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Aortic valve sparing operations versus composite graft implantation in acute aortic dissections

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ABSTRACT

Objectives: Type A acute aortic dissection is life-threatening disease requiring urgent operation. The type of the operation is often a subject of discussion. In our study we present our first experience with two different types of operation with and without preservation of the aortic valve.
Patients and methods: From January 2009 to December 2011 fifty-six patients underwent the operation due to the acute aortic dissection type A. Ascending aorta was replaced in 32 cases and more complex operation was performed in 24 patients due to the simultaneous severe aortic root damage by dissection (study group). In eleven patients (group A) replacement of aortic valve, aortic root and ascending aorta by composite graft (modified Bentall procedure) was performed and in 13 patients (group B) valve sparing operation (reimplantation according to David) was carried out.
Results: There were no significant differences between the groups in preoperative variables. The only significant difference was mean duration of hospitalization; 26.7 ± 13.7 days in group A and 16.4 ± 7.7 days in group B. Hospital mortality was 18.2 % (n = 2) after Bentall procedure, no patient died in group B. There were no or minimal aortic regurgitation in all patients of group B on echocardiography before discharge. The mean follow-up was 17.6 months (3.6–35.8) in group A, and 23.5 months (7.9–38.9) in group B. During this period of time three patients in group A and one patient in group B died; two of cardiac and two of noncardiac reasons. In group B no patient had aortic regurgitation higher than grade I and all patients were in New York Heart Association functional class I or II.
Conclusion: Aortic valve reimplantation in patients with type A dissection can be performed with excellent early and mid-term results. In the hands of an experienced surgeon it represents a good alternative to the Bentall operation. Its main advantage is the preservation of the native valve without the necessity of anticoagulation therapy.

Klíčová slova:
Akutní disekce aorty
Bentallova operace
Reimplantace
Záchovná operace aortální chlopně

SOUHRN

Cíl: Akutní disekce aorty typu A je život ohrožujícím onemocněním, které vyžaduje urgentní operační řešení. Volba ideálního postupu je stále předmětem diskusí. V práci prezentujeme naše zkušenosti se dvěma typy operací se zachováním a bez zachování aortální chlopně.
Soubor a metodika: V období od ledna 2009 do prosince 2011 bylo na našem pracovišti operováno 56 pacientů pro akutní disekci aorty typu A. Ve 32 případech byla nahrazena ascendentní aorta a u 24 pacientů byl z důvodu závažnějšího postižení aortálního kořene proveden rozsáhlejší výkon (studijní skupina). U jedenácti z těchto pacientů (skupina A) byla nahrazena aortální chlopeň, kořen a ascendentní aorta konduitem s chlopní (modifikovaná Bentallova operace). Ve 13 případech (skupina B) byla provedena záchovná operace aortální chlopně (reimplantace dle Davida).

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Výsledky: V předoperačních parametrech nebyl mezi skupinami statisticky významný rozdíl. Průměrná doba hospitalizace se jako jediná statisticky významně lišila; 26,7 ± 13,7 dne ve skupině A a 16,4 ± 7,7 dne ve skupině B. Hospitalizační mortalita po Bentallově operaci byla 18,2 % (n = 2); nikdo z pacientů ve skupině B nezemřel v průběhu hospitalizace. Echokardiografické vyšetření před propuštěním ve skupině B neukázalo žádnou nebo minimální aortální regurgitaci. Průměrná doba sledování ve skupině A byla 17,6 měsíce (3,6–35,8) a ve skupině B 23,5 měsíce (7,9–38,9). Během tohoto období zemřeli tři pacienti ve skupině A a jeden ve skupině B; dva z kardiální a dva z nekardiální příčiny. Ve skupině B neměl nikdo z operovaných aortální regurgitaci větší než stupeň I a všichni kontrolovaní byli ve funkční třídě I a II klasifikace NYHA.
Závěr: Reimplantace aortální chlopně u pacientů s akutní disekcí aorty typu A poskytuje výborné časné a střednědobé výsledky a v rukou zkušeného chirurga může být dobrou alternativou Bentallovy operace. Hlavní výhodou je zachování nativní aortální chlopně bez nutnosti antikoagulační terapie.

Introduction

Type A acute aortic dissection (AAD) (according to Stanford classification) is life-threatening disease requiring urgent operation. The extent of the operation is still the subject of the debates. The minimal extent of the operation covers the replacement of the ascending aorta. In case of aortic regurgitation the resuspension of the commissures should be added. The leaving of the aortic root in place can be followed by dilatation of sinuses of Valsalva and development of aortic regurgitation [1–3]. Increased pressure on the wall of the aortic root has been described as a main risk factor for the development of the secondary aortic regurgitation after operation for AAD [4]. In case of the damage of the aortic root caused by acute dissection, the modified Bentall operation has been considered as the method of choice. Replacement of the entire dissected wall of the root and ascending aorta by the conduit with the artificial valve provides very good results from long-term perspective. The disadvantage of such operation is the presence of mechanical or biological valve and its consequences [5,6].

This disadvantage can be overcome by valve sparing operations. This type of operation has recently gained an increasing importance, even in acute situations. It is possible to use two types of this operation in case of AAD and damage of the root; reimplantation described originally by David [7] and remodelling technique described by Yacoub [8]. The main advantage of these valve sparing operations is the absence of artificial valve but the durability of the competence of the aortic valve is questionable. The long-term results of Yacoub's operation are to certain extent inferior [9]. In our retrospective analysis we present the comparison of early results of modified Bentall operation and reimplantation in AAD.

Material and methods

From January 2009 to December 2011 fifty-six patients underwent an operation due to the acute aortic dissection type A. Ascending aorta and part of the aortic arch (when needed) was replaced in 32 cases. The study group was comprised of twenty-four patients with the impairment of aortic root and aortic regurgitation. In eleven patients (45.8%), the replacement of aortic valve, aortic root and ascending aorta by composite graft (modified Bentall procedure) was performed (group A). The valve sparing operation (reimplantation according to David) was carried out in 13 patients (54.2%) (group B). The diagnosis of AAD was based on the CT angiography and/or echocardiography. The preoperative status and hemodynamic profile of the patients are described in Table 1 and 2. There was no significant difference observed between both groups.

Table 1 – Preoperative demographic and clinical data.

	Group A n = 11	Group B n = 13	*p*
Gender – male	10 (90.9)	11 (84.6)	0.642
Age, mean ± SD	53.1 ± 11	50.8 ± 14.7	0.744
BSA (m^2), mean ± SD	2.1 ± 0.2	2.1 ± 0.2	0.947
Marfan syndrome	1 (9.1)	1 (7.7)	0.902
Hypertension	8 (72.7)	7 (53.8)	0.341
Previous cardiac surgery	2 (18.2)	0 (0.0)	0.108

Values in parentheses represent percentages except where indicated.
BSA – body surface area.

Table 2 – Preoperative hemodynamic data.

	Group A n = 11	Group B n = 13	*p*
LV EF (%), mean ± SD	56.2 ± 8.8	57.7 ± 11.5	0.611
Aortic insufficiency			
Grade 0 (none)	1 (9.1)	1 (76.9)	0.903
Grade I (minimal)	3 (27.3)	3 (23.1)	0.813
Grade II (mild)	2 (18.2)	1 (76.9)	0.439
Grade III (moderate)	4 (36.4)	5 (38.5)	0.916
Grade IV (severe)	1 (9.1)	3 (23.1)	0.360
Preoperative cardiogenic shock	2 (18.2)	4 (30.8)	0.477
Preoperative malperfusion	4 (36.4)	3 (23.1)	0.476
Interval between first symptoms and operation < 24 hours	6 (54.5)	10 (76.9)	0.247

Values in parentheses represent percentages except where indicated.
LV EF – left ventricle ejection fraction.

The final decision about the operation type was based on the surgeon's preference. The transoesophageal echocardiography was performed at the end of all valve sparing operations as well as the transthoracic echocardiography before the discharge and one year after the operation.

Surgical technique

After the heparinisation, the axillary and/or femoral artery were cannulated. After median sternotomy the cannulation of aortic arch (in two patients) for the arterial line and right atrium for cardiopulmonary bypass was performed. Left heart vent was introduced through the right upper pulmonary vein. After the clamping, the aorta was opened above the commissures, and antegrade cardioplegic solution was introduced. In all but two patients the deep hypothermia (24–26 °C) was used. The distal anastomosis of the prosthesis was performed openly with clamp on the truncus brachiocephalicus and with selective antegrade brain perfusion via the cannula introduced into the left carotid artery in these patients. In two remaining patients mild hypothermia (32 °C) and construction of the distal anastomosis during aortic clamping was performed.

Group A – the whole dissected ascending aorta, aortic root as well as the valve were excised. The ostia of the coronary arteries were mobilised. The conduit with mechanical (SJM Masters HP Valved Graft; St. Jude Medical, St. Paul, MN, USA) or biological (Biovalsalva conduit; Vascutek Terumo, Renfrewshire, Scotland) valve was implanted using single pledged 2-0 polyfilament sutures. The coronary ostia were implanted using 5-0 polypropylene sutures. When indicated, hemiarch in addition to ascending aorta was replaced.

Table 3 – Intraoperative data.

	Group A n = 11	Group B n = 13	*p*
Cannulation			
axillary artery	9 (81.2)	11 (84.6)	0.854
aortic arch	0 (0.0)	2 (15.4)	0.174
femoral artery	2 (18.8)	0 (0.0)	0.108
Cardioplegia			
cold blood	1 (9.1)	2 (15.4)	0.642
crystalloid (St. Thomas)	8 (72.7)	10 (76.9)	0.813
crystalloid (Custodiol)	2 (18.2)	1 (7.7)	0.439
Bicuspid aortic valve	1 (9.1)	1 (7.7)	0.903
Aortic arch surgery			
partial arch replacement	5 (45.5)	5 (38.5)	0.247
total arch replacement	0 (0.0)	3 (23.1)	0.089
Djumbodis Dissection System	2 (18.2)	1 (7.7)	0.439
Aortocoronary bypass graft	2 (18.2)	2 (15.4)	0.854
CryoMAZE	0 (0.0)	1 (7.7)	0.347
Aortic cross-clamp time (min), mean ± SD	169.6 ± 71.0	158.7 ± 38.9	0.652
Total C-P bypass time (min), mean ± SD	238.9 ± 85.8	194.2 ± 59.8	0.165

Values in parentheses represent percentages except where indicated.

Group B – the entire aortic root down to the annulus was dissected. The whole ascending aorta and aortic root were excised except the 5 mm rim of the tissue above the valve. The ostia of the coronary arteries were mobilised. The valve was reimplanted into the prosthesis (four times straight, nine times Valsalva; Vascutek Terumo, Renfrewshire, Scotland) using 2-0 U-stiches without pledges placed below the valve. The size of prosthesis was about 3–4 millimetres bigger than the size of aortic annulus measured intraoperatively. The fixation of the valve into the prosthesis was performed by the means of 4-0 polypropylene sutures. The coronary ostia were implanted using 5-0 polypropylene sutures. After implantation of the valve the effective height of the leaflets were checked. No leaflet repair was performed. When necessary, hemiarch or aortic arch replacement in addition to ascending aorta was performed (Table 3).

In particular cases, when the initial part of the descending aorta was dilated and/or dissected, the Djumbodis Dissection System (Saint Côme Chirurgie, Marseille, France) was used to facilitate the closure of false lumen.

Statistical analysis

Continuous parameters were described as mean and standard deviation. Categorical parameters were described by absolute and relative numbers. The significance of differences amongst the groups of patients was tested by ANOVA and chi-square tests for continuous and categorical parameters; the level of statistical significance was set at $p < 0.05$.

Results

The duration of aortic clamping and cardiopulmonary bypass did not differ between both groups. In 13 patients the part of the aortic arch (five patients in both groups) or the whole arch (three patients in group B) was repla-

Table 4 – Intraoperative transesophageal echocardiography.

	Group B n = 13
Aortic insufficiency	
Grade 0 (none)	11 (84.6)
Grade I (minimal)	2 (15.4)
Grade II (mild)	0 (0.0)
Grade III (moderate)	0 (0.0)
Grade IV (severe)	0 (0.0)
Aortic valve mean gradient (mmHg), mean ± SD	9.3 ± 2.8
Aortic leaflet height of coaptation (mm), mean ± SD	9.2 ± 1.5
Coaptation of aortic valve	
type A	10 (76.9)
type B	3 (23.1)
type C	0 (0.0)

Values in parentheses represent percentages except where indicated.

Table 5 – Postoperative outcomes.

	Group A n = 11	Group B n = 13	*p*
Length of intubation (hours), mean ± SD	256.6 ± 369.7	114.5 ± 192.1	0.260
Reintubation	0 (0.0)	2 (15.4)	0.174
Blood loss (ml), mean ± SD	1 476 ± 986	1 652 ± 1365	0.736
Reoperation for tamponade or bleeding	2 (18.2)	3 (23.1)	0.768
Stroke	4 (36.4)	1 (7.7)	0.085
Multiorgan failure	2 (18.2)	0 (0.0)	0.108
Atrial fibrillation	2 (18.2)	1 (7.7)	0.439
Need for pacemaker	0 (0.0)	1 (7.7)	0.347
Deep sternal wound infection	1 (9.1)	1 (7.7)	0.903
ICU length of stay (days), mean ± SD	12.9 ± 15.3	7.8 ± 8.7	0.339
Length of stay (days), mean ± SD	26.7 ± 13.7	16.4 ± 7.7	0.037*
Thirty-day mortality	0 (0.0)	0 (0.0)	
Hospital mortality	2 (18.2)	0 (0.0)	0.108
Late mortality	3 (27.3)	1 (7.7)	0.120

Values in parentheses represent percentages except where indicated.
ICU – intensive care unit; * significant difference.

Table 6 – Follow-up.

	Before discharge		One year after surgery	
	Group A n = 9	Group B n = 13	Group A n = 5	Group B n = 11
LV EF (%), mean ± SD	52.1 ± 7.9	53.2 ± 9.4	58.8 ± 3.7	57.6 ± 7.6
Aortic insufficiency				
Grade 0 (none)	9 (100.0)	11 (84.6)	5 (100.0)	8 (72.7)
Grade I (minimal)	0 (0.0)	2 (15.4)	0 (0.0)	3 (27.3)
Grade II (mild)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Grade III (moderate)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Grade IV (severe)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
NYHA				
Class I			5 (100.0)	7 (63.6)
Class II			0 (0.0)	4 (36.4)
Class III			0 (0.0)	0 (0.0)
Class IV			0 (0.0)	0 (0.0)

Values in parentheses represent percentages except where indicated.
LV EF – left ventricle ejection fraction; NYHA – the New York Heart Association functional class.

ced due to the local finding of the tear of the aortic wall. In five patients the concomitant procedure was performed – coronary artery bypass grafting in four and MAZE procedure in one patient.

The transoesophageal echocardiography was performed at the end of operations in group B patients. No aortic regurgitation in the most of the patients and A or B type of coaptation of the leaflets were found (Table 4). This finding remained the same till the discharge (Table 5).

The time of intubation tends to be longer in group A, the reason was the excessive length in intubation in two patients due to the unconsciousness (1 194 and 659 hours). The time of the hospital stay was significantly longer in group A. There was no difference in any postoperative complications (Table 5). In the postoperative period transient cerebrovascular accident occurred in three patients (two in group A and one in group B). In two other patients in group A stroke with serious ischaemic damage of the brain at CT occurred. Both patients died due to the multiorgan failure 36th and 51th day after operation.

The mean follow-up time was 17.6 month (3.6–35.8) in group A, and 23.5 month (7.9–38.9) in group B. During this period of time four patients died; three in group A and one in group B. Two patients died due to the cardiac cause; one of them because of the cardiogenic shock after allograft replacement of the composite graft because of prosthetic endocarditis, and second one because of cardiac failure three months after the operation. Both patients belonged to group A. Two patients died due to the non-cardiac reasons. In group B no patient had aortic regurgitation higher than grade I and all patients were in New York Heart Association functional class I or II (Table 6). No thromboembolic or bleeding complications occurred in relation to anticoagulation treatment.

Discussion

During the operation for AAD every surgeon has to solve the dilemma whether to perform the easiest and shortest life-saving operation or the complex procedure requiring the removal of all the impaired structures and tissues at the expense of longer and more demanding operation. Nearly in all cases the dissection extends also to the aortic root. In such a situation, the gluing of the dissected walls with one of the biological glues offers a solution together with the resuspension of the affected commissures. This approach represents technically the easiest method, but in the long-term follow-up, it can be connected with the aortic root dilatation and the onset of aortic regurgitation. This risk is the most likely to occur in the patients with Marfan syndrome when the entire ascending aorta and the aortic root should be removed in the first operation [10]. According to the literature the application of GRF glue between the dissected walls of the aortic root is connected with the dilatation of the root during follow-up [11,12]. This may be the main reason for the reoperation [13,14].

In case that the extent of the aortic root damage is so extensive and its preservation is technically not possible, the only possibility is to replace the root with the prosthesis. Modified Bentall technique is the classical method with very good long-term results [15,16]. The negative aspect of this procedure is the presence of artificial valve; in case of biological valve, there is some risk of degeneration, while in mechanical valves the anticoagulation treatment is mandatory. According to the literature, the risk of thromboembolic or bleeding complications in long-term follow-up is about 1.3–8.6% [17,18]. In our group of patients, this type of complications was not proved during mid-term follow-up. Another disadvantage of anticoagulation treatment is the prevention from the thrombosis of the false lumen assuming that the dissection extends to the descending aorta. In such a situation, further dilatation of the aorta can be expected. The existence of false lumen is the significant risk factor for the necessity of the reoperation and increased late mortality [19–21]. All the disadvantages of anticoagulation therapy are eliminated by valve sparing operations. The remodelation described by Yacoub is not generally recommended in AAD [22]. This approach is supported also by Leyh et al. [9] who described higher frequency of reconstruction failure and the necessity of reoperation. The reimplantation technique was described 20 years ago [7]. The indications for this procedure extend with increasing experience and published data show very good long-term results [23–25]. Nowadays they include elective operations in patients with bicuspid aortic valve, patients with Marfan syndrome and also acute operations. During this procedure all the pathological aortic tissue of the aortic root is removed, the native aortic valve is preserved, and the aortic annulus is secured. In the decision making process it is necessary to take into account the higher risk of the failure due to the residual regurgitation in the setting of acute operation and uncertain quality of the tissue. According to our experience, this risk is relatively low in the hands of experienced surgeon which was confirmed by successful early postoperative course with lower complication rate in our patients

The important condition for proper long-term function of the valve is sufficient height of the leaflet coaptation and depth of the coaptation in relation to the aortic annulus. Coaptation type A (above the level of annulus) or type B (in the level of annulus) was achieved in all our patients. None of them had type C coaptation (below the annulus), which is the predictor of failure in long-term [26].

The type of the prosthesis used is given by the preference of the surgeon. Some authors prefer tubular prosthesis [27]. So called neosinuses can be created by plication of the prosthesis on the level of the sinotubular junction (David V procedure). Bethea et al. [28] emphasize the advantage of the prostheses with artificial Valsalva sinuses (Vascutek Gelweave Valsalva). Preformed sinuses decreased the speed of aortic leaflet closure. Higher speed of the closure during diastole can increase the stress, which can predispose the aortic valve to degeneration [29,30]. The tubular prosthesis was used in the first four of our patients, but then we started to use the prosthesis with preformed sinuses, which is the type of choice nowadays.

In comparison to Bentall operation, David's procedure provides also better quality of life [31]. We can prove this experience, since our patients had shorter length of the hospital stay and in the time of clinical examination all of them were in NYHA class I or II without the limitations given by anticoagulation treatment.

Clinical and pathological studies showed that in up to 30% of patients, the tear of the wall progresses also in the aortic arch [32,33]. In these cases, the extension of the replacement to the arch is important in order to prevent late complications and reoperations [10]. The technique of open distal anastomosis with hemiarch or the whole arch replacement combined with selective antegrade brain perfusion is our method of choice nowadays. Even though it prolongs the clamping time a bit, it significantly increases the safety of the anastomosis.

The study has several limitations. The patients were not randomised, the evaluation was retrospective. The study was performed in the period of time, when the operation technique was gradually introduced. The higher numbers of patients and longer follow-up would provide more relevant results.

Conclusions

Valve sparing operation (reimplantation according to David) counts for patients with acute aortic type A dissection a good alternative option to the standard procedure which is represented by Bentall operation. The main advantage of this method is the preservation of the native valve without the necessity of anticoagulation treatment. This is an important aspect, especially when the dissection with false lumen extends into the descending aorta and also in cases of young patients with active way of life. However, the risk of failure of this reconstructive operation in acute situation has to be taken into account in decision making process. Our results showed, that in the hands

of an experienced surgeon, good results can be achieved and we consider the reimplantation procedure as a method of choice if the aortic root has to be replaced.

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