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Benefits of Off-pump Coronary Artery Bypass Grafting in Patients Older than 75 Years of Age

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Abstract

Introduction: There is a permanent interest in the effective surgical management of coronary artery disease worldwide, especially in elderly patients. There are two main elective procedures, i.e. off-pump and on-pump coronary artery bypass grafting.

Objective: Our purpose was to reveal the benefits of off-pump coronary artery bypass grafting over on-pump one in coronary artery disease patients older than 75 years of age.

Methods: During the period between January, 2014 and March, 2017, a total of 85 patients, 56 males and 29 females, underwent myocardial revascularization using either off-pump (n=40), or on-pump coronary artery bypass grafting (n=45) (with or without cardiopulmonary bypass).

Results: Distal anastomoses prevailed in both methods - 103 and 143, respectively. The mean number of distal anastomoses performed differed statistically significantly between off-pump and on-pump procedures (2,6±0.8 versus 3,2±0.8; p=0,003). The need for inotropic support is smaller (in 22,5% versus 33,3%; p=0,012) and the blood transfusions were less (0,5±0,7 versus 1,6±1,1; p<0,001). In-hospital patients' lethality and 30-day mortality rates both were zero. Postoperative atrial fibrillation was statistically significantly less common, too (22,5% versus 37,8%; p=0,003).

Conclusions: The aforementioned benefits of off-pump coronary artery bypass grafting for myocardial revascularization in patients aged over 75 years with coronary artery disease proved this method as a safe alternative to the on-pump coronary artery bypass grafting. It does not differ from the conventional procedure in terms of postoperative death, pulmonary complications and renal impairment.

Keywords: coronary artery disease, elderly patients, off-pump coronary artery bypass grafting, on-pump coronary artery bypass grafting, advantages

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Introduction

Elderly patient population is one of the fastest growing population groups worldwide. Recently, there is a rising number of septuagenarians and octogenarians presenting with coronary artery disease and suitable for coronary artery bypass surgery. However, a variety of comorbidities in elderly population undergoing cardiac surgery should be taken into consideration. Here belong diabetes mellitus, kidney failure, pulmonary and cerebrovascular diseases which, along with advanced age, may be independently associated with mortality in coronary artery bypass surgery patients.

There is ongoing debate that compares the advantages and disadvantages of off-pump coronary artery bypass grafting (OPCAB) and conventional coronary artery bypass grafting (cCABG), i.e. on-pump coronary artery bypass grafting (ONCAB) in a series of recent randomized controlled trials (RCTs) published since 2009 onwards such as CORONARY, DOORS, GOPCABE, and ROOBY (1-3) as well as FRAGILE, a new national, multicentre RCT in Brazil (3).

According to the ISMICS consensus conference and statements of 102 relevant RCTs of a total of 19101 patients comparing OPCAB to ONCAB, OPCAB may improve outcomes in the short-term (stroke, renal dysfunction, blood transfusion, respiratory failure, atrial fibrillation, wound infection, ventilation time, and length of stay) (4). In the

longer-term, however, OPCAB is, probably, associated with reduced graft patency and increased risk of cardiac re-intervention and death.

The purpose of the present article is to identify the benefits of OPCAB in comparison to ONCAB in elderly patients with coronary artery disease.

Methods

The annual dynamics of the number of all the patients with coronary artery disease surgically treated during the period from January, 2011 to March, 2017 in our Department of Cardiac Surgery at St. Marina University Hospital of Varna is illustrated on Figure 1.

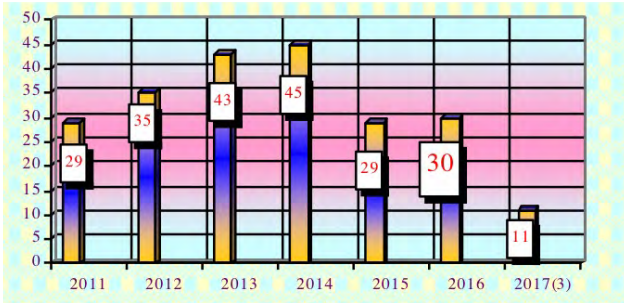

Figure 1. Patients' annual distribution

Our present study covers a total of 85 patients aged over 75 years, 56 males and 29 females, operated on during the period between January, 2014 and March, 2017. During these years, 45 patients have undergone elective ONCAB with cardiopulmonary bypass (CPB) and the rest 40 ones - elective OPCAB (Figure 2).

Patient's demographic characteristics and chronic health status are indicated on Table I and types of coronary artery pathology are shown on Table II.

Operative technique of ONCAB includes median sternotomy and that of CPB consists of standard arterial and venous cannulation, aortic cross-clamp at 34˚C, antegrade or retrograde infusion of crystalloid cardioplegic solution, performing the distal and proximal anastomoses at cross-clamped or side-clamped aorta.

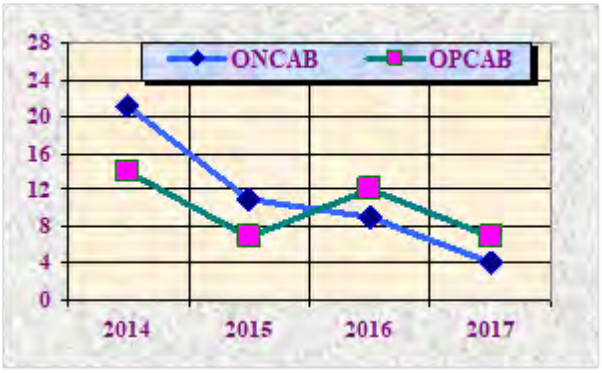

Figure 2. Annual dynamics of elective ONCAB and OPCAB procedures

Operative technique of OPCAB includes median sternotomy, deep pericardial traction sutures for cardiac displacement, vacuum stabilizer at the site of anastomoses and for the apex if needed, silicone stiches and 100% use of intracoronary shunts.

Common adverse effects of CPB used along with ONCAB include systemic inflammatory response syndrome, coagulation status changes, pulmonary and renal dysfunction as well as damage to the central nervous system.

There are some OPCAB-related problems such as beating heart, possible hemodynamic disorders, higher rate of

Table I. Demographic data and chronic health status

Parameters	ONCAB (n=45)	OPCAB (n= 40)	Total (n=85)	p-value
Age	77,6±2,2	77,2±1,9		
Women	17 (37,8%)	12 (30,0%)	29 (34,1%)	=0,023
Diabetes mellitus	10 (22,2%)	17 (42,5%)	27 (31,8%)	=0,006
Ejection fraction <40%	6 (13,3%)	12 (30,0%)	18 (21,2%)	=0,012
Cerebrovascular disease	16 (35,6%)	16 (40,0%)	32 (37,6%)	NS
Preoperative stroke	10 (22,2%)	5 (12,5%)	15 (17,6%)	=0,023
Renal impairment	4 (8,9%)	6 (15,0%)	10 (11,8%)	NS
COPD	2 (4,4%)	5 (12,5%)	7 (8,3%)	NS
Peripheral vascular disease	2 (4,4%)	2 (5,0%)	4 (4,7%)	NS

Table II. Distribution of coronary artery disease

Coronary artery pathology	ONCAB (n= 45)	OPCAB (n=40)	p-value
Three vessel disease+ LM	12 (26,7%)	5 (12,5%)	=0,006
Three vessel disease	29 (64,4%)	30 (75,0%)	NS
Two vessel disease + LM	3 (6,7%)	1 (2,5%)	NS
Two vessel disease	1 (2,2%)	4 (10,0%)	NS
One vessel disease	-	-	-
EuroSCORE (%)	2,86%±2,02	2,83%±1,6	NS

incomplete revascularization, and need for experienced cardiac surgeon, anesthesiologist and perfusionist as well. An important OPCAB advantage is that this technique mostly eliminates the adverse effects of CPB.

Statistical data processing is performed by means of variation analysis (Student Fischer *t*-test) as p-value less than 0,05 is considered statistically significant.

Results

Our results are comparatively demonstrated on six tables. Distal anastomoses prevail in both methods (Table III).

The graft distribution is similar in these methods (Table IV).

The mean number of distal anastomoses performed differs statistically significantly between OPCAB and ONCAB (Table V).

OPCAB overcomes ONCAB concerning two significant operative parameters such as the need for inotropic support and the amount of blood transfusions (Table VI).

The mean peak concentrations of CK-MB and cardiac troponin I are statistically significantly lower in OPCAB than in ONCAB (Table VII).

Postoperative atrial fibrillation is considerable less common in OPCAB, too (Table VIII).

We convincingly prove several essential benefits of OPCAB for myocardial revascularization in patients aged over 75 years with coronary artery disease. We should emphasize the need for angiographic graft patency assessment in such patients.

Table III. Types of anastomoses

Types of anastomoses	ONCAB (n=45)	OPCAB (n=40)	p-value
Distal anastomoses	143	103	
Arterial	51	51	
Venous	92	52	
CABG x 1	-	5 (12,5%)	
CABG x 2	9 (20%)	11 (27,5%)	NS
CABG x 3	21 (46,7%)	20 (50%)	NS
CABG x 4	13 (28,9%)	4 (10%)	0,002

Table IV. Graft distribution

Used graft	ONCAB (n=45)	OPCAB (n=40)
LIMA → LAD and V.S.M → Rcx; RCA	38 (84,4%)	33 (82,5%)
More than one arterial graft	4 (8,9%)	4 (10%)
Total arterial grafts - BIMA	3 (6,7%)	3 (7,5%)

Table V. Anastomosis performance

Mean anastomosis number	ONCAB (n=45)	OPCAB (n=40)	p-value
Performed distal anastomoses	3,2±0,8	2,6±0,8	0,003
Expected distal anastomoses to perform	3,4±0,8	2,8±1,6	
Conversion to CPB	-	0	

Table VI. Operative characteristics.

Operative parameters	ONCAB (n=45)	OPCAB (n=40)	p-value
Operative time	259±52,1	231±46,6	NS
Need of inotropic support	15 (33,3%)	9 (22,5%)	0,012
Blood transfusions	1,6±1,1	0,5±0,7	<0,001
Mediastinal exploration for bleeding	2 (4,4%)	1 (2,5%)	NS

Table VII. Laboratory parameters

Peak values	ONCAB (n=45)	OPCAB (n=40)	p-value
Creatinine	107,7±36,5	109,9±38,8	NS
CK-MB	48,4±19,6	31,2±22,2	0,001
cardiac troponin I	6,6±10,3	2,7±6,0	0,012

Table VIII. Postoperative complications

Complications	ONCAB (n= 45)	OPCAB (n= 40)	p-value
Mechanical ventilation time (hours)	13,9±11,0	12,8±4,7	NS
Atrial fibrillation	17 (37,8%)	9 (22,5%)	0,003
Cognitive disorders	7 (15,6%)	4 (10,0%)	NS
Postoperative stroke	-	-	-
Pulmonary complications	-	-	-
Postoperative stay	9,7±2,8	9,6±2,6	NS

It should be noted that in our contingent, in-hospital patients' lethality and 30-day mortality rates both are zero.

Discussion

Our own results are similar to those reported in the most recent literature on OPCAB and ONCAB.

The comparative analysis in the Nationwide Inpatient Sample databases for 2003-2011 of a total of 134117 octogenarians who have undergone OPCAB (n=39060; 29,12%) or cCABG with CPB (n=95057; 70,88%) demonstrates that stroke rate is statistically significantly lower in OPCAB (2,4% versus 1,8%; p=0,004) (5). OPCAB is associated with lower risk of atrial fibrillation (OR=0,88; 95% CI: 0,82-0,94; p=0,0004) and wound infection (OR=0,61; 95% CI: 0,47-0,78; p=0,0001).

Between November, 2000 and November, 2013, perioperative mortality rate of 97 consecutive patients aged 75 years or above who have undergone OPCAB is 3,09% (6). The ten-year survival rate is 62% with a ten-year major adverse cardiac and cerebral events (MACCE)-free survival rate of 47,4%. Logistic regression analysis indicates that arterial hypertension (OR=1,388; p=0,043) and diabetes mellitus (OR=1,692; p=0,017) are independent MACCE predictors.

The comparison of the safety and efficacy of ONCAB versus OPCAB in 12697 patients aged >70 years and included in the Australian and New Zealand Society of Cardiac and Thoracic Surgeons' database demonstrates that OPCAB patients receive fewer distal anastomoses than ONCAB ones (2,4±1,1 versus 3,3±1,0; p<0,001) (7). High-risk patients prevail in the ONCAB group (p<0.05).

The retrospective investigation of 780 patients undergoing OPCAB and divided into three age groups such as <65 years (262 patients), 65-74 years (329 patients) and >75 years (189 patients) demonstrates similar in-hospital mortality rates (0,8%, 1,2%, and 1,1%, respectively; p=0,862) (8). In multivariate Cox models, independent risk factors predicting cardiac events are the NYHA classification (hazard ratio, HR=1,265; p=0,009) and left ventricular ejection fraction (HR=0,986; p=0,016), but not patient's age.

The overall rate of conversion from OPCAB to ONCAB in a total of 196576 patients undergoing planned OPCAB within the Society of Thoracic Surgeons National Database from July 2007 to June 2014 is 5,5% (9). The planned conversions amount to 49,6% of them.

Logistic regression analysis shows that advanced patient's age, left ventricular ejection fraction <35%, preoperative intraaortic balloon pump placement, increasing number of damaged coronary arteries, preoperative heart failure within two weeks, and urgent procedural status are independent predictors for conversion to ONCAB (p≤0,01).

In a retrospective observational study of 1971 consecutive patients undergoing OPCAB between January 2012 and October 2015, intraoperative conversion to ONCAB is needed by 128 patients (by 6,49% of the cases) (10). Their mortality rate is statistically significantly higher than that of the rest patients (16,41% versus 1,68%; p=0,0001). On multivariate logistic regression analysis, left main coronary artery disease, pulmonary hypertension, and mitral regurgitation independently predict the intraoperative conversion to ONCAB.

A total of 595 patients (11,61% of the cases) undergo intraoperative conversion from OPCAB to CPB (11). These patients present with a higher prevalence of preoperative heart failure, left main coronary artery disease, and three or more diseased coronary vessels when compared to those without conversion. The OPCAB with intraoperative conversion is associated with a higher proportion of readmissions due to postoperative infection (19,1% versus 11,9% of readmissions for CPB).

Within PRAGUE-6, a prospective randomized single-centre study of 206 high operative risk patients with an additive EuroSCORE ≥6 scheduled for isolated coronary surgery, early postoperative myocardial infarction is detected in 12,1% of the cases following ONCAB and in 4,1% of those following OPCAB during the first 30 days (p=0,048) (12).

Within a retrospective observational study, risk stratification in OPCAB is evaluated by means of EuroSCORE II in 1211 patients (13). The all-cause in-hospital mortality is 2,39% while predicted mortality with the EuroSCORE II is 2,03±1,63. Emergency intraoperative conversion to ONCAB occurs in 6,53% of the cases. The mortality in the ONCAB group is statistically significantly higher than that in the OPCAB one (15,18% versus 1,5%; p<0,0001).

There are only eight lethal cases within 30 days postoperatively or before discharge among a total of 1109 consecutive patients at a mean of 67,5±9,8 years who have undergone isolated OPCAB between 2006 and 2013 at Juntendo University, the highest-volume centre in Japan (14). A reduced preoperative left ventricular ejection fraction (<40%) is a risk factor for early postoperative death.

Searches in *PubMed*, *EMBASE*, the *Cumulative Index of Nursing and Allied Health Literature*, *Scopus*, *Web of Science*, the *Cochrane Library*, and major conference proceedings databases for RCTs comparing OPCAB and cCABG and reporting short-term (≤30 days) outcomes identify 100 RCTs with a total of 19192 patients (15). OPCAB is associated with a significant 28% reduction in stroke odds ratios (OR=0,72; 95% CI; 0,56-0,92; p=0,009). There is a significant relationship between patient's risk profile and benefits from OPCAB in terms of all-cause mortality (p<0,01), myocardial infarction (p<0,01), and stroke (p<0,01).

The outcomes of ONCAB and OPCAB in 7822 high risk (AusSCORE >5) patients in Australia and New Zealand are similar in terms of risk profiles, 30-day mortality (3,9% versus 2,4%; p=0,067) and stroke (2,4% versus 1,3%; p=0,104) (16). In the OPCAB group, new postoperative atrial arrhythmia (28,3% versus 33,3%; p=0,017) is less common and blood transfusion requirements (52,1% versus 59,5%; p=0,001) are lower, while intensive care unit stay (97,4±187,8 hours versus 70,2±152,8 hours; p<0,001) is longer.

In a prospective randomized trial, 102 patients with triple-vessel disease and enlarged ventricles (end-diastolic dimension ≥6,0 cm) undergo either OPCAB or ONCAB (17). There is a statistically significant difference between both groups at the time of extubation, intensive care unit stay, hospital stay, blood requirements, incidence of intraaortic balloon pump support, pulmonary complications, stroke, reoperation for bleeding, and inotropic requirements >24 hours (p<0,05). OPCAB exerts a beneficial effect on postoperative complications.

Univariate analysis identifies that diabetes mellitus is associated with longer duration of intensive care unit stay (55,2±53,0 hours versus 49,29±51,30 years; p<0,05) as well as more common postoperative new-onset atrial fibrillation (20,9% versus 14,97%; p<0,05) and postoperative infection (9,2% versus 4,67%; p<0,05) in patients undergoing OPCAB (18). Conventional ONCAB temporarily induces more tubular injury than minimized extracorporeal circulation or OPCAB in 120 patients within the HEPCON trial (19).

The comparison between 234 patients undergoing cCABG and 582 ones undergoing OPCAB does not demonstrate any significant differences between both methods in terms of the percentage of patients experiencing a 10% drop in renal function from baseline at one year (33% in OPCAB versus 35% in cCABG; p=0,73) and five years (16% each; p=0,93) (20).

Cardiac troponin I release is examined in 33 patients after hybrid coronary revascularization as well as in 32 patients after OPCAB (21). Thirty-day and one-year clinical outcomes (death, myocardial infarction, and repeated revascularization) are similar between the two groups (3,0% versus 3,1% and 9,1% versus 6,2%, respectively). Cardiac troponin I release 24 hours after surgery is statistically significantly lower following hybrid coronary revascularization than OPCAB (p=0,001).

Conclusion

Our own results and recent literature data available enable us to draw the conclusion that the benefits of OPCAB for myocardial revascularization in patients aged over 75 years with coronary artery disease prove this method as a safe alternative to the ONCAB. OPCAB does not differ from the cCABG in terms of postoperative death, pulmonary complications and renal impairment.

Conflict of interest

The authors declare that there are no conflicts of interest.

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Evolution and Significance of SYNTAX and Derived Scores in the Heart Team Management Strategies

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Abstract

Introduction: Heart Team decisions regarding myocardial revascularization in complex coronary artery disease are often difficult. In order to clarify and simplify the decisional process cardiovascular risk scores have been developed aiming to identify patients who would benefit more from percutaneous coronary interventions or coronary arterial bypass grafting. Used for the first time in 2005, SYNTAX (Synergy Between Percutaneous Coronary Intervention With Taxus and Cardiac Surgery) score comprises as criteria coronary angiography variables.

Objective: Our aim was to characterize this score and identify its benefits and limitations, taking into consideration the derivative scores as well.

Methods: We used ESC Revascularization Guidelines and main trials which led to validation of various risk scores.

Results: We identified four directions evolving from usage of Syntax Score (SS): 1. Several Syntax-derived scores have been elaborated, namely ACEF, Clinical SS, Functional SS, Global Risk Classification, Residual Syntax, CABG Syntax, with the addition of clinical and biochemical variables. The newest variant is SYNTAX II, currently implemented in ESC Guidelines. 2. Each score was tested on real-world patients (including 1- and 2- vessel disease), the advantages and limits being reported and analyzed. 3. SS was validated in acute coronary syndromes (ACS). 4. SS was correlated with other end-points in ACS, such as estimated glomerular filtration rate, high-sensitivity C-reactive protein, NT-proBNP, and myocardial injury post-angioplasty.

Conclusions: SS and its derivatives facilitate to various extents the decisional process regarding revascularization of complex CAD patients. These tools are often vital for Heart Team in many difficult contexts.

Keywords: SYNTAX score, SYNTAX II, Syntax derived scores, Clinical Syntax, Functional Syntax, Heart Team, Global Risk Classification, residual SYNTAX score, risk stratification

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Introduction

The most frequent cardiovascular disease is coronary artery disease, which is the leading cause of death in developed countries. Despite significant advances in primary prevention of cardiovascular events, studies show that its prevalence will increase by 16.6% in the next 10 years (1,2).

Since the introduction of percutaneous coronary interventions (PCI) in 1977, the outcomes have been impressively improved, especially by introduction of drug-eluting stents (DES) (3). Coronary artery bypass graft (CABG) has been the treatment of choice for stable unprotected left main or multivessel coronary artery disease for over 30 years and the superiority over medical treatment was demonstrated in multiple meta-analyses (4,5).

A multidisciplinary approach, the Heart Team, which includes interventional cardiologists, non-invasive cardiologists and cardiac surgeons, is presently recommended in international guidelines to debate the treatment of patients with complex coronary artery lesions (6,7). The revascularization strategy decided by Heart Team should be based on clinical condition of the patient, severity, localization and characteristics of coronary lesions (6).

SYNTAX score was designed as a decision-making tool, aimed to help guiding the therapy of multivessel coronary artery disease. SYNTAX score takes into account

primarily the coronary anatomy and severity of coronary lesions: number and location, bifurcation, trifurcation or ostial lesions, tortuosity of the affected segment, lesion length, calcification, presence of thrombus or total occlusions. Each lesion with ≥50% stenosis in any vessel with ≥1.5 mm diameter must be scored (8).

SYNTAX score was used since 2005 as the most common angiographic tool to select a revascularization strategy for CABG and PCI (9) in patients with stable coronary artery disease (CAD), STEMI (ST-segment elevation acute coronary syndromes) and non–ST-segment elevation acute coronary syndromes (6).

The SS grouped patients in three risk categories, using as cutt-off value of 22 to differentiate between low and intermediate SS and over 32 for high SS score (6,8).

According to ESC/EACTS guidelines, patients with low score would benefit the most from revascularization with PCI, whereas CABG is recommended in patients with high SS score (6).

Methods

Our main interest was to gather all the information regarding SYNTAX and derived scores utility and applicability. We retrospectively searched the electronic databases of PubMed and ISI Web of Science from inception until February 2018 using the search terms ”SYNTAX score”, ”SYNTAX II score”, ”Clinical SYNTAX score”, ”HEART TEAM” with and without ”guidelines”. Randomized controlled trials (RCTs), observational studies, reviews, meta-analyses and guidelines were included if referring to measures of SYNTAX score or to the derivative scores. Relevant references from the selected articles and guidelines were also searched manually afterwards. We also checked the level of all new recommendations from the ESC Guidelines, regarding SYNTAX and derived scores. We also performed the same evaluation in the supplementary Web Addenda attached to the main documents.

Results

Considering its limitations (SYNTAX score is only an anatomic score, without including functional assessment of coronary lesions during PCI) (8), it has been postulated that adding it to another scoring system will expand the predictive yield. This was made possible by development of the EuroSCORE, used initially to evaluate post-operative prognostic in cardiac patients. Newly developed global risk score (GRS) combined the SYNTAX score and the EuroSCORE to better stratify the risk of CAD patients (4). GRS identifies three categories of risk: low (Euro-SCORE <6 and SYNTAX score <26), intermediate (EuroSCORE >6 or SYNTAX score >26), and high (EuroSCORE >6 and SYNTAX score >26). (10) In contrast to SS alone, GRC had significantly better discriminative ability for risk prediction of cardiac mortality in patients with multivessel CAD undergoing unprotected left main PCI and CABG, especially for patients with intermediate risk of cardiac mortality (4,11).

Another SYNTAX-derived score that added clinical features to SYNTAX Score (age, creatinine clearance and ejection fraction) was Clinical SYNTAX Score (CSS). The aforementioned clinical variables form modified ACEF score (obtained from ACEF score by replacing serum creatinine with creatinine clearance), a model with demonstrated predictive value in patients undergoing PCI(12), CABG (13) and transcatheter aortic valve implantation (TAVI) (14). Clinical SYNTAX Score was developed by Girasis et al. as a tool to stratify more accurately the risk of patients undergoing PCI, having a better discriminatory power than either of the component scores alone for 5-year mortality and MACE, and also CSS was an independent predictor of MACE at both 1-year and 5-year follow-up (11, 15, 16, 17). The CSS was used to stratify patients into three groups based on their scores: low < 30, intermediate 30 - 59 and high risk > 60 (4). The main limitation of this score is that predictive ability of the CSS is reduced when it is used in patients with double- and triple-vessel CAD, as opposed to when it is used in only patients with triple-vessel CAD (16).

Over the past years, the functional component of an anatomical obstruction evaluated through angiography became increasingly recognized, highlighting that there is a significant discrepancy between coronary lesion severity assessed by visual estimation versus their functional correlates as determined by fractional flow reserve (FFR) (11,18). The use of FFR guided PCI is also supported by the decreased rate of major adverse cardiac events (MACE) compared with angiography guided PCI in patients with multi-vessel CAD (11). Fractional flow reserve (FFR) is defined as the ratio of maximum flow in the presence of a stenosis to normal maximum flow (19), and has proved to precisely detect myocardial ischemia, using a cut-off value of 0.80 over which the coronary interventions can be safely deferred (18). The functional evaluation of coronary lesions was integrated into SYNTAX Score, developing the concept of functional SYNTAX score (20), using only ischemia-producing lesions (FFR <0.80) to calculate the score and generate a physiology-based SYNTAX score (18). The functional SYNTAX score was validated in Fractional Flow Reserve *vs*. Angiography for multi-vessel Evaluation (FAME) study (21).

Because of increased risk of MACE associated with incomplete revascularization after PCI in patients with high SYNTAX score (22), residual SYNTAX score (rSS) was proposed as a method to characterize and quantify residual coronary lesions after PCI (11, 23). The rSS assessment is identical to the SYNTAX Score, and is defined as the SS remaining after realization of PCI (11, 24). In ACUITY (Acute Catheterization and Urgent Intervention Triage StrategY) Trial, conducted on 2686 patients with moderate and high-risk acute coronary

syndrome undergoing PCI, rSS was found to be a strong independent predictor of cardiac mortality and all-cause mortality, unplanned revascularization, and MACE at 1 year (11, 23). Residual SYNTAX score was also validated in SYNTAX trial, where it was shown to be a powerful indicator of five-year outcomes, including mortality in patients with left main or de novo 3- vessel disease undergoing PCI (25). By determining the extent and complexity of residual CAD, the residual SYNTAX Score may help to select a potential revascularization strategy of residual lesions and decide a reasonable level of revascularization (11,25).

The data from ACUITY trial was also used by Palmerini et al. to assess the prognostic value of the SYNTAX score in patients undergoing PCI for non–ST-segment elevation acute coronary syndrome. SYNTAX score was an independent predictor of 30-day and 1-year cardiac and all-cause mortality, MACE and target vessel revascularization, even after correcting for clinical parameters (26).

SYNTAX score was also correlated with other end-points in ACS, such as estimated glomerular filtration rate, high-sensitivity C-reactive protein, NT-proBNP, and myocardial injury post-angioplasty. In a study conducted on 380 patients with acute coronary syndrome, Duran et al. indicated that patients with impaired kidney function had high SYNTAX scores, more critical lesions and diseased vessels (27). eGFR decline was associated in several studies with the global burden of atherosclerosis, the extent and severity of CAD and a higher risk of MACE after an acute myocardial infarction (28,29), in close connection inflammation, oxidative stress, endothelial dysfunction, enhanced coagulability present in CKD (27).

Since it is widely accepted that inflammation has an important contribution in the evolution and destabilization of atherosclerotic plaque, multiple biomarkers like C-reactive protein (high-sensitivity assays, hs-CRP), erythrocyte sedimentation rate (30,31), fibrinogen (31), or CRP to albumin ratio (CAR) were assessed to evaluate their prognostic relevance in patients with CAD and acute myocardial infarction (32). In several studies hs-CRP was related to some degree with the extent of coronary disease, but only in the unadjusted analysis, in the multivariate analysis it was not found to be an independent predictor of high Syntax Score (31), and added only slightly to the predictive value of conventional risk factors for coronary artery disease (30). In a recent study conducted on 344 patients with acute coronary syndrome, the CRP to albumin ratio (CAR) was found to be more accurate in predicting an intermediate–high SYNTAX score than CRP, an independent predictor of high SYNTAX score, and also an independent predictor of a high SYNTAX score II, along with decreased albumin levels (32).

Another biomarker that could offer prognostic information in patients with AMI is NT-proBNP (33). A recent study integrated NT-proBNP into Clinical SYNTAX score to develop Bio-Clinical SYNTAX score (Bio-CSS), which was an independent prognostic factor for 1-year MACEs (34).

CABG SYNTAX score seeks to implement the principles of SYNTAX Score in patients who have undergone prior surgical revascularisation (35). CABG SYNTAX score was calculated by determining the standard SYNTAX score in the native coronary vessels and deducting points based graft functionality (11,35). Even though the score was assessed in a pilot study of only 115 subjects, it appeared to have a long-term prognostic role in patients with complex CAD treated by CABG, high CABG SYNTAX score correlating with higher all cause death and MACE (11,35).

Over the last years since the SYNTAX trial, PCI has significantly evolved (the advent of thin strut DES, new techniques for revascularization of chronic total occlusions, intravascular imaging guided stent implantation and optimization, and potent dual antiplatelet therapy) (36). The introduction of newer-generation drug eluting stents has markedly reduced stent thrombosis which was responsible for a considerable proportion of adverse events after paclitaxel eluting stent in SYNTAX, therefore improving both the efficacy and safety of PCI (37).

Like it was previously stated, it is now well known that to accurately stratify the risk of patients undergoing PCI, both anatomical and clinical factors are required. Recently

Recommendation for the type of revascularization (CABG or PCI) in patients with SCAD with suitable coronary anatomy for both procedures and low predicted surgical mortality

Recommendations according to extent of CAD	CABG		PCI		
	Class[a]	Level[b]	Class[a]	Level[b]	Ref[c]
One or two-vessel disease without proximal LAD stenosis.	IIb	C	I	C	
One-vessel disease with proximal LAD stenosis.	I	A	I	A	107,108,160, 161,178,179
Two-vessel disease with proximal LAD stenosis.	I	B	I	C	108,135,137
Left main disease with a SYNTAX score ≤ 22.	I	B	I	B	17,134,170
Left main disease with a SYNTAX score 23–32.	I	B	IIa	B	17
Left main disease with a SYNTAX score >32.	I	B	III	B	17
Three-vessel disease with a SYNTAX score ≤ 22.	I	A	I	B	17,157,175,176
Three-vessel disease with a SYNTAX score 23–32.	I	A	III	B	17,157,175,176
Three-vessel disease with a SYNTAX score >32.	I	A	III	B	17,157,175,176

Figure 1. Recommendation for the type of revascularization in patients with SCAD (6)

developed scores that combine anatomic and clinical variables are focused on overcoming the pitfalls of a system score based only on coronary angiograms (38). The SYNTAX Score II is a recently developed such tool aimed to assist the Heart Team to undertake objective decision-making between PCI and CABG based on 4-year mortality (36). The score was developed in the randomized SYNTAX Trial and validated in the DELTA (Drug-eluting stent for left main coronary artery disease) registry (11). The SYNTAX Score II encompass the anatomical SYNTAX score, presence of unprotected left main coronary artery disease, and six clinical features - age, gender, left ventricular ejection fraction (LVEF), peripheral vascular disease (PVD), creatinine clearance (CrCl) and chronic obstructive pulmonary disease (COPD) (5).

At 1 year follow-up, clinical results of the SYNTAX-II study were associated with improved outcomes compared with the PCI performed in comparable patients from the SYNTAX-I trial (36). PCI undertaken conform to the SYNTAX II strategy was associated with a lower incidence of MACE, target vessel revascularization and definite stent thrombosis. Moreover, patients with intermediate risk calculated through SYNTAX score 23–32, treated with PCI using the SYNTAX score II risk stratification algorithm, had similar short term outcomes to those observed in patients with low anatomical risk (SYNTAX score <22) (36).

After validation of SYNTAX Score II, it was rapidly integrated into latest guidelines on myocardial revascularization, along with the concept of Heart Team (HT) - a multidisciplinary approach with the aim to provide an evidence-based, unbiased, multidisciplinary, decision-making process (7). The SYNTAX II Trial showed a high concurrence between the SSII recommendation and the HT final decision, highlighting the significance of the SSII that provides unbiased individual risk stratification in the decision making (7).

Although SYNTAX II study suggests an increasing role for PCI in multivessel coronary artery disease, validating evidence from adequately powered randomized trials is required. FAME 3 trial (Rationale and design of the Fractional Flow Reserve versus Angiography for multi-vessel Evaluation 3 Trial), will compare in a multicenter, randomized fashion FFR-guided PCI of flow-limiting lesions with contemporary drug-eluting stents to CABG in patients with 3-vessel disease, and hopefully shed some light on the debate (39).

Conclusions

We performed a synthesis regarding SYNTAX and derived scores utility in HEART TEAM decisions. Moreover, we identified all ESC Guidelines recommendations for complex CAD revascularization strategies using these scores. We consider that including more clinical and paraclinical variables into a coronary score, one can predict better a specific strategy and outcome.

Conflict of interest

The authors declare that there are no conflicts of interest.

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Ministernotomy: 7 Years of Experience in Heart Valve Surgery

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Abstract

Introduction, objectives: Minimally invasive approaches to heart valve surgery keep proving its advantages. The aim of this study was to report on our experience after 7 years of practicing partial upper median sternotomy (ministernotomy) in surgery of cardiac valves.

Methods: The study was designed in a retrospective manner, using data from our hospital database. It included all the patients who underwent ministernotomy during the period December 2008 - February 2016. We analysed the data on mean age of patients, type of valve surgery (aortic or mitral) they underwent, postoperative day of extubation, mean extracorporeal circulation time, mean duration of hospital stay (and postoperative hospital stay), volume of drainage, as well as on occurrence of postoperative complications (bleeding that required surgical revision, surgical wound infection, CVI, and instability of sternum). All parameters were analysed trough a learning curve, by dividing them chronologically into 3 groups (December 2008 – December 2009; January 2010 – December 2011; January 2012 – February 2016).

Results: During the observed period, in the Institute for Cardiovascular Diseases of Vojvodina, Clinic for Cardiovascular Surgery, 105 ministernotomies were performed, with 101 aortic valve replacements (96,19%), of which 98 (93,33%) due to aortic valve stenosis, and 3 (2,86%) due to aortic valve insufficiency; and 4 mitral valve replacements (3,81%), of which 1 (0,95%) due to mitral valve stenosis, and 3 (2,86%) due to mitral valve insufficiency. Mean age of the patients was 65,91±9,99 years, of which 50 (47,62%) were females, and 55 (52,38%) were males. On the day of operation 51 (48,58%) patients were extubated; 48 (45,71%) were extubated on the first postoperative day; 2 (1,90%) were extubated on the second postoperative day; and 1 (0,95%) patient was extubated on the seventh postoperative day. On the average, time of 0,58 days (13,5 hours) has passed from operation to extubation of the patients. Mean extracorporeal circulation time was 92,91±29,51 minutes. Mean duration of hospital stay was 18,63±10,68 days (postoperative hospital stay was 11,90±7,32 days). Mean pericardial drainage volume was 430,95±310,89 ml (105 patients). Postoperative complications included: 3 (2,86%) surgical revisions of bleeding; 2 (1,90%) superficial surgical wound infections; 4 (3,81%) transient CVI; and 1 (0,95%) resuture of sternum. Conversion to total median sternotomy was performed on 3 (2,86%) patients. In-hospital death happened in 5 (4,76%) cases.

Conclusion: Ministernotomy still represents an optimal surgical method for interventions on the cardiac valves (especially aortic valve) and whole ascending aorta, with a few significant advantages compared to the surgical approach of total median sternotomy.

Keywords: ministernotomy, minimally invasive surgery, heart valves surgery, cardiovascular surgical procedures

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Introduction

Ever since 1957, total median sternotomy has been used as the first-choice method of approach for cardiac surgery (1). It was proved to be safe and efficient. However, since the 1990s, minimally invasive approaches started gaining on acceptance due to its many advantages over standard methods. For patients, it meant less trauma and improved cosmetics, and on economical point of view, it led to shorter hospital stay due to faster recovery (2). The first attempt of a minimally invasive approach to heart valve surgery was performed through a parasternal line, over the third and fourth cartilages with division of the ribs, followed by thoracotomy and hemisternotomy (3). Later on, in 2000, the Cleveland Clinic group came to the conclusion, after having explored several approaches, that the safest and the best option is upper hemisternotomy (4). Nowadays, it's widely favoured method of choice in elderly and redo patients, when compared with total median sternotomy (5-8). The indications for an upper ministernotomy are isolated aortic

valve surgery, aortic surgery (ascending aorta) and isolated mitral valve surgery through left atrial roof (9-11). It is contraindicative to use ministernotomy in patients who require coronary or heart repair (ventricle aneurysm, septal defects, trauma, etc.) surgery; and also in patients with porcelain aorta, small aortic root and elongated aorta (12).

There is not only one variation of upper median sternotomy. These variations include: J-, L-, S- and T-shaped incisions (letters describe the shape of incision line on sternum) (13-15). The widest acceptance, and the technique that was used in this study for aortic valve surgery is J-shaped, or inversed L-shaped ministernotomy. In mitral valve surgery, L-shaped ministernotomy was performed.

The aim of this study was to show *in extenso* results of using this technique in heart valve surgery in the Institute for cardiovascular diseases of Vojvodina, Clinic for cardiovascular surgery, after promising preliminary results with ministernotomy, published in 2011 (16).

Methods

The study was designed in a retrospective manner, using data from hospital database of the Institute for Cardiovascular Diseases of Vojvodina, Clinic for Cardiovascular Surgery. It included all the patients who underwent minimally invasive cardiac valve surgery through the partial upper median sternotomy, during the period from December 2008 to February 2016 (105 of them). We analysed the data modelled on the (slightly modified) settings of our preliminary study, and it included: mean age of patients, type of valve surgery (aortic or mitral) they underwent, postoperative day of extubation, mean extracorporeal circulation time, mean duration of hospital stay (and postoperative hospital stay), volume of drainage (trough pericardial draining tubes) as well as on occurrence of postoperative complications (bleeding that required surgical revision, surgical wound infection, CVI, and instability of sternum that required resuture). All parameters were also analysed trough a learning curve, by dividing them chronologically into 3 groups: Group 1 with patients who underwent surgery in period from December 2008 to December 2009 (22 of them); Group 2 with patients who underwent surgery in period from January 2010 to December 2011 (24 of them); and Group 3 with patients who underwent surgery in period from January 2012 to February 2016 (59 of them).

All statistical data was processed in SPSS software package, version 17. Descriptive statistics, arithmetic mean, standard deviation, median and percentages were used. For differences in the mean values of numerical variables, ANOVA and post-hoc test were performed. For groups and categorical variables connections, cross-tab and Chi-square test were performed.

Surgical technique

The patient lies in supine position with his arms secured at his side. External defibrillation pads should be applied, for it is hard to place internal paddles on the heart through the restricted operative field. The torso and thighs hair is clipped, and intravenous antibiotic prophylaxis is given (first dose within the first hour after skin incision). Patent is intubated with a single-lumen endotracheal tube, and monitored via standard cardiac surgery methods. Anaesthetic preparation included placing of transoesophageal probe, too. Transparent sterile drape is applied, covering the skin.

Prior to skin incision, the correct landmarks (jugulum, xiphoid and sternal midline) should be identified, in means of incision orientation (this can be challenging in obese patients). An 8 cm incision is performed in the midline between the second (sternal angle/"Louis" angle) and the fourth ribs. Soft tissues are dissected with use of thermocautery, and skin flap retracted upwards, so the approach to sternal incision is as clear as possible. Sternum is cut with use of pneumatic/electric conventional or oscillating saw, from jugular notch to the level of fourth intercostal space. Before the sternotomy, the anaesthetist stops ventilation to avoid accidental injury of underlying structures: pleura, pericardium, innominate vein, brachiocephalic artery and ascending aorta. The upper sternum has to be divided strictly in the midline from the jugulum downwards through the manubrium and the upper corpus and exiting in the dissected intercostal space. The underlying internal thoracic (mammary) artery and vain should remain intact. As said above, in case of aortic valve surgery, sternotomy is turned right (J-shape), and in case of mitral valve surgery, it is turned left (L-shape). Automatic retractor is placed in incision. The fatty tissue (thymus) is divided and ligated. Pericardium is opened (turning lower end of incision to right), and fixed in place to thoracic wall with stay sutures (Figure 1). This also pulls the heart upwards, giving better presentation of aorta and right atrium.

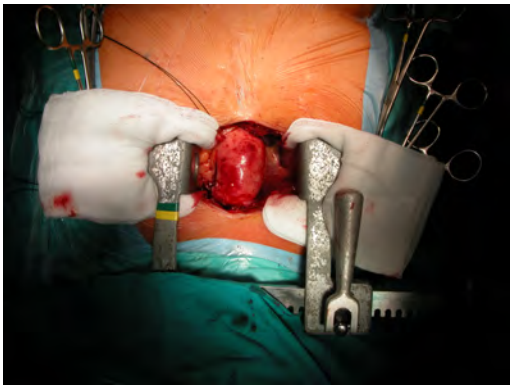

Figure 1. Pericardial exposure

Excessive pulling must be avoided to allow adequate ventricular filling, at least until cannulation is performed. In use of prevention of air embolism, CO_2 line is derived to operating field (with flow rate of 6 litters per minute). Extracorporeal circulation cannulas are placed directly into ascending aorta and right atrium, or in both cava veins in

case of mitral valve surgery. Left heart is vented via the right upper pulmonary vein (Figure 2).

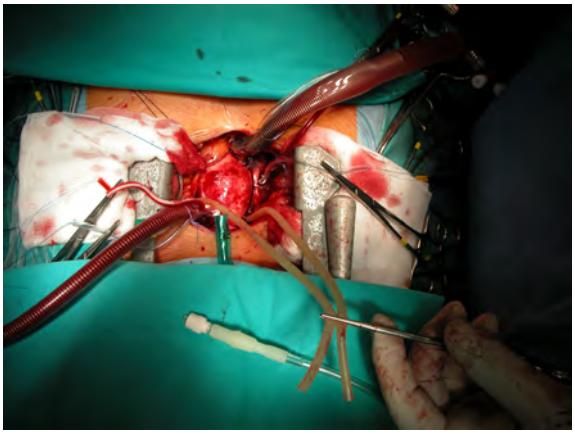

Figure 2. Venting the left atrium via the right upper pulmonary vein

Further operation is identical as one performed via total sternotomy (Figure 3). Certain difference exits in mitral valve approach. In this method, it is approached via transseptal incision, which extends over the roof of left atrium. Incision starts in level of right auricle, going cranially to the roof of left atrium, and caudally to lower cava vein. Septum is opened through *fossa ovalis*, upwards to the roof of left atrium. Pledgeted suture is placed on upper end of septum, and tightened to left.

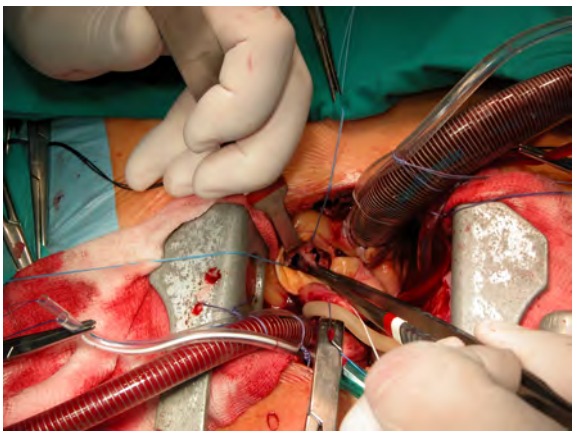

Figure 3. Main operative time

After declamping, deairing and heart reactivation, cannulas are removed in standard procedure. Temporary epicardial pacing wires are set in place, and one pericardial tube is inserted with use of so-called crocodile clamp. The tunnelling must be performed with care and not too deep, because it can result in fatal colic, gastric, hepatic or epigastric pedicle lesions. After adequate bleeding control, osteosynthesis is secured with stainless steel wires (or sternal sutures). One wire/suture is applied to stabilize the opened intercostal space and the others through the upper corpus and sternal manubrium. Subcutaneous tissue and skin are closed with absorbable sutures (Figure 4).

Figure 4. Subcutaneous tissue and skin closure

Results

All the patients

During the observed period from December 2008 to February 2016, in the Institute for Cardiovascular Diseases of Vojvodina, Clinic for Cardiovascular Surgery, 105 ministernotomies were performed (Table I). This technique was used to perform 101 aortic valve replacements (96,19%), and 4 mitral valve replacements (3,81%). Most of aortic valve replacements were due to aortic valve stenosis, 98 (93,33%); and 3 (2,86%) due to aortic valve insufficiency. Only 1 (0,95%) mitral valve replacement was performed due to mitral valve stenosis, and 3 (2,86%) were due to mitral valve insufficiency. There was no case of valve reconstruction in this period.

Mean age of the patients was 65,91±9,99 years, of which 50 (47,62%) were females, and 55 (52,38%) were males.

On the day of operation 51 (48,58%) patients were extubated; 48 (45,71%) were extubated on the first postoperative day; 2 (1,90%) were extubated on the second

Table I. Descriptive statistics of the results

	N	Minimum	Maximum	Mean	Std. Deviation
Age [years]	105	27	83	65,91	9,989
Time to extubation [days]	102	0	7	0,58	0,838
ECC duration [minutes]	105	42	188	92,91	29,513
Hospital stay [days]	105	2	61	18,63	10,678
Postoperative hospital stay [days]	105	0	49	11,90	7,318
Pericardial drainage [ml]	105	0	1750	430,95	310,891

postoperative day; and 1 (0,95%) patient was extubated on the seventh postoperative day. On the average, time of 0,58±0,84 days (13,5 hours) has passed from operation to extubation of the patients.

Mean extracorporeal circulation duration time was 92,91±29,51 minutes.

Mean duration of hospital stay was 18,63±10,68 days. Postoperative hospital stay was 11,90±7,32 days.

All 105 patients were drained via pericardial tube. Mean pericardial drainage volume was 430,95±310,89 ml. Postoperative complications included: 3 (2,86%) surgical revisions for bleeding; 2 (1,90%) superficial surgical wound infections; 4 (3,81%) transient CVI; and 1 (0,95%) resuture of sternum.

Conversion to total median sternotomy was performed on 3 (2,86%) patients.

In-hospital death happened in 5 cases (mortality rate was 4,76%).

Group 1

First group included 22 patients, who underwent surgery via ministernotomy in period from December 2008 to December 2009 (Table II). This technique was used to perform 18 aortic valve replacements (81,81%), and 4 mitral valve replacements (18,19%). Most of aortic valve replacements were due to aortic valve stenosis, 16 (72,73%); and 2 (9,09%) due to aortic valve insufficiency. One (4,54%) mitral valve replacement was performed due to mitral valve stenosis, and 3 (13,64%) were due to mitral valve insufficiency.

Mean age of the patients was 64,18±10,95 years, of which 10 (45,45%) were females, and 12 (54,55%) were males.

On the day of operation 13 (59,09%) patients were extubated; 7 (31,82%) were extubated on the first postoperative day; and 2 (9,09%) were extubated on the second postoperative day. On the average, time of 0,50±0,67 days (12 hours) has passed from operation to extubation of the patients.

Mean extracorporeal circulation duration time was 119,09±28,66 minutes.

Mean duration of hospital stay was 22,41±11,93 days. Postoperative hospital stay was 13,64±9,83 days.

Mean pericardial drainage volume was 493,18±466,57 ml.

Postoperative complications included: 2 (9,09%) surgical revisions for bleeding; 1 (4,54%) superficial surgical wound infection; 2 (9,09%) transient CVI; and no resutures of sternum.

Conversion to total median sternotomy was performed on 1 (4,54%) patient.

In-hospital death happened in 1 case (mortality rate was 4,54%).

Group 2

Second group included 24 patients, who underwent surgery via ministernotomy in period from January 2010 to December 2011 (Table III). This technique was used to perform 24 aortic valve replacements (100%), and no mitral valve replacements. Most of aortic valve replacements were due to aortic valve stenosis, 23 (95,83%); and 1 (4,17%) due to aortic valve insufficiency.

Mean age of the patients was 61,63±11,35 years, of which 12 (50,00%) were females, and 12 (50,00%) were males.

On the day of operation 16 (66,67%) patients were extubated; 7 (29,17%) were extubated on the first postoperative day. On the average, time of 0,30±0,47 days (7,2 hours) has passed from operation to extubation of the patients.

Mean extracorporeal circulation duration time was 103,37±25,94 minutes.

Table II. Descriptive statistics of Group 1 results

	N	Minimum	Maximum	Mean	Std. Deviation
Age [years]	22	42	79	64,18	10,953
Time to extubation [days]	22	0	2	0,50	0,673
ECC duration [minutes]	22	75	172	119,09	28,660
Hospital stay [days]	22	9	58	22,41	11,931
Postoperative hospital stay [days]	22	6	49	13,64	9,835
Pericardial drainage [ml]	22	0	1750	493,18	466,572

Table III. Descriptive statistics of Group 2 results

	N	Minimum	Maximum	Mean	Std. Deviation
Age [years]	24	27	76	61,63	11,348
Time to extubation [days]	23	0	1	0,30	0,470
ECC duration [minutes]	24	71	188	103,37	25,936
Hospital stay [days]	24	2	42	20,54	10,061
Postoperative hospital stay [days]	24	0	26	11,71	6,266
Pericardial drainage [ml]	24	50	1750	375,00	326,043

Mean duration of hospital stay was 20,54±10,06 days. Postoperative hospital stay was 11,71±6,27 days.

Mean pericardial drainage volume was 375,00±326,04 ml.

Postoperative complications included: no surgical revisions for bleeding; no surgical wound infections; no CVI; and 1 (4,17%) resuture of sternum.

Conversion to total median sternotomy was performed on 1 (4,17%) patient.

In-hospital death happened in 1 case (mortality rate was 4,17%).

Group 3

Third group included 59 patients, who underwent surgery via ministernotomy in period from January 2012 to February 2016 (Table IV). This technique was used to perform 59 aortic valve replacements (100%), and no mitral valve replacements. All of aortic valve replacements were due to aortic valve stenosis.

Mean age of the patients was 68,31±8,36 years, of which 28 (47,46%) were females, and 31 (52,54%) were males.

On the day of operation 22 (37,29%) patients were extubated; 34 (57,62%) were extubated on the first postoperative day; and 1 (1,69%) patient was extubated on seventh postoperative day. On the average, time of 0,72±0,98 days (17,3 hours) has passed from operation to extubation of the patients.

Mean extracorporeal circulation duration time was 78,90±22,19 minutes.

Mean duration of hospital stay was 16,44±10,05 days. Postoperative hospital stay was 11,32±6,63 days.

Mean pericardial drainage volume was 430,51±222,64 ml.

Postoperative complications included: 1 (1,69%) surgical revision for bleeding; 1 (1,69%) superficial surgical wound infection; 3 (5,08%) transient CVI; and no resutures of sternum.

Conversion to total median sternotomy was performed on 1 (1,69%) patient.

In-hospital death happened in 3 cases (mortality rate was 5,08%).

Groups and data comparison

Comparison of numeric parameters mean values differences among all groups are represented on Table V, and those among groups themselves on Table VI.

Differences in following numeric variables among groups are significant in: age – p=0,013; ECC duration – p<0,0005 and Hospital stay – p=0,048.

There were no differences in postoperative hospital stay and pericardial drainage.

Differences in mean values of age are statistically significant among group 2 and group 3 (p=0,020). Mean value of age in group 2 is 61,63±11,35 years, and in group 3 is 68,31±8,36 years. Differences in mean values of age among group 1 and group 2 is not statistically significant (p=0,670), neither is among group 1 and group 3 (p=0,238).

Differences in mean values of ECC duration time are statistically significant among group 1 and group 3 (p<0,0005), and group 2 and group3 (p<0,0005).

Mean value of ECC duration time in group 1 is 119,09±28,66 minutes, and in group 3 is 78,90±22,19 minutes. Mean value of ECC duration time in group 2 is 103,38±25,94 minutes, and in group 3 is 78,90±22,19 minutes. Differences in mean values of ECC duration time among group 1 and group 2 is not statistically significant (p 0,100).

Differences in mean values of hospital stay are statistically significant among group 1 and group 3 (p=0,025). Mean value of hospital stay in group 1 is 22,41±11,93 days, and in group 3 is 16,44±10,05 days. Differences in mean values are not statistically significant among group 1 and group 2 (p=0,547), and among group 2 and group 3 (p=0,109).

Discussion

Heart valves surgeries have traditionally been performed through total median sternotomy, but nowadays, as minimally invasive surgery techniques developed, same, if not better results can be achieved with many benefits. Not just considering the cosmetic benefits, but improved post-operative outcomes, too (17).

A recent Shehada and colleagues study showed advantages of ministernotomy over total sternotomy, in terms of reduced need for blood transfusion and lover incidence of respiratory failure in patients who underwent aortic valve surgery (18).

Perrota and colleagues reported that ministernotomy may be used in variety of procedures, using this approach in Bentall procedure, as in elective, so as in emergency and redo patients (19). Svensson and colleagues even used ministernotomy in aortic arch repair procedure (20).

There are reported cases of right coronary artery bypass grafting in combined minimally invasive procedures.

Table IV. Descriptive statistics of Group 3 results

	N	Minimum	Maximum	Mean	Std. Deviation
Age [years]	59	46	83	68,31	8,357
Time to extubation [days]	57	0	7	0,72	0,977
ECC duration [minutes]	59	42	163	78,90	22,195
Hospital stay [days]	59	5	61	16,44	10,049
Postoperative hospital stay [days]	59	4	44	11,32	6,629
Pericardial drainage [ml]	59	50	1200	430,51	222,644

Table V. Comparison of numeric parameters mean values differences among all groups

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min	Max	ANOVA p
						Lower Bound	Upper Bound			
Age	1	22	**64,18**	**10,953**	2,335	59,33	69,04	42	79	**0.013**
	2	24	**61,63**	**11,348**	2,316	56,83	66,42	27	76	
	3	59	**68,31**	**8,357**	1,088	66,13	70,48	46	83	
ECC duration time	1	22	**119,09**	**28,660**	6,110	106,38	131,80	75	172	**< 0.0005**
	2	24	**103,38**	**25,936**	5,294	92,42	114,33	71	188	
	3	59	**78,90**	**22,195**	2,890	73,11	84,68	42	163	
Hospital stay	1	22	**22,41**	**11,931**	2,544	17,12	27,70	9	58	**0.048**
	2	24	**20,54**	**10,061**	2,054	16,29	24,79	2	42	
	3	59	**16,44**	**10,049**	1,308	13,82	19,06	5	61	
Postoper. hospital stay	1	22	**13,64**	**9,835**	2,097	9,28	18,00	6	49	0.448
	2	24	**11,71**	**6,266**	1,279	9,06	14,35	0	26	
	3	59	**11,32**	**6,629**	,863	9,59	13,05	4	44	
Pericardial drainage	1	22	**493,18**	**466,572**	99,473	286,32	700,05	0	1750	0.440
	2	24	**375,00**	**326,043**	66,553	237,32	512,68	50	1750	
	3	59	**430,51**	**222,644**	28,986	372,49	488,53	50	1200	

Table VI. Comparison of numeric parameters mean values differences among groups themselves

Dependent Variable	Group	Group	Mean Difference	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Age	1	2	2,557	2,853	,670	-4,53	9,64
		3	-4,123	2,415	,238	-10,12	1,88
	2	1	-2,557	2,853	,670	-9,64	4,53
		3	-6,680·	2,340	**,020**	-12,49	-,87
	3	1	4,123	2,415	,238	-1,88	10,12
		2	6,680·	2,340	,020	,87	12,49
ECC duration time	**1**	2	15,716	7,235	,100	-2,26	33,69
		3	40,193·	6,124	**,000**	24,98	55,40
	2	1	-15,716	7,235	,100	-33,69	2,26
		3	24,477·	5,935	**,000**	9,73	39,22
	3	1	-40,193·	6,124	,000	-55,40	-24,98
		2	-24,477·	5,935	,000	-39,22	-9,73
Hospital stay	**1**	2	1,867	3,089	,547	-4,26	8,00
		3	5,968·	2,615	**,025**	,78	11,15
	2	1	-1,867	3,089	,547	-8,00	4,26
		3	4,101	2,534	,109	-,93	9,13
	3	1	-5,968·	2,615	,025	-11,15	-,78
		2	-4,101	2,534	,109	-9,13	,93

Shariff and colleagues report on performing it via right thoracotomy, but Lentini and colleagues discussed unpublished data of performing it with a ministernotomy approach (21, 22).

Mikus and colleagues reported on study based on 90 patients who underwent redo surgery (aortic valve replacement) via J-shaped ministernotomy, and came to conclusion that it is as least as safe as the standard (total median sternotomy) procedure in terms of hospital morbidity and mortality rates (23).

Regarding minimally invasive approach on mitral valve surgery, in 512 patients study, Esposito and colleagues described ministernotomy as particularly attractive for combined mitroaortic procedures (11).

One real concern is discussed as a possible flaw of ministernotomy, and that is the reduced ability of de-airing, because the heart can't be mobilized through limited access field. However, as long as standard de-airing techniques, together with CO_2 are used, strokes are rare, and their rate is in level to total sternotomy one (24).

Our results do not differ significantly comparing to much bigger prospective and retrospective studies on the same matter. Considering our preliminary results, improvement is noticed in rate of bleeding that required surgical treatment (preliminary it occurred in 5,88% od patients, and now it dropped to 4,76%); CVI incidence (preliminary occurred in 5,88% of patients, but has dropped to 3,81%), and in conversion to total median sternotomy (preliminary 5,88%, now 2,86%). These results can be explained by the learning curve, expected when new technique is being introduced to surgical team. Bigger rate of wound infection (preliminary 0% of patients, and now 1,90%) and sternum instability that required resuture (preliminary 0% of patients, and now 0,95%) could be explained with the fact that preliminary study included only 17 patients.

The importance of learning curve when introducing new technique is emphasized by setting the methodology of this study. Comparing chronologically divided groups of patients proved that belief. Difference in patients' age among groups may be explained by improving confidence in indicating ministernotomy approach, but the most important improvement is seen in reducing ECC duration time ($p<0,0005$), and duration of hospital stay ($p=0,048$). ECC duration time is statistically different among group 1 and group 3 ($p<0,0005$), and group 2 and group 3 ($p<0,0005$). Duration of hospital stay is statistically different among group 1 and group 3 ($p=0,025$). These advantages do not require explanations in matter of reduced operation risk and treatment costs.

Conclusions

Partial upper median sternotomy (ministernotomy) keeps proving its advantages over total median sternotomy in procedures on aortic valve, ascending aorta and isolated mitral (mitroaortic) valve surgery. It is proved as method of choice for redo operations, as well, and even options of using it in some cases of coronary surgery are being discussed. Considering cosmetic benefits and in many studies confirmed improvement in post-operative outcomes, ministernotomy should definitely be taken as first option approach whenever it is possible. However, it must be noted that the learning curve plays a big role in accomplishing full advantages of this surgical approach.

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Conflict of interest

The authors declare that there are no conflicts of interest.

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Treatment in Arteriovenous Malformations: Current Stage and New Trends

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Abstract

Introduction: Treatment of arteriovenous malformations (AVM) remains a challenge for cardiovascular surgeons due to high recurrence and complication rates.

Objectives: The current study assesses authors' experience in associating different therapeutic procedures in order to obtain a better prognosis in AVM.

Results: There were evaluated 240 cases with AVM treated over a 10 years' period (1993-2013). 156 cases (65%) presented with diffuse lesions (two or more anatomical regions) and 35 (14.6%) had microfistulae. Pretherapeutic evaluation implied Doppler ultrasound and angiographic examination in all cases and computed tomography (CT) in 64 cases. Patients were treated with embolization alone in 84 cases (35%), embolization followed by angiomatoid tissue removal in 112 cases (46.7%), palliative resection and arterial skeletonization in 29 cases (12%) and limited or extensive amputation in 15 cases (6.3%). Embolization was performed using HydroGel emboli, absolute ethanol and coils (mean 3.6 coils/patient). Doppler ultrasound correctly identified the pathogenic mechanisms in most AVM, and all patients required clinical surveillance in order to determine the need for additional therapeutic interventions.

Conclusions:

Endovascular embolization has the potential to become the main therapeutic method as well as an important stage of preoperative preparation in patients with AVM. If an invasive surgical treatment is deemed best for the patient, the affected tissues must be resected completely. After such a radical surgery, the incision and the adjacent area should be grafted with either mobilized muscle flaps (sternocleidomastoid muscle flap, for example) or free tissue transfer flaps using microvascular anastomoses. When the pathologic shunt cannot be removed with endovascular or surgical treatment, amputation is recommended.

Keywords: arteriovenous malformations, angiodysplasia, endovascular embolization

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Introduction

Arteriovenous malformations (AVMs) are defined as defects of the circulatory system that generally arise during embryonic or fetal development or soon after birth. The therapeutic management of AVM remains, even nowadays, a challenge for the cardiovascular surgeon. This pathology has lately gained importance due to the severity of the potential complications such as those induced by the pathologic venous overflow (trophic disturbances, ulcers, hemorrhage from the angiomatoid tissues, central hemodynamics perturbation) (1).

Methods

From 1993 to 2013, 240 patients (i.e. 34.3% of the patients admitted with congenital vascular malformations) diagnosed with AVM were investigated and subsequently treated at the Department of Vascular Surgery, A.V.Visnevsky Institute of Surgery from Moscow, Russia. The disease registered a higher prevalence in the lower limbs with 52.92% of all cases (Figure 1). Diffused lesions affecting two or more areas were identified in 156 patients (65%).

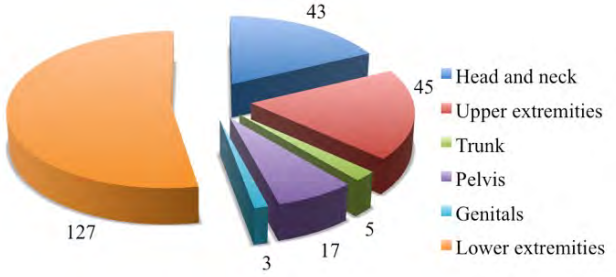


Figure 1. Affection localization in arteriovenous malformations

Depending on the size of the shunt, two distinct types of AVM were identified: micro- and macrofistulous. In the former, the clinical signs include altered skin pigmentation, skin hyperemia, engorged draining veins, and soft tissue and osseous hypertrophy of the affected extremity. Sometimes, a vascular bruit can also be perceived.

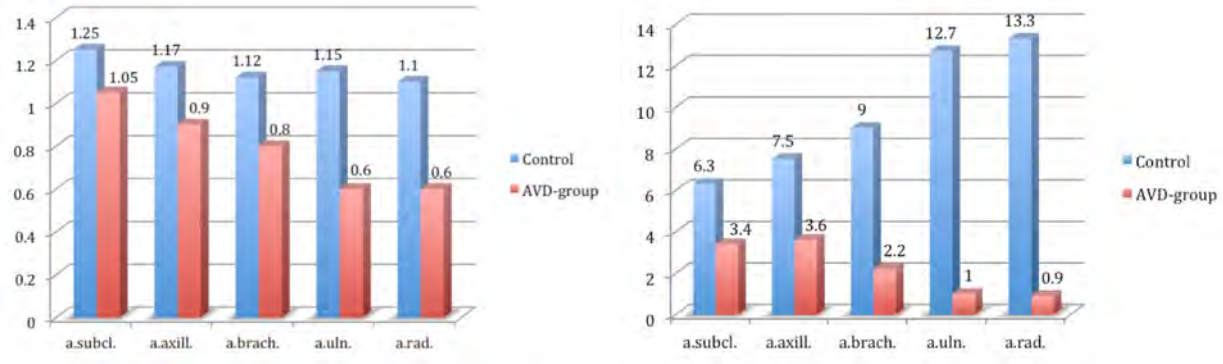
In the second type of AVM (macrofistulous) a change in skin pigmentation can be noticed secondary to venous stasis (from rose pink up to dark brown) alongside with varicose dilatation of superficial veins (when the extremities are affected), intensified vascular pulse, systolic and diastolic bruits above the affected area. This type of AVM is often complicated by trophic lesions, ulcers and periodical profuse bleedings.

In some cases, the final diagnosis can only be established after medical imaging examination including ultrasound (duplex ultrasound, echocardiography), CTA (computed tomography angiography) and MRA (magnetic resonance angiography), radioisotope determination of AV (arteriovenous)-shunting and contrast angiography.

Results

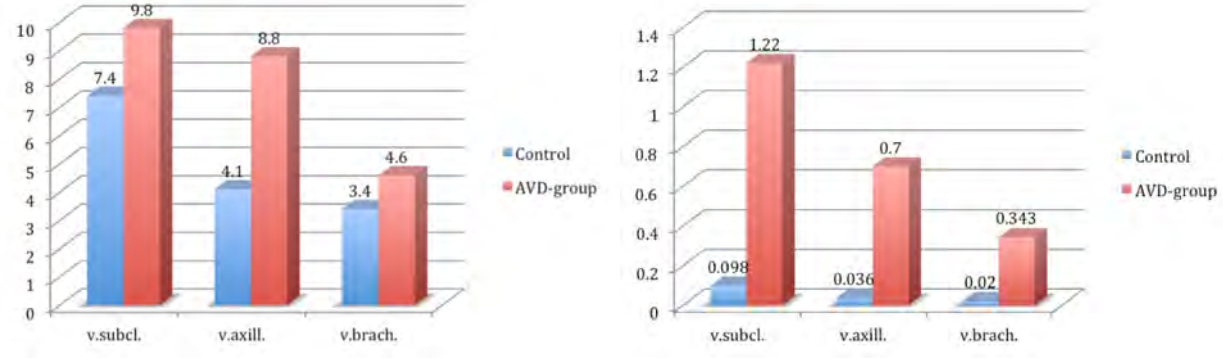
The association of computer tomography angiography with duplex ultrasound (DUS) offers a comprehensive non-invasive evaluation. In cases with diffuse AVM, DUS made it possible to quantify the variation in blow flood from one side of the lesion to the other: peak velocity, resistive index (RI) and pulsatility index (PI) (Figure 2 a and b).

Five to seven times increase in blood velocity was noticed in diffuse AVM cases while a decrease in RI and PI signaled a significant reduction of total peripheral resistance. These variations confirm the abnormal arteriovenous flow. DUS also revealed a 20-30% increase



a. **b.**

Figure 2. Resistive Index – RI (a) and Gosling's pulsatility index – PI (b) in patients with the AVM (diffused form)



a. **b.**

Figure 3. The venous hemodynamics in patients with AVM (diffused form): a) Vein diameter (mm) b) Volume velocity (l/min)

in vein diameter and 5 to 6 times increase in venous blood velocity in the main veins in the immediate vicinity of the lesion (Figure 3).

In microfistulous AVM, the DUS exam did not reveal any statistically significant changes of the blood flow. The extent of the angiomatoid lesion into adjacent tissues was determined through DUS and clinical investigation, while the final diagnosis was further validated by CTA and MRA.

Embolization was attempted for 196 patients (81.7%). In 84 cases (35%) with lesions deemed inoperable, multiple staged embolizations were performed as a primary treatment. The mean number of documented sessions was 3.6. In 17 patients (7.1%), embolization (hydrogel emboles, Gianturco spirals, 90% alcohol) was associated to various surgical techniques.

Radical surgery with angiomatoid tissue removal was attempted in 53 cases (47.3%). If the lesions were extensive and complete removal of affected tissue was deemed too dangerous for the patient, palliative resection was chosen instead. In some patients with microfistulae, skeletonization of afferent arteries was performed during the intervention. In 15 cases, various degrees of amputation (large and small) were necessary depending on the size of the lesion (Table I).

Table I. AVM type of treatment

Intervention type	Number
Embolization	**84 (35%)**
• endovascular	67 (27.9%)
• during surgery	17 (7.1%)
Endovascular embolization followed by angiomatoid tissue removal	**112 (46.7%)**
• radical resection	53 (47.3%)
• resection and defect correction using flaps (microvascular anastomosis, free tissue transfer flap)	11 (4.6%)
• palliative resection	59 (24.6%)
Main arteries skeletonization	**19 (7.9%)**
Straight arteriovenous fistula separation	**8 (3.3%)**
Arterial aneurysm resection and prosthetic replacement	**2 (0.8%)**
Amputation (small)	**11 (4.6%)**
Amputation (large)	**4 (1.7%)**
TOTAL	**240 (100%)**

Case report

The authors present the case of a 50-year-old Caucasian male patient that was admitted at A.V.Vishnevsky Institute of Surgery with tissue deformation and persisting pain on the left side of the face. The first signs compatible with an AVM appeared when patient was 4 years old. Rapid growth of the angiomatoid tissue occurred by the age of 24. By the age of 40 the complications started to appear, the patient presenting extensive hemorrhages from the upper eyelid and lower lip (Figure 4 a and b). The patient has been subjected to a surgical intervention aiming to ligature the affected vessels. Additional exophthalmia (Figure 5) was diagnosed in the same time period.

In 2003 an angiography was performed in order to localize the source of blood flow in the external carotid territory. Subsequently, four staged embolization sessions were performed in the affected area, followed by angiomatoid tissue resection from the upper eyelid and left frontal area (2000 mL hemorrhage, reinfusion of 1200 mL of washed erythrocytes) (Figures 6 and 7).

After 6 months, the angiomatoid tissues in the left temporal region, left zygomatic region, left buccal region, and left upper lip were also resected followed by defect repair using a mobilized sternocleidomastoid flap (Figure 8). The functional state of the left eye was completely restored, with no further hemorrhage. At the time of writing the current article, the patient was scheduled for additional surgical interventions in order to completely restore tissue function.

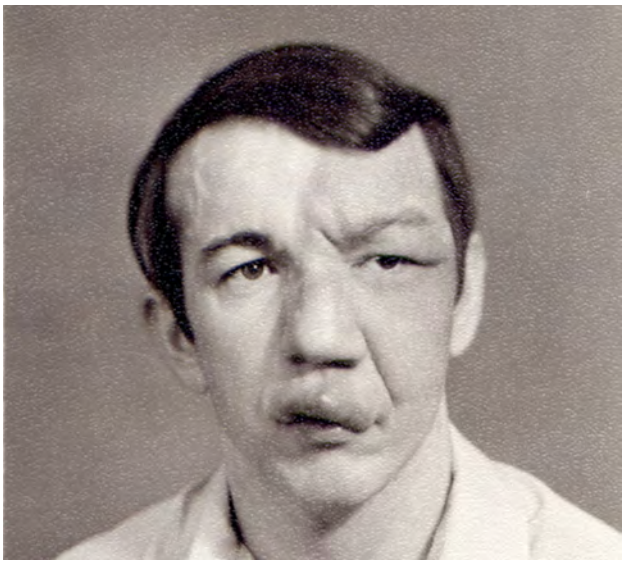
The current clinical case shows that temporizing AVM treatment is unadvisable as static and dynamic loads increase secondary to aging thus leading to an increased progression rate of the disease. It is therefore necessary to start treatment immediately after confirming the diagnosis.

Discussion

Despite the major developments in the field of AVM management, many issues concerning their diagnoses and treatment still occur (1,2). In the past decades, there has been a marked increase in the usage of advanced imaging methods (DUS, CTA, MRA) in diagnosing AVM. Currently, practitioners can determine with certitude the type of disease (arterial, arteriovenous) in up to 30-50% of cases. Doppler ultrasound offers precious information concerning soft tissue blood supply and identifies non-invasively the vessels supplying the angiomatoid mass (3). By employing DUS investigation, the practitioner can determine whether there is only one or several feeding/draining vessels. The results of the current study also illustrate the importance of DUS in the evaluation of the cortical osseous tissue, a significant variable in determining the surgical approach.

Because it offers more conclusive information compared to CTA, MRA is increasingly being used for diagnosis, especially in diffuse lesions and for evaluating the soft tissue around angiodysplasia (4). Some recent studies support the theory that MRA evaluation offers differential diagnostic criteria between arteriovenous and venous malformations (5). Even if it facilitates the identification of main arteries and veins, MRA cannot precisely indicate the vessels supplying the angiodysplasia.

Radioisotopic studies on the other hand allow quantifying AV-shunting. Despite all imaging methods mentioned above, the main diagnostic method still remains



a.

b.

Figure 4 (a, b). The angiomatoid tissues growth in the course of time

Figure 5. Patient Sh., 50 years old, before the combined treatment

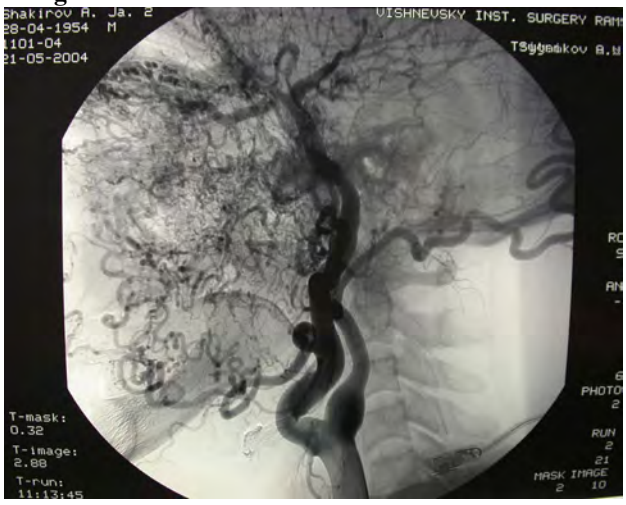


Figure 6. Selective angiography – angiomatoid tissues are fed from the external arteria carotis reservoir

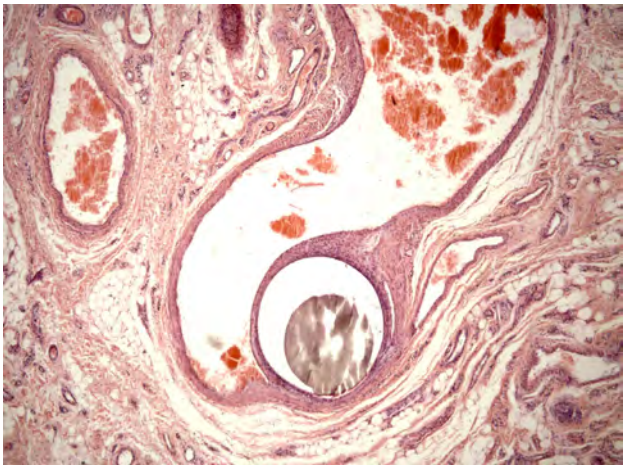


Figure 7. The hydrogel embole in the arterial lumen (Hematoxylin and eosin stain x 50)

Figure 8. Result obtained after two stages of the treatment – angiomatosis resection followed by mobilized grafting from the neck

the conventional angiographic study of the AVM as a base for any future treatment plans.

To date, there are three main concepts in AVM treatment:

1. Patients with AVM have no indication for urgent surgical treatment as the lesion is initially small and relapses frequently occur;
2. Surgery is necessary in all AVM cases at one moment in disease evolution;
3. There is no consensus concerning the therapeutic management of AVM up to date.

According to the authors, the most favorable approach is represented by a combination of super selective embolization and staged surgical interventions (Table II) (6,7,8).

In 50% of the cases, embolization was completed by using Gianturko metallic coils and injecting 90% ethanol. The metallic coils diminish the blood flow in the affected artery by creating turbulences with a pro-thrombotic effect. Meanwhile, ethanol injection activates tissue thromboplastin production. Several articles confirm the benefit of associating two embolization techniques (hard and liquid) (8,9).

In our opinion, if a surgical approach is considered adequate for an AVM patient, several steps have to be performed. The potential for endovascular embolization should be evaluated first and thoroughly exploited in order to diminish and better delineate the lesion prior to surgery (9). The time period between the endovascular embolization and the actual surgical intervention must never exceed 7 to 10 days to reduce the risk of collateral revascularization. The surgical intervention should aim a maximum resection, with no recurrence of clinical symptoms for at least one year after surgery. Excessive hemorrhage during such an invasive intervention could be avoided by applying a tourniquet in the proximal part of the affected extremity thus offering "bloodless" conditions. Tourniquet application for 70-80 min has not led, to date, to any ischemic and/or neurologic complications. Consequently, the ligature of all afferent arteries is an important preliminary stage that precedes the surgical intervention itself in order to subsequently diminish hemorrhage. Finally, in the most severe of cases advanced technological support may be needed. Cell-Saver for example allows surgeons to operate on patients deemed inoperable with earlier methods.

Table II. Therapeutic interventions in AVM

	Surgical interventions variants	**Endovascular interventions**	**Combined treatment**
Radical interventions	Resection Amputation	-	Preoperative embolization + resection
Hemodynamic interventions	Skeletonization Afferent arteries ligation Arteriovenous-shunt selective ligation	Endovascular embolization	Pre- and postoperative embolization + skeletonization; Skeletonization + intraoperative embolization
Additional interventions	Phlebectomy, perforating veins ligation Autodermografting – graft on the microvascular anastomosis - grafting with free split skin graft	-	-

In order to achieve maximum endovascular occlusion efficiency, the following conditions must be respected:

- Before each endovascular occlusion session an arteriography has to be performed in order to evaluate all afferent arteries together with the angio-architectonics of tissues surrounding the lesion. Possible collateral circulation should also be determined before embolization;
- Staged super-selective endovascular occlusion is mandatory for all arteries feeding the malformation;
- Calibrated emboli should be used, the correct sizing of the emboli being mandatory for procedural success. Emboli measuring 0.5 mm in diameter were used for the embolization of microfistulous AVM. After a decrease of blood flow through the arteriovenous orifices, emboli diameter should be increased to 0.75 mm. The arterial occlusion must be stopped if retrograde blood flow decreases suddenly or catheter blood flow stops as the two signal the appearance of the "*stop-blue*" syndrome;
- Emboli flow and localization should be strictly controlled during the endovascular procedure by using radio-opaque products;
- Coagulation parameters should be supervised continuously in the post-embolization period for an early correction of hypercoagulability.

Patients with microfistulous AVM together with some with the macrofistulous AVM (especially those with distal limb involvement), must be closely supervised. For such patients, the therapeutic procedures must be carried out under strict indications, such as: refractory painful syndrome, progressive trophic damage, recurrent hemorrhage. Treating patients with none or mild symptoms is considered justified in case of organic damage – in such cases a radical surgical intervention may be preferable. In

microfistulous AVM, recurrences often occur. A potential explanation could be represented by the "sleeping" fistula theory that describes the evolution of AVM from a latent form with no clinical significance.

In case of macrofistulae complications independent to the AVM, a hybrid approach involving both embolization and surgical treatment is strongly recommended (10) in order to prevent heart failure. The proper time for this intervention is determined based on the central hemodynamic parameters, clinical symptoms and complications. If severe symptoms and cardiac overcharge are absent, the patient must be supervised in the hospital. Lastly, if heart failure symptoms occur, the elimination of pathologic outflow must be taken into consideration (11).

Conclusions

Endovascular embolization has the potential to become the main therapeutic method as well as an important stage of preoperative preparation in patients with AVM. If an invasive surgical treatment is deemed best for the patient, the affected tissues must be resected completely. After such a radical surgery, the incision and the adjacent area should be grafted with either mobilized muscle flaps (sternocleidomastoid muscle flap, for example) or free tissue transfer flaps using microvascular anastomoses. When the pathologic shunt cannot be removed with endovascular or surgical treatment, amputation is recommended (in distal limb lesions such interventions, although widely considered as rather radical, are not seen as debilitating).

In order to increase long-term post-operative survival rates, patients must be kept under strict supervision in the hospital, with any additional treatment closely taken into consideration. Such a surveillance period is necessary as a vast majority of cases with surgically treated angiodysplasia (especially those with endovascular embolization) register a rather radical evolution. After hospital discharge, all patients must be periodically called for follow-up investigations and supervised by their caring physician.

Patient education is also important as patients have to decrease their workload to avoid compressing the operated extremity. Regular ultrasound investigations (DUS and echocardiography) are necessary to evaluate the treated region, exclude cardiac overload and establish the following stages of the treatment.

Conflict of interest

The authors declare that there are no conflicts of interest.

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Aspergillus Pseudoaneurysm of the Right Lower Lobe Pulmonary Artery: Case Report and Review of Literature

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Abstract
Introduction: Infectious or mycotic pulmonary artery aneurysm (PAA) is a rare diagnosis of a vascular abnormality with an associated high mortality rate due to the potential of rupture and massive hemoptysis.
Case presentation: The authors present a case of pulmonary mycotic aneurysm associated with pulmonary aspergillosis in a 54-year-old woman with acute myeloid leukemia in complete remission after induction complicated by febrile neutropenia and pneumonia. The initial contrast enhanced helical computed tomography (CT) scan revealed an aspect compatible with the diagnosis of invasive aspergillosis associated with an aneurysmal dilatation of the right lower lobe pulmonary artery. An embolization of the aneurysm was attempted but the super-selective catheterization was not possible. A proximal embolization with a metallic coil was performed. Two weeks later the patient presented again to the emergency room for hemoptysis and epistaxis, which remitted after the treatment was changed. The patient deceased from septicemia after a massive, complicated hemoptysis in another service one month after the last CT scan control.
Discussion: The presented case underscores the difficulty in correctly diagnosing the lesion, and illustrates the high mortality associated with delayed diagnosis.
Conclusion: Experience in the management of mycotic pulmonary aneurysms is limited and the correct clinical diagnosis is rare.
Keywords: pulmonary artery mycotic pseudoaneurysm, aspergillus, embolization, myeloid leukemia

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Introduction

Infectious or mycotic pulmonary artery aneurysm (PAA) represents a rare acquired vascular abnormality characterized by a high mortality rate due to the potential for rupture and massive hemoptysis (1).

Non-infectious PAA can be associated with a variety of conditions, including Behcet disease, Hughes-Stovin syndrome, trauma, connective tissue disorders, and pulmonary hypertension.

Infectious PAA may be caused by a variety of microorganisms, such as bacteria including *Staphylococcus aureus* and *Streptococcus* species, *Mycobacterium tuberculosis* and *Treponemapallidum*, and rarely by fungi (2).

Radiologic manifestations of thoracic aspergillosis are diverse, including peripheral air-space consolidation, mass like opacity, cavitations, hilar or mediastinal lymphadenopathy, empyema, osteomyelitis and soft tissue mass secondary to chest wall involvement, eventually accompanied by fistula formation (3).

A case of pulmonary mycotic aneurysm associated with pulmonary aspergillosis is recorded in the current presentation.

Case presentation

A 54-year-old woman with acute myeloid leukemia in complete remission after a complicated induction was hospitalized for hemoptysis. The induction was obtained with Idarubicine-Cytosar association, complicated in evolution by febrile neutropenia and pneumonia.

Four months after the induction the patient presented to the emergency room with hemoptysis. Laboratory data revealed an increase in C-reactive protein (CRP) at 2.5mg/dl, leucopenia (3800/ml) with neutropenia (1900/ml) and mild thrombocytopenia (138.000/ml).

The initial contrast enhanced helical computed tomography (CT) scan performed at admission showed

basal densifications of the lower lobes, a complete atelectasis of the middle lobe and an aneurysmal dilatation of the right lower lobe (RLL) pulmonary artery measuring 10 x 8 mm and located between the apical arterial branch and the artery for the basal pyramid. The anterobasal segmental bronchus of the RLL and the middle lobe bronchus were completely occluded and a tissue bud was detected in the apical brochus of the RLL. Dense nodules surrounded by a ground-glass infiltrate were identified in the right upper lobe (RUL). The CT scan also showed numerous bronchoceles and a ground-glass infiltrate of laterobasal and posterobasal segments of the right and left lower lobes. The radiologic aspect was suggestive for the diagnosis of invasive aspergillosis.

A bronchial endoscopy was performed in order to confirm the diagnosis and revealed fresh blood in the trachea and a complete obstruction of the middle lobe bronchus by a whitish tissue. A treatment with voriconazole was initiated.

A second CT scan realized a month later showed a secondary anterolateral dilatation of the original anevrysmal sac. The tissue bud inside the apical bronchus of the RLL was no longer visualized and a partial repermeabilization of the anterobasal bronchus of the RLL was also noted. Most of the RUL nodules disappeared and others reduced in size (Figure 1).

An embolization of the aneurysm was attempted but the super-selective catheterization was not possible. A proximal embolization with a metallic coil was performed.

Two weeks after the second scan the patient presented again to the emergency room for hemoptysis (4-5 blood expectorations/day) and epistaxis. The treatment was changed to an association of Ambisome, Acyclovir, Exacyl and Tazocin and a new CT scan was indicated (Figure 2).

The third CT scan revealed a decrease in size of the anterolateral dilatation and the appearance of a new anteromedial dilatation of the aneurysmal sac. The biggest RUL nodule showed a central cavitation.

A control CT scan (the forth) was performed a month after the treatment was changed and displayed a subtotal filling of the lower lobe bronchi associated to a retractile densification of the anterobasal and posterobasal segments of the RLL. The biggest RUL nodule further diminished in size and the anterolateral dilatation of the aneurysmal sac disappeared.

The patient deceased from septicemia after a massive, complicated hemoptysis at another hospital, one month after the last CT scan.

Discussion

Aneurysms of any type affecting the pulmonary arteries are very rare compared with aortic, intracranial or other major vascular locations and may occur in association with congenital cardiovascular anomalies, infection, trauma,

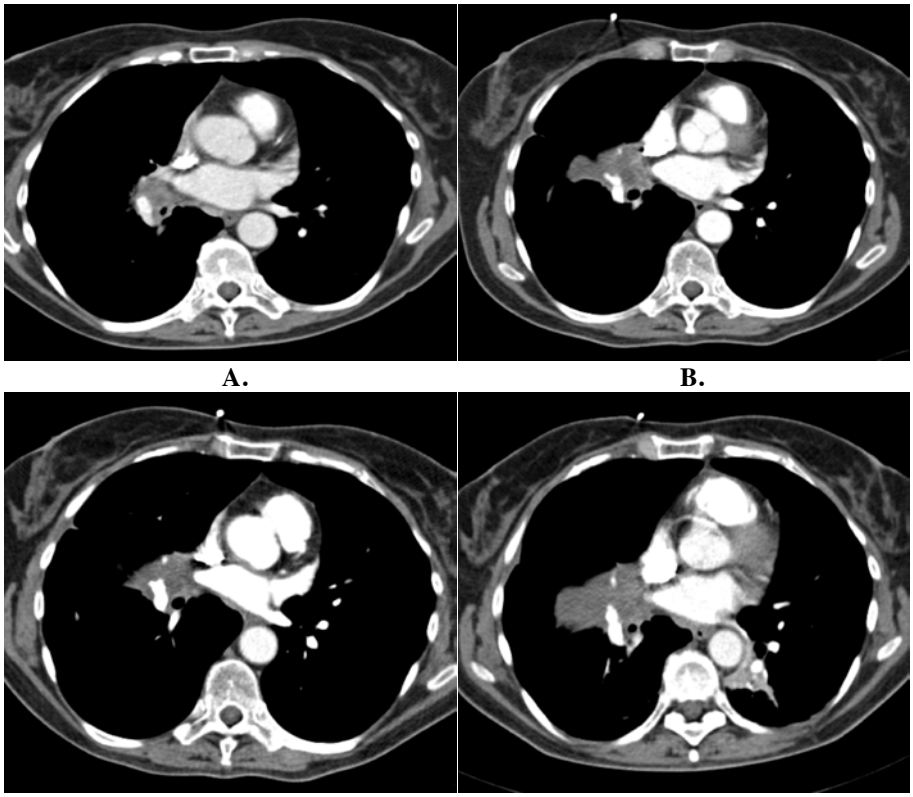
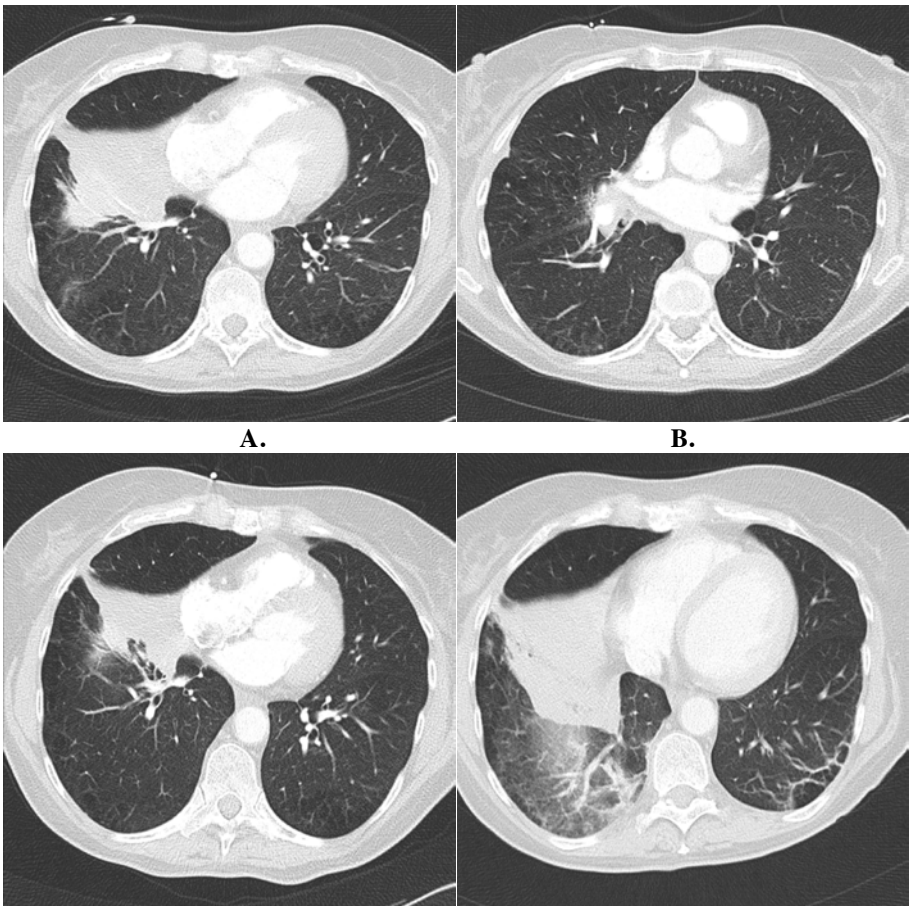


Figure 1. A. The original aneurysmal sac. B. The secondary anterolateral dilatation C. The anteromedial dilatation D. Disappearance of the anterolateral dilatation



A. **B.**

C. **D.**

Figure 2. A. Middle lobe and right lower lobe anterobasal segment atelectasis, B. Tissue buds in the right lower lobe bronchus. C. Repermeabilization of the anterobasal bronchus. D. Reappearance of retractile densification of the anterobasal segment

generalized vasculitis or pulmonary hypertension. Of these conditions, infection is the major cause of pulmonary aneurysms. The microorganism produces proteolysis enzymes that allow the infection to cross the fascial planes (4).

Although the aggressive nature of the infiltration and frequent presentation of hemoptysis have been well described, aspergillosis involving the pulmonary vasculature has rarely been documented in the current medical literature (5).

Pyogenic microorganisms, including *Staphylococcus* and *Streptococcus*, are the most frequent causes of infectious pulmonary aneurysms; however, aneurysms caused by treponema, mycobacteria, and rarely fungal organisms like *Aspergillus* and *Candida* species, have also been reported. Tuberculosis and syphilis, once considered major causes of infectious pulmonary aneurysms, are now better managed since the introduction of antibiotics (6).

The proposed pathologic mechanisms of an infectious pulmonary aneurysm include direct involvement of an adjacent pulmonary artery from a focus of suppurating pulmonary infection, as in tuberculosis, ischemic injury to the pulmonary arterial wall as a result of infection of the *vasa vasorum*, as in syphilis, and direct extension into a vessel wall from an intraluminal septic thromboembolus or the blood itself, as in bacterial endocarditis. Among these mechanisms, in the current case the first was thought to be the most likely responsible for the development of the pulmonary aneurysm. Virulent organisms produce severe destruction of all layers of the arterial wall, resulting in the formation of a false aneurysm, whereas indolent organisms tend to cause a true aneurysm, as the arterial wall is less severely damaged.

Although pulmonary angiography was previously the gold standard of diagnosis, CT and magnetic resonance imaging (MRI) have recently become important alternatives. Both contrast-enhanced CT and MR imaging clearly demonstrate the vascular nature of a mass like lesion resulting from a pulmonary aneurysm. In our case, CT disclosed a hyper enhancing nodule, connected with a pulmonary vessel within the parenchymal lesion of low attenuation.

The enhancing nodule had a similar attenuation value as the surrounding vessels, which was virtually the diagnostic of a pulmonary aneurysm. The radiographic appearance of a mycotic pulmonary aneurysm includes well or ill-defined

pulmonary nodules or focal parenchymal consolidation, indistinguishable from those caused by infectious or neoplastic diseases.

From our point of view rapid change in the shape of a nodule may occasionally suggest a mycotic aneurysm, but, as in the current case, a mycotic aneurysm associated with necrotizing pneumonia can be difficult to diagnose.

Conclusions

Experience in the management of mycotic pulmonary aneurysms is limited and the correct clinical diagnosis is rare. CT scan classically reveals a central arterial type of enhancement within a hematoma or a lung consolidation. Other radiological findings include an enhancing mass next to a pulmonary artery, thrombus within a dilated pulmonary artery, and an enhancing nodule with a low attenuation halo.

The management is usually surgical, and involves aneurysmectomy, lobectomy, aneurysmorrhaphy or banding.

The above case underscores the difficulty in correctly diagnosing the lesion, and illustrates the high mortality associated with a delayed diagnosis.

Conflict of interest

The authors declare that there are no conflicts of interest.

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Evolution of Pulmonary Hypertension and Right Ventricular Function after Cardiac Surgery

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Abstract
Objective: To identify the impact and the evolution of pulmonary hypertension (PH) and right ventricular (RV) dysfunction after cardiac surgery.
Methods: We included 159 patients with preoperative PH due to left heart disease and we followed the by echocardiography two years after cardiac surgery. The preoperative echocardiographic exam included: left ventricle ejection fraction, systolic pulmonary artery pressure (sPAP), end-diastolic right ventricle diameter, the indexed area of the right atrium, RV end-diastolic and end-systolic area, the severity of the tricuspid regurgitation and the presence of pericardial fluid. RV systolic function was quantified before surgery using TAPSE, S' wave velocity at the tricuspid ring, RV fractional area change. Postoperative exams included sPAP and TAPSE.
Results: Preoperative sPAP was 60.37±17.14 mmHg. sPAP dropped after cardiac surgery, but rose to 47.52±16.7 mmHg at 24 months (p=0.036). The degree of late postoperative rise of sPAP correlated with the severity of preoperative PH. Patients with lower LVEF tend to rise their sPAP after an initial favorable evolution. Preoperative TAPSE was 19.59±5.79 mm; postoperative TAPSE was 13.87±3.13 mm at 5 days (p<0.001) and 15.24±3.2, 18.78±5.21 mm at 1 and 6 months, respectively. Postoperative RV dysfunction is associated significantly with higher mortality, longer ICU stay, mechanical ventilation and inotropic support.
Conclusions: We noted a biphasic postoperative evolution of sPAP. Perioperative RV dysfunction is common in patients with PH and has a major prognostic impact. RV dysfunction tends to improve over time, but not completely.
Keywords: Pulmonary hypertension, right ventricle, cardiac surgery, prognostic

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Introduction

Pulmonary hypertension (PH) represents a hemodynamic and physiopathological condition defined by the increase of the mean pulmonary pressure, determined at the right heart catheterization, at more than or equal to 25 mm Hg at rest (1). The current PH classification was adopted within the fourth International Symposium regarding the PH, held in 2008, in Dana Point, California. At present, there are six clinical groups defined. From a surgical point of view, the pulmonary hypertension due to left heart diseases raises a special interest (group no. 2). PH due to left heart diseases represents the most frequent cause of PH (2).

PH occurrence represents a negative prognostic factor for the patients suffering from heart failure. PH impact on cardiac surgery has largely been debated in recent years and there is significant evidence that preoperative PH is associated with the increase of the early and late postoperative death rate, postoperative systolic dysfunction of the left heart and adverse cardiac events (3-5). PH is included in both the Parsonnet and Euroscore models, where it significantly contributes to risk stratification.

Right ventricular dysfunction has been shown to be a significant prognostic factor in cardiac surgery and heart transplantation. A lot of studies support the prognostic value of right ventricular function in patients undergoing valvular heart surgery. In patients undergoing mitral valve surgery, right ventricular dysfunction was a better predictor of postoperative circulatory failure than pulmonary arterial pressure, suggesting that morbidity and mortality associated with PH is dependent on right ventricular adaptation to pulmonary vascular disease (6).

The objective of our study was to identify the evolution of pulmonary hypertension and right ventricular

dysfunction in patients undergoing cardiac surgery, both in the perioperative period and late after the surgery. The primary objective in the perioperative period was mortality. The secondary end points included the following: pericardial, pleural, hepatic, and renal complications; need for a new surgical procedure; postoperative mechanical ventilation >24 hours; length of intensive care unit stay; duration of postoperative inotropic support; need for an intra-aortic balloon pump; need for pulmonary vasodilator drugs (endothelin receptor antagonists [ERAs], phosphodiesterase type 5 inhibitors [PDE5Is], or prostanoids). We defined renal complications as an increase in serum creatinine of 0.3 mg/dL or 50% in <48 hours, hepatic complications as hepatic cytolysis syndrome and/or a spontaneous international normalized ratio >1.5, pleural complications as significant pleurisy necessitating thoracentesis, and pericardial complications as a large amount of pericardial fluid with signs of compression and/or a need for surgical reintervention.

Methods

We included 159 patients with preoperative pulmonary hypertension due to left heart diseases. The average age of the group was of 63.45 ± 12.13 years old (limits of 10 and 92 years old). The male gender was preponderant (61.1% vs. 38.9%).

The preoperative echocardiographic examination included the determination of the volumes of the left ventricle and the ejection fraction (LVEF) using Simpson biplane method; the determination of the systolic pressure in the pulmonary artery (sPAP) based on the tricuspid regurgitation jet; the determination of the end-diastolic diameter of the right ventricle (RVEDD); the measurement of the right atrium surface, indexed to the body surface; the right ventricular end-diastolic (RVEDA) and end-systolic area (RVESA) (measured in the apical 4-chamber view); the assessment of the tricuspid regurgitation severity (TR) and presence of pericardium fluid. The systolic function of the right ventricle was determined, before surgery, by TAPSE measurement, the measurement of the fractional area change of the right ventricle and the velocity of S' wave in pulsed tissue Doppler at tricuspid ring level. The right ventricular fractional area change (RVFAC) is determined in the 4-chamber view, according to the formula (RVEDA-RVESA)/ RVEDA x 100.

In the postoperative phase, the right ventricle the function was followed up by TAPSE measurement.

The patients were followed up by clinical and echocardiographic examinations 5 days, 1, 6, 12 and 24 months after surgery.

The echocardiographic assessment of the systolic pressure from the pulmonary artery was performed based on the tricuspid regurgitation envelope, using the simplified Bernoulli equation, to which we added the right atrium pressure, assessed based on the inspiration diameter and variations of the inferior vena cava.

Surgical procedures were conducted with standard cardiopulmonary bypass and consisted of: mitral valve repair in 39 patients (24.52%); mitral valve replacement in 32 cases (20.12%); aortic replacement in 28 patients (17.61%); aortic replacement and mitral plasty in 24 cases (15.09%); mitral plasty and coronary artery by-pass graft surgery in 14 patients (8.8%); aortic replacement and coronary artery by-pass graft surgery in 10 cases (6.28%); aortic replacement, mitral plasty and coronary artery by-pass graft surgery in 12 patients (7.54%). Mitral valve repair was carried out via neochordal insertion (for both the anterior and posterior mitral leaflet), quadrangular resection of the posterior mitral leaflet, triangular resection, anterior mitral leaflet augmentation, commissuroplasty, complete or incomplete annuloplasty with an annular ring, resection, and closing of perforations. All mitral valve replacements were carried out with preservation of the subvalvular mitral apparatus. De Vega tricuspid annuloplasty was performed in 29 patients (18.23%).

The statistical analysis employed the MedCalc program, version 12.1.3. (MedCalc Software, Mariakerke, Belgium). The continuous variables were expressed as average ± SD (standard deviation). ANOVA test was used in order to compare the continuous variables, while χ^2 test was preferred for the category variables.

Results

The results of the preoperative echocardiographic examination are presented in Table I.

We registered 4 deaths (death rate of 2.51%). Table II shows the clinical and echocardiographic parameters, according to the vital status of the patients. We identified significant differences from a statistical point of view for the preoperative NYHA class IV, TAPSE, the fractional area change of the right ventricle and S' wave velocity at the level of the tricuspid ring, the indexed surface of the right atrium and the presence of pericardial fluid.

We defined severe pulmonary hypertension as sPAP value above 60 mm Hg and we analyzed its impact on the death rate and on the postoperative complications. The results are presented in Table III. Severe pulmonary hypertension is associated with a significant death rate increase, the length of intensive care unit stay, mechanic ventilation for more than 24 hours, increased necessary for inotropic support and surgical reintervention, increased rate of renal, liver and pericardial complications and need for pulmonary vasodilator drugs.

The preoperative systolic dysfunction of the right ventricle, defined as TAPSE < 16 mm, is accompanied by a significant increase of the early postoperative death rate, but also by the complication rate increase (Table IV).

The average value of preoperative TAPSE was of 19.59 ± 5.79 mm. The immediately postoperative period is marked by a significant reduction of TAPSE value (13.87 ± 3.13, $p<0.001$), with a slow improvement towards the preoperative

Table I. Preoperative Echocardiographic Parameters

Parameter	Values
sPAP, mm Hg	60.37±17.14
RVEDD, mm	38.41± 7.9
RVEDA, cm^2	20.84± 8.33
RVESA, cm^2	15.3± 7.43
Indexed RA area, cm^2/m^2	14.4± 5.52
TAPSE, mm	19.59± 5.79
RVFAC, %	28.22± 15.18
S', cm/s	10.43± 2.96

Table II. Clinical and Echocardiographic Parameters according to Mortality

Parameter	Nonsurvivors N=4	Survivors N= 155	p
Age, years	62.75 ± 17.92	58.73 ± 11.62	0.5
Male sex	2 (50%)	92 (61.29%)	0.7
Preoperative NYHA IV	**3 (75%)**	**17 (26.35%)**	**< 0.001**
sPAP, mm Hg	71.75 ± 5.06	58.73 ± 17.03	0.13
LVEF, %	46.75 ± 12.2	51.81 ± 13.19	0.45
RVEDD, mm	41.33 ± 6.11	36.09 ± 6.45	0.16
Pericardial fluid	**1 (25%)**	**3 (1.93%)**	**0.003**
Indexed RA area, mm/m^2	**20.91± 4.3**	**13.78 ± 4.35**	**0.002**
TAPSE, mm	**13.5± 7.4**	**18.69 ± 4.71**	**0.03**
RVFAC, %	**29.56 ± 15.79**	**16.45 ± 5.12**	**0.05**
S', cm/s	**11.68 ± 3.32**	**9.84 ± 2.6**	**0.05**
Preoperative TR ≥ 3	2 (50%)	36 (23.22%)	0.21

Table III. Influence of Severe PH on Complications

Parameter	sPAP < 60 mm Hg N= 92	sPAP > 60 mm Hg N = 67	p
Death, n	0 (0%)	4 (5.97%)	0.017
Mechanical ventilation > 24h	2 (2.17%)	20 (29.85%)	< 0.001
Renal complications	2 (2.17%)	7 (10.44%)	0.025
Liver complications	4 (4.34%)	12 (17.91%)	0.003
Pericardial complications	2 (2.17%)	12 (17.91%)	< 0.001
Pleural complications	6 (6.52%)	4 (5.97%)	0.839
Reintervention	0 (0%)	3 (4.47%)	0.04
Intra-aortic balloon pump	0 (0%)	2 (2.98%)	0.09
ERA/prostanoids/PDE5I	2 (2.17%)	9 (13.43%)	0.005
Hospitalization in ICU, days	6.57 ± 2.01	10.41 ± 4.39	<0.001
Need for inotropic support, days	4.06 ± 2.42	7.86 ± 4.44	< 0.001

Table IV. Influence of Right Ventricular Dysfunction on Postoperative Complications

Parameter	TAPSE<16 mm N = 49	TAPSE>16 mm N = 110	p
Death	4 (8.16%)	0 (0%)	0.002
Mechanical ventilation > 24h	14 (28.57%)	8 (7.27%)	0.0003
Hospitalization in ICU, days	11.58 ± 4.5	6.59 ± 3.17	<0.0001
Reintervention	3 (6.12%)	0 (0%)	0.008
ERA/prostanoids/PDE5I	8 (16.32%)	3 (2.72%)	0.001
Inotropic support duration, days	9.5 ± 3.84	3.97 ± 2.95	<0.0001

sPAP: systolic pulmonary artery pressure; RVEDD: right ventricular end-diastolic diameter; RVEDA: right ventricular end-diastolic area; RVESA: right ventricular end-systolic area; RA: right atrium; TAPSE: tricuspid annular plane systolic excursion; RVFAC: right ventricular fractional area change; S': S wave velocity; NYHA: New York Heart Association; LVEF: left ventricular ejection fraction; TR: tricuspid regurgitation; ERA: endothelin receptor antagonist; PDE5I: phosphodiesterase-5 inhibitor; ICU: intensive care unit.

value up to 6 months after the surgery (Figure 1). TAPSE postoperative average reduction was of 4.18 ± 5.66 mm and correlated with preoperative TAPSE (r=0.85, p<0.01) and with the severity of the preoperative tricuspid regurgitation (p=0.03). The tricuspid plasty was performed in 29 patients (18.23%). The patients to whom the tricuspid plasty was performed had a significantly more dilated tricuspid ring in the preoperative phase, as compared to the ones for whom the plasty was not necessary (39.42 ± 6.83 mm vs. 36.1 ± 6.68 mm) (p=0.019). TAPSE postoperative reduction was much more significant in patients to whom the tricuspid plasty was performed (5.84±2.64 mm) as compared to those for whom the tricuspid valve surgery was not performed (1.25 ± 6.89 mm) (p=0.01).

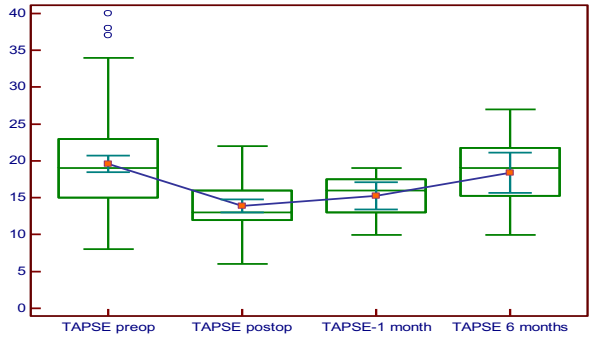

Figure 1. Right ventricular function postoperative evolution

TAPSE: tricuspid annular plane systolic excursion

The pulmonary systolic pressure in the postoperative phase was of 41.72± 10.93 mm Hg, 37.97± 12.3 mm Hg, 40.08 ± 11.82 mm Hg, 40.67 ± 13.19 mm Hg in 5 days, 1, 6, 12 months, respectively, and increased significantly up to 47.52 ± 16.7 mm Hg 24 months after the surgery (p=0.036) (Figure 2).

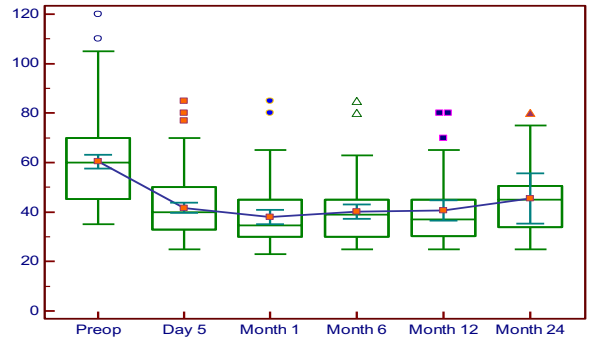

Figure 2. Systolic pulmonary artery pressure postoperative evolution

Patients with residual PH had a more severe preoperative PH (p<0.001) and a left ventricle ejection fraction significantly smaller (p=0.05). Patients with residual PH had a significantly longer hospitalization in the intensive care unit (p<0.001) (Figure 3) and a longer duration of the necessary of inotropic support (p<0.001) (Figure 4). 24 months after the surgery, patients with preoperative diameter of the tricuspid ring smaller than 40 mm had an average sPAP value of 37.97 ± 11.13 mm Hg, while those with the tricuspid ring diameter larger than 40 mm had a sPAP value of 44.4 ± 11.48 mm Hg (p=0.02).

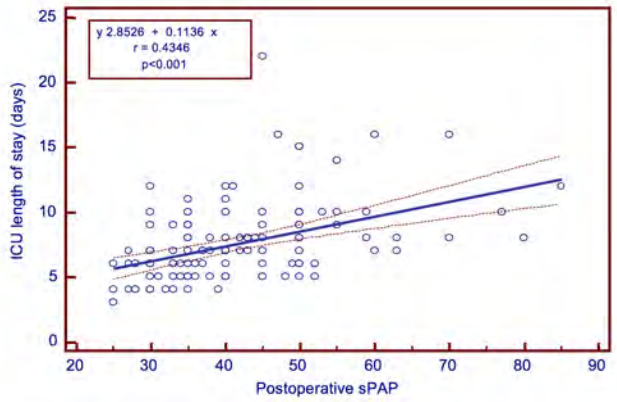

Figure 3. Correlation between ICU length of stay and postoperative sPAP

ICU: intensive care unit; sPAP: systolic pulmonary artery pressure

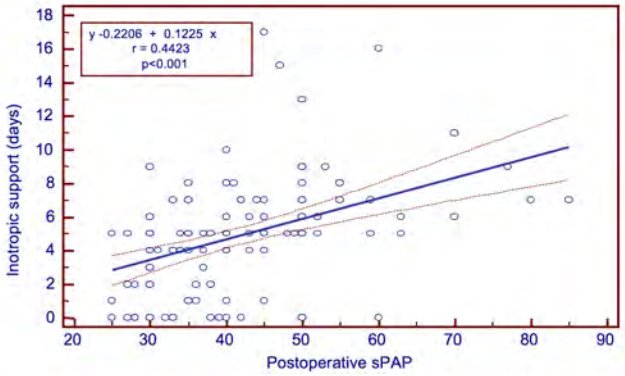

Figure 4. Correlation between the need for inotropic support and postoperative sPAP

sPAP: systolic pulmonary artery pressure

Discussion

Age and gender did not influence patients' postoperative evolution.

Among the clinical parameters, preoperative NYHA class was an important predictor of death rate and of the occurrence of postoperative complications. This remark is an argument of the early surgical correction after the onset of symptoms.

Among the echocardiographic parameters, we identified that the presence of the pericardial fluid, the indexed surface of the right atrium and the systolic dysfunction of the right ventricle (determined by TAPSE, RVFAC and S' velocity) are significantly correlated with the death rate. In literature, among the echocardiographic parameters classically recognized as having prognostic value in patients with PH, the most frequently met are the presence of the pericardial fluid and the indexed surface of the right atrium (7,8). The pericardial effusion represents a manifestation of right heart failure, caused by the faulty lymphatic and venous drainage due to the pressure increase in the right atrium. In the

absence of certain organic abnormalities of the tricuspid valve, the right atrium dilatation is generally a manifestation of the increased pressure in the right atrium, secondary to the functional tricuspid regurgitation or to the increase of the diastolic pressure of the right ventricle, both of them being consequences of the right ventricular failure. The indexed surface of the right atrium, measured by echocardiography, is significantly correlated with the right atrium pressure (7) and with invasive parameters of right ventricular diastolic filling and it predicts correctly a high right ventricular end-diastolic pressure (9). The right atrium dilation is a simple, quantitative and reproducible echocardiographic marker which indicates the occurrence of the right ventricular failure (10).

The right ventricle systolic function is an important factor which determines outcomes in patients with PH. Decreased systolic excursion of the tricuspid ring (TAPSE below 12-19 mm) is proved in literature to have prognostic value both in patients with idiopathic pulmonary artery hypertension and in those with PH secondary to left heart diseases (11,12,13,14). TAPSE smaller than 18 mm is correlated with a heart index lower than 1.9 l/min/m^2 at heart catheterization, and for each 1 mm in minus of the TAPSE value, the death risk increases by 17% (11). In our study, we found that TAPSE below 16 mm is accompanied by a significant increase of the early postoperative death rate, a significantly increased risk of reintervention, longer stay in ICU and mechanical ventilation, prolonged need for inotropic support and increased use of pulmonary vasodilator drugs.

The normal value of RVFAC is of more than 40%. As compared to other methods of quantification of the systolic function of the right ventricle (TAPSE and the transversal shortening fraction), the fractional area change presents the best correlation with data obtained at the nuclear magnetic resonance (15). Right ventricle fractional area change has a prognostic significance in patients with heart failure and PH (16). RVFAC lower than 35% represents a major risk factor in the heart surgery (17). As in the case of the volumetric measurement of the ejection fraction, the method presents the disadvantage of its pre-load dependence. Other error sources of this method could be related to the intense right ventricular trabecularism and weak endocardial definition.

Normally, S' wave velocity exceeds 14 cm/sec. The occurrence of the systolic dysfunction of the right ventricle is marked by the reduction of S' wave velocity under 11.5 cm/sec, with a very good correlation with an ejection fraction under 45% at the radionuclide angiography (18). S' wave velocity presents excellent correlations with TAPSE and the right ventricle fractional area change and it identifies the systolic dysfunction of the right ventricle regardless of PH severity (19). Patients with slight or moderate tricuspid regurgitation present a very good correlation between S' wave velocity and the right ventricle ejection fraction determined by radionuclide ventriculography. Instead, the presence of a major tricuspid regurgitation decreases the power of the relationship between S' wave velocity and the right ventricle ejection fraction. In these patients, the interpretation of S' wave velocity must be prudently performed (20).

The systolic pressure in the pulmonary artery (sPAP), assessed by echocardiography, is not classically considered as having a prognostic significance (1,7). Nevertheless, in certain subsets of patients, such as PH due to left heart diseases which require cardiac surgical interventions, sPAP value determined by echocardiography is associated with survival rate or complications' occurrence. sPAP higher than 50 mm Hg in patients with chronic mitral regurgitation represents an independent predictor of mortality after heart surgery (3). sPAP higher than 60 mm Hg was correlated with a composite end point of cardiac death, hospitalizations for heart failure phenomena or cardiac arrhythmias in patients with mitral regurgitation (4) and with a reduced short-term or long-term survival in these patients (5). In our study, severe PH, defined as sPAP above 60 mm Hg, was significantly associated with death rate increase and the rate of the postoperative complications.

In our study, the ejection fraction of the left ventricle was not significantly associated from a statistic point of view with the death rate, which suggests that the occurrence of the right ventricle dysfunction plays a more important role in patients with pulmonary hypertension.

The main determining factors of the postoperative death risk in patients with PH are in our study either direct markers of the right ventricular dysfunction (TAPSE, S' wave, RVFAC), either, as shown above, indirect signs of right ventricle dysfunction, such as the presence of the pericardial fluid and the right atrium dilatation. The conclusion of our study is that the right ventricle systolic function must be systematically and rigorously researched in patients with PH who are subject to cardiac surgical interventions, as it represents the main postoperative death risk factor in these patients.

Residual pulmonary hypertension represents a major problem after heart surgery. In our study, patients with residual PH had a more severe preoperative PH, a significantly smaller left ventricle ejection fraction and a significantly more dilated tricuspid ring. Patients with severe preoperative PH and small left ventricle ejection fraction have the tendency of increasing their pulmonary pressure after an initially favorable evolution. Residual PH presents prognostic implications which are important for the immediately postoperative period. Patients with residual PH had a significantly longer hospitalization in the intensive care unit and a longer duration of the necessary of inotropic support. In spite of an initially favorable evolution, sPAP has the tendency to increase again after the surgery, the difference being significant from a statistic point of view after 24 months. This increase of sPAP despite the surgical resolution of the affection which generated PH is due to the occurrence of irreversible alterations in the pulmonary circulation. The early surgical interventions, knowing the

preoperative risk factors and choosing the optimal surgical technique could help to reduce this phenomenon. In this respect, there are reasons for the routine performance of the tricuspid annuloplasty in all patients with marked dilation of the tricuspid ring (>40 mm), regardless of the severity degree of the tricuspid regurgitation, as proven in other previous studies (21,22).

Over the immediately postoperative period, we registered a significant reduction of TAPSE value. Even though at successive controls we noticed an amelioration tendency of the right ventricle systolic function, the rehabilitation was not complete even after 24 months from the surgery. The postoperative decline of the systolic function of the right ventricle was noticed in other studies too, in patients subject to coronary artery by-pass graft surgery and in patients with congenital heart disease (23,24). The mechanisms of the postoperative the right ventricle dysfunction are multiple: perioperative ischemia, air emboli, changes in RV geometrics in association with changes in inter-ventricular septal paradoxical motion, harmful effects of the cardioplegic solution (25). A problem which has to be taken into account when interpreting the results is the pre-load dependency. TAPSE, RVFAC and S' wave velocity are influenced by the tricuspid regurgitation severity (20). Therefore, the more significant reduction of postoperative TAPSE in patients to whom tricuspid plasty was performed (reducing therefore in a significant manner the right ventricular pre-load) can also be explained by means of this mechanism. The use of certain echocardiographic parameters as pre-load independent as possible (such as the myocardial performance index or the isovolumic contraction acceleration) would be ideal within these conditions, but these parameters are more time-consuming and more difficult to determine within immediately postoperative conditions (poor acoustic window due to oral tracheal intubation).

Conclusions

We noticed a biphasic postoperative evolution of the systolic pulmonary artery pressure. Perioperative right ventricle dysfunction is common in patients with pulmonary hypertension and has a major impact on clinical outcomes. Right ventricle dysfunction tends to improve over time, but not completely. PH, mainly the severe one, constitutes a major independent surgical risk factor, which must be taken into account in the preoperative assessment of the patient. The occurrence of the right ventricle dysfunction in patients with pulmonary hypertension is accompanied by a significant increase of perioperative death rate and complications, and by an incomplete and late recovery of the right ventricular function. All these conclusions drawn up from our study represent arguments in favor of a careful preoperative research of the pulmonary circulation and of the right heart and plead for the early performance of surgical intervention, before the installation of irreversible alterations.

Conflict of interest

The authors declare that there are no conflicts of interest.

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- Image of the month
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Sincerely yours,
Grigore Tinica M.D. Ph.D.
Editor-in-chief
Professor of Cardiovascular Surgery
University of Medicine and Pharmacy „Gr. T. Popa" Iasi
President of "The Euro-Asian Bridge" Society

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