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David versus Bentall – a Comparison of Early Postoperative Complications

The aim of the work: to analyze and compare the early postoperative complications in patients operated due to the presence of aneurysms of the root and ascending aorta and aortic valve pathology by the David and Bentall technique.

Materials and Methods. It was a retrospective study. There were 107 patients who were routinely treated surgically at the Heart Institute of the Ministry of Health of Ukraine from 2015 to 2023. Patients were divided into two groups depending on the type of surgical intervention: in group A – David operation was performed, in group B – Bentall operation. All data were collected and compared in preoperative, intraoperative, and postoperative period.

Results and Discussion. According to the duration of operations, the indicators are higher in patients of group A. Thus, the total duration of the operation was (291.23±12.67) minutes in group A and (244.418±7.67) min. in group B, respectively (p 0.001). The total duration of artificial blood circulation was (170.28±8.77) minutes in group A and (138.73±6.47) min. in group B, respectively (p 0.003). Aorta clamping time – (122.02±5.92) min. in group A and (95.82±4.79) min. in group B, respectively (p 0.000).

Patients of group A had faster extubation. They spent less days in the intensive care unit and in the hospital in general.

Among the early postoperative complications, it is important to note a greater proportion of arrhythmias in patients after Bentall operation. The share of acute respiratory failure with repeated reintubation is statistically higher in group B. Other indicators did not differ statistically among patients. The frequency of cell saver use was almost the same in the two groups of patients. The rate of reoperations due to bleeding did not differ statistically and was 3 (5.66 %) for group A and 6 (10.91 %) for group B (p 0.328).

Key words: aneurysm of the root and ascending aorta; David operation; Bentall operation; days of hospitalization; postoperative complications.

The statement of the problem and analysis of the latest research and publications. The incidence of thoracic aortic aneurysms has increased over the past two decades, in part due to an aging population, increased smoking, introduction of screening programs, and improvements in diagnostic tools. This disease is more common in men, with prevalence rates estimated at 1.3–8.9 % in men and 1.0–2.2 % in women [1,2]. Aneurysms of the thoracic aorta occur in 5–10 cases per 100,000 population [3]. According to location, thoracic aortic aneurysms are classified into aneurysms of the root or ascending aorta, which are the most common (≈60 %), followed by aneurysms of the descending aorta (≈35 %) and aortic arch (<10 %) [4,5]. The treatment of this pathology is only surgical after a detailed assessment of the size of the aneurysm, the functioning of the aortic valve and weighing all the patient's data [1,3].

In 1968 Bentall and De Bono invented an operation using a composite valve-containing conduit or a composite conduit and aortic prosthetic valve for the surgical treatment of aneurysms of the root and ascending aorta [5–7].

Tirone David was the first who performed valve-preserving surgery of the root and ascending part of the aorta in 1889 [4].

Aortic valve-preserving surgeries are an alternative to replacing the aortic root with a conduit. They provide excellent long-term results and are associated with a low rate of prosthetic valve complications.

Despite the long performance of both Bentall and David operations, there are many postoperative complications. These complications are in the form of arrhythmias, respiratory failure, postoperative bleeding, etc. All this leads to a long stay of the patient in the intensive care unit and a longer discharge from the hospital [8–11].

The aim of our work was to analyze and compare the early postoperative complications in patients operated due to the presence of aneurysms of the root and ascending aorta and aortic valve pathology by the David and Bentall technique.

Materials and Methods. It was a retrospective study. There were 107 patients who were routinely treated surgically at the Heart Institute of the Ministry of Health of Ukraine from 2015 to 2023. Patients were divided into two groups depending on the type of surgical intervention: in group A, David surgery was performed (number of men – 47 (88.68 %), average age (49.11±1.54) years), in group B - Bentall surgery (men – 53 (96.36 %), average age (52.36±1.56) years).

Preoperative, intraoperative and postoperative data were collected. The demographic characteristics (age, height, sex, body weight, body mass index), echocardiographic parameters (left ventricular ejection fraction, end diastolic volume index, diameter of the root and ascending aorta) and accompanying pathology were recorded at the preoperative stage. Intraoperative data are duration of operation, artificial blood circula-

tion, aortic clamping, duration of hypothermic circulatory arrest, and level of hypothermia. Data collected during the postoperative period included duration of mechanical ventilation, use of cell saver, frequency of postoperative complications (acute respiratory failure, acute renal failure, gastrointestinal bleeding, rethoracotomy, etc.), length of intensive care unit staying, and length of hospitalization (Table 1).

Table 1. Baseline characteristics of the patients

Indicator		Group A (n=53)	Group B (n=55)	P
Sex	Male	47 (88,68)	53 (96,36)	0,130
	Female	6 (11,32)	2 (3,64)	
Age, years		49,11±1,54	52,36±1,56	0,141
Height, cm		180,83±1,18	180,073±1,05	0,632
Weight, kg		87,58±2,23	87,43±2,52	0,965
Body mass index kg/m ²		26,81±0,65	26,93±0,74	0,905
Bicuspid aortic valve		9 (16,98)	31 (56,36)	0,000
Tricuspid aortic valve		44 (83,02)	24 (43,64)	0,000
End diastolic volume index, ml/m ²		94,00±5,26	116,75±7,41	0,035
Left ventricular ejection fraction, %		58,34±1,16	54,82±1,41	0,091
Ascending aorta, mm		46,02±2,31	54,15±1,43	0,003
Aortic root, mm		46,09±2,24	51,13±2,08	0,102
<i>Accompanying pathology</i>				
Pulmonary hypertension		20 (37,74)	32 (58,18)	0,034
Smoking		11 (20,75)	32 (58,18)	0,162
Myocardial infarction in the past		1 (1,89)	2 (3,64)	0,582
History of cerebrovascular events		2 (3,77)	2 (3,64)	0,679
Previous interventions on the heart (stenting and open operations)		3 (5,66)	3 (5,45)	0,963
Diabetes		1 (1,89)	2 (3,64)	0,582

The study was approved by the local ethics committee and individual patient consent.

David surgical technique. Median sternotomy was performed. Opening of the pericardium. Central connection of the heart lung machine (System 1 (Terumo, Japan) or HL20 (Maquet, Germany)). A dose of heparin of 300 IU/kg of body weight was administered intravenously prior to artificial blood circulation to achieve an activated clotting time (aPTT) of more than 480 s. with measurement every 30 min. Hypothermia up to 32 °C. In patients where a complete

stoppage of blood circulation was expected for the formation of a distal anastomosis – 22°C. Artificial heart fibrillation. Crossclamp of the aorta in front of the proximal part of the aortic arch. An aortotomy was performed. Selective pumping of cardioplegic cold crystalloid solution "Kustodiol". Excision of the aneurysmal part of the ascending aorta and the root in the area of the sinuses was performed. Excision of the buttons of the coronary arteries was carried out and they were taken on tripods. Aortic valve leaflets were evaluated. After measuring the height of the aortic

valve commissures, appropriate markings were made on the vascular dacron tubular prosthesis (Maquet). 9 stitches were applied – 3 on the tops of the commissures and the base of the commissures, 3 stitches with Prolene 4.0 in the middle of the sinuses. After sewing 9 stitches through the vascular prosthesis, it was implanted. The prosthesis was stitched from the inside with three sutures placed in the middle of the sinuses. Reimplantation of the buttons of the coronary arteries was carried out. In patients where there was a need for a complete stoppage of blood circulation, parallel cerebral perfusion was performed (10 % of the work of the artificial blood circulation). A distal anastomosis was formed. After that, warming up, prevention of air embolism with removal of the aortic clamp were performed. Normal heart rhythm was restored. Hemostasis control. Artificial blood circulation was stopped. Exit by venous cannula and left ventricular drainage. After stopping the artificial blood circulation, protamine sulfate was used to counteract the anticoagulant effect of heparin. The initial filling volume consisted of 500 ml of colloid solutions, 100 ml of 4.2 % sodium bicarbonate solution, 300 ml of 0.9 % sodium chloride solution, and 100 ml of 15 % mannitol solution. Exit with an aortic cannula and wound closure with placement of drains and epicardial electrodes.

Surgical technique of performing Bentall operation. The course of the operation before pumping the cardioplegic solution and after the restoration of cardiac activity is the same for both types of interventions. Features exist in the main stage.

After pumping the cardioplegic solution, excision of the aneurysmal part of the ascending aorta, the root in the area of the sinuses, and the leaflets of the aortic valve were performed. Excision of the buttons of the coronary arteries was performed and they were fixed on tripods. Alternate stitches were placed on pads on the fibrous ring of the aortic valve. After sewing these seams through the cuff of the valve conduit, its implantation was carried out. Reimplantation of the buttons of coronary arteries was carried out. A distal anastomosis was formed. After that, warming up, prevention of air embolism with removal of the aortic clamp were performed. Normal heart rhythm was restored. The next steps are the same as in David operation.

Intraoperative monitoring included invasive control of blood pressure, central venous pressure, cerebral perfusion, electrocardiogram control, diuresis control, arterial blood oxygen saturation, end-respiratory concentration of sevoflurane, temperature in the nasopharynx and bladder. Maintenance of general anesthesia was carried out by titration of sevoflurane in a dose from 1.5 to 2.5 % to maintain BIS values between 40 and 60. Sevoflurane was introduced into the

oxygenator circuit during artificial blood circulation through a calibrated vaporizer. Artificial ventilation of the lungs was performed using Mindray anesthetic machines with FiO₂ 50 % air-oxygen mixture in normal ventilation mode under the control of arterial blood gases (pCO₂ values of arterial blood were maintained at the level of 35–40 mm Hg).

Study results were reported as mean (M) ± standard deviation (SD). Under the condition of normal data distribution, the Student's t-test was used to determine the significance of statistical indicators, in the absence of normal distribution, the non-parametric Mann-Whitney U-test was used. Differences at $p < 0.05$ (95.5 %) were considered statistically significant. The SPSS Statistics 27 statistical data processing program was used to analyze the obtained data.

Results and Discussion. A total of 107 patients who underwent planned operations at the Heart Institute of the Ministry of Health of Ukraine from 2015 to 2023 are included in the study. According to the duration of operations, the indicators are higher in patients of group A. This is probably explained by the greater technical complexity of this type of surgical intervention. Thus, the total duration of the operation was (291.23±12.67) minutes in group A and (244.418±7.67) min. in group B, respectively ($p < 0.001$). The total duration of artificial blood circulation was (170.28±8.77) minutes in group A and (138.73±6.47) min. in group B, respectively ($p < 0.003$). Aorta clamping time – (122.02±5.92) min. in group A and (95.82±4.79) min. in group B, respectively ($p < 0.000$) (Table 2).

Complete circulatory arrest with hypothermia up to 22 °C with parallel cerebral perfusion was observed in patients of both groups. This was necessary in some patients of both groups to form a distal anastomosis. Among the patients of group A, this proportion was 6 (11.32 %) patients with a duration of (11.83±1.62) min., in group B – 10 (18.18 %) patients with a duration of 9.40±0.43 min. (Table 2).

Among the early postoperative complications, it is important to note a greater proportion of arrhythmias in patients after Bentall operation. This is probably due to the fact that this operation involves excision of the aortic valve, stitching of the aortic ring, implantation of an artificial mechanical prosthesis, and postoperative edema. David surgery, preserving the patient's native valve, does not involve these manipulations (Table 3).

The share of acute respiratory failure with repeated reintubation is statistically higher in group B.

Other indicators were not statistically different in patients. The frequency of cell saver use was almost the same in the two groups of patients, since both ope-

Table 2. Perioperative characteristics and intensive care unit staying

Indicator	Group A (n=53)	Group B (n=55)	p
Total operation duration (min)	291,23±12,67	244,418±7,67	0,001
Total duration of artificial blood circulation (min)	170,28±8,77	138,73±6,47	0,003
Aortic clamping time (min)	122,02±5,92	95,82±4,79	0,000
Average minimum temperature (°C)	30,12±0,37	29,36±0,38	0,160
Complete stoppage of circulation	6 (11,32)	10 (18,18)	0,320
Duration of complete circulatory arrest (min)	11,83±1.62	9,40±0,43	0,092
Number of patients extubated up to 8 hours after surgery	48 (90,57)	41 (74,55)	0,029
Duration of stay in intensive care unit (days)	2,94±0,03	4,84±0,33	0,000
Duration of stay in hospital (days)	13,81±0,54	16,98±0,91	0,004

Table 3. Postoperative complications

Complications				
Reoperation due to the bleeding	3 (5,66)	6 (10,91)	0,328	
Acute respiratory failure	2 (3,77)	10 (18,87)	0,047	
Acute renal failure	0	1 (1,82)	0,326	
Cell saver	4 (7,55)	7 (12,73)	0,376	
Arrhythmias	2 (3,77)	9 (16,36)	0,031	
Encephalopathy	1 (1,89)	1 (1,82)	0,979	
Implantation of a pacemaker	0	2 (3,64)	0,163	
Pericarditis	1 (1,89)	2 (3,64)	0,562	
Gastrointestinal bleeding	0	1 (1,82)	0,326	
Sepsis	1 (1,89)	2 (3,64)	0,562	

rations require aortic root resection and coronary arteries reimplantation, which requires a large area of manipulation and possible bleeding sites.

The rate of reoperations due to bleeding did not differ statistically and was 3 (5.66 %) for group A and 6 (10.91 %) for group B (p 0.328) (Table 3).

Discussion. The results of our study showed that patients after David operations have faster extubation, they spent less days in the intensive care unit and in the hospital in general. This group of patients has a statistically smaller number of arrhythmias and acute respiratory failure.

David and Bentall operations are technically complex operations. These types of interventions are performed only in highly specialized centers. The topic of complications is extremely important and requires detailed study to improve the technique.

According to Sergey Leontyev et al. (2020) regarding Bentall and David's operations, the proportion of reoperations due to bleeding for David operations was 6.9% and Bentall was 5.3%; respiratory failure 7.7 and 6.5 %, respectively; acute renal failure 1.2 and 1.9 %, respectively. The indicators are similar to ours with the exception of respiratory failure for the Bentall group. In our opinion, the reason for the high value of this indicator is the decompensated condition of the majority of patients who are hospitalized for surgery in Ukraine. Screening systems in Europe allow early detection of pathology and faster intervention in a more compensated state of the patient.

During 20 years from 1988 to 2010, Dr. Tyrone David performed 374 valve-preserving surgeries for aortic root and ascending aortic aneurysms. He showed excellent results. Therefore, this intervention

is no longer experimental, but can be used in all cardiosurgical centers. He used this type of operation for both bicuspid and tricuspid aortic valves. The issue of observing separate results with a bicuspid valve remains relevant. We are just introducing these operations into the practice of bicuspid aortic valve and this will be our further research [12].

Due to results N. Hashrul Rashid et al David's operation is characterized by lower long-term mortality compared to Yakub's operation. That is, even when comparing two types of valve-sparing operations, David's procedure shows better results. According to the authors, the results still need to be studied due to different observation periods and the retrospective nature of the research [13].

Ničovský, J. and authors analyzed from January 2006 to December 2015 a total of 137 patients (mean age 46.3 ± 14.5), range 16–65) who underwent surgery for aortic root aneurysm without valvular structural defects. Replacement by mechanical composite graft (Bentall procedure) has been performed in 46 patients while 91 patients underwent David procedure. Overall 9 patients died during follow-up. Five patients were after Bentall procedure and 4 were after reimplantation of aortic valve. Thromboembolic and bleeding complications were observed in 7 patients, 5 of them were after Bentall surgery and 2 after reimplantation of the aortic valve. They showed less bleeding complications in patients after David procedure [14].

Lukas Schamberger et al showed excellent results after comparing biological Bentall procedure and David procedure. The long-term outcomes were associated with comparable survival and freedom from reop-

eration. Authors concluded that David procedure may be preferable in patients with suitable pathoanatomy comparing with biological Bentall procedure [15].

All these data and details are important. After receiving the results, we realized that in the future we need to conduct studies with larger number of patients in order to fully analyze all factors and, accordingly, the complications that arise. This will make it possible to find ways to reduce of their occurrence and improve the quality of life of patients.

Conclusions. This study showed that despite the longer duration of artificial blood circulation, aortic compression, David operation still has many advantages. This was manifested in a shorter length of staying on a artificial ventilation, less days of hospitalization in the intensive care unit and in the hospital. Patients after David operation have a lower frequency of arrhythmias and acute respiratory failure compared to Bentall operation. Valve-sparing operations should be studied in detail and increasingly introduced into cardiac surgical practice.

Contribution of the authors. I. O. Stetsyuk – collection and statistical processing of material, writing the text of the article; B. M. Todurov – idea, concept, analysis and discussion.

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ОПЕРАЦІЯ ДЕВІДА ЧИ БЕНТАЛЛА – ПОРІВНЯННЯ РАННІХ ПІСЛЯОПЕРАЦІЙНИХ УСКЛАДНЕНЬ

Мета роботи: аналіз та порівняння ранніх післяопераційних ускладнень у пацієнтів, оперованих з приводу аневризми кореня, висхідної аорти та патології аортального клапана за методиками Девіда та Бенталла.

Матеріали і методи. В ретроспективному дослідженні взяли участь 107 пацієнтів, яким у плановому порядку проведено операційне лікування в ДУ "Інститут Серця МОЗ України" від 2015 до 2023 р.

Пацієнти були розділені на дві групи залежно від виду операційного втручання: у групі А проводили операцію Девіда, у Б групі – операцію Бенталла. Проводили збір та порівняння доопераційних, інтраопераційних та післяопераційних даних.

Результати. За тривалістю проведення операцій, показники є вищими у пацієнтів групи А. Так, загальна тривалість операції становила $(291,23 \pm 12,67)$ хв у групі А та $(244,418 \pm 7,67)$ хв у групі Б відповідно ($p=0,001$). Загальна тривалість штучного кровообігу становила $(170,28 \pm 8,77)$ хв у групі А та $(138,73 \pm 6,47)$ хв у групі Б відповідно ($p=0,003$). Час перетискання аорти становив $(122,02 \pm 5,92)$ хв у групі А та $(95,82 \pm 4,79)$ хв у групі Б відповідно ($p=0,000$).

У пацієнтів групи А спостерігали швидшу екстубацію, меншу кількість днів, проведених у відділенні інтенсивної терапії та стаціонарі загалом.

Із ранніх післяопераційних ускладнень важливо відзначити більшу частку аритмій у пацієнтів після операції Бенталла.

Частка гострої дихальної недостатності із повторною реінтубацією є статистично більшою у пацієнтів групи Б. Інші показники у хворих статистично не відрізнялись. Частота використання cell saver була практично однаковою у двох груп пацієнтів. Частка повторних операцій через кровотечу статистично не відрізнялась та становила 3 (5,66 %) для групи А та 6 (10,91 %) для групи Б ($p=0,328$).

Ключові слова: аневризма кореня та висхідної аорти; операція Девіда; операція Бенталла; ліжкодні; післяопераційні ускладнення.