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ROTATIONAL CORONARY ANGIOGRAPHY IN HEART TRANSPLANT RECIPIENTS

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As a screening method for detecting coronary lesions, coronary angiography (CAG) is becoming increasingly important in the activities of transplant centers. Angiography examination of coronary arteries is performed in potential recipients of various organs, related donors, and annually in heart recipients. Given the grave condition of recipients in the early post-transplant period and annual angiographic studies, it is necessary to strive for reduction of radiation load on the body and reduction of dose of X-ray contrast agents used. **Objective:** to assess the possibilities of using rotational CAG in the activities of transplant centers. **Materials and methods.** We observed 254 patients who underwent CAG. Their ages ranged from 21 to 79 years (mean 46.92 ± 1), and 90% were men. All patients were divided into two groups: group 1 included 142 patients who underwent rotational CAG, while group 2 was the control group (where classical polyprojection CAG was performed) and included 112 patients. Group 1 was divided into 2 subgroups – the subgroup of patients after heart transplantation who underwent endomyocardial biopsy along with CAG (n = 51), and the subgroup of patients who underwent only rotational CAG. **Results.** In 91% of patients, CAG was performed by radial access. In group 1, stenotic lesions were detected in 33 patients: 19 had single-vessel lesions, 9 had two-vessel lesions, and 5 had three-vessel lesions. A total of 56 hemodynamically significant stenoses were detected, 9 of which were chronic total occlusions. In 83 patients (60%), performing only 2 series of rotational scans (one left and one right coronary artery) was sufficient. In 32 (23%) patients, one more clarifying projection was required, in 17 patients two and in 9 – 3–5 additional projections. In 3 cases, we switched to polyprojection CAG. The average amount of contrast agent used was 24.4 ± 0.9 ml, the average X-ray dose was 34561.3 ± 1695.2 mGycm^2. The need for a contrast agent was significantly higher in the comparison group – 24.4 ± 0.9 mL and 103.5 ± 1.7 mL, respectively. The average X-ray dose in the main group was 34561.3 ± 1695.2 mGycm^2, in the comparison group 41430.9 ± 4141.7 mGycm^2. However, there was no significant difference between the groups. Subgroup analysis showed that patients who underwent only rotational CAG had lower radiation exposure compared to patients who underwent CAG combined with endomyocardial biopsy biopsy (EMB), as well as significantly lower load compared to the control group. **Conclusion.** Rotational CAG can be considered as the method of choice at transplant centers, where screening diagnostics of the state of the coronary bed is required, which is equivalent in terms of information content and safety. Rotational CAG allows to reduce the amount of injected contrast agent by more than three times, which in turn reduces the number of associated complications, as well as the radiation exposure of patients and medical personnel.

Keywords: rotational coronary angiography, heart transplantation, transplantology.

INTRODUCTION

Coronary angiography is becoming increasingly important in transplantation centers as a screening tool for detecting coronary lesions [1, 2]. Rejuvenation of atherosclerosis in modern civilization, and its increasing spread in the population, reduces the pool of potential donors and becomes a contraindication for recipients [3]. Cardiac recipients are a special category of patients in whom coronary angiography is considered the gold standard for evaluating the condition of the coronary arteries. These patients undergo CAG immediately after heart transplantation to detect donor-associated atherosclerotic lesions in the graft coronary arteries. And subsequently, a CAG screening is performed annually to detect and control the progression of heart transplant vasculopathy. Every related organ donor over 30 years of age, as well as all recipients of other organs, with the exception of pediatric patients, undergo a CAG prior to the removal and transplant surgery [4].

Rotational CAG (rCAG) is a relatively modern method, which allows to optimize the CAG procedure as much as possible, by reducing the procedure time and reducing the use of contrast agent. The latter is especially relevant for patients with end-stage renal failure, potential recipients with severe concomitant conditions, as well as potential related donors, who are exposed to contrast-induced nephropathy after CAG, which in turn requires correction and rescheduling of transplantation.

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Consideration of the advantages of rCAG, in comparison with classical polyprojection CAG, is a hot issue in transplantation practice.

Objective: to compare rCAG with conventional coronary angiography in patients admitted at Shumakov National Medical Research Center of Transplantology and Artificial Organs.

MATERIALS AND METHODS

We present results on observation of 254 patients who were admitted at Shumakov National Medical Research Center of Transplantology and Artificial Organs from 2018 to 2020 for CAG. The age of study subjects ranged from 21 to 79 years (mean 46.92 ± 1); 90% were men. All patients were divided into two groups: group 1 included 142 patients for whom rCAG was performed; group 2 was the control group (where conventional polyprojection CAG was performed), which included 112 people. Group 1 was divided into 2 subgroups: a subgroup of patients after orthotopic heart transplantation (OHTx), in whom endomyocardial biopsy (EMB) was performed together with CAG (n = 51), and a subgroup of patients in whom only rCAG was performed. All patients underwent standard examination, which included ECG and EchoCG. ECG included 12-channel recording of heart potentials using a Megacart device (Siemens, Germany). EchoCG was performed on a VIVID 9 apparatus (GE, USA). Conventional poly-projection CAG was performed according to M. Judkins technique by femoral or radial access using ALLURA XPER apparatus (Phillips, The Netherlands). The standard protocol included 5 projections for the left coronary artery and 2 projections for the right one. Rotational CAG was performed on ALLURA XPER (Phillips, The Netherlands) using the XperSwing software.

The study data were processed by parametric statistics using Microsoft Excel and IBM SPSS Statistics version 22. The arithmetic mean of the indices and standard errors of the mean were given in the study. The significance of differences was assessed by criteria for nonparametric variables: Wilcoxon signed-rank test for pairwise comparisons of dependent variables and Mann–Whitney U test for comparisons of independent variables.

RESULTS

The procedure recorded a 100% success. CAG was performed by radial access in 91% of patients, and by femoral access in the rest of the patients. Radial access had technical difficulties in 10 patients: 2 vascular loops of the brachial or radial artery, 1 radial artery occlusion, and 7 severe radial artery spasms. Two cases required conversion of the access to femoral access. A single bilateral diagnostic catheter was required to perform 90% of CAG. None of the studied patients showed signs of contrast-induced nephropathy.

CAG in the first group revealed stenotic lesions in 33 patients: 19 patients had single-vessel lesions, 9 patients had two-vessel lesions, and 5 patients had three-vessel lesions. A total of 56 hemodynamically significant stenoses were detected, 9 of which were chronic total occlusions. In 83 patients (60%), only 2 series of rotational imaging (one of the left coronary arteries and one of the right one) were enough. Due to the severity and prevalence of stenotic lesions, 32 (23%) patients required one more clarifying projection, 17 patients required two, and 9 patients required 3–5 additional projections. In 3 cases, there was a transition to polyprojection CAG. The average amount of contrast agent used was 24.4 ± 0.9 mL, the mean X-ray exposure dose was 34561.3 ± 1695.2 mGycm^2.

When comparing the groups of patients who underwent rotational and conventional polyprojection CAG, there was a significantly greater need for a contrast agent – 24.4 ± 0.9 mL and 103.5 ± 1.7 ml, respectively. The mean X-ray dose in the main group was 34561.3 ± 1695.2 mGycm^2, in the comparison group 41430.9 ± 4141.7 mGycm^2. However, there was no reliable difference between the groups. Radiation exposure indicators are presented in Table.

This can be explained by the fact that in 51 patients, EMB was performed along with CAG, which increased fluoroscopy time and consequently radiation exposure. This was confirmed by a subgroup analysis, which showed that patients who underwent rCAG alone had a lower radiation exposure compared with patients who underwent CAG in combination with EMB, as well as a significantly lower exposure compared with the comparison group.

Table

Comparison of groups (subgroup groups) by the amount of contrast agent used and X-ray dose

Group	Main group		Comparison group	p
Subgroup	CAG subgroup	CAG + EMB subgroup		
Quantity of contrast agent used, mL	24.4 ± 0.9		103.5 ± 1.7	**0.001**
Dose, mGycm	34561.3 ± 1695.2		41430.9 ± 4141.7	0.678
	28390.9 ± 1679.8			**0.001**

DISCUSSION

Transplant coronary artery disease is a major cause of graft death in heart recipients, which in turn reduces quality of life and increases mortality in this patient population. CAG remains the screening method of choice for detecting donor-transmitted coronary artery atherosclerosis in the early postoperative period. Recent guidelines on the management of heart transplant recipients consider CAG as the gold standard for detecting coronary lesions in the graft bed, both in the early postoperative period and cardiac allograft vasculopathy (CAV) in the long-term period. The nature of coronary bed lesions is determined according to S.Z. Gao classification, which was modified at Shumakov National Medical Research Center of Transplantology and Artificial Organs [5, 6]. The Stanford classification is used to describe the morphology of coronary lesions from discrete atherosclerosis to concentric arterial obliteration [5, 7].

However, analysis of polyprojection angiograms may underestimate both the prevalence and the extent of CAV due to vascular remodeling involving the entire coronary bed, which does not always reduce the lumen diameter at an early stage [8, 9]. Therefore, angiograms should be interpreted serially, as new, concentric lesions may not be visualized on single-plane angiograms. Because of these limitations, additional imaging techniques, such as intravascular ultrasound (IVUS), and optical coherence tomography (OCT) and the like have been proposed to increase CAV detection sensitivity.

Technological advances in angiographic equipment and software have made it possible to perform rCAG. Rotational CAG is a relatively new imaging technique that involves a predefined algorithm for rotating the X-ray tube around the patient in all required axes. The obtained angiograms provide significantly more information and allow to reconstruct a three-dimensional image of the vascular bed and visualize each coronary artery in different projections using a single injection of a radiopaque contrast agent into the left or right coronary artery system [10–12].

Numerous studies have demonstrated the advantages of rotational angiography, including reduced volume of radiopaque contrast agent, reduced procedure time, and less radiation exposure compared to standard coronary angiography [13, 14–16]. Adult studies have shown that rCAG provides comparable, and in some cases superior, image quality to static angiography for the evaluation of coronary heart disease. There is evidence on the use of rCAG in children. The International Society for Heart and Lung Transplantation (ISHLT) recommends coronary angiography even once a year in patients after heart transplantation [17, 18].

Since OHTx patients generally do not suffer from angina, due to donor heart denervation, coronary artery stenosis is an incidental finding, which is a prognostic sign of graft rejection process. Along with heart recipients, there are additional categories of patients (potential recipients of kidneys, livers, lungs, etc., related organ donors) in transplant centers that require CAG screening. For these groups of patients, rotational CAG is preferred as a highly informative diagnostic method with minimal risks of complications (e.g. contrast-induced nephropathy, etc.).

CONCLUSION

Rotational coronary angiography represents a relatively new angiographic method, which is equivalent in terms of image quality and information content, requires less use of contrast agent, is characterized by less radiation exposure and less CAG procedure time, as compared to the conventional polyprojection CAG. This approach can be preferable in the activities of transplantation centers, where screening diagnostics of coronary bed condition is required, because it is informative, and allows to reduce by more than threefold the amount of contrast agent introduced in the patient and the associated risks of complications, as well as reduce radiation exposure on patients and medical staff.

The authors declare no conflict of interest.

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