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Contents

Alcohol Septal Ablation for Treatment of Hypertrophic Obstructive Cardiomyopathy

Haran BURRI, Ulrich SIGWART

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Introduction

About 25% of patients with hypertrophic cardiomyopathy (HCM) have left ventricular outflow obstruction under resting conditions (1, 2). Medical therapy with negative inotropic drugs may alleviate symptoms in many of these patients; however, a certain number may remain refractory to drug therapy. This subset of patients may represent 5-10% of the total population with this disease (3). Surgical myectomy has been shown to reduce outflow gradients, and has been practiced since the 1960's. Some patients may, however, not be regarded as favorable candidates for this major intervention because of advanced age, concomitant medical conditions or previous cardiac surgery (4). In 1994, a catheter treatment using absolute alcohol to induce a myocardial infarction localized to the interventricular septum has been introduced as an alternative to surgery. An alcohol-induced septal branch ablation procedure was first described as therapy for ventricular tachycardia (5). This technique was applied to HCM after noting clinical improvement in a patient with septal hypertrophy who suffered an anterior myocardial infarction, as well as the transient reduction in left ventricular outflow pressure gradients observed with temporary septal artery balloon occlusion. Since the first series of 3 patients reported in 1995 (6), there has been growing enthusiasm for this technique. During the first five years, over 800 cases had been performed (7), the number probably now being several thousand. Although initially confined to Europe and North America, this technique is now being practiced worldwide.

Patient selection

In addition to stable patients, those at high risk of surgical morbidity and mortality (including patients of advanced age or with comorbidities such as pulmonary or renal disease) may be evaluated for alcohol ablation. The criteria listed in table 1 may be used to select candidates.

Septal wall thickness should be i 18 mm, and the anatomy of the septal perforator branches should be adequate.

It has been a subject of debate whether patients with gradients that are present only by provocation benefit from alcohol ablation. A report compared patients in NYHA class III and IV with gradients of > 30 mm Hg at rest, to those who whose gradient was only present after an extrasystolic beat, and found that the hemodynamic and functional benefit was similar in both groups (8).

Little experience with alcohol ablation has been reported so far in patients with mid-ventricular obstruction, although this is technically feasible.

Surgical myectomy is preferable to ablation in patients with concomitant cardiac conditions requiring surgery such as extensive coronary artery disease or valvular disease, and morphological changes of the mitral valve and papillary muscles responsible for gradient formation or mitral regurgitation.

Table 1. Patient selection criteria for alcohol septal ablation

- NYHA or CCS class III or IV despite drug therapy with a resting gradient of i 30 mm Hg or i 60 mm Hg under stress (47)
- NYHA or CCS class II with a resting gradient of > 50 mm Hg or > 30 mm Hg at rest and i 100 mm Hg under stress (48).
- Symptoms due to left ventricular obstruction after having to discontinue medication due to side effects.
- Previous but hemodynamically unsuccessful surgical myectomy or pacemaker therapy.

Mechanisms of treatment efficacy

Alcohol ablation induces a well-demarcated subaortic necrosis, corresponding to approximately 10% of the left ventricle by PET and SPECT imaging (9-11). Despite the creation of a septal infarct, new Q-waves in the septal leads are rarely seen (12).

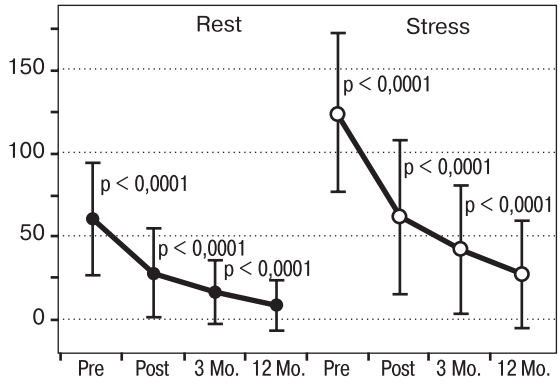

Figure 1. Acute effect of alcohol septal ablation with evolution of outflow gradient over time (reproduced, with permission, from ref-

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The left ventricular outflow tract (LVOT) gradient usually falls immediately after alcohol ablation, with a further fall in the gradient over the following months (fig. 1). The mechanisms of acute reductions in gradients have been studied by echocardiography. First, alcohol ablation induces a decrease in septal contraction, thus reducing subaortic narrowing in systole (13-15). Second, there appear to be global changes in left ventricular ejection, with a slower acceleration and a later peak ejection velocity (13). This may be due to a reduced septal contribution to left ventricular ejection. Alternatively, changes in electro-mechanical activation secondary to right bundle branch block or left anterior hemiblock may induce inhomogeneous left ventricular contraction.

The long-term relief in outflow obstruction is probably linked to LVOT remodeling with widening due to infarction necrosis and myocardial scar formation (13, 14). Furthermore, there appear to be geometrical changes in the left ventricle, resulting in a more parallel angle between ejection flow and the mitral valve, with less drag forces that lead to systolic anterior motion (13).

In addition to relief of LVOT obstruction, changes in diastolic function also seem to contribute to improve long-term hemodynamics resulting from alcohol ablation. This may be due to more favorable relaxation (16-18), as well as a reduction in left ventricular stiffness secondary to regression of hypertrophy (19-21) and a decrease in interstitial collagen (20)

Outflow obstruction relief results in higher aortic diastolic pressure along with a lower left ventricular

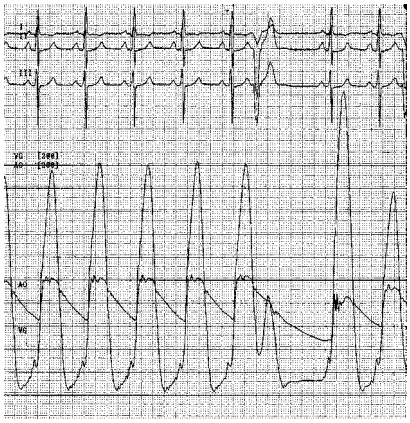

Figure 2. Hemodynamic monitoring showing a resting peak-to-peak gradient of 100 mm Hg, with a post-extrasystolic gradient of about 170 mm Hg.

end-diastolic pressure. This serves to increase coronary flow, thus decreasing ischemia which may participate in the patients' symptoms (16). Lastly, reductions in the severity of mitral regurgitation may contribute to clinical improvement (22).

The technique

A 5F pigtail catheter with side holes situated close to the tip introduced retrogradely in the left ventricle can be used to measure the pre-stenotic pressure. Many operators prefer this approach to the technique described initially whereby a Brockenbrough catheter is placed in the left ventricular inflow tract after a transseptal puncture (6). The post-stenotic pressure is measured via a 7-F guiding catheter (for example, Judkins L4, Cordis) placed in the ascending aorta. After having excluded a valvular gradient, the peak-to-peak intraventricular gradient should be measured at rest, during isoproterenol infusion, and after extrasystoles (fig. 2). A temporary pacing wire should be placed in the right ventricle to ensure backup pacing in the advent of AV block.

After having performed a left coronary angiogram (figure 3A), a balloon catheter is placed in the proximal segment of the first septal perforator over a 0,014-inch guidewire (fig. 3B). The balloon is then inflated and correct positioning verified by injecting contrast agent into the left coronary artery and then distally via the lumen of the balloon catheter using about 1cc of contrast dye (fig. 3C). Absence of retrograde leakage and the stability of balloon position (especially with shorter balloons) should be verified attentively. Furthermore, the extent of myocardium supplied by the septal branch and shunting of flow to non-targeted regions can also be analyzed, ideally using 2 different projections. The outflow gradient should be monitored continuously to check for a drop in the resting gradient by > 30 mm Hg or the post-extrasystolic gradient by > 50 mm Hg within 5 minutes of balloon occlusion. If these criteria are not met (as is the case in about 20% of patients) (19), the balloon catheter may be positioned in another septal branch. Occasionally, the culprit vessel may originate from an intermediate or diagonal branch (23).

Myocardial contrast echocardiography has proved to be extremely useful in targeting the culprit septal branch, increasing success rates despite a reduced infarct size, which in turn avoids complications (11, 23, 24). Before injecting alcohol, 1-2 ml of echo contrast (for example, Sonovue™, Levovist™, Optison™, Albunex™ etc) is injected via the inflated balloon catheter under transthoracic echography in the apical 4- and 5-chamber views. This serves to verify whether

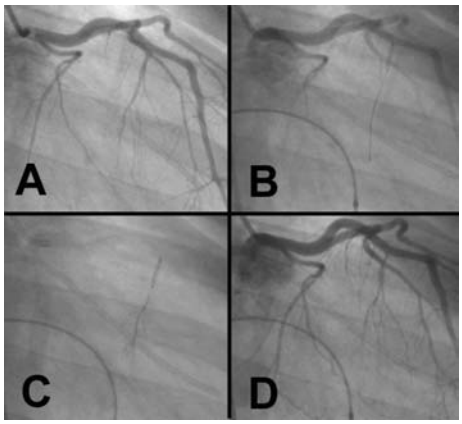

Figure 3. A. RAO angiogram of the left coronary artery. B. Balloon catheter inflated and positioned in the first septal branch over a 0,014" guidewire. C. Contrast dye is injected via the balloon catheter to confirm the absence of retrograde leakage D. Angiogram after alcohol injection. Note that the first septal branch is patent.

the opacified myocardium is adjacent to the region of maximal flow acceleration, and to withhold alcohol injection in case of a mismatch, such as for example if the right side of the interventricular septum is opacified (25). Furthermore, this technique also helps in delineating the infarct zone and to rule out retrograde leakage or involvement of myocardium distant from the expected target region (26) such as the ventricular free wall (11, 24) or papillary muscles (24, 27). Transcapillary passage of the echo contrast into the ventricles is usually observed during the injection. If echo contrast is not available, echocardiography may also be performed during regular contrast dye injection in the septal perforator via the occluded balloon catheter.

Once the septal perforator is considered suitable, 0,7-3 ml of 96% alcohol may be slowly injected through the inflated balloon catheter. The electrocardiogram should be monitored closely, and the injection aborted upon the development of atrioventricular block. There has been a tendency over the last years to reduce the amount of alcohol injected to a maximum of 2 cc (9, 19), which may help reduce complications. The balloon should be inflated for at least 5 minutes after alcohol injection. Left coronary angiography should be repeated after balloon deflation in order to confirm patency of the left anterior descending artery (fig. 3D). The target septal vessel may not necessarily be occluded, although flow is usually slowed down. Injection of alcohol results in a significant contrast effect that is easily visible by echocardiography (fig. 4B).

If the residual gradient after alcohol injection is > 30 mm Hg at rest, the balloon may be positioned more proximally or a shorter balloon used if branches of the septal perforator were occluded by the balloon during the first injection. Alternatively, a second septal perforator may be targeted using the same procedure as for the first branch. Most patients will only require one target perforator branch, especially since the advent of myocardial contrast echocardiography. A residual gradient of < 30 mm Hg is acceptable, as it has been shown that a further decrease in outflow gradient may be observed over the following months the due to ventricular remodeling (24, 28) (fig. 1) in about 50% of patients (29).

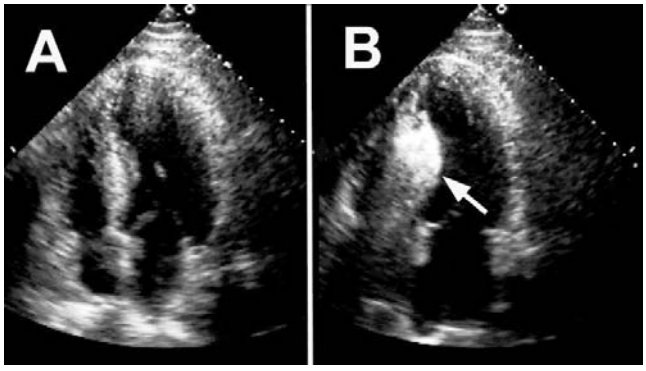

Figure 4. A. Apical 4-chamber echocardiogram showing the hypertrophied septum. B. After alcohol injection, the area of necrosis becomes echodense (arrow).

Following the procedure, patients should be observed in the coronary care unit for 24 hours, with removal of the temporary pacing wire at the end of this period in the absence of atrioventricular block. The patient may then be transferred to a telemetry unit for the remainder of the hospital stay.

Treatment efficacy

There is growing evidence to indicate that alcohol ablation is comparable to surgical myectomy with respect to hemodynamic and functional improvement (18, 30-32), although no randomized comparative studies exist to this date. Gradient reduction can be achieved acutely in about 90% of patients (22, 23, 33, 34). In a series of 241 patients, acute reductions in mean rest gradients from 72 to 20 mm Hg and mean post-extrasystolic gradients from 148 to 62 mm Hg were achieved (35).

Although very long-term follow-up data are still lacking, reports indicate maintenance of clinical and hemodynamic benefits for at least a year (19, 22, 33, 36, 37). In a series of 178 patients observed for 2-5 years (37), gradients at baseline compared to last follow-up were 60 ± 35 mm Hg versus 7±14 mm Hg ($p < 0,001$) at rest and 127 ± 50 mm Hg versus 20 ± 28 mm Hg ($p < 0,001$) with Valsalva. The outflow gradient may even decrease over time (23, 24, 28, 29), indicating a remodeling process (fig. 1). Functional class, exercise capacity and quality of life are also significantly improved over follow-up (22, 28, 33, 37-39). Redo procedures may sometimes be required due to recurring gradient and symptoms despite initial success, as was necessary in a series in 7 of 50 patients (22).

Risks of the procedure

Mortality associated with the procedure is low, ranging from 0 to 4%, which is comparable to that with surgical myectomy. In the registry from the German Society of Cardiology (34), of 242 patients, there were 3 (1,2%) in-hospital deaths. There are also reports of death due to stroke (33, 36), complete heart block (33, 36), dissection of the left anterior descending artery (22), and to right coronary artery thrombosis (22). A dreaded complication is retrograde leakage of alcohol into the left anterior descending artery, which may result in a massive infarct (40, 41). This complication is however extremely rare, and the importance of the different precautions mentioned previously to check for leakage before alcohol injection cannot be over-emphasized.

Spontaneous ventricular fibrillation and tachycardia has been reported to occur within 48 hours of the procedure (33, 38, 40). The most frequent complication of alcohol ablation however is transient or permanent complete atrioventricular block, which has been reported to occur in up to 70% of patients (23). The block is usually observed shortly after alcohol injection (but may even appear at 72 hours) (42) and is most often

transient. Complete heart block may resolve within the first 12 hours of alcohol ablation, and then recur within the following week, requiring pacemaker implantation (19). We and others (8, 43) implant a pacemaker if the block persists for > 48-72 hours, although with longer observation, atrioventricular conduction may recover in many patients. About 10-20% of patients ultimately require a pacemaker. In a recent series of 224 patients, the incidence of pacemaker implantation was 14% (43). Baseline conduction abnormalities (especially left bundle branch block) may increase the risk for complete heart block after ablation (10, 12, 43). Other factors found to be independently predictive of pacemaker implantation are female gender, bolus injection of ethanol, and injection into more than one septal artery (43). Use of myocardial contrast echography helps limit infarct size, and in one series reduced the need for permanent pacemaker implantation from 17% to 7% (23), which is still higher than the 2% incidence with surgical myectomy (31, 44).

Right bundle branch block may be observed in over half of the patients (12, 19, 45). This is not surprising, as the right bundle is a discrete structure that is vascularized by septal branches from the left anterior coronary artery in 90% of patients, whereas the left bundle is fan-like and receives a dual blood supply from perforator branches both the left anterior descending and posterior descending arteries. The left conduction system may nevertheless be involved, and new left anterior fascicular block is reported to appear in 11% of patients (12).

Alcohol ablation may result in loss of capture in patients implanted with a pacemaker if the ventricular lead is placed near the septum (46). It may be prudent to increase pacing to maximal output during the first days following the procedure in these patients.

There was no evidence for the creation of an arrhythmogenic substrate by alcohol ablation as assessed by serial electrophysiological studies before and after the procedure in a total of 78 patients in 2 different series (19, 33), and none of the published reports indicate an increase in incidence of ventricular arrhythmias or sudden death over follow-up.

Conclusion

Alcohol ablation is progressively replacing surgical myectomy as the first treatment of choice for drug-resistant obstructive HCM. Data indicate that procedural success is high, and comparable to that of surgery, with the advantage that it may be performed in patients in whom major surgery may be considered unsuitable. Benefits in comparison to myectomy also include shorter hospitalization, minimal pain, and avoidance of complications associated with surgery and cardiopulmonary bypass. Alcohol ablation has an important learning curve, with potentially serious complications, the most frequent of which is atrioventricular block requiring a pacemaker in 10-20% of patients. Although these rates are declining with continuing experience and with the advent of imaging techniques such as myocardial contrast echocardiography, the procedure should only be practiced by experienced operators and on carefully selected patients.

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In Search of the Vulnerable Plaque

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The pathogenesis of plaque rupture has been clearly described in recent literature as being primarily a consequence of inflammation (1). The formation of plaque occurs as a response to endothelial injury that first results in endothelial dysfunction. Subsequently, adhesion molecules form on the endothelium that recruit and facilitate migration of monocytes and T-cells into the vessel wall (2). Chemoattractant molecules generated by the endothelium, monocytes, and smooth muscle cells stimulate further cellular adhesion and infiltration of the injury zone (3). The endothelium, which normally has anticoagulant properties, becomes procoagulant and triggers platelet adherence (4). If the early inflammatory response does not succeed in neutralizing the offending agent, this cascade of pathophysiologic events will continue with smooth muscle cell migration and further T-cell and macrophage infiltration (5, 6). Eventually, the inflamed region will be inundated with lipid-laden macrophages (foam cells) that comprise the gelatinous, necrotic core of an advanced plaque. This highly thrombogenic «gruel» is tentatively sealed off from the circulation by a fibrous cap, but is prone to rupture and acute clot formation due to the eroding action of macrophage-released metalloproteinases and shear stress (7, 8).

As our understanding of this process unfolds, we must keep a particular question in mind: Is the inflammatory process confined to a single vulnerable plaque or is it a more widespread process in the coronary vasculature? If it is a focal process, then current attempts to seek and treat such lesions have merit. If it is indeed a widespread process, our approach must reflect that in the form of a systemic therapy. Recent literature seems to strongly support the latter (9, 10). Finally, is there room for both approaches?

The four main components that play a role in the risk of plaque rupture are (1) the size and consistency of the lipid core, (2) thickness and collagen content of the fibrous cap, (3) plaque neovascularization, and mainly (4) inflammation. The diagnostic tools developed thus far attempt to determine plaque stability based on assessing one or more of those characteristics.

Angiography. The risk of plaque rupture correlates only weakly with the degree of stenosis as determined by conventional angiography. This lack of ability to predict plaque stability based on lesion size is demonstrated in the Coronary Artery Surgery Study (CASS) which prospectively evaluated 2938 nonbypassed segments in 298 patients (11). Five year angiographic follow-up demonstrated that while individual severe stenoses (>80%) resulted in total occlusion with greater frequency than individual less severe lesions (<80%), most occlusions originated from the less severe stenoses.

Complex lesion morphology (ulceration, haziness, fissuring, filling defects) has long been thought to be an angiographic hallmark of plaque instability; but searching for such lesions angiographically is an insensitive means of discerning a priori which lesions are life threatening. There are several reasons why this is the case. First, due to the imaging resolution limitations of angiography, it is easy to underestimate the presence, severity, and complex architecture of lesions (12). Secondly, there is growing evidence that plaque instability is a widespread process (9, 10, 13-15). The appreciation of a complex plaque by angiography is associated with worse outcomes (9, 14), but, on the whole, it is an insensitive tool for anticipating plaque rupture. Consequently, there have been attempts to discover new diagnostic modalities to distinguish between stable and unstable lesions.

Thermal detection. Thermography is among the more promising invasive vulnerable plaque detecting modalities. Casscells and Willerson showed ex vivo that human carotid atherosclerotic plaques have temperature heterogeneity and that plaques with thinner caps and higher macrophage infiltration give off more heat (16). Later, Morteza Naghavi invented the ThermoBasket catheter and showed in vivo temperature heterogeneity in hypercholestrolemic dogs and Watanabe rabbits (17).

Recent studies have used a Microchip thermistor probe that has gold plated lead wires that change in resistance in response to temperature differences. This transducer is brought into contact with the endocoronary region of interest and attached at the other end of the catheter to an external processor that correlates voltage changes with temperature in a linear fashion between 33 and 43 °C (18).

Stefanadis et al. have observed a higher temperature in the plaques of patients with unstable angina (USA) and myocardial infarction than those with stable angina and controls (18). In this trial of 90 patients, there was a direct correlation between patient symptoms, CRP, and plaque temperature. A subsequent study by the same group measured 5 points along a single region of interest and calculated the DT (maximum plaque temperature — background temperature) (19). They demonstrated a correlation between thermal heterogeneity and outcomes. The DT was greater in pts with USA than stable angina (significant) and the trend was toward a higher DT in AMI pts (nonsignificant). Patients who suffered cardiac events during fol-

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low-up had a greater DT than those with an uncomplicated course [0,939 ± 0,49 vs. 0,428 ± 0,42 °C]. A threshold DT value above which the risk of an adverse outcome was significantly increased was 0,5 °C. The sensitivity for this cut-off point was 86% and specificity was 60%. The authors detected thermal heterogeneity among 5 points of interest along a single lesion in patients with USA or AMI. However, there was no comparison of DT between different lesions within the same patient — a critical point if the objective is to discriminate which plaques require intervention. Another potentially confounding factor is the observation by the same investigators that blood flow has a potential cooling effect on atherosclerotic plaques (20). This could result in the underestimation of plaque thermal heterogeneity of lesions in vessels with adequate flow compared to those that are more restrictive.

It is not clear why an unstable plaque would generate heat, but it is theorized that it is in some way related to inflammation. While thermography adds a new dimension to the diagnosis of plaque instability, it may prove impractical to implement in clinical practice. If indeed plaque vulnerability is a manifestation of pancoronary inflammation, such a state can be more simply and cost-effectively diagnosed by CRP, electrocardiography, cardiac enzymes, and a good old fashioned history. If thermography is to establish a role in interventional practice, it must provide cardiologists with the ability to anticipate which plaque(s) in an inflamed environment are most prone to rupture.

Angioscopy. Angioscopy is a technique that allows the cardiologist to directly visualize the coronary wall. The lipid core of unstable plaques is perceived as a yellow hue and thrombus is seen as a white or red substrate with a cottony or ragged contour adhering to the vessel lumen. A recent study investigated 58 coronary arteries containing 21 culprit lesions in 20 patients who suffered AMI (21). The investigators determined the prevalence of yellow plaques and thrombus in the coronary tree and compared infarct and non-infarct related arteries. While investigators detected yellow plaques in the culprit vessel, a mean of 3,2 yellow plaques were also seen in nonculprit segments. The investigators concede that while appreciating yellow plaque is a sign of atheromatous instability, patients with AMI have extensive disease and it is not currently possible to predict which ones are most vulnerable.

Expound on MRI. Other techniques. High-frequency ultrasound has been tested but currently lacks the needed sensitivity (22). As noninvasive imaging techniques such as MRI become more refined, we will see them elevated to a more prominent role in visualizing coronary anatomy. However, while MRI is already the preferred method for diagnosing ischemia at institutions where it is available, neither whole-body, nor intravascular MRI currently have the resolution to accurately localize coronary inflammation (23). Optical coherence tomography possesses a high resolving capability but its penetration depth is limited to 1-2 mm (24). Raman spectroscopy, electrical impedence measurement, and laser-induced fluorescence spectroscopy are also among the devices currently undergoing testing.

Widespread coronary inflammation. There is mounting evidence that the inflammatory process leading to plaque rupture is a systemic rather than focal process. Several studies have demonstrated multifocal plaque instability in patients with unstable angina or who have suffered acute myocardial infarctions (AMI). In an autopsy study of patients who died within 6 hours from an AMI, pathologists identified 115 separate thrombi in 74 coronary segments (13). A study of 253 AMI survivors demonstrated multiple complex coronary plaques in 39,5% (9). Several angiographic natural-history studies demonstrated that patients with unstable angina or AMI were observed to have a rapid progression of non-culprit complex as well as culprit lesions (14, 15).

An Italian study recently published in the New England Journal of Medicine sheds further light on this subject by quantifying neutrophil activation in the vasculature of cardiac patients (25). Neutrophils become activated after passing over an inflamed vascular bed. The degree of neutrophil activation can be measured by isolating the neutrophils from a blood sample and assaying the myeloperoxidase content. Negative values for myeloperoxidase content represent depletion of the enzyme due to neutrophil activation. Previous studies have detected a transcoronary depletion of neutrophil myeloperoxidase in unstable angina patients (26, 27).

In this study, samples of blood were drawn from the great cardiac vein, femoral vein, and aorta in 5 groups of patients: two groups of patients with unstable angina and stenosis in either the left anterior descending artery (24 pts) or right coronary artery (9 pts); 13 with chronic stable angina; 13 with variant angina and recurrent ischemia; and 6 controls. The great cardiac vein selectively drains blood from the left but not right coronary artery, thus permitting investigators to measure a difference in myeloperoxidase content between the culprit and nonculprit vessels — and thus detect an inflammatory state that may be localized to a specific region.

The neutrophil myeloperoxidase content of aortic blood was similar in both groups of patients with unstable angina and significantly lower than in the other three groups ($p < 0,05$). If inflammation had been localized to the stenotic region in patients with USA, patients with right sided lesions should not have an appreciable drop in myeloperoxidase content in blood samples from the great cardiac vein. Instead, it was noted that, independently of the site of the culprit lesion, the neutrophil myeloperoxidase content in blood from the great cardiac vein was significantly decreased in both groups of patients with unstable angina (-6,4 in those with a left coronary lesion and -6,6 in those with a right coronary lesion). It was not

decreased in patients with stable angina and multiple stenoses, patients with variant angina and recurrent ischemia, or controls (24). These findings suggest that inflammation was present equally in the RCA and LAD of patients with USA regardless of the location of the stenosis.

Further support for the above conclusion is found in an autopsy study conducted at the University of Rome. Spagnoli et al analyzed the degree of inflammatory cell infiltration in the coronary arteries of three groups of patients: those who suffered an AMI, those with an old MI, and those with no ischemic heart disease (28). This was the first postmortem study to address the question of whether activation of inflammatory cells, particularly T lymphocytes, is limited to only the culprit lesion, or instead, diffuse in the coronary circulation. Cell suspensions of enzymatically digested coronary arteries were stained for flow cytometry with CD3, CD68, alpha-smooth muscle actin, and human leukocyte antigen (HLA)-DR antibodies. They found that there was a greater number of inflammatory cells in the vessels of AMI patients than those of old MI and nonischemic patients. More importantly, there was diffuse T-cell activation in the whole coronary tree of the AMI group, not just in the culprit vessel. This manifestation of widespread inflammation was not appreciated in the other subjects.

In light of the above evidence, attempts to seek out unstable plaques with an interventional probing device may prove impractical. Thermography and angioscopy have the best documented capability to detect an inflamed state in the intracoronary vasculature and correlates well with CRP, patient symptoms, and even outcomes. However, since inflammation is most likely a widespread process, it is unclear what additional diagnostic and theraputic benefit these techniques offer above and beyond current modalities. CRP, a marker of systemic inflammation, has been demonstrated to be a highly significant independent risk factor for cardiac events. Compared to a $20 CRP assay, it would be difficult to convince a managed care provider to fund any of these expensive and/or invasive diagnostic techniques solely for the purpose of detecting inflammation.

Given the available data, our energies must focus on therapies that convert inflamed atherosclerotic disease to a quiescent state. The documented success of HMG-CoA reductase inhibitors, red wine, tightened glycemic control, abstinence from smoking, and aspirin strengthens our resolve to this end.

Beyond the Vulnerable Plaque. In order to better capture the large number of victims of cardiovascular disease who were apparently healthy and die suddenly without prior symptoms, several new concepts have been proposed that extend the scope of investigation beyond the plaque itself. Recent data suggests that, in addition to the vulnerable plaque, vulnerable blood (prone to thrombosis), and vulnerable myocardium (prone to fatal arrhythmia) may also play an important role in patient outcomes. Stemming from this belief that vulnerable plaques are not the only culprits for the development of acute coronary syndromes and sudden cardiac death, a consensus statement by a group of leading researchers in the field has sought to broaden the terminology from «vulnerable plaque» to «vulnerable patient» (29).

While still speculative, vulnerable blood may occur in conjunction with systemic inflammation as manifested by increased CRP and IL-6, or independently as a function of increased thrombogenicity and/or serum viscosity. Elevated whole blood viscosity has been shown to be an independent risk factor for cardiovascular disease. Vulnerable myocardium is due to an increased susceptibility of the myocardium to arrhythmia during acute ischemia that may be due not only to well know pathologies such as long-QT syndrome, but also due to decreased vagal tone. Many pre-clinical and clinical studies have demonstrated that sympathetic hyperactivity favors the genesis of life-threatening ventricular tachyarrhythmias, whereas vagal activation exerts an antiarrhythmic effect.

Due to the failure of traditional risk factor assessment models to predict CHD in 25-50% of patients, new screening tools are needed to identify the vulnerable patient. The above-described techniques for identifying vulnerable plaque tend to be expensive and/or invasive, and not readily applicable to an asymptomatic population. As more clinical data unfolds, new strategies will emerge to screen and treat the vulnerable patient.

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Merits and Limitations of Endomyocardial Biopsy in Cardiomyopaty and Chronic Heart Failure

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Key words. endomyocardial biopsy, clinical merit, cardiomyopathy, heart failure.

Background. Endomyocardial biopsy (EMB) is a safe technique to obtain sample of myocardial tissue. Only definite indications for EMB are monitoring of rejection or anthracyline toxicity. Clinical merit of EMB in management of another situations is less clear.

Aim. To analyze efficacy of EMB in the management of patients with congestive heart failure (CHF) due to cardiomyopathy.

Patients and methods. EMB was performed in 86 pts. (median of age 39 years, 20 female) with CHF. 68 patients had dilated cardiomyopathy (DCMP), 11 restrictive/constrictive myocardial dysfunction and in 7 was EMB indicated because of thickening of left ventricular wall of unknown etiology. EMB was performed from right ventricle using transjugular approach. 3,3 (1-6) samples were obtained in average.

Results. EMB gained diagnostic information in 25 (30%) of patients. In 16 pts. myocarditis, in 5 amyloidosis, in 3 hypertrophic cardiomyopathy, and in 1 eozinophylic myocarditis were found. EMB was diagnostic in 15 (22%) of pts. with DCMP, 6 (65%) of pts. with restrictive/constrictive pathophysiology and 5 (72%) of pts. with thickening of left ventricular wall. In seven cases only result of EMB had influence on management of patient.

Conclusion. Information from EMB only sporadically had impact on management of patient with CHF and cardiomyopathy. EMB is most useful in pts. with restrictive/constrictive pathophysiology and thickness of left ventricular wall of unknown origin.

Endomyocardial biopsy (EMB) is an invasive diagnostic method allowing to obtain specimens of endocardial and myocardial tissues intravitally under physiological circumstances, without undesirable surgical intervention (1).

The first bioptome for transvenous endomyocardial biopsy was developed in Japan and later improved in the U.S.A. It has been in use in this design with several modifications up to the present time.

The presented study gains from its first author's nearly 20-year experiences with this technique. From 1980 through 2001, with a several year pause, he gradually performed EMB with former and current colleagues, at first at the Institute of Clinical and Experimental Medicine (IKEM) in Prague, Czech Republic, and in the last period at the Slovak Institute of Cardiovascular Diseases (SUSCH), Bratislava, in the total of 504 patients. (Table 1). 136 of them were heart transplant patients and the rest were examined for other reasons. More than 2500 biopsies were performed and more than 10,000 tissue specimens were taken and examined from all these patients.

The method is safe. Recently Felker et al. (2) reported on complications of EMB in 1230 patients. Their results show the overall mortality reached 0,2% and other adverse events occurred in additional 8 % patients of the analysed cohort. We ourselves have dealt with this issue earlier and in other places (3, 4). For the current idea of EMB risks we present the incidence of our complications for the SUSCH only (Table 2). Apart from the adverse events displayed in the Figure, other extraordinary complications may arise. In an other study (4) we brought a detailed description of a specific technological bioptome failure that had been successfully solved surgically.

Table 1. Number of patients with EMB and number of interventions in IKEM and the Institute of Cardiovascular Diseases UKVCH/SUSCH in the years 1980-1989 and 1994-2002

Institute	IKEM	UKVCH/SUSCH	Total
Years	1980-1989	1994-2002	9
Patients	314	203	507
After HTx	49	95	144
Other	265	108	373
Interventions	1362	1411	2773
After HTx	1077	1299	2376
Other	285	112	397
Samples	5564	5470	11 034

Table 2. Complications in 203 patients who undewent 1411 EMBs in the years 1994-2002

Complication	Number of patients	%
Mortality	0	0
Need of surgical intervention	0	0
Haemopericardium	33	0,02
Cardiac tamponade	0	0
Pneumothorax	11	0,007
Arterial puncture	44	0,03
Haemothorax	1	
Dislocation of the pacemaker electrode	1	
Tricuspid valve trauma	1	

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Indications of EMB can be, without atomising them into unclear and complicated schemes, classified into three basic levels. EMB is definitely indicated in heart transplant patients for the recognition and monitoring of rejection, and assessment of efficacy of immunosuppressive therapy. EMB plays a similar essential role in diagnosing and treatment of anthracycline toxicity in patients with malignancies. EMB is useful for recognising of myocarditis, specific cardiomyopathies, and differentiating between restrictive versus constrictive disorders of cardiac function. Opinions regarding the importance of EMB in dilated cardiomyopathy and ventricular tachycardias of unknown origin are discrepant and non-conclusive (5, 6).

In this study we focused on assessment of merits of EMB in identifying etiology of heart failure (HF) of unknown origin and the method's importance for treatment strategy decision making.

Patients and metods

With regard to the aim, the cohort consisted of 86 patients (20 females) with advanced clinical heart failure syndrome. A total of 89 biopsies were performed. According to the echocardiographic findings, the patients were divided into three groups to be individually assessed. There were 68 patients with left ventricular dilation (left ventricular diastolic diameter ı 60 mm) and impaired systolic function (left ventricular ejection fraction median 27 ± 8%) in the first group. In 11 of them clinical suspicion of myocarditis had been raised. The second group consisted of 11 patients with HF where EMB had been indicated due to restrictive/constrictive left ventricular dysfunction. 7 patients with the echocardiographic finding of left ventricular wall thickening (thickness of the interventricular septum and/or the posterior wall of the left ventricle ı 13 mm) of unclear origin were assigned into the third group.

EMB was performed using Seldinger's technique almost exclusively via the internal jugular vein. An alternative, however in this cohort always transvenous approach, was employed only exceptionally and was required by anatomical abnormalities or by other reasons. The samples counting 1 — 6 (average 3,3) were taken from the right ventricle and were immediately preserved in the 4% formaldehyde solution. All of the samples went through standard processing and were examined using light microscope according to generally approved approaches and criteria that had been described in an other study (7, 8).

For the purpose of the assessment of the EMB diagnostic merit, the result of the examination was considered either diagnostic — if it was definitely decisive for the diagnosis, or confirmative — if the finding supported the clinical diagnosis, and at last non-contributive in case the result had no influence on the diagnostic conclusion in any way or the obtained material was unable to be examined. The results of EMB bringing an important information for the diagnosis and/or prognosis and having an influence on treatment decision at the same time were considered «pragmatic».

Results

Diagnostically contributive images were present in 25 (30%) out of 86 patients (Table 3). Myocarditis was found in 16 (19%) patients, in 2 patients acute and in 14 patients borderline myocarditis.

In 5 patients, myocardial amyloidosis was revealed (in 4 cases the AL type, in one the AA type). In 3 patients the diagnosis was hypertrophic cardiomyopathy and in one patient eosinophilic myocarditis (Table 3). Illustrative and representative histolological findings are presented in Figures 1-4.

Evaluating the diagnostic benefit we found that EMB is the least testimonial in the group of 68 patients with a dilated left ventricle with impaired function. The results were diagnostic in 15 (22%) out of them. In all cases, myocarditis was the diagnosis. The findings rated as confirmative were found in 49 (72%) and non-contributive in 4 (6%) patients. In the group of patients with the confirmative result of EMB, non-specific findings on cardiomyocytes and in the myocardial interstitium supporting the diagnosis of dilated cardiomyopathy were present (Chart 1).

Table 3. Diagnostic EMB findings in 86 patients with HF of unknown etiology

Diagnosis	Number	%
Myocarditis	16	19
Amyloidosis	5	6
Hypertrophic cardiomyopathy	3	4
Eosinophilic myocarditis	1	1
Total	25	30

Out of 11 patients with restriction/constriction, the findings were diagnostic in 6. In 2 of them a finding typical for hypertrophic cardiomyopathy was present. In one case myocarditis, in one case amyloidosis and in one case eosinophilic myocarditis with the thick-

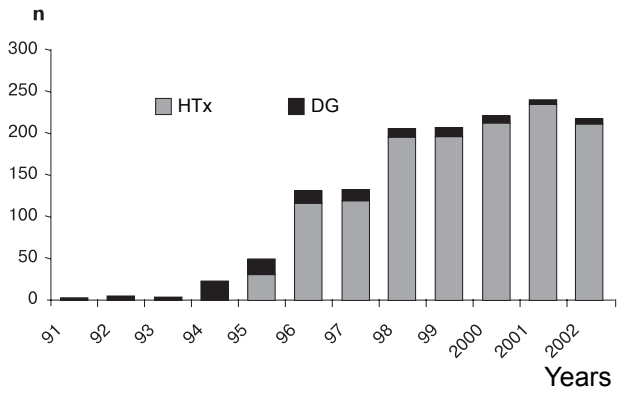

Chart 1. Diagnostic merit of EMB in patients with clinical diagnosis of dilated cardiomyopathy (DCMP), restrictive/ constrictive disorder of the myocardial function (R/C) and left ventricular wall thickening of unknown origin.

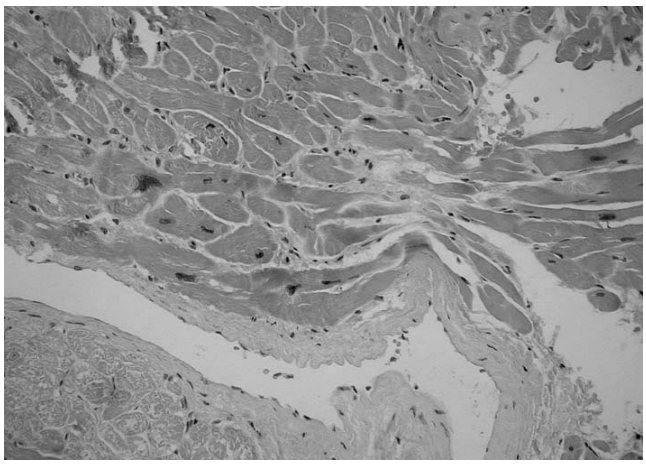

Fig. 1. Dilated cardiomyopathy. Alternating atrophic and hypertrophic cardiomyocytes and fibrosis

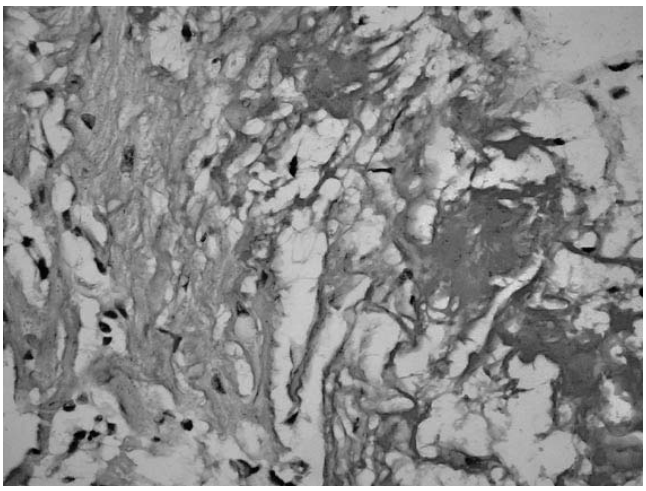

Fig. 3. Amyloidosis. Deposits of amorphous material

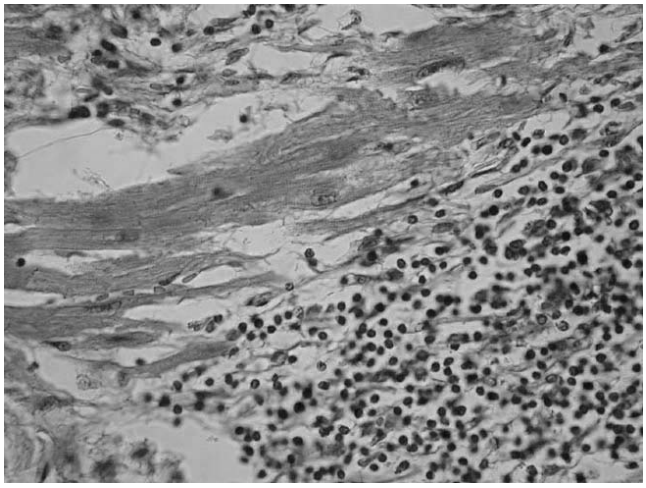

Fig. 2. Viral myocarditis. Marked focal mononuclear infiltrate

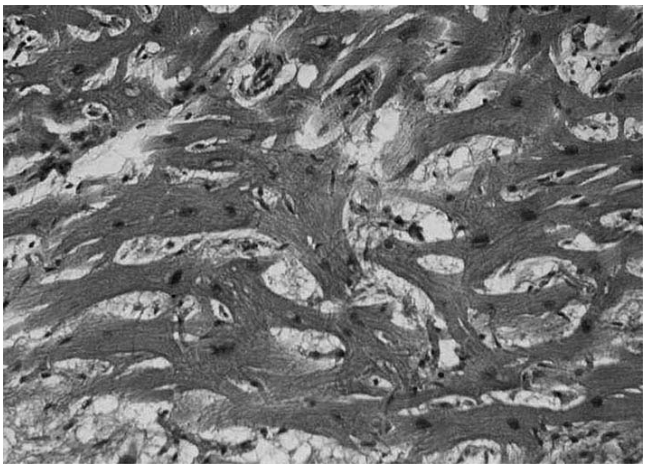

Fig. 4. Hypertrophic cardiomyopathy. Typical chaotic arrangement of cardiomyocytes (so called disarray)

ened endocardium were found. The endomyocardial finding was absolutely normal in one patient. This finding supported the diagnosis of constrictive pericarditis and the patient underwent surgery later on. In 5 patients, non-specific pathological changes were discovered which was compatible with the clinical diagnosis of idiopathic restrictive cardiomyopathy.

The maximum diagnostic benefit was achieved in the group of 7 patients with left ventricular thickening of unclear etiology. In this group, four cases of amyloidosis, one case of myocarditis, and one case of hypertrophic cardiomyopathy were confirmed. In one patient severe vacuolization of cardiomyocytes was found. Content of the vacuoles was not specificated by the techniques used.

In addition to this, it turned out that out of all diagnostically contributive EMBs (30%), the acquired information was useful for the next treatment strategy decision making (the «pragmatic» results) in only 7 (8%) of them (Table 4). Treatment of the underlying disease was started in 3 patients with amyloidosis of the heart. However, in all of them the proof of the disorder lead the determination of prognosis and contraindication of heart transplantation as one of treatment modalities.

Discussion

We have devoted a number of articles to the topic of EMB for the last nearly 20 years. They have been published mainly in Czech and Slovak medical journals. We have presented the essential information on the EBM technique and its safety, complications, methods of sample processing, benefits and limitations for clinical diagnosing, treatment and prognosis of heart disease but also for the pathophysiologic studies of cardiomyopathy and graft rejection. This is why we desist from detailed repetition of this information. Those who are possibly interested are referred to our selected essential essays devoted to this topic. They also contain main and primary bibliographic sources related to this area (1, 5, 9).

In this paper we focus on problems of diagnostic efficiency of EMB in patients with heart failure of unclear origin.

The clinical importance of EMB in the diagnosing of cardiomyopathies is limited and unclearly defined. It is generally accepted that the benefit of EMB in dilated cardiomyopathies is small. In the cohort of Kasper and Co. (10) consisting of 673 patients with dilated cardiomyopathy of unclear etiology EMB explained the cause in 155 (17%) of them. The most frequent underlying disorder (81 patients) was myocarditis.

According to the majority of authors, diagnostic efficiency of EMB in dilated cardiomyopathies varies from 4% to 10% (11-14).

In our cohort of patients with the dilated dysfunctional left ventricle, myocarditis was revealed in 15 (22%), which is more than expected according to literary sources. This finding could be explained by patient selection. In comparison with other cohorts, our patients were younger and their left ventricular function was impaired more severely.

The fact of real benefit derived from the acquired information for the patient's management in dilated cardiomyopathy makes an independent issue of the EMB indication. In case of myocarditis, that is the most frequently diagnosis found, the routine immunosuppressive treatment is currently not recommended as its effectivity has not been proven. From this point of view, revealing myocarditis as the cause for left ventricular dilation and dysfunction is just of academic value.

It is being expected that the treatment for myocarditis (virostatics, interferon, immunosuppressive drugs, immunoadsorption) will be depending on the proof of the viral genome presence, detailed immunohistochemic analysis of the inflammatory infiltrate and subsequent decision between viral and autoimmune character of the inflammatory process (15). Individual treatment strategies are currently in the clinical trial phase. Based on results of these trials, the contribution of EMB in dilated cardiomyopathies/myocarditis is therefore to be re-evaluated.

The clinical benefit of EMB in dilated cardiomyopathy is undisputed in some rare, mostly infiltrative disorders (sarcoidosis, hemochromatosis, amyloidosis, giant cell and eosinophilic myocarditis, Chagas disease), possibly in cardiomyopathies related to connective tissue disorders (lupus erythematosus, scleroderma, polyarteriitis nodosa). According to the latest data, they have been set as responsible for 8% cases of unclear cardiomyopathy (2, 16, 17). In the vast majority of cases not only signs of myocardial dysfunction but also specific non-cardiac symptoms are present which allows an aimed EMB indication.

As our study has shown, both the diagnostic and «pragmatic» values of EMB significantly increased in patients in whom EMB was indicated for unexplained thickening of the myocardial wall and in patients with restrictive/constrictive character of the left ventricular filling. These parameters are echocardiographically well detectable.

In restrictive/constrictive myocardial dysfunction, not only the proof of a specific cause of cardiomyopathy but also normal myocardial finding is important. In this case, as in one of the presented patients, the further diagnostic procedure is shifted towards the search for the cause of pericardial constriction (18).

The importance of EMB is dramatically increasing in the areas of concurrent heart transplant programme. Our experiences are in consent with this trend. While EMB had been performed in our Institute only sporadically until 1994, the rate of this examination significantly increased during preparation of the HTx programme and after its launch (Chart 2). Such an intensity of examinations makes a perfect warranty for the methodical command of the technique, for its safety, effectivity, and quality. We are convinced that EMB should be concentrated to centres with a functioning HTx programme and should not be dispersed to a width of many workplaces.

As it has already been noted, the new view on the position of EMB in case of myocarditis will be determined by non-traditional techniques for processing and examination of the obtained material. Morphometric measurements, immunohistochemistry, proof and quantification of apoptosis, molecular biology methods are able to provide new information on the origin and prognosis of the heart disease (13, 19, 20).

When assessing the diagnostic effectiveness of EMB, it is necessary to be aware of limitations of this diagnostic approach. The most important one is known as the «sampling error». It lies on the fact that the samples obtained and referred for examination do not necessarily contain the suspected pathological process. This can chiefly occur in localized disorders (myocarditis, sarcoidosis, connective tissue disorders, vasculitis). In order to limit the likelihood of this fact, it is considered optimal to take four to five samples from various places of the right ventricle (6, 14).

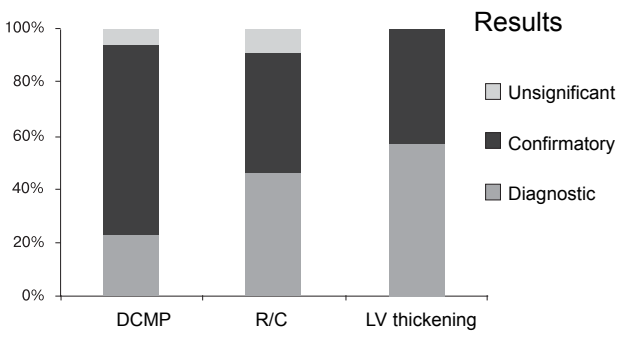

Chart 2. Frequency of EMB in the Slovak Institute of Cardiovascular Diseases in particular years.

It is unlikely for the EMB technique to go through more substantial changes. In the course of time, it is possible to increase the bioptome quality. The bioptomes are likely to become finer, their shaping would make catheterization easier and would permit better focusing of the sample taking from the inner walls of the heart cavities. Anyway, these trends have also been described in the medical literature (21).

It is possible to expect a certain development in imaging methods used with EMB. Until now, the dominating imaging technique has been X-ray fluoroscopy that is simple and transparent. Its biggest disadvantage is the radiation exposure. Cumulative radiation doses can reach high and clinically important values mostly in patients surviving longer periods after HTx. These individuals are often likely to undergo 50 and

more EMBs. From this point of view, EMB is risky for medical staff, too. EMB performed under echocardiographic control makes an alternative solution. This method even dominates and is used routinely in some centres (22).

Conclusion

EMB is a safe invasive method that allows to obtain the image of the endocardial and myocardial tissues intravitally, under physiological circumstances.

It is of dominant importance in the assessment of graft rejection and evaluation of the anthracycline toxicity.

In heart failure syndrome of unknown origin it can contribute to the exact diagnosing mainly in patients with thickening of the left ventricle of unknown etiology and in differential diagnosis between myocardial restriction and constriction. Its clinical importance in dilated cardiomoypathy is small.

The practical impact of the EMB information on the treatment strategy is relatively limited but irreplaceable in individual cases.

Acknowledgment

For many years, many of our co-workers collaborated on these problems. They deserve respect and thanks. It is impossible to list all of them. This is why we just mention those physicians who played a more important role not only in performing and evaluating of EMB but also in publishing activity. In alphabetical order, first those from the IKEM, Prague, and then the others from the UKVCH/SUSCH.

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Percutaneous Closure of the Left Atrial Appendage

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Patients with atrial fibrillation (AF) are at high risk of stroke. More than 15 % of all strokes are due to atrial fibrillation. So far anticoagulation is the treatment of choice with a risk reduction of almost 70%. On the other hand anticoagulation has many side effects such as intracranial or gastrointestinal hemorrhage. Closing the left atrial appendage (LAA) might be an alternative in patients who cannot take anticoagulation treatment due to contraindications or conditions in which the hazard of hemorrhage is larger than the potential clinical benefit. The PLAATOΦ system (Percutaneous Left Atrial Appendage Transcatheter Occlusion) is a new device to close the LAA by catheter technique. The device consists of a self-expandable nitinol cage which is covered with ePTFEΦ. It is delivered via a specially designed 12 F transseptal sheath. Small anchors along the struts prevent the occluder from embolizing. After device implantation patients are placed on aspirin only.

The results of the dog model and the first clinical experiences in humans have been very promising.

Introduction

More than 15% of all strokes are attributable to atrial fibrillation (AF) (1-3). This percentage increases with age to almost 25% in patients older than 80 years. The prevalence of atrial fibrillation in this age group is almost 10% (4). Besides hemodynamic problems atrial fibrillation leads to enlargement of the left atrium and a reduction of blood flow velocity. Since atrial contraction is not only responsible for blood ejection out of the left atrium but also out of the left atrial appendage (LAA) the absence of contraction leads to blood stagnation, especially in this small sacculation. Echocardiography and autopsy studies have shown that more than 90% of all thrombi in patients with non-rheumatic AF originating in the left atrium form in the left atrial appendage (5). Thrombus formation in the LAA increases the risk of stroke by three times (6).

Several clinical trials have shown that oral anticoagulation is effective in preventing future ischemic events. With a risk reduction of almost 70% it is superior to antiplatelet therapy or low-dose warfarin plus aspirin (7, 8, 9). On the other hand chronic oral anticoagulation is linked to a lot of side effects. Numerous restrictions for the patients, a narrow therapeutic range and the potential risk to suffer from major (1% to 2% per year) or minor (5% to 10% per year) hemorrhagic complications lead to an extensive anticoagulation under-use (10). Despite the proven efficacy of anticoagulation in preventing ischemic strokes Stafford and Singer found that less than 40% of patients with atrial fibrillation were taking warfarin (11, 12).

The idea of closing or removing the left atrial appendage in order to reduce the risk of stroke in patients with atrial fibrillation goes back to the 1930's when surgeons removed or obliterated the LAA during mitral valve surgery (13, 14). In contrast to those days when the dilated left atrium as a result of mitral stenosis led to very large left atria the most frequent ethiology of atrial fibrillation today is of non-rheumatic. Therefore, thrombus formation is almost exclusively located in the LAA since the left atrium is not enlarged as at presence of a mitral valve stenosis. Heart surgeons still close the LAA when it is convenient during surgery for other indication. Recently the Left Atrial Appendage Occlusion Study (LAAOS) was initiated (15). Within this randomized clinical trial patients undergoing so called «routine» coronary artery bypass graft surgery will have their LAA closed by ligation, purse string technique or surgical stapler. Others even propose that LAA obliteration makes sense as a primary therapy and not necessarily in conjunction with an otherwise indicated cardiac surgery. So far this approach has not been widely accepted because of its invasive character.

In August 2001 we used for the first time a less invasive, transvenous system in order to close the LAA: PLAATOΦ — Percutaneous Left Atrial Appendage Transcatheter Occlusion. The PLAATOΦ device (Figure 1) consists of a self-expandable nitinol cage (range of diameter 15-32 mm) which is covered with expanded polytetraflouroethylene (ePTFE). The membrane occludes the orifice of the appendage and allows tissue incorporation into the device. Three rows of anchors along the struts help stabilizing the device in the LAA.

Currently in order to be eligible for the PLAATOΦ procedure patients should have at least one additional risk factor for stroke besides atrial fibrillation. According to the National Registry of atrial fibrillation those risk factors are prior TIA or stroke, age i 65 years, arterial hypertension, diabetes, coronary artery disease or former myocardial infarction, poor LV-function (LV < 40%) or echo as a risk factor (flow

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Figure 1. The PLAATO™ device
(Percutaneous Left Atrial Appendage Transcatheter Occlusion); Nitinol framework; ePTFE covering; Small anchors along the struts stabilize the occluder in the orifice of the appendage. LA — Left Atrium, LAA — Left Atrial Appendage

velocity J 20 cm/s or moderate or dense spontaneous echo contrast in the LAA).

Case report

A 71 year old male with atrial fibrillation and arterial hypertension experienced severe gastrointestinal bleeding three years after anticoagulation was initiated. Thereafter coumadin treatment was discontinued and replaced by aspirin. Two years later the patient suffered from a stroke with left sided hemiparesis and aphasia.

Before interventional LAA occlusion a physical and neurological examination, routine blood tests, an electrocardiogram (ECG) and chest-x-ray were performed. Transthoracic and transesophageal echocardiography give important information on the LAA's morphology as well as contraindications for the PLAATOΦ procedure such a thrombus formation in the left ventricle or atrial appendage (Figure 2a).

The procedure was performed under local anaesthesia. After venous groin access and transseptal puncture a transseptal sheath was advanced under TEE guidance into the left atrium. In order to obtain a good angle for device delivery the septum should be punctured as inferior as possible. Heparin was administered to keep the activated clotting time over 250 seconds. A 4 F pigtail catheter was introduced into the sheath and thereafter into the LAA. Dye-injection provided the first information on the appendage's morphology. By using a stiff wire the transseptal sheath was replaced by the specially designed 12 F transseptal sheath. After advancing the tip of the sheath into the LAA another dye-injection (appendogram) gave exact information on the diameter of the ostium as well as the length of the LAA. According to the appendogram a suitable device was chosen. It should be 20-40% larger than the diameter of the orifice of the LAA. After loading and advancing the occluder into the LAA the device was placed in the ostium of the appendage. Proximal and distal dye-injections as well as echocardiography were performed to verify the good seal of the appendage (Figure 2b, 3b, c). Afterwards the delivery system and the transseptal sheath were withdrawn from the left atrium. The post-procedure regime contained aspirin, 300 mg per day indefinitely, 75 mg clopidogrel per day as well as subacute bacterial endocarditis prophylaxis for the following six months. No complications occurred during the follow-up of 18 months.

Discussion

So far the PLAATOΦ procedure has been successfully performed in more than 90 patients (16). Because of the promising results transcatheter closure of the left atrial appendage may become an alternative in patients with atrial fibrillation and a contraindication for warfarin treatment. Even though surgical closure of the LAA as an adjuvant procedure during coronary artery bypass graft or mitral valve surgery may be an adequate treatment in order to reduce the risk of stroke in patient who already have or are likely to develop atrial fibrillation within the near future surgery as primary therapy may not be the appropriate treatment. Furthermore surgical closure does not always lead to a complete and long-lasting occlusion of the LAA (17). So far the percutaneous approach has been convincing. Because of its minimal invasive character it is less straining for the patient. Nevertheless there is a need for longer-term studies to show an effective reduction of stroke in patients with atrial fibrillation who are suboptimal candidates for anticoagulation treatment.

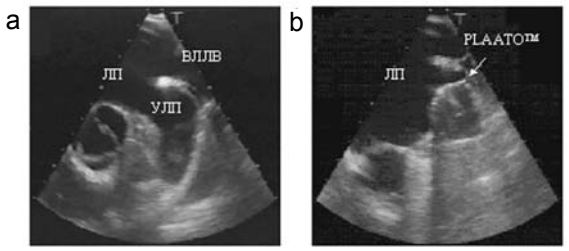

Figure 2. Transesophageal echocardiography shows the left atrial appendage (LAA) before (a) and after (b) the PLAATO™ procedure; LA — Left Atrium, SLPV — Superior Left Pulmonary Vein

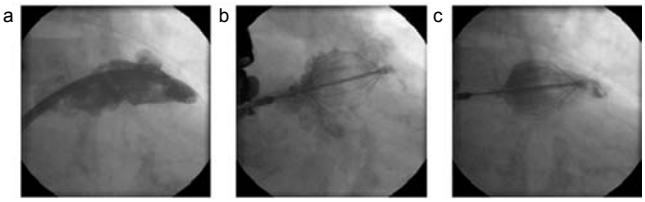

Figure 3. Angiogram of the left atrial appendage (LAA): (a) after venous and transseptal puncture a specially designed transseptal sheath is advanced into the LAA, dye-injection provides information on the diameter of the ostium and the morphology of the LAA; (b) proximal and (c) distal dye-injection after device's expansion reveal the degree of occlusion

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Emergency Stent-Graft Placement in Thoracic Aortic Dissection and Evolving Rupture

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Key words. Aorta, Stents, Mortality, Impending rupture

Abstract

Background. Even with rapid diagnosis and effective medical treatment mortality in type B aortic dissection with evidence of extraaortic leakage of blood remains high. Considering a mortality rate of 29-50 percent associated with emergency surgical repair, the concept of endovascular stent-graft placement may become a life-saving option in impending or evolving rupture by endovascular sealing of the entry tear and subsequent abortion of leakage.

Methods. The concept was tested by comparing short-term and 1 year outcome of 11 patients after emergency endovascular stent-graft placement with historic-matched control patients subjected to conventional therapy all patients had acute type B dissection complicated by loss of blood into periaortic spaces.

Results. Emergency stent-graft placement was successful without periprocedural morbidity, aborted leakage and ensured reconstruction of the dissected aorta; at a mean follow-up of 15 ± 6 months no death had occurred in the stent-graft group whereas 4 patients had died with conventional treatment ($p < 0,05$).

Conclusion. With appropriate logistics and expertise type B aortic dissection with leakage and evolving rupture may benefit from nonsurgical reconstruction of the dissected segment by endovascular stent-grafts.

Condensed abstract

Considering an excess mortality associated with both surgical repair and medical treatment in type B dissection with evolving rupture, the concept of endovascular stent-graft placement may emerge as a life-saving option by sealing the false lumen and aborting ongoing leakage of blood. With appropriate logistics and expertise type B aortic dissection with evolving rupture may benefit from nonsurgical reconstruction by stent-grafts.

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Acute aortic dissection is a catastrophic event. Mortality remains high (1) with life threatened by tamponade, coronary or cerebral malperfusion, aortic rupture and/or organ ischemia (2, 3). Surgical repair in type B (distal) dissection is only advocated for specific cases complicated by progression, formation of expansive aneurysms, critical malperfusion syndrome or impending rupture heralded by contained or profuse bleeding (3-5). With a current mortality rate of 29% to 50% associated with emergency surgical repair of both type A and B aortic dissection (6-9), endovascular stent-graft repair may become a life-saving option in cases of paraaortic leakage and impending rupture. While nonsurgical reconstruction of thoracic aortic dissection with stent-grafts is being considered a promising concept in subacute dissection (10, 11), the strategy of focal sealing of entry tears has not proven life-saving potential in presence of paraaortic leakage and impending rupture.

Methods

Patient Population. Since 1998, 22 patients with instable dissection (and evidence of blood loss) on tomographic imaging were admitted to the intensive care unit for initial stabilization by blood transfusion, sedation, titration of blood pressure to a mean of approximately 55 mm Hg by intravenous metoprolol, and mechanical ventilation, if needed.

All 11 patients (selected from 1998 to 1999) treated conservatively (age 56 ± 12 years, range 40 to 74) and the 11 matched patients (age 54 ± 14 years, range 43 to 70) subjected to stent-graft placement after 1999, had a history of severe hypertension. According to contrast-enhanced CT imaging the proximal entry was always located between the left subclavian artery and the diaphragm; additional entries were found in 10 patients by transesophageal ultrasound. Eight patients revealed thoraco-abdominal extension of the dissection, two had retrograde dissection through the arch into the ascending aorta and three had local (obviously incomplete) disruption at the level of the descending aorta. All revealed collection of blood and ongoing bleeding into paraaortic pleural (n = 15) or mediastinal space (n = 7); blood loss was estimated between 0,6 and 6 liters (tables 1

and 2). Patients with Marfan syndrome or other connective tissue disease were not included.

Stent-graft placement and follow-up

All procedures were performed in the cardiac catheterization laboratory under general anesthesia and ventilation with percutaneous access via a femoral artery guided by fluoroscopy and simultaneous transesophageal ultrasound. A second pigtail catheter was inserted from the left subclavian artery and navigated along the true lumen to connect with the femoral pigtail catheter. After confirming the position in the true lumen a stiff guide wire (0,035 inch diameter) was inserted and a TALENT endoprosthesis of appropriate dimension (according to quantitative measurements on computed tomography, TEE or calibrated angiograms) was advanced and launched as previously shown (10). Stent-grafts were centered on the proximal entry in the attempt to obliterate the false lumen, abort leakage and reconstruct the dissected segment (10, 12). Closure of the entry tear was documented by transesophageal ultrasound; in four cases the left subclavian artery was overstented to ensure sealing. All procedures were technically successful and terminated within 65 minutes (average 50 ± 18 minutes); in five cases low pressure (2 atm) balloon molding was required to abolish residual Doppler flow signal in the false lumen. Distal and abdominal side branch perfusion was documented in all cases. Follow-up tomographic imaging using contrast-enhanced computed tomography or magnetic resonance imaging at 7 days and 3 months demonstrated reconstruction of the aorta with complete or partial thrombosis of the false lumen and no more evidence of paraaortic collection of blood (table 3).

Table 1. Demographic and clinical characteristics (conventional treatment)

Patient	Age	Sex	Leakage	Symptoms on Admission	Admission to Dx, hrs	Medical treatment, outcome
1	44	M	pleura	hypovolemic shock	3	-
2	70	M	pleura	hypovolemic shock	5	-
3	54	F	mediastinum	shock	3	-
4	61	M	retrograde expansion mediastinum	shock, PRIND	3	death+ 9 m
5	47	M	pleura	hypovolemia	6	-
6	50	M	abdomen	shock, ta	2	death (+) 9 hrs
7	60	F	mediastinum	hypovolemia	7	-
8	72	M	pleura	paraplegia, ta	3	-
9	70	M	mediastinum, pleura	shock	6	death (+) 2 hrs
10	68	M	pleura	preshock, ta	7	death (+) 4 hrs
11	56	M	pleura	preshock	9	-

ta — thoracoabdominal extentension; MI — myocardial infarction; M — male; F — female; m — months; hrs — hours

Table 2. Demographic and clinical characteristics (stent-graft placement)

Patient	Age	Sex	Leakage	Symptoms on Admission	Admission to Dx, hrs	Time to stent-graft, hrs
1	53	M	pleura	paraplegia	4	20
2	50	F	pleura, abdomen	hypovolemic shock	2	12
3	54	M	pleura	hypovolemic shock, ta	1	4
4	80	M	pleura, mediastinum, pericardium	preshock, MI, retrograde expansion	1	18
5	43	M	pleura	hypovolemia, ta	2	24
6	74	M	mediastinum	hypovolemia, ta	1	22
7	45	F	pleura	transit paraplegia	6	24
8	40	M	pleura	hypovolemia	1	6
9	60	M	mediastinum	hypovolemia, ta	2	24
10	53	F	pleura	preshock, ta	2	20
11	59	M	pleura	preshock, hypovolemia	4	24

ta — thoracoabdominal extentension; MI — myocardial infarction; M — male; F — female; m — months; hrs — hours

Table 3. Morphological and clinical outcome after emergency stent-graft placement

Patient	Stent-graft		False lumen obliteration	Leakage	Recovery
	length, mm	width, mm			
1	120	40	complete	abolished	+
2	100	36	complete	abolished	+
3	120	40	complete	abolished	paraplegia
4	150	42	partial	abolished	pacemaker, MI
5	150	42	complete	abolished	+
6	120	40	partial	abolished	+
7	100	40	complete	abolished	minor stroke
8	150	40	complete	abolished	+
9	150	36	partial	abolished	+
10	100	44	partial	abolished	+
11	130	40	partial	abolished	+

MI, myocardial infarction; + denotes full recovery

Statistics

Continuous variables are expressed as means and standard deviation. For group comparison the appropriate t-tests and F-tests were utilized; P values of < 0,05 were considered statistically significant.

Results

Three patients with conventional treatment died within nine hours of arrival, one developed paraplegia at day 3, and one after nine months from complete aortic rupture. Considering both excessive surgical risk and adverse short-term outcome with conservative treatment in such patients interventional stent-graft placement was instituted and utilized in 11 cases with similar risk profile. All aortic endovascular stent-grafts were correctly positioned to seal the proximal entry tear (Figures 1, 2 and 3). There was no procedure-related complication and median hospitalization was nine days (range 6 to 38 days). At a mean follow-up of 15 ± 6 months no death has occurred in the stent-graft group versus 4 deaths with conventional treatment ($p < 0,01$, table 4). While both clinical course and follow-up imaging at 7 days and 3 months failed to demonstrate any recurrent leakage from the stented aorta (or adjacent segments), two patients did not recover completely from neurological symptoms, already acquired before stent placement (1 paraplegia, 1 incomplete brachiofacial neuroplegia from right-side stroke). Moreover, one patient with retrograde dissection developed posterior myocardial infarction with total AV block and required a permanent dual chamber pacemaker (table 3). Conversely, patients subjected to medical treatment only, median hospitalization was 21 days (range 12 to 41), four had died at 1 year, three of which within the initial 24 hours of diagnosis (table 1). Careful monitoring and titration to ~55 mm Hg mean arterial pressure by intravenous metoprolol, blood transfusion (if necessary) and sedation was used irrespective of treatment in all patients.

Discussion

Aortic dissection is a catastrophic event associated with a variety of clinical manifestations. Leakage of blood from the dissected aorta is one of the most ominous signs of evolving rupture and imminent death with surgical repair considered last resort. However, surgical mortality in this scenario may reach 50 percent even in distal (type B) dissection (6-9). We report both feasibility and success by interventional (and thus less traumatic) repair of acute aortic dissection with signs of paraaortic bleeding. While nonsurgical reconstruction of the aorta has been recently introduced (10-12) emergency stent-grafting in evolving rupture takes the concept a step further. Especially the mechanism to stop profuse outward bleeding from the dissected aorta, and to convert a fragile into a stable setting, deserves attention. While the exact site of bleeding into adjacent pleural or mediastinal spaces was precisely known in 6 of 11 cases, the stent-graft with an average length of 130 ± 33 mm did not necessarily cover the entire aspect of dissection. However, sealing of the most proximal (and critical) entry site with subsequent reapposition of the dissecting lamella and obliteration of the false lumen was eventually documented. Thus, paraaortic bleeding channel was abolished (table 3), most likely by virtue of two mechanisms, first, direct coverage by graft material with subsequent thrombus formation, and, second, obliteration and compression of the false aortic lumen. Moreover, even patients in critical condition recovered rapidly after the intervention without the need for additional

Table 4. Follow-up of medical treatment alone or endovascular stent-graft placement in type B aortic dissection with evidence of extraaortic leakage of blood

	Medical	Stent-graft	P
Mortality (% 30 days 1 year		 0 0	 ns <0,05
Morbidity (%) 30 days 1 year			 ns ns

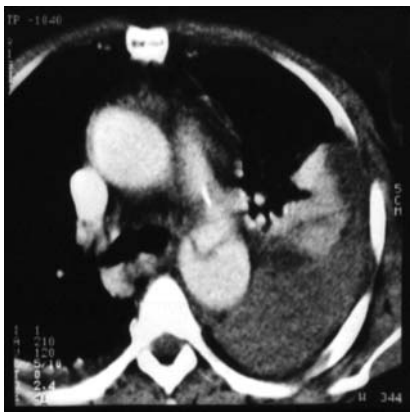

Figure 1. Thoracic X-ray computed tomogram in transverse orientation showing collection of blood in the left pleural space as a result of extraaortic leakage in acute type B dissection. Note the dissecting lamella in the descending aorta separating the fully perfused true and false lumen.

Figure 2. Digital subtraction angiogram in left anterior oblique view of the leaking type B thoracic aortic dissection as shown in figure 1. The distal thoracic aorta reveals evidence of leakage distal to the site of aortic wall disruption.

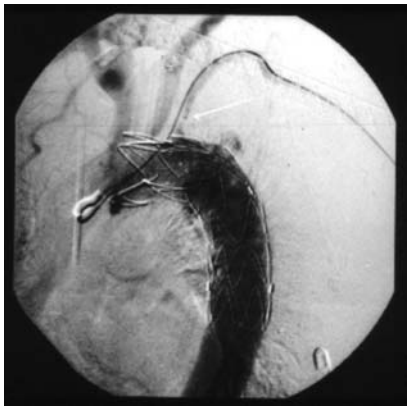

Figure 3. After interventional stent-graft placement both the entry to the false lumen and the site of leakage are sealed and the aortic segment is reconstructed with a normal diameter of the true lumen, and obliteration with thrombosis of the false lumen.

blood transfusions (besides those given prior to stent-graft placement). Conversely, surgical repair of the dissected aorta (although recommended in the setting of evolving rupture or bleeding) was rejected because of the excess perioperative mortality and considerable morbidity (3, 4, 13, 14). Thus, in the light of an adverse outcome of both emergency surgery and medical treatment, and with growing expertise in the use of aortic stent-grafts (10), endovascular repair was considered a realistic alternative in an emergency setting. Similar to previous experience in elective cases, the endovascular intervention in the emergency setting was not associated with excess neurological or peripheral complications (10, 11); no ancillary procedures such as side branch stenting or fenestration maneuvers were necessary (15, 16) since malperfusion syndrome was not encountered after stent-graft placement. Even overstenting of the subclavian artery (in four instances) was not associated with subclavian steal syndrome or brachial ischemia, and postinterventional surgical transposition of the left subclavia artery to the left carotid could be avoided. Ideally, the contralateral vertebral artery should be interrogated and functional on Doppler ultrasound. Moreover, no evidence of spinal cord ischemia with neurological symptoms occurred although stent-grafts were placed relatively low at the level of the diaphragm in two cases; one of these two patients, however, was paraplegic on admission and did not recover. Thus, preservation of the integrity of the paraaortic collateral network (often traumatized at surgery) appears important to preserve blood supply to the spinal cord (10).

Limitations

Although based on matched historic comparison this study provides strong data to support stent-graft placement in aortic dissection with imminent rupture. Randomization in such a scenario would neither be ethical nor necessary(17). Although conceptually convincing current experience with stent-grafts in aortic dissection is still limited to short-term observation. However, with growing expertise and improved stent-graft devices even a fragile and disintegrated aorta may be suitable for endovascular repair. Morphometric assessment of the aorta from contrast-enhanced CT, spin echo MR or 3-dimensional appears indisputable even for selection of MR I of suitable stent-grafts in urgent cases; high volume centers may both shelf a variety of devices and install logistics for the multidisciplinary approach required for interventional treatment of acute aortic pathology.

Conclusion

With appropriate logistics and expertise nonsurgical reconstruction of the aorta using stent-grafts is feasible even in cases of evolving rupture with indisputable (short-term) benefit. Focal sealing of the entry is required to obliterate the false channel and induce stability.

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Percutaneous Endovascular Repair of Aneurysms after Previous Coarctation Surgery

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Keywords. coarctation, aneurysm, endovascular stent-graft, aortic reconstruction

Background. Formation of aortic aneurysm late after surgical repair of coarctation carries a significant risk of rupture and lethal outcome, and even repeat surgery is associated with a 14 percent in-hospital mortality and morbidity from paraplegia, injury to the central nervous system or from bleeding. The potential of nonsurgical endovascular repair by the use of stent-grafts in lieu of repeat surgery for post-coarctation aneurysm is unknown.

Methods and Results. The concept of post-surgical endovascular stent-graft placement was evaluated with respect to feasibility and safety in 6 consecutive patients with late aneurysm formation after coarctation repair; while all patients had aneurysm formation late after patch aortoplasty, placement of an elephant trunk during surgical repair of secondary type I dissection proceeded in formation of a local aneurysm in 2 cases. Patient age was 49 ± 12 years ranging from 31 to 68 years. Transluminal placement of customized stent-grafts was successful with no 30-day or 1-year intervention-related mortality or morbidity. Follow-up survey of 11 — 47 months revealed optimal reconstruction of the thoracic aorta; one patient died 11 month after endovascular repair from cancer.

Conclusions. Nonsurgical aortic reconstruction of post-surgical thoracic aneurysms forming late after coarctation repair is safe and feasible; interventional stent-graft placement has potential to avoid repeat surgery of post-surgical aortic aneurysms.

Severe adult-type coarctation accounts for 4 percent of congenital cardiovascular malformation and is usually corrected by surgical repair. Despite primary success 9 percent of patients develop local aneurysms late after coarctation surgery with inherent risk of rupture and lethal outcome (1). Post-surgical aneurysm formation is observed with subclavian flap angioplasty in 17 percent, after patch angioplasty in 14 percent, after interposition graft repair in 6 percent, and occasionally with end-to-end anastomosis in presence of persistent systemic hypertension or after the use of Dacron sutures (2); post-surgical aortic aneurysm may present as false, true or dissecting (3). Balloon-expandable endovascular stents have been used successfully as primary treatment for coarctation and recoarctation (4-5). The concept of endovascular stent-grafts for secondary repair of post-surgical aneurysm, however, has not been tested. This alternative was subsequently utilized to avoid repeat surgery for post-coarctation aneurysm in six consecutive cases.

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Methods

Patient characteristics. Patient characteristics are listed in table 1. All patients underwent previous surgical repair for aortic coarctation with excellent primary results; the 6 index patients represent 8 percent of the total number of 75 patients operated for coarctation by use of either patch aortoplasty or surgical variants over 2 decades; 17±4 years after initial repair local aortic aneurysm of 63,5±10 mm diameter had developed at the site of patch aortoplasty. While all patients had undergone patch aortoplasty, in two cases an elephant trunk was inserted as an adjunct to manage new-onset type I dissection after previous patch aortoplasty. Both patients had a patch repair of adult-type coarctation and developed acute type I aortic dissection of an ectatic ascending aorta (with a bicuspid aortic valve) 4 and 6 years later. Both underwent aortic root reconstruction with interposition grafting and adjunctive intraoperative placement of an elephant trunk sutured to the distal aortic arch. Despite this precaution a local aneurysm developed at the site of coarctation repair despite the inlining coaxial distal end of the elephant trunk.

When a second (patient 1-4) offered and third (patient 5 and 6) surgical repair or customized endovascular treatment with optional surgical conversion, all patients opted for an endovascular procedure as an alternative to repeat surgery and signed a written informed consent form approved by the Institutional Ethics Committee.

Endovascular Stent-Graft

The stent-graft prosthesis (Talent, MedtronicAVE, Santa Rosa, CA) is based on a self-expanding circumferential nitinol stent covered with a Dacron shell; each stent is customized with respect to width, length, and configuration of each end (bare stent segment or covered ends for optimal apposition) and delivered from a 22-to-24-French polytetrafluoroethylene (Teflon) housing; the nitinol rings are interconnected

by a longitudinal wire to ensure stability and prevent twisting. Morphometric measurements from 3-dimensional MR scans served as blueprint for each customized configuration (Figures 1a, 2a).

Imaging Protocol

All patients underwent spin-echo (anatomical) magnetic resonance imaging (MRI) and three-dimensional magnetic resonance angiography (MRA) with individual bolus tracking of gadolinium-diethylenetriamine pentaacetic acid (gadolinium-DTPA; Magnevist, Schering, Berlin, Germany). Gadolinium-DTPA produces contrast-induced T1-shortening effects and eliminates saturation problems from slow flow or turbulence-induced signal voids. A body-array coil was used for signal transmission and reception. Using an ultrafast gradient on a 1,5 tesla magnet (Magnetom Vision, Siemens Medical Systems, Germany), acquisition was performed in breath hold technique. A FLASH (fast low-angle shot) three-dimensional sequence was used to create maximal-intensity projections; echo and repetition times were as short as 1,9 and 4.0 msec, respectively. With a field of view of 390 to 450 mm, a 512-by-512 matrix provided an in-plane resolution of 1,1-by-1,6 mm (6). Slice thickness varied from 2 to 4 mm; a flip angle of 30 degrees was selected. Imaging of 64 interpolated contiguous slices with half-k-space data acquisition in the phase-encoding direction took 20 to 28 seconds. With subvolume multiplanar reconstruction MR scans and angiograms were evaluated for morphometric measurements for manufacturing the individualized endovascular prosthesis before stent implantation and for follow-up comparison (6).

Implantation Technique

Stent-graft placement was performed in a cardiac catheterization laboratory rigged for surgical conversion with patients under general anesthesia and ventilation. The procedure was begun by injecting 5000 U of heparin and introducing a 6-French pigtail catheter (Cordis, Hamburg, Germany) via the left brachial artery for landmarking the subclavian artery and intraprocedural aortography. The femoral or distal iliac artery was surgically exposed to accommodate a protected 0,035 inch guide wire. With wire position confirmed by fluoroscopy and transesophageal ultrasound the stent-graft sheath was introduced at blood pressure titrated to 50 mm Hg by intravenous sodium nitroprusside before unloading the stent-graft; with correct positioning of the endoprothesis cessation of flow and exclusion of the aneurysmal sac was documented by both color Doppler ultrasound and contrast aortography before removal of sheath and guidewire. The access site was closed by vascular microsurgery.

Results

Procedural Success. Transfemoral stent-graft deployment was uneventful and successful in all patients. Complete exclusion of the aneurysm and absence of endoleak was documented by transesophageal echocardiography and aortography. No patient required adjunctive procedures or a second stent. Initiation of thrombosis was seen in all patients and none required blood transfusion or inotropic support; yet, 120 ± 20 ml of contrast material was necessary and fluoroscopic examination lasted 9 ± 3 minutes (range 5-16 min). Recovery allowed ambulating at day 2 and discharge within 5 days.

Immediate and Long-Term Outcomes

Both intra- and postprocedural outcomes were uneventful. Monitoring transesophageal ultrasound revealed intensifying echodensity (thrombosis) within minutes of aneurysm exclusion and no persisting endoleak. Transient post-implantation syndrome with mild leukocytosis, elevated levels of C-reactive protein, and moderately elevated body temperature occurred in all patients; maximal C-reactive protein level was 148 mg per liter, and leukocyte count was $11 \pm 9 \times 10^6/cm^3$ on day 3 ± 2, but normalized thereafter.

Spin-echo MRI and MR angiography at discharge, 3 month and 1 year follow-up documented normal patency of stent-grafts and complete fibrotic remodeling of the aorta with retraction of the aneurysm (shrinkage). Neither migration nor twisting of the stent-graft, nor any leakage was noted. To ensure full exclusion of the post-surgical aneurysm the grafted part of three endoprosthesis was placed over the origin of the left subclavian artery and led to a 55 percent reduction in distal arterial pressure; interestingly, no patient

Table 1. Characteristics of the patients

Patient	Gender/ Age at surgical repair	Detailed surgical Interventions	F/U interval after surgery	Dimension of aneursym	Age at SG-implantation	F/U interval after SG
1	f/ 13 y	Patch aortoplasty	31 y	68 mm	44 y	47 months
2	m/ 7 y	Patch aortoplasty	24 y	66 mm	31 y	16 months
3	f/ 20 y	Patch aortoplasty	27 y	65 mm	47 y	19 months
4	m/ 42 y	Patch aortoplasty	20 y	60 mm	62 y	11 months
5	f/ 16 y	Patch aortoplasty, Root reconstruction & ET for type I AD	24 y	60 mm	40 y	31 months
6	f/ 52 y	Patch aortoplasty, Root reconstruction & ET for type I AD	16 y	62 mm	68 y	11 months

F/U = follow-up; ET = elephant trunk; AD = aortic dissection; SG = customized stent-graft.

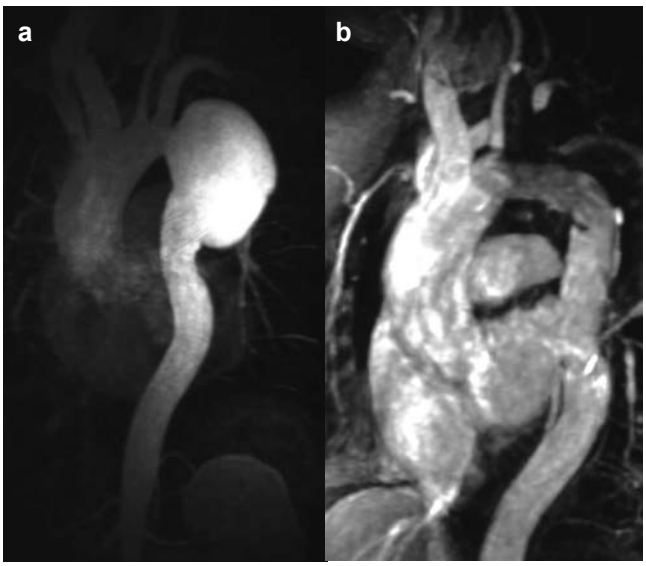

Figure 1. MRA before (1a) and 16 months after stent-graft exclusion of an aneurysm (1b) late after surgical correction of aortic coarctation. The left subclavian artery is occluded without any symptoms and the aneurysm is completely thrombosed and shrunk.

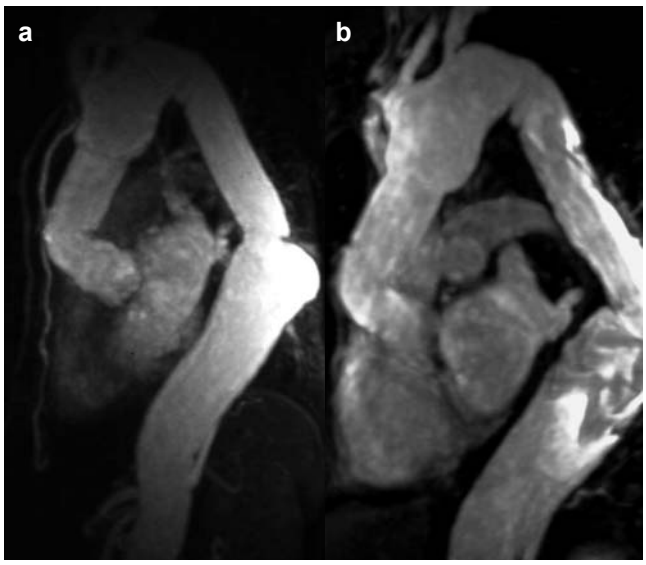

Figure 2. MRA before (2a) and 13 month after (2b) stent-graft exclusion of aortic aneurysm forming late at the distal end of an elephant trunk previously implanted as an adjunct to surgery for type I dissection some years after preceding initial coarctation surgery (patient 5). This patient had developed acute type I aortic dissection from an ectatic ascending aorta 6 years after initial patch aortoplasty for adult-type coarctation, and underwent aortic root reconstruction with interposition grafting and adjunctive intraoperative placement of an elephant trunk sutured to the distal aortic arch. Despite this precaution a local aneurysm developed at the site of coarctation repair despite the inlining coaxial distal end of the elephant trunk.

experienced pain or notable symptoms of dysfunction or fatigue (Figure 1a, b). Distal left arm arterial pressure was unchanged in 3 patients. Individual follow-up is summarized in table 1; 1 patient died 11 month after stent-graft implantation from colorectal cancer while all others enjoy an active unrestricted life.

Discussion

Adult-type coarctation usually requires surgical resection of the abnormal aortic segment either by end-to-end anastomosis, subclavian flap aortoplasty, or patch graft aortoplasty using synthetic material or autologous arterial wall (7-9). However, relapse after coarctation repair and complications related to surgical procedures are not uncommon, with aneurysm formation, stenosis or occlusion of bypass grafts (10-12). Recurrent coarctation used to be the only late complication amenable to interventional treatment in lieu of surgical graft interposition or end-to-end anastomosis (13-15); post-surgical aneurysm may quality next for interventional repair.

Secondary surgical repair of post-surgical complications in complex forms of coarctation has been associated with high mortality and morbidity (3); yet optimal management is far from settled and in favour for palliative rather than corrective surgical repair due to considerable risk. Our encouraging results in 6 consecutive patients undergoing endovascular repair for post patch-graft aortoplasty aneurysms suggest potential for a new nonsurgical option (3, 11, 16). The problem of post-surgical aneurysm formation has also been recognized after bypass-grafting for long aortic coarctation and even after subclavian flap aortoplasty (12, 16). Reoperation after previous patch-graft aortoplasty carries both 14 percent mortality and significant morbidity including paralysis of the nervus recurrence and bleeding complications (3, 17); similarly, Kieffer et al. found that open surgery for thoracic aneurysms in association with aberrant subclavian arteries is associated with 23,5 percent mortality and 13 percent paraplegia rate (18). Yet conservative management of aneurysms after surgical coarctation repair remains unpredictable and associated with 100 percent rate of rupture within 15 years in Knyshov's single center experience (3).

Our preliminary series demonstrates promising potential of endovascular stent-graft treatment in 6 patients with late aneurysm formation after complex surgical repair of coarctation (Figure 2a, b). Transfemoral stent-graft deployment was safe and completed within 54 ± 19 minutes in a multidisciplinary effort of an interventional cardiologist, a vascular surgeon for open femoral access, and anesthesiologist, and led to favourable intra- and post-interventional outcomes (6). Preservation of the integrity of the aorta by endovascular access rather than surgical resection has previously proven to protect spinal arteries and avoid neurological events (6, 19).

Considering an immediate vicinity of the aneurysm to the left subclavian artery complete occlusion was necessary in 3 cases, followed by a post procedural drop in ipsilateral systolic brachial pressure to 55 mm Hg without any signs of malperfusion. Even at follow-up over 16-47 months neither symptoms, nor functional deficits or differences in temperature were noted, lending credence to the notion that secondary transposition of the left subclavian artery is rarely necessary (20). Although conceptually promising management by custom-made stent-grafts requires the

support of long-term follow-up data. On the other hand, over several years of follow-up after stent-graft placement for the treatment of both thoracic and abdominal aneurysms, late adverse effects were infrequent, justifying the use of stent-grafts in younger patients after coarctation surgery (6, 19, 20).

Finally, the custom-design of each stent-graft currently limits the concept to patients undergoing elective procedures. In addition, sophisticated imaging techniques are required for planning and executing such delicate procedures. Given these prerequisites placement of customized stent-grafts may be a promising nonsurgical strategy offered in specialized centers to avoid complicated secondary or tertiary aortic surgery.

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Uterine Artery Embolization for Uterine Myomata: Peculiarities of Catheterization Technique[1]

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Introduction

Since 1995, when a French gynaecologist J. Ravina published his results of successful treatment of uterine myomata with uterine artery embolization (1), this technique has become extensively developed in the world. By the end of 2003 over 40 thousand uterine artery embolization (UAE) procedures have been performed worldwide for uterine fibroids (2).

Benefits of UAE include: minimal invasiveness, high efficacy, low complication rate, universality, and absence of recurrences.

Selective uterine artery (UA) catheterization is one of the most complicated aspects of UAE performed for uterine myomata. Despite the enlargement of UA during myomata progression, the arteries remain relatively small and prone to spasm. They often run at right or obtuse angle and can be significantly tortuous along their entire length. The catheterization is further complicated because of overlapping of other pelvic arteries, which make the X-ray identification of UA difficult. Fortunately the majority of patients with myomas are young women with minor atherosclerotic lesions and tortuosity of iliac arteries.

UAE is barely known to general practitioners in Russia (3). There are isolated reports concerning the use of UAE in clinical practice (4, 5).

The purpose of this report is to describe catheterization technique based on published data and the authors' personal experience.

Anatomy of uterine vessels

Uterus is supplied with blood mostly through the uterine artery (a.uterina), which origins from the internal iliac artery on either side. The numerous types of internal iliac artery embranchments can hardly be classified. The artery usually has two branches (anterior and posterior) — in 77% of cases; three branches in 14% of cases and four or more branches in 3% of cases (6).

There are five variations of superior gluteal artery (posterior branch) and inferior gluteal artery (anterior branch) origins, as well as the origins of largest terminal branches of the internal iliac artery and the uterine artery (7):

1. Uterine artery is the first branch of the inferior gluteal artery.
2. Uterine artery is the second or the third branch of the inferior gluteal artery.
3. Uterine, superior gluteal and inferior gluteal arteries are three branches of the internal iliac artery, thus forming a trifurcation.
4. Uterine and superior gluteal arteries form a bifurcation, inferior gluteal artery — is the branch of the superior gluteal artery.
5. UA origins directly from the internal iliac artery.

The first type is the most common. Trifurcation accounts for 40% of cases (8).

Uterine artery goes in anteromedial or anterolateral direction, on the sharp angle, frequently forming a common trunk with lower bladder artery. Uterine artery is up to 3 mm in diameter and 15 cm in length (6). Uterine artery has a tortuous course, travelling along the inferior border of the wide ligament of the uterus. The uterine artery has a descending portion, which lies along the lateral pelvic wall, then goes along the round ligament of the uterus. Before perforation of the tunica serosa the artery gives two branches: ureteral artery, carrying the blood to the distal portion of ureter, and cervico-vaginal artery, which carries the blood to the cervix and the upper part of vagina. In 9% of cases the cervico-vaginal artery arises directly from internal iliac artery. Making an U- turn the uterine artery then goes upwards along the edge of the uterus. The ascending branch of the uterine artery gives collaterals, such as intramural branches and branches of the uterine fundus. Distal portion of the uterine artery ends in the wide ligament of the uterus, forming two branches: tubal branch (r.tubarius), which travels along the uterine tube, and ovarian branch (r. ovaricus). One of the uterine arteries may be absent in 1-2% of women, in 0,4% of women neither uterine artery could be found (9).

Ovarian artery (a.ovarica) plays an important role in the blood supply of the uterus. The artery origins from the anterior surface of aorta, immediately under the origins of renal arteries, at L2-L3 level. Ovarian artery is 0,8 to 1 mm in diameter, therefore it can't be identified on the aortogram. The ovarian arteries origin from aorta in majority of cases (83%), from renal artery (17%) or, in some cases, from other arteries (10). Ovarian artery is absent in 4% of women, in which the ovary is supplied with blood only from the uterine artery.

[1] While discussing this article the members of the Editorial Board weren't unanimous. However we decided to publish it and we invite our readers to share with us their opinions on this particular article as well as on the problem in the whole.

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Terminal branches (r.tubarius, r. ovaricus) of the uterine artery form anastomoses with the uterine artery. The diameter of the ovarian-uterine anastomoses is around 500 microns, which has to be taken into account during UAE (11). The anastomosis between uterine artery and artery of the round ligament (a branch of a. epigastrica inferior) has also been described (12).

The ovary is supplied with blood from both ovarian and uterine arteries in 30% of cases, from uterine artery — in 30% of cases, from ovarian artery — in 40% of cases. Uterine tubes receive blood from uterine arteries in 60% of cases, while from ovarian arteries — in 40% of cases (13, 10).

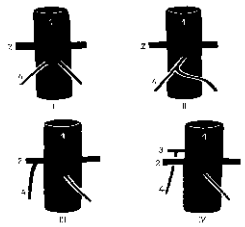

Fig.1. Variations of ovarian artery origin (Luzha D., 1973)

The choice of catheter

The type of selective catheter used for AUE can vary greatly and depends on the physician's preferences and his experience with different catheter devices. The catheter has to meet the following requirements: high radiodensity, steerability and the presence of a soft steerable tip. The most common catheter diameters are 4F and 5F, while the frequently used configurations include: Cobra, Berenstein, Simmons I, Levin, etc. A new Roberts catheter for UAE was recently created by Cook company.

Microcatheter

The use of a microcatheter is justified in certain clinical settings. Microcatheter is less in diameter (3F), more soft and flexible than a common catheter. Microcatheter can be used for embolization of uterine arteries, which are prone to spasm. Careful technique and a microcatheter use helps to avoid UA spasm. In small UA the microcatheter maintains antegrade blood flow, necessary for distal embolization. A microcatheter is more easily advanced further into UA, than a common catheter. Placement of the catheter's tip distal to the origin of cervico-vaginal branch avoids its accidental embolization. Embolization with coaxial catheter-microcatheter device allows for easy replacement of a microcatheter in case of its occlusion with the embolization particles.

Besides its high cost, microcatheter is more difficult to identify at fluoroscopy, it has smaller internal lumen, requiring the use of more diluted embolization solutions, leading to increased time of embolization and radiation exposure. Wortington-Kirsch analyzed over 2300 UAE procedures and reported, that half of the operators used microcatheters, while the remainder used 4-5F catheters (14).

Choice of guidewire

In contrast to catheters, there is no big choice among guidewires. Hydrophilic wires such as «Terumo» are most commonly used. Ipsilateral catheterization sometimes necessitates the use of more flexible guidewires.

Arterial approach

In the majority of cases UAE is performed through the right common femoral artery approach. As in all endovascular radiological procedures, this approach is the most convenient and easy for right-handers. As a rule, catheterization and embolization of the left contralateral UA are not associated with technical difficulties.

Loop method described by Waltman (15) is commonly used for catheterization of the right ipsilateral UA. Some authors use a special Roberts (Cook) catheter or an original catheterization technique (16). This stage of the procedure can be rather difficult or prolonged. In some patients with anatomical variations, ipsilateral catheterization is sometimes impossible. In such cases a second approach through the left contralateral common femoral artery can be useful.

Another approaches, free from the difficulties associated with ipsilateral catheterization, are through axillary, brachial or radial artery. Puncture of the arteries of the upper limbs reduces radiation exposure for the physician and doesn't limit the patient's physical activity immediately after the procedure. However, the diameter of radial and brachial arteries is small, which increases the risk of arterial injury. Catheterization of axillary artery is associated with difficult hemostasis using a pressure bandage after catheter removal, as well as with neurological complications (17). Upper limbs are rarely used for UAE approach in clinical practice.

Some operators use bilateral simultaneous approach through the common femoral arteries (18). This approach avoids difficulties associated with UA ipsilateral catheterization, at the same time reducing the radiation exposure (19). However, the bilateral catheterization increases the risk of common femoral artery injury and thrombotic or embolic complication. This approach requires two physicians and concurrent use of two catheters.

Technique of contralateral UA catheterization

Uterine artery origin is very often overlapped with other pelvic arteries. Optimal visualization, as a rule, requires oblique projections. Yet, the choice of and optimal view is time demanding, increasing the radiation exposure. Therefore, the «random guidewire introduction» is initially used for UA catheterization. After placement of a selective catheter in the internal iliac artery, guidewire is carefully introduced. Medial position of the guidewire in the lower third of pelvis indicates its presence in UA. However, the guidewire can

lie in other arteries, too (such as hemorrhoidal or vaginal arteries). Watching the progress of a guidewire one can accurately identify the moment when the guidewire is advanced into UA without contrast injection. When in UA, the guidewire is moved several centimeters downwards and medially, and then, making a sharp turn, goes up. In other arteries the guidewire remains straight.

When the catheterization using «random guidewire introduction» technique is impossible, another technique is used. A selective catheter is proceeded upon a guidewire deep in internal iliac artery,distal to UA origin, then after injection of contrast media, the catheter is slowly pulled back. The catheter is stopped after the identification of UA. The catheter is rotated so as to position its orifice opposite to UA ostium. Usually the guidewire is further introduced into UA without any difficulties. Use of roadmapping can be effective.

Many physicians actually use roadmapping from the moment of internal iliac artery catheterization. As described above, the choice of projection for roadmapping can be difficult, thus increasing the radiation exposure. Therefore, routine use of roadmapping during catheterization of UA is unnecessary.

After the guidewire is inside the UA, the selective catheter is proceeded for 1-2 cm or less. The guidewire is removed and the UA angiography is performed. Absence of antegrade blood flow through UA may necessitate the replacement of selective catheter with a microcatheter or administration of nitroglycerine (100-200 mg).

At the next stage the catheter (microcatheter) is advanced more distally. An optimal position of a catheter is the distal portion of horizontal UA (bent) after the origin of cervico-vaginal branch. In certain instances the optimal position of a catheter is unfeasible due to the marked tortuosity of UA. In such cases UAE is possible, though the risk of retrograde embolization and accidental embolization of cervicovaginal branch is high.

Catheterization of ipsilateral UA

Waltman loop method (15) is commonly used for ipsilateral UA catheterization.

Following the embolization of contralateral UA a hydrophilic guidewire is introduced to reach the aortic bifurcation, thus making the proximal part of the selective catheter more rigid (see Fig. 2).

Using the fluoroscopic guidance the catheter is advanced forward and rotated to form a loop in the aorta (see Fig. 3).

Then the catheter is slowly introduced into the aorta, while the distal part is positioned against the origin of the right common iliac artery by rotating the catheter (see Fig. 4).

Using the fluoroscopic guidance the catheter is pulled back and introduced into the right common iliac artery (Fig. 5, Fig. 6). Further catheterization is similar to that in contralateral UA.

Fifty UAE procedures were performed in the Division of Angiography and Interventional Radiology of Magnitogorsk.

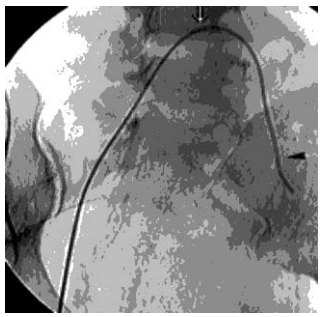

Fig. 2. UA Catheterization stages, distal portion is positioned in the internal iliac artery (dark arrowhead), the guidewire is set on the level of aortic bifurcation (light arrowhead).

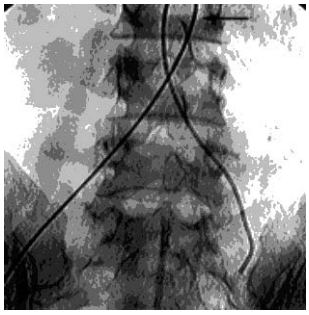

Fig. 3. Stages of catheterization, a loop is in the aorta (arrowhead).

The approach was made through the right common carotid artery in 92% of cases, bilateral approach was used in 8% of cases. Catheterization was performed with Cobra C3 catheters — Tempo5, Infiniti or Supertorque (Cordis) 5F; cobra C1 — Optitorque (Terumo) 5F; J curve — Optitorque (Terumo) 4F; microcatheter — «Infusion catheter» (Cook) 3F and 0,035'' guidewires with Radifocus hydrophilic coating (Terumo).

Fig. 4. Stages of catheterization, the entire catheter is located in the aorta.

Waltman loop technique was used for ipsilateral catheterization of the right UA.

Emboli used were 0,5 mm spherical hydrogel or 0,6-1,0 mm cylindrical hydrogel.

Simultaneous bilateral UAE was performed in 47 (94%) patients. In three patients (6%) bilateral catheterization was successful when an additional approach through the left common femoral artery. We failed to perform catheterization in one patient (2%) from either side.

Fig. 5. Stages of catheterization, selective catheter in the right internal iliac artery.

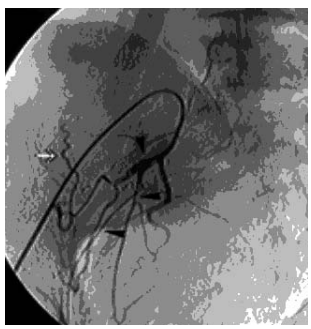

Fig. 6. Stages of catheterization, contrast study of the right internal iliac artery showing the right uterine artery (dark arrowhead).

The technical success rate was 98%.

Microcatheter was used in one patient (2%). Intraarterial nitroglycerine in a dose of 150 mg was required for two (4%) patients.

One procedure was complicated by the thrombo-

sis of the external iliac artery. This was treated by emergency thrombectomy.

The correct choice of instruments and technical maneuvers allows for safe and effective embolization of uterine arteries for uterine myomata.

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Letter to the Editor

Notes and ideas concerning the article by J. Ready «Uterine artery embolization», International Journal of Interventional Cardiology, 2003; 3: 51-57.

Endovascular procedures have become widely adopted for the treatment of many disabling and fatal illnesses. Particular success has been achieved in the treatment of atherosclerosis. For example, coronary angioplasty is now doubtlessly the leading method of CHD treatment. Embolization, another major trend in endovascular surgery, is well frequently used in clinical practice for a number of conditions, either alone or either as an adjunctive symptomatic treatment. Till recently, however, embolization has not been used routinely for the most common diseases.

The use of uterine artery embolization (UAE) for uterine fibroid (1, 2) has been reported since 1995, however, Dr. John Ready points to the fact that the method of embolization had been used to treat symptomatic metrorrhagia for 2 decades before (7).

The first results were promising and to date, by different reports, up to 50 000 patients all over the world have underwent the procedure (2, 3).

Simplicity of the procedure and the ability of medical business to incorporate new technically assisted method, which requires tools for superselective catheterization and embolization agents, proper choice of uterine embolization site, professional skill, have contributed to its rapid introduction. Fibroids are the most common surgical pathology in women, and endovascular surgeons were given an opportunity to take an active part in routine treatment of diseases of the fair sex. They seem to have expected such a chance since they started routine treatment of coronary heart disease — the most common illness in adult men.

Great number of research and practice information, detailed description of indications and contraindications, preoperative therapy, intraoperative and postoperative management, surgical technique; special equipment and embolization agents along with the will and opportunity to participate in the treatment of the most common women's disease have allowed to start clinical use of uterine artery embolization for fibroid. Having met Dr. John Ready we invited him to perform first demonstration of such procedures in our hospital, and, what seemed most important to us, to hold a discussion with Russian gynecologists. These events took place in June 2003. It must be mentioned, that the Department of Gynecology of Endosurgery and Lithotripsy Center is the leader in endoscopic treatment of uterine fibroid in Russia. More than 1500 endoscopic conservative myomectomies and hysterectomies have been performed in this institution. Therefore, even within our hospital we had a strong rival with favorable results of minimally invasive surgery. In addition, the presence of such a strong group of endoscopic specialists have been an obstacle in the way of our urge towards the project.

By February 1, 2004 our experience of uterine artery embolization for uterine fibroids have reached 35 patients. This letter is intended to share certain administrative and medical considerations.

This disease is, of course, well known, studied and susceptible to therapy.

Conservative hormone therapy is useful, as it reduces fibroid size and helps to relief of symptoms, however, only for a short time of treatment. Subsequently the disease resumes its normal course (13). In addition, hormone therapy may cause adverse events or conditions, including malignant tumors.

Open and endoscopic hysterectomy. The results of myomectomy are questionable; the recurrence rate is around 25% (14, 15). At the same time, hysterectomy is a radical procedure for, as a matter of fact, absence of the organ excludes any diseases involving it. However, not all is doubtless even from this point of view. Hormone imbalance leads to aggravation of a number of diseases; reproductive function becomes impaired; mental disorders occur in women with removed uterus (including sexual discomfort); postoperative scars are left on the skin.

We have developed UAE program and created a group of gynecologists and endovascular surgeons. Our experience have shown, that, similar to the world's medical practice, only association and mutual understanding of these specialists can ensure specific outcome. It is gynecologists who must refer patients for embolization, i. e., find indications to surgery, however, as mentioned in the article, internet gives patients an opportunity to make their own choice and, in some instances, directly address endovascular surgeons. It seems that everything is already known. Almost all types of fibroids (except for subserous fibroid) without concomitant infection or pregnancy can be treated with UAE. The most severe complication of UAE — hysterectomy — is common for these illnesses and occurs seldom (less than in 1% of cases) (1).

Having been operated on with further analgesia during several days postoperatively the patient can be referred to gynecologist for outpatient management. This is what we have in practice. And after all the entire fame comes to endovascular surgeon.

However, competition dramatically aggravates the situation from the very beginning of examination. Due to satisfactory outcome of surgery, particularly the minimally invasive endoscopic procedures, a gynecologist can feel free to offer a patient one of these treatments. Therefore, we have to explain patients that UAE is less invasive in the treatment of fibroid, requires no general anesthesia, has few complications and no recurrences have yet been observed. But this is still a gynecological disease. We are all general practitioners, but today we have to

cooperate with each other, and, if tomorrow the gynecologists will engage in endovascular surgery... then, as they say, time will show everything. However, subspecialization can exist in endovascular surgery, too, as it has happened in neuroradiology.

Thus, the choice is made by the patient, but only upon the advice of a gynecologist, responsible for postoperative management.

But whither shall we, the endovascular surgeons, find ourselves in this succession of specialists? Having got used to be responsible for the patient's fate, we are now becoming nothing but the operators. Our work will only be limited by the operating room — if we agree or not?

I was at first surprised with such a role after I had performed UAE in 35 patients with fibroids. Usually my colleague, a gynecologist, calls me up and informs me of a patient who could benefit from UAE. My role in preoperative examination is only to get acquainted with the patient, check the pulse on femoral artery and ask whether she was allergic to any medications, including contrast media. Then, in the operating room, usual procedure lasting 15 to 90 min (mean 25 min) is being performed under local anesthesia with additional analgesia. In one case the duration of the procedure was 90 min due to inability to catheterize left uterine artery. Such a situation has been previously reported to occur in 2,5-10% of cases (6). When the intervention is over and hemostasis is secured the patient is reallocated to gynecological department. Only a gynecologist observes her thereafter.

As a result, we agree to be merely operators. We don't need anything else in management of this disease and I operate these patients on with great pleasure.

All of the patients were diagnosed «symptomatic uterine fibroid». The size of fibroids ranged from 6 to 24 weeks.

We used femoral approach, which is convenient, less invasive and reduces the time of operation. A single Roberts catheter (COOK, USA) was used for selective catheterization of both uterine arteries, 500 mm polyvinyl alcohol particles were used for embolization (COOK, USA; CORDIS, USA). Mean hospital stay was 1-2 days.

Results. Relief of symptoms was achieved in all patients. The size of fibroids decreased by 40-75% (mean 50%). Follow-up period was 7 months. The patients were assessed by duplex ultrasound pre- and postoperatively.

In this situation patient's subjective estimation of the results of surgery is particularly crucial, because of pain in uterus and the presence of fibroid — a space-occupying lesion — though substantially decreased in size. Thirty-three patients (94%) were contented with the results of intervention. In one female patient after 3-month follow-up the fibroid decreased by 45%, the pain was reduced, but abundant menstruation persisted. In another patient with 20-24 weeks of pregnancy fibroid was reduced to 14 weeks of pregnancy 6 weeks following UAE. Necrotic discharge associated with fever was noted during 4 weeks postoperatively. After antibacterial therapy the body temperature came to normal range within 6 weeks, leukocyte count was reduced from 17 000 to 10 000 x 10^9/l, ESR — from 65 to 35 mm per hour.

Complications and problems

In one female patient selective catheterization of the left uterine artery (small-sized) was unsuccessful. In this patient the uterine artery had complex angioarchitecture. Embolization of the right uterine artery (which was twice larger) was performed. Despite the incomplete UAE the symptoms disappeared and the size of fibroid decreased from 12 weeks to 9-10 weeks of pregnancy. Repeated examination was planned postoperatively so as to perform the embolization of compensatory enlarged left uterine artery if the symptoms persist.

In another patient, described above, necrotic discharge was observed after UAE.

Medical and technical research in this field implies development of the following agents:

embolization agents with various additives: cytostatics, antibiotics, immunomodulators, etc.;

catheter systems, though the latter are almost optimal.

Russian reality

Professional competition between gynecologists (particularly the surgeons) and endovascular surgeons has not yet reached its maximum. Traditions, conservatism, stagnancy, large number of patients, the fear of innovations so far have given the gynecologists an advantage. However, they showed interest in this new method. Such situations already happened before in medicine. Surgical gynecologists are loosing the most common intervention and, therefore, resist, sometimes using dishonest methods. It is worthy of notice that some have used administrative resources in different ways to start a more active program of UAE. The reality of today's situation is as follows: from complete rejection of the method to either «love» assisted by administrative resources or the patient's desire to preserve uterus and undergo UAE.

Equipment and instruments

The entire range of instruments and polyvinyl alcohol embolization agents of different size are provided by «COOK» and «CORDIS». The high cost of UAE is determined by the price of these agents. Unfortunately, it is believed by Russian endovascular surgery specialists, that the artery can be obstructed with «anything available», therefore, the risk exists that embolization materials from improvised means of inappropriate size and quality, doubtful biological compatibility and toxicity profile will be used to make the procedure less expensive. The use of such

agents or devices can lead to aggravation of results both immediately and in the long run.

By the example of our clinic — Endosurgery and lithotripsy center — the cost of open surgery, endoscopic procedure and UAE were made similar to exclude their mutual competition. The benefit from UAE is higher as compared to other methods, which is consistent with the world's situation. As for pricing in other clinics of Russia, it is quite difficult, because hospital stay is covered by government.

What is most alarming?

First of all, everything is convenient and easy, and there is great euphoria among endovascular surgeons (however, quite understandable). The solution can be based on the assessment of immediate and long-term results. This can give us an understanding of whether this euphoria is justified. We hope it is.

The possibility of surgical technique violation. The use of various embolization materials, sometimes inappropriate for uterine artery, for the treatment of uterine fibroids in order to make the intervention less expensive may ultimately lead to deterioration of long-term results. This can be managed using international standards of surgical practice, despite the high cost of consumables.

Conservative approach or unawareness of potential benefits of this operation from the gynecologist's point of view. The solution lies in the assessment of comparative trials with different therapies for fibroids and permanent popularization of this method among gynecologists and public.

Possible recurrences after long-term period with potent collateral vasculature. The solution is repeated embolization.

Future prospects

Treatment of all types of fibroids regardless of their size. The first step is preoperative embolization of giant fibroids for exsanguination and decrease of size with further endoscopic removal. The most important prospect is that UAE leaves the chance to conceive (1, 6, 15).

In our professional activity we, the endovascular surgeons, have always extended helping hand to many of our colleagues: cardiologists and cardiac surgeons — when performing coronary angioplasty, vascular surgeons — when performing peripheral arteries angioplasty, neurologists — when performing carotid artery stenting. We believe that time has come to enter into an alliance with gynecologists in the name of treatment of the most common surgical illness of the fair sex.

Z.A. Kavteladze

Center of Endosurgery and Lithotripsy, Moscow.

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Center of Endosurgery and Lithotripsy, Department of Cardiovascular Surgery

Moscow.

The first multy-discipline private hospital in Russia — Center of Endosurgery and Lithotripsy (CELT) — was founded in 1993. It has been headed by its originator — Professor A. Bronshtein.

Minimally invasive surgery is the Center's main ideology. Joined under this major principle, departments of surgery, urology, gynaecology, pain clinic, diagnostic department, out-patient clinic, radiology department, pediatric department, acute care unit, dentistry department have been successfully working in CELT.

In autumn 1993 the department of cardiovascular surgery (CVS) was introduced in CELT. Physicians from the Russian Academy of Sciences Research Centers, specialized in endovascular diagnostics and therapy (among them Z. Kavteladze, A. Babunashvili and D. Dundua) became the first full-time specialists of the department.

From the day of its foundation, CVS department has been a separate clinical subdivision of the Center of Endosurgery and Lithotripsy. Its unique feature is the association of specialists of different types, such as interventional cardiologists or radiologists, vascular surgeons, cardiologists, which provides a possibility for complete diagnosis and treatment of the most prevalent cardiovascular disorders. To date the department includes 12 physicians, among them 5 doctors and 2 candidates of medicine. The department is headed by Professor Z. Kavteladze, MD.

For the last ten years the CVS department has successfully united practice and research. Since 1995 four International Symposia on cardiovascular radiology have been organized, the fifth Symposium is scheduled for April 22-24, 2004. In 1997, for the first time in Russia, the symposium included live case demonstrations from CVS department of CELT. The staff members take an active part in research work; make presentations in Russian and International forums, their works are published in medical periodicals. Five monographs on interventional cardiology and angiology, along with dozens of articles were published during the decade.

CELT strives to popularize modern technology and share experience with colleagues. A training course of minimally invasive therapy was successfully organized by the Department of Novel Medical Technology, Sechenov's Moscow Medical Academy. Physicians working in the cardiovascular surgery department deliver lectures and provide practical training for the students. The department routinely conducts seminars with demonstration of surgical operations for various healthcare specialists — cardiologists, therapeutists, neurologists, vascular surgeons, gynecologists.

The Inernet provides unique cooperation opportunity for colleagues all over the world. Towards this end in February 2004 the cardiovascular surgery department of CELT launched a new project — regular interactive online demonstration of endovascular procedures. The access is unlimited for everyone, which is crucial for young specialists in Russia and CIS.

Our primary trends of activity include percutaneous transluminal coronary angioplasty and stenting for CHD, percutaneous procedures and endograft deployment for PAD, visceral arteries or aortic arch branch lesions.

Introduced in 1993, coronary stenting has by now become a routine procedure, performed with assisted circulation since 1997. Drug-coated stents have been used since 2002. This provided new indications for endovascular management of CHD. Percutaneous myocardial revascularization is performed in patients with severe CHD. More than half of all patients admitted have multi-vessel coronary stenoses, left main disease, chronic occlusions, acute coronary syndromes, compromised myocardial function.

We have developed and introduced into practice a new self-expanding Za-stent for endovascular stenting of vessels and hollow organs. The acknowledgement of our work is confirmed by the fact that Za-stent manufactured by COOK company is used in clinical practice in Europe and USA.

Our physicians have unique experience in endovascular aortic aneurysm repair. We designed an original aortic endovascular stent-graft system, in 1995 this procedure was for the first time performed through percutaneous approach. For the first time this approach was used for endovascular repair of abdominal aorta aneurysm with bifurcation graft in 1997.

Experiments with novel technological advances, such as temporary stents and cava filters, were conducted in close cooperation with University hospital of Liege (Belgium). A new trend — temporary endovascular grafting of peripheral arteries — has been successfully introduced into clinical practice. As a result of cooperation with the department of interventional radiology of St. Thomas Hospital (London) a new promising procedure — uterine artery embolization for uterine myomata — was introduced in CELT in 2003.

Embolization of arteries and veins, congenital and acquired heart diseases treatment are performed in the department. In addition, we perform conventional vascular interventions and combined procedures (percutaneous and open surgery).

The department is provided with two interventional radiology units, two angiography units (stationary Philips Integris 3000 and mobile Philips BV29). Intraaortic balloon pump machine and intravascular ultrasound are available in the department of interventional radiology.

The department possesses 12 beds (6 of them —

with permanent monitoring system). Every year we provide medical aid for around 1200 patients. Mean hospital stay required for diagnostic studies is 0,5-1 days and 1,5-2 days for percutaneous interventions.

In 2002-2003 diagnostic studies were performed in 1559 patients, among these 1259 coronary angiographies.

Table 1 summarizes the number of patients and the diagnostic studies performed in 2002-2003.

A total of 1640 patients underwent surgery or interventional procedures in 2002 — 2003. Table 2 represents interventions and the number of patients exam-

Table 1

Investigation	Number of patients	
	2002	2003
Coronary angiography	543	716
Aortography	178	102
Pulmonary angiography	3	3
Phlebography	3	7

ined in 2002-2003.

Percutaneous transluminal coronary angioplasty

Table 2.

Procedure	Number of patients	
	2002	2003
Coronary angioplasty, stenting	366	385
Angioplasty, stenting of peripheral arteries	126	116
Retrieval of temporary stents	-	16
Renal angioplasty	16	19
Endovascular repair of aortic and peripheral arterial aneurysms	4	5
Arterial embolization	2	26
Embolization of veins	6	9
Cava filter implantation	9	15
Arterial surgery	35	32
Vein surgery	210	243

mortality rate was 0,3% (2/751). There were no lethal cases related to peripheral artery angioplasty or open surgery.

Federal Center for Roentgenosurgical Methods of Diagnostics and Treatment

(117049, Moscow, Leninskiy prospect, 8/1)

The Center is headed by
Professor V. I. Prokubovsky,
The Head of the Laboratory for intracardiac and contrast methods of roentgenological research
of Russian State Medical University (RSMU),
Professor S. A. Kapranov
The Head of the Department for roentgenosurgical methods of diagnostics and treatment of Moscow Clinical Hospital (MCH) №1,

Russian Republican Center for intracardiac and contrast methods of roentgenological examinations was created in 1975. In 1988 it was renamed into the Federal Center for X-ray Diagnostics and Radiosurgery (resolution issued by the Minister of Public Health on June 22, 1998).

The Center is based on the Department of Facultative Surgery named after S.I. Spasokukotsky of RSMU and MCH №1 named after N.I. Pirogov.

The patients of 3 surgical, gynecologic, urologic and cardiologic Hospital departments are treated in the Center.

There are 3 roentgenological operating rooms equipped with angiocardiographic sets «Integris V 3000» (1994), «SCHUS 9800» (2001) and «Integris Allura» (2003) in the Center. Eight highly skilled X-ray surgeons with an experience from 3 to 42 years are working in the Center. The first Russian angiography emergency service was organized in the Center.

The diagnostic and curative service is for adults only.

The scope of interest includes the following

The diagnostics of heart diseases, arterial and venous diseases, diseases of the internal organs by means of heart and pulmonary artery catheterization, coronary angiography, angiopulmonography, ventriculography, angiography of thoracic and abdominal aorta, angiography of brachiocephalic arteries, major arteries of pelvis and extremities, celiaco- and mesentericography, venocavography, phlebography of major veins of pelvis and extremities, percutaneous transhepatic portography, retrograde venography.

Prevention and treatment of cardiac and vascular diseases by means of:

balloon angioplasty and stenting in patients with chronic obstruction of coronary, subclavian, iliac, femoral, popliteal and renal arteries and iliac veins;

regional thrombolysis and catheter thrombectomy for acute thrombosis of major vessels of pelvis and extremities;

implantation of permanent and temporary vena cava filters for prevention of pulmonary embolism;

rotational disobstruction, fragmentation and thrombolysis in patients with pulmonary artery embolism;

embolization of the culprit vessel in case of gastrointestinal bleeding, arteriovenous and arteriobiliary anastomoses in liver;

transjugular intrahepatic portosystemic shunt in patients with hepatocirrhosis and cirrhotic complications;

endovascular removal of foreign bodies from the heart and vessels;

Percutaneous transhepatic biliary interventions for treating obstructive jaundice of different etiology using external, external-internal and internal drainage, balloon dilatation and bile duct stenting.

During the year 2001, one thousand ninety five patients were examined in the Center. Five thousand forty three roentgenosurgical interventions have been executed including 485 endovascular and endobiliary interventions. Among them there were 3042 emergency cases.

During the year 2002, medical assistance was rendered to 1017 patients who underwent 452 curative interventions and 3866 diagnostic procedures. There were 2126 urgent cases.

The scientific research in the Center is focused on the following subjects

Endovascular surgery of venous system and pulmonary artery diseases.

Endovascular surgery of acute and chronic occlusion of pelvic arteries and lower extremity arteries.

Endovascular methods for treatment of uterine myoma and its complications.

During the last 7 years four models of permanent and demountable vena cava-filters, thromboextractor «TREKS» for catheter endovascular removal of thrombi from inferior vena cava and iliac veins, nitinol stent for implantation in pelvic arteries and extremity arteries have been developed and introduced into clinical practice with participation of the specialists of the Center. The methods of temporary implantation of vena cava filters, gonadal veins embolization in patients with varicose pelvic veins, arterial embolization for treating uterine myomas were introduced into clinical practice of the Center.

Department for Roentgenosurgical Methods of Diagnostics and Treatment (RSMDT)

is a part of Altay Region Cardiologic Dispensary (ARCD) opened in 1988.

(Malachov str., 46, Barnaul, 656055, Russia)

The Dispensary is a part of Inter-Regional Center for Cardiac Surgery. The Dispensary possess a clinic with 300 beds and an out-patient clinic for 500 visits per day.

Four of 50 surgery beds belong to RSMDT.

The Department was opened in 1993 and led by V. F. Gridasov, the physician of the highest category. Now he is the Head Doctor of ARCD.

In 1994 method of balloon angioplasty of coronary arteries was mastered and introduced into clinical practice. Coronary artery stenting was introduced into practice in 1997.

Emergency endovascular aid for patients with acute coronary syndrome was organized in the RSMDT in 1997. Now the urgent service for this group of patients is available round-the-clock. According to the Order of Health Committee №332/389 «About organization of emergency aid for cardiology patients...» all patients with myocardial infarction and acute coronary syndrome who are residents of Barnaul city and nearby areas of Altay Region should be hospitalized in ARCD.

The Department has 2 operating rooms equipped with angiographic imaging systems «Integris 3000» (Philips) and «Advantics» (General Electric).

The Department is staffed by 5 interventional specialists. Three of them are physicians of the first category.

The physician of the highest category A.G. Tirishkin is the Head of the Department since 2001.

The diagnostic and curative manipulations carried out in the Department are the basis for urgent and scheduled cardiosurgical aid in the Altay Region.

Scheduled diagnostic procedures and curative interventions:

1. Coronary angiography with ventriculography is necessary for the following cases:
   - patients requiring coronary artery bypass surgery and aortic valve replacement;
   - patients with drug-resistant coronary heart disease to determine further treatment tactics.
2. Cardiac catheterization for the diagnosis of complex congenital and acquired valvular diseases.
3. Coronary artery balloon angioplasty and coronary artery stenting.
4. Balloon angioplasty for pulmonary valve stenosis, coarctation of aorta, renal artery stenosis accompanied by symptomatic arterial hypertension.
5. Implantation of permanent pacemakers.

Due to the new principles of rendering assistance to the patients with acute myocardial infarction (AMI), 80% of patients with AMI are delivered in the Center within the first 6 hours from the onset of symptoms, 31% of patients with AMI undergo highly effective endovascular procedures. The number of urgent endovascular interventions has increased almost twice in comparison with the year 2001:

Aggressive methods of treating acute myocardial infarction

	Number of patients		
	2000	2001	2003
Number of patients with AMI	675	609	751
Urgent coronary angiography	134	136	251
Urgent angioplasty	70	64	125

Mortality rate in patients with AMI undergoing interventional procedures continues to reduce constantly. By the end of 2003 the mortality rate was 6%.

Selective endovascular interventions

	Number of patients	
	2001	2002
Diagnostic examinations	415	634
Interventions	39	72

The scientific research is focused on the following subjects

1. Evaluation of left ventricular diastolic function in patients with acute myocardial infarction undergoing urgent myocardial revascularization.
2. Angina pectoris in patients with normal coronary arteries.

The doctors of the Department participate actively in the research and inculcation of state-of-the-art technologies into clinical practice. They had fellowship training at the cardiology centers of Moscow, Tomsk and Novosibirsk.

There are training courses for the doctors working in the clinics of Altay Region and nearby areas of the country organized in the Department.

Department for Roentgenosurgical Methods of Diagnostics and Treatment

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e-mail: vasilisa@aport.ru)

Roengenosurgical service of the Regional Clinical Hospital is represented by an independent unit — the Department for roengenosurgical methods of diagnostics and treatment.

The Department has 2 operating rooms equipped with the systems «Diagnost 56» and «Integris H 3000» (Philips).

There are four interventional surgeons in the Department.

There are 1080 beds in the hospital. 10 of them belong to the Roentgenosurgical Department.

The clinical practice of the Department is focused on interventional cardiology, arrhythmology, neuroradiology, angiology, phlebology, endourology, endobiliary surgery including pediatric and emergency cases.

The number of diagnostic examinations: 1340 in 2001, 1791 in 2002.

Department for roengenosurgical methods of diagnostics and treatment was founded in 1998. At that time it consisted of a single X-ray operating room equipped by X-ray diagnostic system «Diagnost 56». Nevertheless up to 1500 diagnostic examinations and 250 curative roentgenosurgical interventions per year were performed in the Department, including the following procedures:

- various types of angiography (except coronary angiography)
- peripheral angioplasty and stenting including brachicephalic artery and visceral branches of the abdominal aorta
- aortoplasty for coarctation of the aorta
- various types of endovascular occlusions under X-ray guidance in the oncology patients with bleeding (pulmonary, uterine, renal, nasal bleeding etc.) during preoperative period
- implantation of vena cava-filters in patients with pulmonary artery thromboembolism
- various endobiliar and endourologic interventions
- intravascular neurosurgical interventions for various types of arteriovenous malformations and arteriovenous anastomoses (including carotid-cavernous fistula management with detachable balloons).

Since 1999 various models of permanent pacemakers have been implanted in the Department.

In 2002 Regional Clinical Hospital got a new angiographic system «Integris H 3000» and since then intravascular roentgenosurgery in the Department has quickly developed. The first coronary angiography as well as first balloon angioplasty and stenting were performed in the Department the same year.

Today the Department for roentgenosurgical methods of diagnostics and treatment has 10 bedded clinical block and an operating block consisting of two X-ray operating rooms. Up to 2000 diagnostic procedures and more than 350 curative interventions in 750-800 patients are performed per year.

Today the Department is staffed by highly skilled doctors and provides a wide range of diagnostic and curative services. The founder of roentgenosurgical service in the region M. Solonetz who has more than 20 years of experience is working in the Department. It was M. Solonetz who performed the earliest balloon dilatations of occlusive and stenotic lesions of lower extremity and renal arteries, endourologic and endobiliary interventions more than fifteen years ago. In 1996 A. Vasiliev became the first surgeon to perform the implantation of a venous cava-filter. He also carried out the most complicated neuroroentgenosurgical interventions which can be performed in a few Russian clinics. Furthermore, in 2002 A. Vasiliev became the first physician in Vladimir to perform a complete coronary angiography in a patient with coronary heart disease. He has the widest experience in coronary angioplasty. In cooperation with high-skilled electrophysiologist S. Rodina, in 1999 various methods for treating patients with arrhythmias were introduced into clinical practice. Currently in the Department we have about 100 pacemaker implantations and more than 300 electrophysiologic studies per year including electrophysiologic endocardial mapping. The procedure of radio-frequency ablation in patients with tachyarrhythmias is introduced into clinical practice. Thanks to anesthesiologist V. Chepenko, the safety of most complicated interventions has significantly increased. There are several promising young doctors in the Department: S. Jakonjuk who was the first of the young doctors to master coronary angiography and now he learns to perform coronary angioplasty; M. Vlasov, a promising young phlebologist, and A. Korobenin, a promising peripheral vascular surgeon.

The doctors working in the Department are the authors of more than 100 publications. The Russian Patent is received for a method of treating migraineous headache in women. Physicians of the Department participated in various workshops and conferences. In 2002 the Head of the Department A. Vasiliev successfully accomplished the PhD work on cardiovascular surgery and cardiology.

Volgograd Regional Cardiology Center

(Gornaya Polyana
Volgograd
Russia, 400008)
The Head of the Center -
V. Schuchkin, PhD, the Honored Doctor
of the Russian Federation.

The Department for endovascular roentgenosurgery and angiography is an independent structural unit of Volgograd Cardiologic Center.

There are 300 beds in the Cardiology Center.

There are two X-ray operating rooms in the Department equipped with biplane angiographic system «Bicor TOP» and angiographic system «Siregraf-D-2-Angio» manufactured in 1996.

The staff of the Department:

B. Shukurov (1959), PhD, Head of the Department, radiologist of the highest category.

G.V. Kozlov (1972), cardiovascular surgeon, physician of the first category.

I.V. Gorelov (1969), cardiovascular surgeon, physician of the first category.

Over 1500 patients with various cardiovascular diseases have been examined and treated in the Department since May 1998. The Department provides the following roentgenosurgical interventions:

1. All types of aortography and arteriography (including transvenous digital subtraction angiography).
2. Cardiac catheterization.
3. Angiocardiography in patients with congenital and acquired heart malformations.
4. Coronary angiography, shuntography.
5. Venous catheterization (renal, hepatic and other veins draining internal organs).
6. Selective intraarterial injections.
7. Transluminal balloon angioplasty and stenting (vascular endoprosthesis implantation) of various arterial segments.
8. Transluminal balloon angioplasty and stenting of coronary arteries.
9. Endovascular chemical ablation of hypertrophic subaortic stenosis.
10. Thrombolysis (clot-selective coronary thrombolysis, visceral artery thrombolysis etc.).
11. Implantation of vena cava filters.
12. Embolization of patent ductus artriosus.
13. Embolization of arteriovenous malformations (including coronary fistulas).
14. Transluminal balloon valvuloplasty of pulmonary artery stenosis and aorta stenosis.
15. Transluminal balloon angioplasty of coarctation of aorta.
16. Endovascular interventions in cyanotic congenital heart diseases.

In 2002 endovascular surgical interventions were performed in children with the following diseases:

1. Patent ductus arteriosus (PDA).
2. Coarctation of aorta (CoA).
3. Valvular aortic stenosis.
4. Valvular pulmonary stenosis.
5. Atrial septal defect II
6. Peripheral pulmonary stenosis.
7. Transposition of the great arteries.

At the moment there is no emergency service in the Department, however 2 procedures of transluminal balloon angioplasty (TBA) and stent implantation in patients with myocardial infarction and 11 procedures of TBA and stent implantation in patients with unstable angina were performed this year.

Such endovascular interventions as chemical ablation of hypertrophic subaortic stenosis and embolization of patent ductus arteriosus with the new type of «detachable» emboli were performed in the Department for the first time in Russia.

The following interventions were introduced into clinical practice of the Department: transradial coronary angiography, embolization of arteriovenous malformations, direct stenting of coronary arteries, left main coronary artery stenting, Rashkind operation, endovascular repair of atrial septal defect and PDA using Amplatzer device, stenting of peripheral pulmonary stenoses, embolization of coronary fistulas.

The scientific research in the Department is focused on the following subjects:

- evaluation of the efficacy and results of endovascular closure of PDA using new type of detachable coils;
- evaluation of the efficacy of interventional methods for treating patients with coronary artery disease and congenital cardiovascular malformations (pulmonary artery stenosis and aorta stenosis, PDA, atrial septal defects, coarctation of aorta).

	2001	2002
Number of diagnostic procedures	2125	2340
Number of interventions	48	61

Records of the Russian Society of Interventional Cardiology board meeting, January 16, 2004

Agenda

1. Possible date of Second Congress of RSICA
2. Subjects of the Congress
3. Selection of curators for specific sections of the Congress
4. General questions

Attended by. A. Arablinsky, A. Babunashvili, G. Belozerov, V. Boshkov, D. Iosseliani, Z. Kavteladze, L. Kokov, V. Kucherov, V. Mazaev, V. Plekhanov, A. Pokrovsky, V. Prokubovsky, S. Semitko, A. Filatov, N. Chigogidze

As established by the First Congress of RSICA (March 2002), the Second Congress of the Society of Interventional Cardiology is scheduled on the beginning of 2005. The meeting of the Society board was dedicated to the discussion of this question.

Opening address was delivered by Professor D. Iosseliani, the President of Russian Society of Interventional Cardiology, Chief Cardiologist of Moscow Health Care Department, who declared the agenda and proposed to discuss the first question concerning «the date of the Second Congress».

The first question was discussed by Z. Kavteladze, A. Babunashvili, D. Iosseliani. After intensive study of the arrangements scheduled for 2005 it was decided to establish March 28-30, 2005 as the dates of Congress.

The second question was discussed by G. Belozerov, who suggested an additional section of the Congress — «Endovascular interventions for surgical emergency»; L. Kokov, on behalf of Yu. Volynsky, proposed to expand the Congress' subjects with «Informational and communicational technology in interventional cardioangiology» section.

V. Prokubovsky offered to divide the subjects between sections, such as «interventional cardiology, oncology, pediatrics» and etc., which could include more specific questions as sub-sections, thus avoiding undesirable repetitions and/or omissions of subjects, being of interest for experienced specialists. This point of view was approved and supported by A. Pokrovsky.

V. Kucherov suggested to combine the sections, reflecting various concerns of angioplasty for MI, in a single section — «Endovascular surgery for acute coronary syndrome».

N. Chigogidze proposed to give concrete expression to «Coronary angioplasty in high risk patients» section by subdivisions, such as LCA stenosis surgery, multiple lesions of coronary arteries, bifurcation stenosis.

A. Babunashvili offered to organize a separate subsection — «Therapeutic approach to complications of interventional surgery».

L. Kokov suggested to include the section of «Terminology in interventional cardiology» into the agenda.

Considering the above listed proposals, the board of the Society approved the preliminary version of the Congress subjects, which shall be further updated by curators of the corresponding sections.

A proposal to include «The contest of young scientists» into the agenda

Decision

1. Approve March 28-30, 2005 as the date of the Second Congress of RSICA.
2. Approve preliminary version of the Congress subjects:
   1. Interventional radiology in pediatric practice.
   2. Interventional neuroradiology.

3. Interventional radiology in nephrology and urology.

4. Interventional radiology in gynecology and obstetrics.

5. Interventional radiology in oncology.

6. Covered stents: the solution for the problem of in-stent stenosis or just the decrease of its rate?

7. Non-invasive methods of evaluation of endovascular methods of treatment of cardiovascular diseases

8. PTCA in high-risk patients.

9. Endovascular procedures for congenital and acquired heart diseases.

10. Endovascular interventions on visceral arteries.

11. Long-term results of the correction of in-stent stenoses.

12. Endoprosthetics of the aorta and great arteries.

13. Stenting of small coronary arteries: are there any changes in the last years?

14. Acute and chronic diseases of the venous system: the tactics of interventional procedures, early and late results.

15. Balloon angioplasty and stenting of the peripheral vessels.

16. New technologies in interventional radiology.

17. Endovascular interventions on the pelvic organs.

18. Stenting of the «unprotected» left main trunk.

19. Transradial approach: advantages and drawbacks, can it become an alternative to transfemoral approach.

20. Recanalization and angioplasty of chronically occluded coronary arteries: a technically spectacular procedure or an effective method of treatment.

21. Combination of endovascular procedures and CABG on different stages of CAD treatment.

22. Endovascular procedures in high-risk patients.

23. Endovascular procedures with the use of different protective devices: do they decrease the risk of embolization?

24. Treatment of bifurcational stenoses.

25. Catheter cell and tissue transplantation for the restoration of the myocardium.

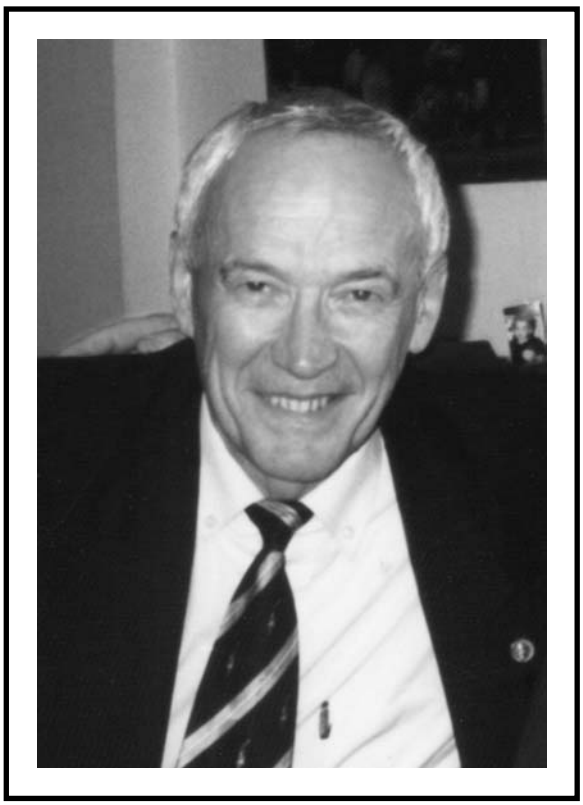
26. AMI — what is more effective: thrombolysis, balloon angioplasty, stenting, or staged combination of those methods?

27. Complications of interventional procedures.

28. Informative and communication technologies in interventional cardioangiology.

3. The curators of the main sections have been approved.

4. The organizational committee of «The contest of young scientists» has been formed (chairman — V. Mazaev).



The Russian medical society suffers irreplaceable loss. The outstanding Russian clinical physician, the scientist and the researcher, member of Board of the Russian society of Interventional Cardioangiology, corresponding member of the Russian Academy of Medical Science, **Anatoly Ivanitzky** has untimely died full of life and energy.

A. Ivanitzky was a well known Russian cardiologist and radiologist. The scope of his scientific and practical activities was extremely wide — from pediatric cardiology up to interventional cardiology and radiology.

A. Ivanitzky was born in 1937 in Moscow in a family of well-known radiologists. Having graduated from Moscow State Medical Institute in 1962, he started working as a resident, and finally he became the Head of the X-ray diagnostics Department of the Bakoulev Scientific Centre for Cardiovascular Surgery of the Russian Academy of Medical Science.

A. Ivanitzky's activity has been always focused on new trends in diagnostics and treatment of cardiovascular diseases. He was among the firsts in the former USSR who started to study X-ray criteria for diagnostics of complex congenital heart diseases. Last years he actively promoted endovascular methods of treating different congenital heart defects including closure of patent foramen ovale and atrial septal defect repair. He was the first in Russia to perform endovascular procedure of balloon atrial septotomy under echocardiographic guidance in a child with complete transposition of the great arteries.

Alongside with active work in the area of endovascular correction of heart defects A. Ivanitzky devoted much time to invasive and non-invasive methods of diagnostics of cardiovascular diseases. He is the author of publications on prenatal diagnostics of heart diseases, echocardiographic diagnostics of ventricular septal defects and other complex congenital heart malformations. Last years his scope of interest was focused on computed tomography for the diagnosis of cardiovascular diseases. A. Ivanitzky is the author of many publications concerning the digital X-ray imaging.

A. Ivanitzky founded scientific school of X-ray surgeons. He is the author of 9 books and more than 250 scientific publications.

A. Ivanitzky was a member of numerous international scientific organizations, including the European Society of Pediatric Radiology. During several years A. Ivanitzky was the chairman of Moscow branch of Russian Society of Interventional Cardioangiologists.

Despite heavy schedule A. Ivanitzky lived active and full-fledged life. Being the master of sport, he devoted much time to bicycle sport and took part in veteran competitions till the last days of his life.

The Board of Russian Society of Interventional Cardioangiologists, editorial staff of the «International Journal of Interventional Cardioangiology» and the staff of the Moscow City Center of Interventional Cardioangiology express their sincere and deepest condolences to the family of Anatoly Ivanitzky.