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VALVE-SPARING AORTIC ROOT RECONSTRUCTION

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This paper reviews the current main approaches to valve-sparing aortic root reconstruction. The advantages of valve-sparing surgeries are obvious – low mortality, longer survival, better quality of life of the operated patients, since the techniques save the heart's pumping reserves and free the patient from continuous intake of direct-acting oral anticoagulants and laboratory control of the hemostasis system, as well as other prosthesis-associated specific complications.

Keywords: aortic valve, aortic root, aortic insufficiency, valve-sparing surgery.

In 1956, the first successful valvuloplasty was performed in a patient with severe aortic regurgitation by French surgeon C.W. Lillehei, stitching two cusps, thereby eliminating prolapse and insufficiency (Kwasny L., 1913).

The main causes of aortic insufficiency can be divided into two large etiological groups. These are congenital abnormalities of the development of the aortic root and the ascending aorta, entailing a disruption in valve geometry. Considered are both genetic hereditary mutations and sporadic gene changes, as well as disorders in the embryogenesis of the cardiovascular system under the influence of external factors.

The second group of acquired aortic insufficiency includes various inflammatory diseases, in which infectious agents either directly affect the valve leaflets and the aortic wall, or systemic diseases in which antibodies are produced targeting the cardiovascular system, particularly elastin and elastase located in the connective vascular and valve tissues (rheumatic diseases, syphilis, tuberculosis, systemic lupus erythematosus, systemic scleroderma, etc.), as well as non-inflammatory – atherosclerotic, autoimmune. In this case, the pathogenetic process will be associated with local medionecrosis and thinning of the vessel wall; increased internal pressure of the pulse wave provokes expansion, rupture and stratification. It should be noted that the pathological mechanism is mostly triggered in the areas subjected to the highest hemodynamic stress – the aortic root and the physiological bends of the aorta.

Postoperative and posttraumatic cases of aortic insufficiency should be distinguished separately. The degree and severity of aortic regurgitation will be directly determined by the nature and location of the lesion.

All mechanical prostheses have pressure differences, whose magnitude, in addition to the features of the model and its size, depends on the shock output and heart rate. This dependence is not linear in nature and is accompanied by energy loss and extra work with each cardiac cycle. At rest, the most advanced prostheses are characterized by an average pressure gradient of 10 mmHg in the aortic position, which is an additional constant load for the left ventricular myocardium, which can be particularly fatal in the early postoperative period in decompensated patients with reduced ejection fraction. Thrombus formation, bleeding and septic endocarditis are among the specific complications following a valve replacement surgery (Konstantinov B.A., 1989).

However, despite the fact that valve replacement is the standard procedure in most aortic insufficiency cases, valve plasty or valve-sparing surgery should be considered in patients with elastic uncalcified tricuspid or bicuspid valves, aortic insufficiency type I (aortic root enlargement with normal leaflet mobility) or type II (leaflet prolapse) (Lancellotti P., 2008).

The main methods of aortic root reconstruction include (Molchanov A.N., 2017):

– Resuspension – "suspension" of the aortic valve commissures to the reconstructed sinotubular junction;
– Remodelling – excision of all 3 sinuses, cutting out the corresponding matched tubular prosthesis with creation of neosinuses and suturing it to the aortic ring;
– Reimplantation – the aortic ring and leaflets are placed inside the tubular prosthesis.

Resuspension is performed when the sinotubular junction is dilated after its diameter has been restored. The commissures are tightened with sutures on the spacers. When aneurysmal dilatation spreads to the non-coronary sinus, the Wolfe procedure is performed, including reconstruction of the sinotubular junction and non-coronary sinus; otherwise known as partial remodelling (Wolfe W.G., 1983).

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In classic remodelling using the Tirone David II technique (Fig. 1), all sinuses are excised and button-shaped coronary artery ostia are cut out. It is suggested that a prosthesis 1–2 mm smaller than the aortoventricular junction be used. The prosthesis is cut out from the distal end in a U-shape then sutured to the root. For remodelling, spherical Valsalva prostheses are used to create artificial sinuses, thereby reducing the hydraulic effect on the valve leaflets.

The difference with the Yacoub procedure is that the prosthesis is not cut in a U-shape, but in a V-shape. The Tirone David III procedure, like the Hopkins procedure, consists of additional external aortic valve annuloplasty.

The aortic valve can be reimplanted into the prosthesis using the David I and Florida Sleeve procedures, as well as their various modifications.

The David I procedure is a complex technique that involves all components of the aortic root: aortic annulus, aortic valve leaflets, Valsalva sinuses and sinotubular junction (David T.E., 2019).

The David I procedure (Fig. 2) mobilizes the aortic root just below the aortic annulus. The coronary artery orifices are cut out as "buttons". The sinuses are excised, departing from the commissures by about 5 mm. After measuring the annulus diameter, the prosthesis is selected one size larger than the size of the annulus. The prosthesis is fixed by stitching the fibrous ring with separate U-shaped sutures. The commissures are fixed to the prosthesis with three sutures, tightening as much as possible without stretching the prosthesis using polypropylene sutures. The level of location of the commissures should ensure satisfactory coaptation of the aortic valve cusps of at least 4 mm. Next, the sinuses are fixed with a twisted or mattress suture. Additional leaflet plasty is applied as needed and at the surgeon's discretion (Beckmann E., 2019).

This valve-sparing operation was designed to correct dilated aortic annulus and sinotubular junction, but it removed the aortic sinuses and placed the valve in a rigid cylindrical structure (David T.E., 2019). Several studies have shown that the rate of opening and closing of the aortic valve can be reduced by reconstructing the aortic sinus (De Paulis R., 2001, Aybek T., 2005). To solve this problem, several types of prostheses with extensions mimicking the sinuses of Valsalva have been proposed, but most of them are spherical. The aortic root is a cylinder with three bulges; in spherical prostheses, the horizontal plane will be changed into an oblique linear one, which will further affect the durability of aortic valve cusps; the most anatomical is the Uni-graft prosthesis, with three separate sinuses, which showed good hemodynamic outcomes almost similar to physiological indicators (David T.E., 2019). The prostheses are presented in Fig. 3.

A simpler reimplantation option is the Florida Sleeve procedure (Fig. 4). Under this technique, measurement and selection of a prosthesis are performed only by assessing the diameter of the fibrous ring. The aortic root is placed in the prosthesis by passing the coronary arteries through prepared keyhole-type slots. The sinotubular junction is sutured to the Dacron prosthesis with a curling suture. It is important to position the commissures at the correct height in order to create a satisfactory coaptation of the leaflets. This suture narrows the sinotu-

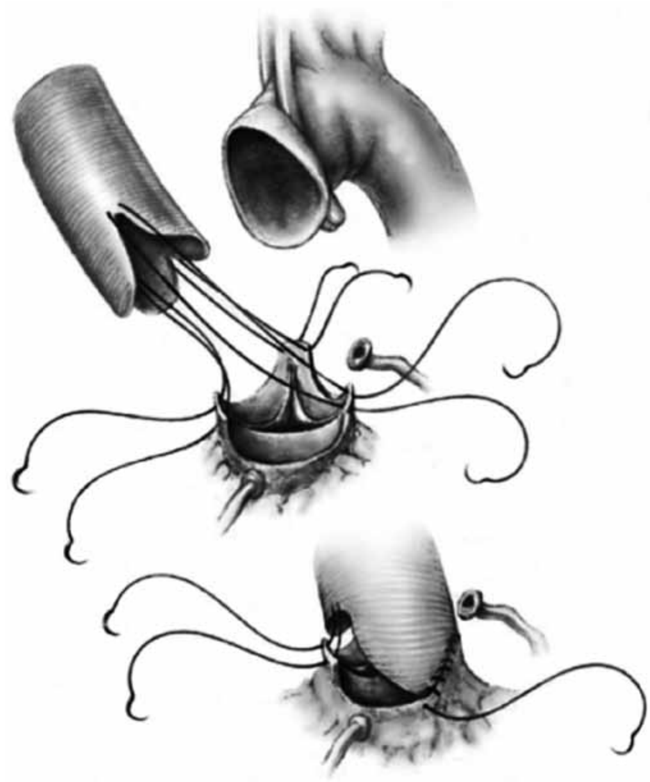

Fig. 1. Tirone David II/Yacoub procedure

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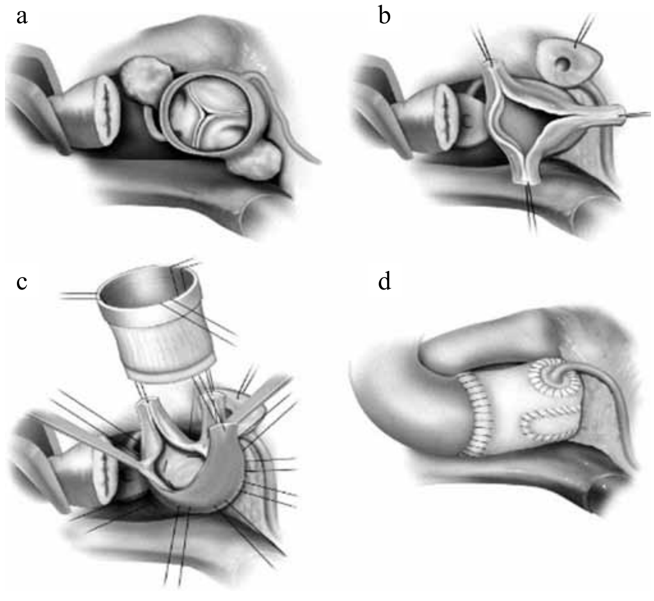

Fig. 2. Aortic valve reimplantation into the prosthesis using the Tirone David I procedure

bular junction to the required diameter. Hegar dilators are used for a more accurate measurement, controlling the final diameter. However, it is not always possible to bring the sinotubular junction to the proper size due to its pronounced dilatation. In such cases, a supracoronary prosthesis with a smaller diameter prosthesis is used for additional narrowing. This technique also allows you to strengthen and fix the aortic root in the required patient anatomical parameters (Hess P.J., 2005).

Uni-graft

Gelweave Valsalva

Fig. 3. Vascular prostheses

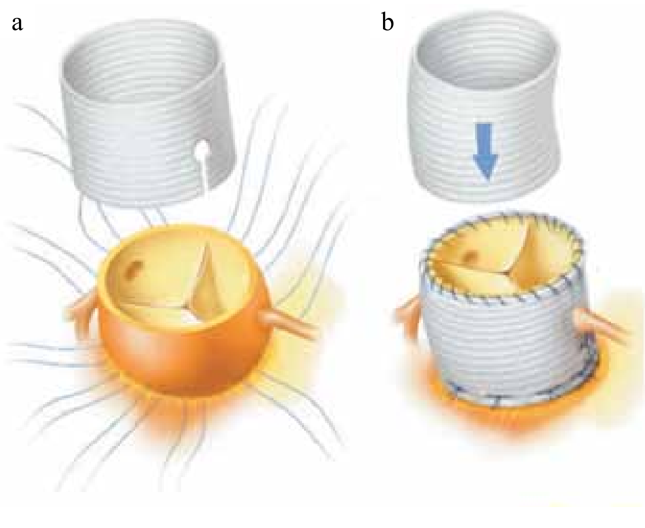

Fig. 4. Aortic valve reimplantation into the prosthesis using the Florida Sleeve procedure

Most patients with aortic root aneurysm have annuloaortic ectasia of varying severity with the development of aortic valve insufficiency. Aortic annuloplasty is an important component of preventing further expansion of the annulus fibrosus and progression of aortic regurgitation. Although a separate annuloplasty can be performed during the remodeling procedure, it is already included in the reimplantation technique (David T.E., 2001, Urbanski P.P., 2013, Michael A., 2018).

The advantages of aortic root reimplantation are confirmed by positive outcomes, lower risk of reintervention and lesser manifestation of aortic insufficiency in the long-term postoperative period (Belov Yu.V., 2006, Liu L., 2011).

According to European studies, dystrophic diseases constitute the main group of patients with aortic insufficiency – about two-thirds of all observations (Iung B., 2003). Among them there is a significant group of patients with elastic uncalcified tricuspid or bicuspid valves, with aortic insufficiency type I (aortic root enlargement with normal leaflet mobility) or type II (leaflet prolapse) (Lancellotti P., 2010; le Polain de Waroux J.B., 2007; Lansac E., 2008).

For this group of patients, many cardiac surgeons recommend valve-sparing techniques for surgical correction of aortic insufficiency. However, an analysis of the database of the Society of Thoracic Surgeons shows that replacement of the aortic valve and ascending aorta are performed in 80% of patients (Detaint D., 2009; Stamou S.C., 2015).

Pressure differences occurring in all mechanical prostheses depend not only on the hemodynamic characteristics of the model, but also on the shock output and heart rate. This dependence is not linear in nature and is accompanied by increased energy consumption of the myocardium at each cardiac cycle. At rest, mechanical prostheses are characterized by an average pressure gradient of 10 mm Hg in the aortic position, which is also an additional constant load for the left ventricular myocardium, which must be borne in mind when managing patients in the early postoperative period, especially in decompensated patients with reduced ejection fraction. Thrombus formation, bleeding and septic endocarditis are among the specific complications after a valve replacement surgery (Konstantinov B.A., 1989).

CONCLUSION

The advantages of valve-sparing surgeries are obvious as they are accompanied by low mortality, longer survival, better quality of life of the operated patients since they save the pumping reserves of the heart and free the patients from constant intake of direct anticoagulants and laboratory control of the hemostasis system, as well as other prosthesis-associated specific complications.

The authors declare no conflict of interest.

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