course "Modern Trends in the Treatment of STEMI – from Guidelines to Daily Practice" was held in Moscow World Trade Center on October 5–7, 2016. The Course was dedicated to the 20th anniversary of Moscow City Center of interventional Cardioangiology. The program included six sessions with lectures, presentations and live case demonstrations of endovascular procedures in patients with acute coronary syndrome, as well as one satellite symposium. The leading international manufacturers exhibited the samples of medical equipment and expandable materials.

Russian manufacturer of the products for interventional procedures – Angioline Interventional Devices Ltd – held its satellite symposium "Use of Calypso Stent in Real Clinical Practice (long-term follow-up, evaluation of the effectiveness and the safety" on October 5th. The main topic of the symposium was the discussion of the results of the use of drug-eluting stent Calypso in everyday clinical practice. The symposium was chaired by Professor Avtandil Babunashvili. Many well-known experts from various regions of Russia took part in its work. They discussed the problems of the effectiveness of Calypso, the short- and long-term clinical follow-up of patients with various forms of coronary heart disease, presented interesting clinical cases. Active discussions concerned different aspects of the use of drug-eluting stents in the management of patients with coronary heart disease. The specialists confirmed their interest in the products made in Russia.

In accordance with the tradition, the leading Russian and foreign cardiologists took part

Opening Ceremony of the Course. Welcome address by David Iosseliani.

The audience

The panel of the Course. Left to right: Alexander Osiev, Cindy Grines, Anthony DeMaria, Andrejs Erglis, Christoph Naber. In the stands – David Iosseliani

in the work of the Course. The opening remarks were made by the Chairman of the Organizing Committee, the Director of Moscow City Center of Interventional Cardioangiology, Corresponding member of Russian Academy of Sciences, Professor David Iosseliani. The President of Russian Society of Interventional Cardioangiology Professor Alexander Osiev greeted the audience. The attendees received welcoming addresses from the Chairman of the Government of the Russian Federation Dmitry Medvedev, the Minister of Healthcare of the RF Veronica Skvortsova, the Chairman of the Executive Committee – the Executive Secretary of CIS Serguey Lebedev, the assistant of the President of the RF Academician Serguey Glaziev and other eminent persons. World-wide known experts – Cindy Grines (USA), Anthony DeMaria

Flavio Ribicini

Cindy Grines

Richard Conti

(USA), Andrejs Erglis (Latvia), Christoph Naber (Germany), Richard Conti (USA), Flavio Ribicini (Italy), Marie-Claude Morice (France), Florim Cuculi (Switzerland), as well as many reputed Russian specialists participated in the work of the Course. In total, 475 attendees were registered, who came from different regions – Moscow and the Moscow region, St.Petersburg, Oriol, Vladimir, Krasnodar, Ulianovsk, Grozny, Perm, Riazan, Magnitogorsk, Kaluga, Kazan, Penza, Yekaterinburg, etc.

During the first day of the Course a great interest was provoked by the lecture of Dr. C. Grines (Detroit, USA) covering the problem of the state of stents in the infarct-related artery (IRA) in the long-term follow-up. Dr. Grimes presented the results of major randomized trials concerning the various generations of the coronary stents. It is important to note the lecture of Dr. F. Ribicini (Verona, Italy), who spoke of intravascular imaging in patients with acute coronary syndrome. The lecturer presented all the routine methods of intravascular imaging used in the practice of a modern cath. lab, described in details the advantages and the drawbacks of each technique, particularly, in the context of acute myocardial infarction. Dr. Ribicini provided several interesting clinical examples illustrating the capabilities of the methods of intravascular imaging for the optimization of the tactics of interventions in patients with myocardial infarction. Between the lectures the audience watched a live case of endovascular procedure performed in Moscow City Center of Interventional Cardioangiology in a 79-years-old male with AMI. The operating team was headed by Drs. Ilya Kovalchuk and Dmitry Kurtasov. The Chairpersons and the attendees had the opportunity for remote discussion of the case, to ask questions, to share their experience, to give their recommendations. The patient underwent coronary angiography revealing the left-type coronary circulation, a critical extended stenosis of the circumflex branch of the left coronary artery (CxB LCA), as well as a chronic occlusion of the LAD. After panel discussion with the audience and the Chairpersons it was decided to perform the stenting of the affected segment of the CxB LCA supplemented by IVUS. The attempt of recanalization of the chronically occluded LAD failed. The live case provoked an active interest of the audience towards this format of conference.

An original and mostly correct position relating to the management of patients with non-STEMI was offered by the eminent American cardiologist Richard Conti (Gainesville, USA). He emphasized the necessity and the importance of a common approach to the tactics of treatment of AMI regardless of the presence or the absence of ECG changes indicating the STEMI or non-STEMI. This lecture was followed by an active and interesting discussion. Dr. F. Cuculi (Luzern, Switzerland) who has a large experience with the clinical use of bioresorbable scaffolds, reported the results of these scaffolds use in patients with AMI. Cited clinical cases illustrated the advantages and the drawbacks of bioresorbable scaffolds, that still are not fully studied in all the aspects and raise a lot of questions. In particular, it concerns the use of bioresorbable scaffolds in patients with acute coronary syndrome. The second live case from the cath.lab – a successful stenting performed in a patient with acute coronary syndrome and multivessel coronary disease – afforded ground for a vivid interesting discussion. The team headed by D.Kurtsaov


Marie-Claude Morice


Anthony DeMaria


Andrejs Erglis

and I. Kovalchuk used optical coherence tomography (OCT) and fractional flow reserve (FFR) for the diagnosis and during the intervention. OCT was used for the evaluation of eventual stent apposition in the infarct-related artery, while the degree of stenosis in other coronary arteries was assessed with FFR. The attendees could evaluate the diagnostic and the therapeutic techniques, share their own experience as well as discuss the particularities of various manipulations.

The PCR-branded session "STEMI in multivessel disease" was chaired by A. Erglis (Riga, Latvia) and C. Naber (Essen, Germany). Russian doctors Oleg Sukhorukov and Evgueny Merkulov acted as moderators. This was an interactive session: the attendees discussed a pre-recorded case with a detailed presentation of all stages of management of AMI in an elderly female in a London hospital. Successive stages and tactics of decision making and treatment of this pathology were shown from the ambulance up to the intensive care unit. During the interactive session, at the wish of the attendees, the film could be stopped, the episodes could be replayed, and everyone could make remarks, give recommendations and express wishes, share one's opinion or tell examples from the practice. The session turned out to be fruitful and educative, the young specialists had the opportunity to contact with experienced colleagues and received their recommendations and instructions.

On the second day, the first session started with a live case from the cath. Lab of Moscow City Center of Interventional Cardioamgiology. The team of interventionists headed by Djamil Asadov and Dmitry Kurtasov performed a procedure in a 84-years-old female with complex and rare form of multivessel coronary disease with multiple aneurismal dilatations of the vessels. This ambiguous and rare case provoked a vivid discussion concerning the etiology of such changes of the coronary arteries and the pathogenesis and the causes of acute ischemia, as well as the tactics of treatment. Some experts suggested to abstain from any endovascular or surgical interventions. Taking into account the stable patient's condition and rather severe changes, it was decided to perform coronary stenting. As a result, multiple stenting was carried out under the guidance of OCT, with good immediate results. During the same session, the well-known French cardiologist M.-C. Morice presented a lecture on the tactics of reperfusion in patients with non Q-wave MI. The eminent American Professor A. DeMaria shared his experience with the management of myocardial infarction and also presented a lecture on the follow-up of STEMI patients after endovascular reperfusion of IRA. An interesting and rather poorly studied subject of combined lesion of the treatment of patients with acute coronary syndrome and pre-existing severe aortic valve disease was highlighted in the lecture of professor A. Erglis (Riga, Latvia). It is known that aortic stenosis is a severe structural heart pathology often concomitant with acute myocardial infarction and negatively influencing the long-term prognosis. To date, there is no commonly adopted tactics of the treatment of these two associated pathologies. Just the first steps are being undertaken in this direction. While discussing the lecture, some attendees suggested the necessity of simultaneous procedures of stenting of the IRA and balloon angioplasty of the aortic valve in such patients. However, it is necessary to continue the search

Live case from the cathlab

of the most optimal tactics for the treatment of severe concomitant pathology.

In accordance with the tradition, Dr. Tamara Djordjikia presented the long-term clinical and angiographic follow-up of patients who had been treated during the 3rd Course, and this lecture was met enthusiastically. The patients were present in the audience, and the opportunity to ask them various questions added a special originality to the session.

The seminar "Thrilling problems of out-patient cardiology – prospects of examination and rehabilitation of a coronary patient" was held within the frames of the Course by two Pirogov University clinics – the clinic of conservative endovascular and surgical cardioangiology and the clinic of general medical practice.

The formal meeting dedicated to the 20th anniversary of the foundation of Moscow City Center of Interventional Cardioangiology was held after the end of the Course. The Center's Director, Corresponding member of the Russian Academy of Sciences, Professor David Iosseliani gave an account of the Center, described in details the history of its foundation and development, told about people who stood at the origins of the Center. The attendees commemorated the employees of the Center who had died before their time. A special place in the talk of David Iosseliani was assigned to the achievements of the Center in the development and practical introduction of new techniques of diagnosis and treatment of cardiovascular diseases. The attendees congratulated the staff of the center, presented their wishes of further fruitful work in the most important field – the preservation of people's health.