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Рутинная коронарография и функциональные кардиологические пробы перед резекцией аневризмы брюшной аорты у пациентов без симптомов ишемии миокарда

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АННОТАЦИЯ

Введение. Кардиальные осложнения занимают первое место в структуре смертности пациентов после резекции аневризм брюшной аорты (АБА). В последние годы появляется все больше данных о возможности проведения инвазивной коронароангиографии (КАГ) в качестве метода дооперационной оценки состояния коронарных артерий.

Цель. Оценить тактику рутинной КАГ и профилактической реваскуляризации миокарда в сравнении с неинвазивными функциональными пробами у пациентов без клинических проявлений ишемической болезни сердца (ИБС) с позиции госпитальных исходов резекции АБА.

Материалы и методы. Ретроспективное исследование; включено 205 пациентов без клинических и инструментальных признаков ИБС, которым в 2001–2021 гг. на базе Национального медицинского исследовательского центра хирургии имени А. В. Вишневского была выполнена резекция АБА. Пациентам первой группы (n = 55) перед резекцией АБА была выполнена КАГ и при обнаружении значимых стенозов коронарных артерий — реваскуляризации миокарда. Пациентам второй группы (n = 71) перед операцией были выполнены только функциональные кардиальные пробы. Пациенты третьей группы были прооперированы без дополнительной оценки кардиального статуса.

Результаты. У 30,9% пациентов первой группы выявлены значимые коронарные поражения, среди них в 29,5% случаев наблюдалось вовлечение ствола левой коронарной артерии. Это потребовало выполнения 10 чрескожных коронарных вмешательств и 5 коронарных шунтирований, что в сумме составило 27% от числа больных этой группы. Случаев развития инфаркта миокарда в данной группе зарегистрировано не было. Во второй и третьей группах зарегистрировано по одному случаю инфаркта миокарда (p = 0,688). Послеоперационная летальность значимо не различалась во всех трех группах (1,8%; 4,2%; 2,5% соответственно; p = 0,704). При этом, что максимально инвазивная диагностическая тактика увеличила среднее время ожидания резекции АБА: 52,2 ± 6,0 суток в группах без выполнения КАГ и реваскуляризации миокарда против 99,2 ± 13,0 суток в первой группе.

Заключение. В когорте пациентов без анамнестических и клинических проявлений ИБС тактика рутинной КАГ с последующей профилактической реваскуляризацией миокарда не улучшила ближайшие результаты резекции АБА, при этом увеличился срок ожидания вмешательства на брюшной аорте. Предоперационная тактика с проведением функциональных кардиальных проб также не повлияла на результаты лечения.

Ключевые слова: *аневризма брюшной аорты; кардиальные риски; коронароангиография; ишемическая болезнь сердца; стеноз; коронарная артерия; ишемия миокарда*

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Routine Coronary Angiography and Functional Cardiac Tests before Resection of Abdominal Aortic Aneurysm in Patients without Symptoms of Myocardial Infarction

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ABSTRACT

INTRODUCTION: Cardiac complications are leaders in the structure of mortality of patients after resection of abdominal aortic aneurysms (AAA). In recent years more data have been obtained on the possibility of performing invasive coronary angiography (CAG) as a method of preoperative assessment of the condition of the coronary arteries.

AIM: To assess the tactics of routine CAG and preventive revascularization of the myocardium in comparison with non-invasive functional tests in patients without clinical manifestations of coronary heart disease (CHD) from positions of the hospital outcomes of AAA resections.

MATERIALS AND METHODS: A retrospective study included 205 patients without clinical and instrumental signs of CHD who underwent AAA resection at National Medical Research Center of Surgery named after A. Vishnevsky in 2001–2021. Patients of the first group (n = 55) underwent CAG before AAA resection and, if significant stenosis of coronary arteries was detected, revascularization of the myocardium was performed. In patients of the second group (n = 71), only functional cardiac tests were conducted before the operation. Patients of the third group were operated on without additional evaluation of cardiac status.

RESULTS: In 30.9% of patients of the first group, significant coronary lesions were detected, in 29.5% of them with the involvement of the left main coronary artery. This required 10 percutaneous coronary interventions and 5 coronary artery bypass surgeries, which made 27.0% of patients in this group. No cases of myocardial infarction were recorded in this group. In the second and third groups, one case of myocardial infarction in each group was recorded (p = 0.688). There was no significant difference in the postoperative mortality in all the groups (1.8%; 4.2%; 2.5%, respectively; p = 0.704). To this end, maximally invasive diagnostic tactics increased the average waiting time for AAA resection: 52.2 ± 6.0 days in groups without coronary angiography and myocardial revascularization versus 99.2 ± 13.0 days in the first group.

CONCLUSION: In a cohort of patients without anamnestic and clinical manifestations of coronary artery disease, the tactics of routine coronary angiography followed by prophylactic myocardial revascularization did not improve the short-term results of AAA resection, while the waiting period for intervention on the abdominal aorta increased. Preoperative tactics with functional cardiac tests also did not affect the treatment results.

Keywords: *abdominal aorta aneurysm; cardiac risks; coronary angiography; coronary heart disease; stenosis; coronary artery; myocardial ischemia*

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ECO•VECTOR

LIST OF ABBREVIATIONS

AAA — abdominal aortic aneurysm
CA — coronary artery
CABG — coronary artery bypass graft
CAG — coronary angiography
CAD — coronary artery disease
CI — confidence interval
ECG — electrocardiography
EchoCG — echocardiography
IEES — intra-esophageal electrophysiological study
MI — myocardial infarction
PCI — percutaneous coronary intervention
Stress-EchoCG — stress-echocardiography

INTRODUCTION

Assessing cardiac risks in patients with abdominal aortic aneurysms (AAA) before surgical treatment is an urgent problem of modern vascular surgery. A frequent combination of AAA and coronary artery disease (CAD) in one patient, pronounced intraoperative hemodynamic overloads, significant intraoperative blood loss make the coronary pathology and its complications the leader in the structure of postoperative mortality reaching 22.5% [1–4].

For two decades now, various clinics have been attempting to introducethe practice of routine coronary angiography (CAG) and prophylactic myocardial revascularization in the preoperative period in patients with and without stable CAD [5–8].

At Vishnevsky National Medical Research Center of Surgery, the tactics of preoperative cardiac examination of patients with AAA passed the way from standard electrocardiography (ECG) and echocardiography (EchoCG) at rest, through obligatory use of stresstests, to introduction in 2016 of routine CAG and, on identification of hemodynamically significant stenoses of epicardiac arteries, prophylactic coronary revascularization. By the moment, a fairly large material has been accumulated and it is reasonable that it 76 be processed and interpreted.

According to the literature, CAG is often performed in all patients without differentiation by the presence or absence of clinical and/or instrumental signs of CAD; patients without cardiologic symptoms are considered together with patients with severe CAD [7–9]. Our study included only patients without clinical or instrumental signs of CAD. We have not found such publications in the world literature.

The **aim** of this study to evaluate the tactics of routine coronary angiography and prophylactic myocardial revascularization compared with non-invasive functional tests in patients without manifestations of coronary heart disease from positions of hospital outcomes of resection of the abdominal aortic aneurysm.

MATERIALS AND METHODS

A retrospective cohort single-center study included 205 patients (26 women and 179 men; mean age 66.6 ± 7.5 years) who underwent surgical interventions for abdominal aortic aneurysm at Vishnevsky National Medical Research Center of Surgery from 2001 to 2021. The study was approved by the Local Ethics Committee ofthe Russian Medical Academy of Continuous Professional Education (Protocol No. 12 of October 20, 2021). All patients were signing voluntary informed consent at each stage of treatment.

Inclusion criterion: a confirmed AAA requiring resection, signing the Informed consent form.

Exclusion criteria: history of exertion angina and myocardial infarction (MI), history of myocardial revascularization, chronic heart failure, history of ventricular arrhythmias, identification of signs of coronary insufficiency by ECG data, impaired myocardial contractility or identification of local disordersin myocardial contractility by EchoCG data, stenosis or insufficiency of heart valves higher than 2 degree by EchoCG, decompensated diabetes mellitus (glycated hemoglobin in blood > 7.5%).

At the preoperative stage, all patients underwent a *standard* examination including laboratory tests, computed tomographic angiography of the aorta, color duplex scanning of the aorta and brachiocephalic arteries, ECG, and EchoCG. The groups were formed based on preoperative tactics: 55 patients underwent coronary angiography in the preoperative period (***group 1***); in 71 patients, cardiac stress tests were performed to assess the risk of cardiac complications: stress echocardiography (stress EchoCG) or intra-esophageal electrophysiological study (IEES) (***group 2***); 79 patients were examined without use of invasive or stress methods, only with standard ECG and EchoCG at rest (***group 3***). On detection of significant lesions of the large coronary arteries (CA), patients from group 1 underwent surgical treatment stenting or coronary artery bypass grafting (CABG) on a planned basis after discussion at the consultation.

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Groups showed significant differences in age, however, a pairwise comparison did not revealed such (Table 1). There was no statistically significant difference between the groups in such parameters as gender, presence of diabetes mellitus, atrial fibrillation, C4–C5 stage chronic kidney disease, acute cerebrovascular accident in history, intermittent claudication.

Table 1. Baseline Clinical Characteristics of Patients of Study Groups

Parameters	Group 1	Group 2	Group 3	p
n	55	71	79	–
Age, Me (Q1; Q3), years	68,0 [64,5; 71,5]	68,0 [62,5; 72,5]	65,0 [59,5; 70,0]	***0,036***
Female gender, (95% CI), %	16,4 [8,2; 29,3]	11,3 [5,3; 21,2]	11,4 [5,7; 21,0]	0,631
Diabetes mellitus, (95% ДИ), %	5,5 [1,4; 16,1]	4,2 [1,1; 12,7]	5,1 [1,6; 13,1]	0,946
Atrial fibrillation, (95% CI), %	1,8 [3,3; 20,7]	1,40 [0,07; 8,70]	3,8 [1,0; 11,5]	0,601
Chronic kidney disease C4–C5 stages, (95% CI), %	5,5 [1,4; 16,1]	5,6 [1,8; 14,6]	11,4 [5,7; 21,0]	0,317
Acute cerebrovascular accident in history, (95% CI), %	7,3 [2,3; 18,4]	7,0 [2,6; 16,4]	5,1 [1,6; 13,1]	0,837
Intermittent claudication, (95% CI), %	14,5 [5,7; 25,1]	25,4 [16,1; 37,3]	19,0 [11,4; 29,7]	0,205

Note: CI — confidence interval

Primary endpoints: hospital all-cause mortality, development of cardiac complications in post-operative period. Additionally, waiting time from the day of the first visit and identification of indications for the intervention for AAA to the day of surgery was evaluated.

Statistical calculations were carried out using the Jamovi program (The Jamovi Project 2021, Version 2.2.; https://www.jamovi.org). Quantitative variables were tested for compliance with the law of normal distribution using Shapiro–Wilk test. Normally distributed continuous data are presented as the mean with standard deviation; non-normally distributed data are presented as medians with the boundaries of the interquartile range, Me (Q1; Q3). For binary data, the proportion (%) is presented with the boundaries of the 95% confidence interval calculated using Wilson's formula. To compare quantitative data, non-parametric Kruskal–Wallis test was used. If statistically significant differences were identified between the three groups, pairwise comparison of the groups were performed using Dwass–Steel–Critchlow–Fligner test. To test the hypothesis of equality of binary data, Pearson $\chi 2$ was used; if significant differences were identified between the three groups, pairwise comparison was performed using the same criterion. Differences were considered statistically significant at $p < 0.05$.

RESULTS

According to the results of CAG, inpatients of group 1 significant stenoses (> 50.0% for the left main CA and > 70.0% for the remainingepicardial arteries) were detected in 30.9% of cases. In 29.5%of them there was a lesion of the left main CA, in almost half (47.1%) a proximal lesion of its anterior interventricular branch.

According to the results of CAG, 10 patients (18.0%) underwent percutaneous coronary intervention (PCI) a total of 16 stents were implanted. CABG was performed in 5 (9.0%) patients. There were no complications of CAG and PCI, after CABG one patient developed atrial fibrillation paroxysm which was relieved with medication.

In group 2, stress-EchoCG was performed in 19 patients (26.8%),IEES of atria in 69 patients (97.2%). By the results of IEES,4 patients had reduction of the coronary reserve identified bymore than 1 mm depression of ST segment at heart rate 140 per minute. They were administered optimal drug therapy (anti-platelet agents, statins, beta-blockers), AAA resection was performed without additional examination of the coronary artery. There were no postoperative cardiac complications in these patients. In patients, who underwent stress-EchoCG, no latent myocardial ischemia was identified.

In patients who underwent coronary angiography, the average waiting time from the day of the first visit and identification of indications for intervention for AAA to the day of surgery was 99.2 ± 13.0 days, in groups without coronary angiography on average 52.2 ± 6.0 days ($p = 0.007$). Patients who underwent myocardial revascularization waited 185 ± 36 days

for surgery, and patients who underwent coronary angiography without revascularization waited 67 ± 7 days ($p < 0.001$). In 3 cases, a long wait for intervention was accompanied by AAA expansionby 6 mm or more. In 1 case, AAA expanded in diameter from 65 mm to 73 mm, which was accompanied by appearance of pain and thinning of the wall with the threat of rupture according to tomographic angiography. Characteristics of the performed operations arepresented in Table 2 (AAA diameter in group1 was statistically significantly higher than in group 2, $p = 0.021$), the outcomes of interventions are given in Table 3, results of pairwise comparisons in Table 4.

Table 2. Comparative Characteristics of Surgical Interventions in Study Groups

Parameters	Group 1	Group 2	Group 3	p
n	55	71	79	–
Aneurysm diameter, Me (Q1; Q3), mm	56.0 [50.5; 67.5]	48 [43; 62]	53.0 [45.0; 63.5]	***0.022***
Juxta- or pararenal aneurysm, (95% CI), %	26.3 [13.7; 37.3]	22.5 [13.8; 34.3]	17.7 [10.4; 28.3]	0.656
Retroperitoneal access orthoracophrenolumbotomy, (95% CI), %	3.6 [0.6; 13.6]	5.6 [1.8; 14.5]	11.4 [5.7; 21.0]	0.179
Linear prosthetics, (95% CI), %	56.4 [42.4; 69.4]	42.3 [30.8; 54.5]	52.6 [40.4; 63.2]	0.247
Compression above kidneys, (95% CI), %	9.1 [3.4; 20.7]	5.6 [1.8; 14.5]	7.6 [3.1; 16.4]	0.755
Time of aortic compression, Me (Q1; Q3), minute	40 [32; 47]	45.0 [37.5; 62.0]	50 [40; 60]	***< 0.001***
Duration of surgery, Me (Q1; Q3), minute	205.0 [162.5; 255.0]	210.0 [156.5; 265.0]	230.0 [165.0; 260.0]	0.85
Blood loss, Me (Q1; Q3), ml	700 [500; 1250]	800 [500; 1500]	1000 [800; 1500]	***0.008***

Note: CI — confidence interval

Table 3. Comparative Analysis of Surgery Outcomes in Study Groups

Parameters	Group 1	Group 2	Group 3	p
n	55	71	79	–
Surgical complications, (95% CI), %	10.9 [4.5; 22.9]	10.0 [4.4; 19.8]	8.9 [3.9; 18.0]	0.924
Cardiac complications, (95% CI), %	3.6 [0.6; 13.6]	4.2 [1.1; 12.7]	2.5 [0.4; 9.7]	0.845
Death, (95% CI), %	1.8 [0.1; 11.0]	4.2 [1.1; 12.7]	2.5 [0.4; 9.7]	0.704
Myocardial infarction, (95% CI), %	0 [0; 8.10]	1.4 [0.07; 8.7]	1.30 [0.07; 7.80]	0.688
Acute lesion of kidney, (95% CI), %	12.7 [5.7; 25.1]	9.9 [4.4; 19.8]	6.3 [2.4; 14.8]	0.444
Postoperative bed days, (95% CI), day	8 [7; 10]	9 [8; 10]	10 [8; 14]	***< 0.001***

Note: CI — confidence interval

Table 4. Pair wise Comparisons of Quantitative Data in Groups Using Dwass–Steel–Critchlow–Fligner Test

Compared Groups	Compared Parameters				
	Age	Aneurysm diameter	Compression of aorta	Blood loss	Postoperative bed days
First and second	0.980	***0.021***	***0.005***	0.307	0.055
First and third	0.057	0.180	***< 0.001***	***0.006***	***< 0.001***
Second and third	0.091	0.393	0.844	0.189	0.242

Note: in cells, p values are presented calculated from pairwise comparisons between groups

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The time of aortic compression in group 1 was significantly less than in groups 2 and 3 (p = 0.005 and < 0.001, respectively), and blood loss in group 1 was less than in group 3 (p = 0.006). Despite this, the frequency of surgical, cardiac, renal complications and mortality did not significantly differ among all the three groups.

In the group of routine CAG, no cardiac mortality and/or cases of MI were recorded, while in the other two groups one case of MI was recorded in each group (p = 0.688). It should be noted that in one case of group 2, technical difficulties arose intraoperatively, which increased the time of aortic compression above the renal arteries to 40 minutes, and the total compression time to 80 minutes, and prolonged the operation to 280 minutes, which ultimately led to the development acute MI on the operating table and death of the patient on the 2nd day after the intervention. A patient of group 3 was also operated on with a long time of aortic compression; in the postoperative period he developed retroperitoneal bleeding, which required revision of the surgical wound on the 8th day. With the underlyinganemia and developing multiorgan failure on the 11th day, type 2 MI developed, coronary angiography was performed, which detected 80.0% stenoses of the anterior interventricular artery and of the intermedial branch, and stents were implanted. The patient died 3 days after PCI due to recurrent bleeding, which required repeated revision, and due to build-up of symptoms of sepsis and multiple organ failure.

Hospital mortality in group 1 made 1.8%. The only patient died due to necrosis of the colon and the development of multiorgan failure.

In group 2, 3 deaths were recorded (4.2%). One patient died due to acute MI and multiorgan failure against its background (this case was described above); in another patient bleeding started immediately after the surgery in result of failure of all anastomoses, which led to disseminated intravascular coagulation syndrome and death on the operating table. The third patient underwent amputation of the lower limb due to irreversible ischemia and gangrene, and resection of gut and exteriorization of stoma for mesenteric ischemia against the background thrombosis, which led to multiorgan failure and death on the 59th day after the intervention.

Mortality rate in group 3 was 2.5%. The first case is described above; the second patient died on the 28th day due to progression of acute renal and respiratory failure. The structure of surgical and cardiac complications is given in Table 5. There were less postoperative bed days in patients of group 1 compared to groups 2 and 3 (p = 0.055 and p< 0.001, respectively).

Table 5. Comparative Analysis of Surgical and Cardiac Complications of Surgical Interventions in Study Groups

Complications	Group 1	Group 2	Group 3
n	**55**	**71**	**79**
Atrial fibrillation, n	1	2	0
Acute myocardial infarction, n	0	1	1
Acute heart failure, n	1	1	2
Paresis of gut, n	2	0	0
Necrosis of gut, n	1	1	1
Pancreatitis, n	0	1	0
Bleeding, n	1	2	4
Gastrointestinal bleeding, n	1	0	0
Thrombosisof branch/thromboembolism in lower limb arteries, n	1	3	0
Thrombosis of prosthesis of renal artery, n	0	0	1
Eventration, n	0	0	1

Note: no statistically significant differences were found for all complications, p > 0.05

DISCUSSION

The European Society of Cardiology recommendations CAG and *prophylactic* myocardial revascularization not be conducted in patients with stable CAD or without CAD [10]. These recommendations are supported

by the results of two randomized multicenter studies CARP and DECREASE-V. The studies included patients with stable CAD having 3 and more risk factors for cardiovascular complications. Despite this, no advantages of *prophylactic* coronary-artery revascularization were found in these patients compared to the optimal medical therapy [11, 12].

In 2007, a meta-analysis was published including 3,949 patients from 10 studies, which compared prophylactic coronary revascularization with medical management before non-cardiac surgeries. In terms ofcardiac mortality or development of MI both in the early postoperative period and in the long-term, the coronary revascularization did not show any significant advantage over medical management [13].

A number of authors have claimed the possible benefits of more aggressive tactics of primary invasive examination. In 2009, the only prospective randomized study was published that demonstrated some advantages of routine coronary angiography and myocardial revascularization prior to surgeries for AAA and atherosclerotic lesions of the aorta and iliac arteries. Patients with medium-to-high risk of cardiac complications were compared, the study includedpatients with severe angina and chronic heart failure. In the first group, stress tests were performed, and with positive CAG result, revascularization was also performed, and in the second group, all patients primarily underwent CAG. The effect of this approach on the immediate postoperative period did not reach statistical significance, but in the long-term period, the incidence of adverse cardiovascular events and the severity of coronary artery disease were significantly lower in the CAG group, and over time, the difference became more and more noticeable [5].

In some review articles ,the authors report a low frequency of cardiac complications in patients who underwent prophylactic myocardial revascularization, butthey do not report a comparison group and do not take into account the heterogeneity of patients in terms of the presence or absence of coronary artery disease in history [6, 9]. Some studies included heterogeneous groups of patients [7].

To avoid such shortcomings, we selected patients *without clinical or instrumental signs of CAD*; no statistically significant differences in the incidence of the concomitant pathology were obtained between the study groups.

As a result, no cases of MI were observed in the CAG group, while in other groups one case of acute MI in each was recorded in the postoperative period, the differences were not statistically significant.

Invasive examinations and additional surgeries require significant funding. The approximate financial costs of the interventions to the healthcare system based on the tariffs of compulsory medical insurance for 2022 are given in Table 6 [14].

Table 6. Estimated Costs of Coronary Angiography and Myocardial Revascularization to Healthcare System

Procedure	Price, rubles	Number of Procedures, n	Total Cost, rubles
Coronary angiography	36 275	55	1 995 125
Percutaneous coronary intervention	167 220	10	1 672 200
Coronary artery bypass grafting	387 407	5	1 937 035
In total	–	70	5 604 360

The main drawback of this tactics is ignoring the fact that CAD is, first of all, a *functional* concept (mismatch between the inflow of blood and the myocardial demands), and not a *morphological* one (the existence of CA stenosis). If in patients with the clinical picture of CAD, the development of intraoperative myocardial ischemia can be expected, in asymptomatic patients it is doubtful.

Our data evidence no impact of invasive tactics of coronary bed examination on theimmediate results of AAA resection in patients without manifestations of CAD, which is in general consistent with the international recommendations. The tactics of stress cardiac tests did not show advantages versus standard ECG and EchoCG at rest either. To note, in group 3 despite a longer period of aortic compression and 1.5 times higher blood loss, no aggravation of the early postoperative period was noted.

Shortening of postoperative hospital stay of patients of group 1 is associated with changes in the patient management tactics. In earlier years, patients were more often discharged only after removal of stiches, but nowthis has been abandoned.

At the same time, CAG is an *invasive procedure*, carrying *certain risks* in itself [15], not to mention the possible complications of PCI and, especially, CABG.

Although there were no complications of coronary interventions in our study, it would be short-sighted to ignore the potential dangers of over diagnosis.

Another important factor is a delay of *surgical intervention* in connection with conducting invasive examination and subsequent surgical treatment of cardiac pathology. Thus, after PCI, in most cases, a double antiplatelet therapy is administered minimum for 6 months, and extensive surgical intervention in this period is associated with a high risk of bleeding [16, 17]. Upon that, the maximal recommended period to identify indications for surgical treatment of AAA in stable patients is 8 weeks [18]. However, not a single patient included in the study presented with rupture of AAA during the waiting period, and only in three patients a significant expansion was identified.

Limitations of the study: The study is single-center retrospective non-randomized, which, together with a small number of studied patients, undoubtedly reduces the reliability of the obtained results. Nevertheless, the presented material reflects the clinical experience of one of the leading surgical centers of our country, which may be useful in a comprehensive assessment of this problem.

CONCLUSION

From the point of view of the immediate postoperative results, invasive coronary angiography in patients without a clinical and instrumental picture of the coronary artery disease did not improve the outcomes of resection of the abdominal aortic aneurysm and at the same time led to a noticeable increasein the costs to the healthcare system. We have yet to assess the effect of such invasive tactics in the long-term.

Non-invasive stress testing had no benefit either in this cohort of patients versus standard testing.

Coronary angiography and prophylactic myocardial revascularization significantly prolong the waiting time for surgery, which can potentially increase the risk of rupture of the abdominal aortic aneurysm.

Performing a blind randomized study with stratification of patients by risk factors will permit to more accurately determine the indications for invasive examination and prophylactic coronary revascularization.

ADDITIONALLY

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