Research Article

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The Choice of Tactics for Surgical Treatment of Acute De Bakey Type I Aortic Dissection in a Multidisciplinary Surgical Hospital

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BACKGROUND Acute proximal aortic dissection (Stanford type A) remains the most common fatal pathology of the thoracic aorta. Despite the improvement of surgical technologies, hospital mortality after emergency surgical interventions is 17–25%, in complicated cases it can reach 80–90%.

AIM OF STUDY Description of the perioperative treatment tactics adopted at the N.V. Sklifosovsky Research Institute for Emergency Medicine as well as the evolution of approaches that make it possible to obtain satisfactory hospital and long-term results in the treatment of aortic dissection.

Material and methods the study included 278 patients operated on from 2015 to 2021 in the acute stage of aortic dissection (less than 48 hours from the moment of manifestation of the disease). The operated patients were divided into two groups, depending on the presence of complicated forms: group A, 102 patients with uncomplicated course of the disease; group B, 176 patients with complicated course of the disease. Additionally, patients were divided depending on the level of distal reconstruction performed: group I, 83 patients, surgery was limited to prosthetics of the ascending aorta, without removing the clamp; group II, 137 patients who underwent hemi-arch surgery; group III, 58 patients, with distal reconstruction involving the aortic arch.

RESULTS Total hospital mortality was 28.1%: 25.3% in group I, 29.1% in group II, 29.3% in group III. In the group of uncomplicated dissection, postoperative mortality was 18.6%, while in the group of complicated dissection it was 33.5%.

Conclusion An integrated multidisciplinary approach with the formation of an "aortic team", an individual approach to surgery, depending on the anatomy of the dissection and the clinical status of the patient, will improve the results of the treatment of acute aortic dissection, as the most severe and multiple organ pathology of the aorta.

FINDING 1. Hospital mortality of complicated forms of dissection remains significantly higher — 33.5% versus 18.5% of uncomplicated course. 2. The most optimal method of distal reconstruction in patients with the peracute stage of dissection is an open anastomosis with the aorta using the "hemi-arch" technique. 3. If it is necessary to extend the surgical intervention on the aortic arch, a distal anastomosis in areas 0, 1, 2 with the possibility of a subsequent endovascular stage is the priority.

Keywords: aortic dissection, acute stage, surgical treatment, distal anastomosis, acute aortic syndrome, complicated course, Penn classification

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AC — assisted circulation
BCV — brachiocephalic vessels
CCA — common carotid artery
ECG — electrocardiography
EchoCG — echocardiography
FL — false lumen
HCA — hypothermic circulatory arrest
MSCT — multislice computed tomography
TEE — transesophageal echocardiography
TL — true lumen

INTRODUCTION

Acute proximal aortic dissection (Stanford type A) remains the most common fatal pathology of the thoracic aorta. The relevance of timely and effective treatment of acute aortic dissection is dictated by the extremely unfavorable prognosis of the natural course of the disease, especially in the first 48 hours, more than 50% of patients die [1, 2].

The diagnosis of aortic dissection is difficult and often delayed, and an erroneous diagnosis (myocardial infarction, pulmonary embolism, mesenteric thrombosis) can lead to delayed surgical treatment and death.

W. C. Roberts et al. found that in more than 23% of the total pool of patients with aortic dissection, pathology was diagnosed either at autopsy or during surgery performed for an alternative clinical condition [3].

In foreign and domestic literature, a separate group of authors introduced the concept of the “acute” stage of aortic dissection, which is limited to the first 24 and 48 hours, respectively [1, 4] from the manifestation of the disease and is an extremely dangerous life-threatening period of the disease. Surgical treatment in this time interval is characterized by increased mortality due to the need for surgical intervention in a significant proportion of "complicated" patients.

The main goal of primary surgery for acute proximal dissection is to prevent death [5, 6]. Despite the improvement of surgical technologies, complicated forms of acute type A aortic dissection remain a significant adverse risk factor in terms of survival: hospital mortality after emergency surgical interventions is 17–25%, in complicated cases it can reach 80–90% [7, 8].

The desire to minimize the volume of surgery in relation to the level of distal reconstruction is dictated by the known facts of the adverse effects of the timing of assisted circulation (AC) and hypothermic circulatory arrest (HCA), which can take a significant time period during operations on a dissected aorta. On the other hand, limiting the scope of intervention increases the risk of aorta-associated complications in the postoperative period and the need for repeated intervention [5, 9, 10].

The aim of the present work is to describe the perioperative treatment tactics adopted at the N.V. Sklifosovsky Research Institute for Emergency Medicine, as well as the evolution of approaches that make it possible to obtain satisfactory hospital and long-term results in the treatment of aortic dissection.

MATERIAL AND METHODS

In the period from 2015 to November 2021 at the N.V. Sklifosovsky Research Institute for Emergency Medicine, 634 patients with type A aortic dissection were hospitalized, of which type I according to DeBakey accounted for 455 patients (71.8%). The acute stage of aortic dissection in the present study was defined as a time interval less than 48 hours from the onset of the disease.

The total number of patients with type I aortic dissection in the acute stage was 344 patients. Emergency reconstruction of the proximal section with different levels of distal reconstruction was performed in 278 patients (78.2%).

The operated patients were divided into two groups, depending on the presence of complicated forms. To select patients by groups, the classification of the University of Pennsylvania [11] was applied (Fig. 1):

— group A — 102 patients with an uncomplicated course of the disease, which corresponded to the Penn A class;

— group B — 176 patients with a complicated course of the disease, corresponding to the Penn class B, C, B+C.

The operated patients were additionally divided into three groups depending on the level of distal reconstruction performed:

— group I — 83 patients, surgical intervention was limited to replacement of the ascending aorta, without removing the clamp from the aorta (historical group until 2019);

— group II — 137 patients who underwent hemi-arch surgery;

— group III — 58 patients with extension of the volume of distal reconstruction to the aortic arch.

clinical class	Clinical picture
Penn A	No manifestations of ischemia, stable hemodynamics without impaired perfusion of the aortic branches
Penn B	Stable hemodynamics, there are local disturbances or insufficient perfusion of vessels extending directly from the aorta, manifested by the stroke of the brain and spinal cord; acute renal failure; mesenteric ischemia; ischemia of the upper and lower extremities
Penn C	Instability or collapse of hemodynamics, generalized ischemia with centralization of blood circulation due to: hemopericardium with the development of cardiac tamponade: dissection of the coronary arteries or their separation from the aortic root; acute insufficiency of the aortic valve; aortic rupture
Penn B&C	Combination of local and generalized ischemia, a combination of the above clinical conditions

Fig. 1. Penn classification [11]

DIAGNOSTICS

The majority of patients (204, 73.4%) were admitted to the Institute by transfer from other hospitals with a verified diagnosis. In the conditions of the Institute, the diagnosis of aortic dissection was established in 74 patients (26.6%).

Routing of all patients admitted to the Institute was carried out according to the road maps developed in the clinic. Depending on the quality of the diagnostic input information (Fig. 2), a decision was made to conduct additional examinations. Unsatisfactory data from imaging studies from previous medical institutions were obtained in 81 patients (39.7%).

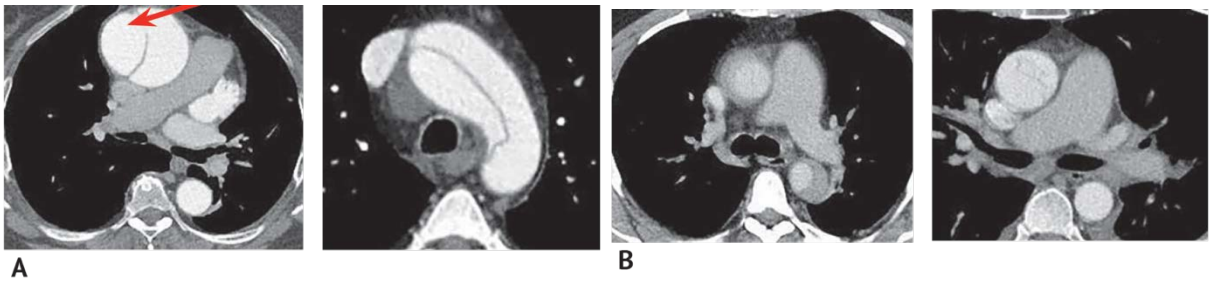

Fig. 2. Multislice computed tomography of the aorta with bolus contrast enhancement: A — satisfactory quality of the study, no fenestration in the aortic arch, the arrow indicates the site of primary fenestration in the ascending aorta; B - unsatisfactory quality of research

The diagnosis of primary patients was carried out on the basis of generally accepted criteria up to test probability [12] and imaging objective research methods: 1) cardiosynchronous multislice computed tomography (MSCT) with contrast enhancement, according to clinically accepted standards [13, 14]; 2) echocardiography (EchoCG); 3) ultrasounography.

Electrocardiography (ECG) in standard leads was performed in all patients. This made it possible to identify coronary malperfusion. Transthoracic echocardiography was performed when the patient was hemodynamically stable. The hemodynamic significance of the fluid in the pericardial cavity, the state of the valvular apparatus, global and local contractility of the heart chambers were assessed. The state of organ blood flow was assessed by ultrasound with Doppler mapping. Standard coronary angiography and aortography were not performed, however, the indication for primary angiographic examination was the need for primary endovascular intervention (9.4% and 4.7%, respectively).

Laboratory studies were generally performed: clinical and biochemical blood tests, coagulogram, acid-base status.

OPERATIONAL TECHNIQUE

Intraoperative monitoring: to assess the adequacy of perfusion and complete intraoperative monitoring, the following are used: 1) three arterial accesses (left and right radial arteries, femoral artery); 2) catheterization of the pulmonary artery; 3) cerebral oximetry (NIRS); 4) transesophageal echocardiography (TEE). The latter method is of particular importance for monitoring the state of perfusion of the false lumen (FL) and true lumen (TL) in the thoracic aorta, depending on the arterial cannulation site used and the stages of the operation that are critical in terms of changing aortic perfusion parameters.

Access and connection of cardiopulmonary bypass: access to the heart was carried out through a standard complete median sternotomy. In cases of hemopericardium with signs of cardiac tamponade, pericardiotomy was performed only after arterial cannulation. In the case of extremely unstable hemodynamics, a dosed evacuation of fluid from the pericardium was performed with parallel provision of arterial access for cannulation.

The choice of the site of arterial cannulation is of great importance for adequate perfusion throughout the whole course of assisted circulation (AC). The site of arterial cannulation was chosen differentially, after evaluation of MSCT data, depending on the morphology of aortic dissection, involvement of the lateral branches, and the severity of the patient's condition.

Recently, the preferred method of arterial cannulation is the use of the right axillary artery, which allows easy unilateral antegrade perfusion of the brain [5, 9]. When using this method, the connection of the arterial line to the artery was carried out through a vascular prosthesis (8-10 mm), after the formation of an anastomosis with the artery according to the "end-to-side" type.

The cannulation of the femoral artery has not lost its significance. The method is preferred in hemodynamically unstable patients, due to the speed of execution. However, cannulation of the femoral artery requires special control of the consistency of perfusion according to TL and FL at the AC stage, has a high risk of retrograde embolism and malperfusion, and also implies the possibility of changing the cannulation site if perfusion parameters deteriorate [15].

The direct cannulation of the aorta is recognized as the only possible technique in patients with peripheral vascular dissection, which requires the use of the Seldinger technique and a clear location of the cannula in the true lumen [9, 16]. In some patients, especially with multifocal extension of the dissection to the lateral branches of the aorta and a well-established aortic valve, an alternative method is cannulation of the ascending aorta through the apex of the left ventricle [5, 6, 9]. Our clinic has limited experience with these techniques.

Venous return in most cases was carried out by cannulation of the right atrium with a two-level cannula. Given the lack of information about the state of the coronary bed, the possibility of dissection spreading to the orifices of the coronary arteries, the method of choice for myocardial protection is retrograde cardioplegia through the coronary sinus with its "blind" cannulation. The expected duration of aortic clamping motivates the widespread use of pharmaco-cold cardioplegia with Custodiol solution.

Proximal Reconstruction: Proximal reconstruction is performed during systemic cooling and/or rewarming of the patient. The volume of proximal reconstruction depends on the location of the fenestrations relative to the level of the sinotubular junction, the condition of the aortic root and aortic valve cusps. The most common method of proximal reconstruction is supracoronary prosthetics with plasty of the sinotubular junction zone using the “sandwich” method, adventitial intussusception or the “neo-media” method. If aortic root replacement is necessary, the most common aortic root replacement is the Kouchoukos technique. In young patients with an intact tricuspid valve and favorable anatomy, a valve-preserving aortic root replacement using the David technique is performed. In the case of localization of fenestration in the non-coronary sinus and (or) its isolated dilatation with intact aortic valve leaflets, partial aortic root replacement is performed according to the Wolf method. In case of detachment of the orifices of the coronary arteries with the formation of fenestration in the coronary sinuses, aortic root prosthesis was combined with suturing the orifice of the severed artery and coronary artery bypass grafting.

Protection of the brain: in patients of group I, the distal anastomosis was formed directly under the aortic clamp. For groups II and III, distal aortic reconstruction was performed under conditions of circulatory arrest and antegrade/retrograde brain perfusion. In most patients with an estimated circulatory arrest time of less than 45 minutes, selective antegrade unilateral cerebral perfusion was used under conditions of moderate systemic hypothermia (26–28°C). In cases of predicted long-term circulatory arrest, as well as a significant decrease in perfusion of one of the hemispheres, bilateral cerebral perfusion was the method of choice. When the dissection spread to the brachiocephalic trunk to its bifurcation, visualized fenestration in the trunk, as well as the spread of the dissection to the right common carotid artery, retrograde cerebral perfusion under conditions of deep systemic hypothermia (18–20°C) was an appropriate method of protection [17]. In all patients, pharmacological neuroprotection (barbiturates, glucocorticosteroids) is used as standard.

Choice of distal reconstruction site: Ishimaru classification of aortic zones was used to standardize the extent of reconstruction of the proximal part of the ascending aorta and arch, planning subsequent endovascular procedures [18].

In group I patients (n = 83), the main goals of surgical treatment were resection of the aortic section containing the primary fenestration (fenestration-oriented approach) and prevention of rupture of the ascending aorta. In the case of localization of the primary fenestration in the tubular part of the ascending spine, these problems were solved by isolated prosthetics of the ascending spine with the formation of a distal anastomosis under the aortic clamp, without the need for hypothermic circulatory arrest (HCA). Indications for expanding the scope of intervention on the aortic arch were only: 1) primary fenestration in the aortic arch; 2) the diameter of the aortic arch is more than 40 mm.

In patients of group II (n = 137), a fenestration-oriented approach was also used, with the difference that the distal anastomosis was superimposed with an “open” aorta under conditions of HCA and brain perfusion — the “ hemi-arch” technique. Despite the different level of anastomosis (complete resection of the lesser curvature of the arch/anastomosis at the level of the orifice of the brachiocephalic vessels (BCV)) all patients were assigned to group II. Currently, the method is widely used in cases where there are no indications for expanding the volume of surgery on the aortic arch.

Accumulation of experience, improvement of surgical technique, as well as analysis of the incidence of aorto-associated complications in certain groups of patients identified additional indications for primary extended intervention on the aortic arch: 1) concomitant aneurysm of the descending aorta; 2) distal malperfusion; 3) young age; 4) confirmed connective tissue dysplasia.

The main alternative to the "hemi-arch" method was total aortic arch replacement (zone 3), however, the invasiveness of the intervention, the technical complexity of imposing a distal anastomosis and anastomosis with the left subclavian artery, the duration of HCA and AC, the likelihood of difficult-to-control bleeding make this technique a rather risky procedure, especially in "complicated" patients [5, 9], and is practically not used in our clinic. The "elephant trunk" technique, which somewhat reduces the technical complexity of the operation, is rarely used in patients with "acute" dissection due to the small diameter of the aorta in zone 3.

Group III (n = 58) included patients who underwent interventions on the aortic arch using various methodological schemes, followed by staged endovascular treatment. In 18 patients, the ascending aorta was replaced with transposition of the brachiocephalic trunk and the left common carotid artery onto a vascular prosthesis. For these purposes, the Lupiae prosthesis was used , or an anastomosis was made between the ascending aortic prosthesis and the bifurcation prosthesis, the branches of which were anastomosed with the BCV and the left common carotid artery (OCA). In all cases, the distal anastomosis was formed in zone 0, on the "open" aorta, proximal to the BCV mouth. The advantage of this approach is the short duration of HCA, the absence of the need for resection of the part of the aortic arch containing the primary fenestration.

Partial prosthesis of the arch and initial parts of the epiaortic vessels was performed in 36 patients. In 16 patients, the distal anastomosis was performed in zone 1, in 20 patients — in zone 2. Proximalization of the anastomosis in the 1st–2nd zone makes it technically easier to perform, reduces the HCA time, easier to control bleeding, while at the same time making it possible to resect a significant portion of the proximal arch aorta containing the primary fenestration.

The solution to the issue of obtaining acceptable hospital results in patients requiring an expansion of the volume of intervention on the arch is the use of hybrid or staged endovascular technologies. On the one hand, these approaches, in the acute period, are limited by their negative effect on the body with an already activated systemic inflammatory response, and on the other hand, they allow radically extended reconstruction of the arch and proximal part of the descending aorta, which will reduce the risk of developing aorto-associated complications in the future..

An effective method that allows radical reconstruction of the entire aortic arch and the proximal part of the descending aorta is the frozen elephant trunk technique (FET) [19]. In combination with proximalization of the anastomosis in zones 1 or 2; the method shows good results in patients with acute aortic dissection. This method is especially recommended for patients with malperfusion syndrome, young patients, as well as for connective tissue dysplasia. In group III, 4 interventions were performed using the FET method.

RESULTS

The average age of the subjects in the groups was 54.5±2.5 years. The vast majority of patients (203) were men. A long history of arterial hypertension was noted in 86.5% of patients, 70% of whom had never controlled blood pressure. In 84 patients, manifestations of one of the types of malperfusion (Penn B) and (or) their combination were observed. 113 patients had hemopericardium, clinically manifested by cardiac tamponade in 59 patients (Penn C), 38 patients had acute aortic valve (AV) insufficiency (Penn C). A combination of 2 or more complicating clinical conditions (Penn B+C) occurred in 18 cases. Connective tissue changes were found in 23 patients: Marfan's syndrome was found in 15 cases, one case of Shereshevsky-Turner syndrome, in 7 more patients the diagnosis was not established with severe clinical manifestations of dyshistogenesis.

In the group of "acute" dissection at the stages of routing, additional examination, preparation for surgical treatment, 66 patients died.

The difference in the types of surgical intervention on the aortic root (supracoronary prosthesis, 214 patients; or aortic root prosthesis using different techniques, 64) did not affect mortality.

The overall hospital mortality was 28.1% (78 patients). In group I (83 patients), who underwent reconstruction without removing the clamp from the aorta, mortality was 25.3% (21 patients). In the II group of patients (n = 137), operated according to the "hemi-arch" technique , the lethality was 29.1% (40 patients). In group III (58 patients) with the expansion of the scope of surgery on the aortic arch, the mortality rate was 29.3% (17 patients).

In the uncomplicated dissection group (group A), postoperative mortality was 18.6% (n =19/102), while in the complicated dissection (group B) it was 33.5% (n =59/176).

In the overwhelming majority of cases (70%), the lethal outcome was a consequence of the syndrome of multiple organ failure, which was predicted by the initial clinical conditions (Penn B, C, B+C), the aggressiveness of surgical tactics due to the forced expansion of the volume of surgical treatment, and the severity of concomitant pathology. It should be noted that acute lung injury in the acute stage of dissection is one of the most common perioperative complications, accounting for about 50% of the total patient pool. The presence of this complication increases surgical mortality by more than 3-fold, which is confirmed by our data and literature data [20].

DISCUSSION

The adoption of algorithms for providing care to patients with acute coronary syndrome, the widespread development of a network of regional vascular centers has led to a significant increase in the number of patients with chest pain hospitalized in specialized hospitals in the early stages from the moment of disease manifestation. The wide diagnostic capabilities of these centers allow not only to detect various acute coronary pathologies, but also to diagnose alternative clinical conditions with a similar clinical picture.

Early diagnosis of acute aortic syndrome in the first hours after the onset of the disease dramatically increased the flow of patients to departments providing emergency cardiac surgery. In these terms, a characteristic feature of the cohort of patients with acute aortic dissection, in particular, is a high percentage of patients with complicated forms of the disease, which have a high probability of death in the first 48 hours from the natural course of the disease.

On the one hand, early detection of aortic dissection can save the patient's life with great success, and on the other hand, it requires the aortic team to solve many tactical problems depending on its clinical status. To solve these problems, from our point of view, the Penn classification is optimal for assessing the clinical status in the first two days. After this period, it loses its relevance due to the small number of complicated forms of the disease due to high natural mortality in this time period [11, 21].

According to clinical guidelines, the extent of distal reconstruction in patients with acute aortic dissection remains a controversial issue, and is largely determined by the clinical condition of the patient. The volume of aortic root reconstruction does not affect the immediate results of treatment and is not discussed in this publication.

The determination of the optimal volume of distal aortic reconstruction depends on the need to obtain a satisfactory immediate result, both the main task of a life-saving operation, and minimizing the risk of developing aorto-associated complications in the future and the need for reoperation.

The formation of distal anastomosis under the aortic clamp, in our opinion, is a historical method due to the significant residual portion of the distal part of the ascending aorta, frequent cases of artificial fenestration at the level of aortic clamping and distal anastomosis, and the complexity of anastomosis under the aortic clamp. However, in some cases, this approach is reasonable, but can only be performed if the primary fenestration is located in the tubular part of the ascending aorta, without differences in the immediate results of surgical treatment between the groups of clamped and "open" aorta, which is reflected in the literature data [22, 23].

The most optimal method of distal reconstruction in patients in the acute stage is the imposition of a distal anastomosis using the "hemi-arch" technique. The method allows complete removal of the ascending aorta with possible excision of the entire lesser curvature of the aortic arch. This tactical approach is especially applicable to patients with impaired systemic perfusion (Penn C type), older patients. The advantage of this technology is full compliance with the tasks of a life-saving operation, an adequate volume of resection of the pathologically altered aortic wall, and short terms of HCA. Due to comparable results of in-hospital and long-term survival, freedom from reinterventions, it is not advisable to expand the scope of surgical treatment [24–26], however, long-term dynamic monitoring of the state of the lower aorta is necessary.

The need for intervention on the aortic arch appears in cases of localization of primary fenestration in the arch, if it cannot be eliminated by the “hemi-arch” technique, if the diameter of the aortic arch is more than 40 mm. In our opinion, total aortic arch replacement in patients in the early stages of dissection is inappropriate due to the aggressiveness of this technique and its inconsistency with the concept of life-saving surgery [5, 9]. The formation of distal anastomosis in the 1st and 2nd zones is technically much simpler, less traumatic, reduces the time of circulatory arrest, it is easier to control hemostasis [27, 28], which in patients with the acute stage of dissection

corresponds to the concept of a life-saving operation with general radical type. The use of this technique involves further staged endovascular intervention on the aorta directly from the level of the distal anastomosis to zone V inclusive. An alternative method is the use of type II hybrid technology, with the imposition of a distal anastomosis in the 0 zone [10, 29, 30].

In patients with malperfusion (Penn B), the timing of proximal aortic reconstruction depends on the severity of symptoms, affected sites, and the time interval from the development of malperfusion symptoms to the time the patient is admitted to a specialized hospital. When the duration of the malperfusion syndrome is less than 6 hours, peripheral and visceral forms, it is advisable to consider the issue of primary proximal reconstruction of the aorta. Restoration of adequate blood flow in the true lumen, along with the elimination of primary fenestration, is the cornerstone of effective treatment for this group of patients. The use of type III hybrid technologies with proximalization of the distal anastomosis zone during the primary operation is most appropriate [5, 8, 9, 27, 28].

Patients whose clinical status corresponds to Penn B+C are the most difficult category of patients, the concepts of surgical treatment of which are poorly reflected in the world literature. Mortality in this group of patients remains at a very high level. Currently, the “hybrid operating room concept” is considered the most effective technology for their treatment.

CONCLUSION

Optimal surgical solutions, applied depending on the anatomy of the dissection and the clinical status of the patient, will improve the results of the treatment of acute aortic dissection, as the most severe and multiple organ pathology of the aorta. An integrated multidisciplinary approach with the formation of an "aortic team", the concept of a hybrid operating room and an individual approach to each patient are strong points for reducing perioperative mortality and the development of aortic-associated complications.

1. Hospital mortality of complicated forms of dissection remains significantly higher than 33.5% versus 18.5% of uncomplicated course.

2. The most optimal method of distal reconstruction in patients with an acute stage of dissection is the imposition of an open anastomosis with the aorta using the "hemi-arch" technique.

3. If it is necessary to expand the surgical intervention on the aortic arch, the imposition of a distal anastomosis in zones 0, 1, 2 with the possibility of a subsequent endovascular stage is a priority direction of treatment.

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