

## Кровозбереження в хірургічному лікуванні мітральної хвороби серця

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## The blood preservation in surgical treatment of the mitral disease of the heart

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### Реферат

**Мета.** Дослідження сучасних можливостей безкровної техніки хірургічного лікування мітральних вад серця (МВС) в умовах штучного кровообігу (ШК).

**Матеріали і методи.** Обстежено 727 пацієнтів з МВС. Всіх пацієнтів розподілили на дві групи: основну та порівняльну. Основну групу склали 637 пацієнтів, у яких застосовували різні варіанти кровозбереження без переливання препаратів крові, без використання селсейвера, гемоконцентруючих колонок та ультрафільтрації крові; порівняльну – 90 пацієнтів, яким переливали препарати крові. Описано методику забезпечення анестезії та перфузійних заходів під час заміни мітрального клапана, а також особливості управління інфузійною терапією під час операції в умовах ШК.

**Результати.** У пацієнтів основної групи частота післяопераційних інфекційних ускладнень становила 1,2%, порівняльної – 9,9%, середня тривалість перебування на штучній вентиляції легенів –  $(6,7 \pm 2,3)$  та  $(12,3 \pm 8,4)$  год відповідно, середня тривалість перебування в реанімаційному відділенні –  $(58,4 \pm 12,4)$  та  $(116,3 \pm 45,2)$  год відповідно ( $p < 0,05$ ). Об'єм інтраопераційної крововтрати в основній групі був значно меншим, ніж у порівняльній:  $(261,2 \pm 33,8)$  та  $(533,1 \pm 131,6)$  мл відповідно ( $p < 0,05$ ). На всіх етапах операції та в післяопераційному періоді рівень гемоглобіну залишався в межах компенсації, що відповідало безпечному рівню кисневої ємкості крові.

**Висновки.** Впровадження інтраопераційних варіантів резервування аутокрові без використання препаратів донорської крові, селсейвера та гемоконцентруючих колонок не супроводжувалось зниженням доставки і споживання кисню та розвитком лактат-ацидозу.

Удосконалена методика анестезіологічного забезпечення полягала в проведенні інфузійно-трансфузійної терапії (стимуляція діурезу, контроль водного балансу, поєднання гострої нормоволемічної гемодилуції (ГНГ) із ШК і зниження гемодилуції за рахунок ретроградного заповнення оксигенатора аутокров'ю); використанні методів ексфузії аутокрові і їх комбінацій, зміні тактики інфузійної гемостатичної терапії; контролі центрального венозного тиску (ЦВТ) і підтримці середнього артеріального тиску ( $AT_{cp}$ ) за різних методів ексфузії аутокрові.

Впровадження описаної методики забезпечило добрий клінічний ефект без трансфузійних ускладнень на госпітальному етапі.

**Ключові слова:** штучний кровообіг; методика кровозбереження без використання донорської крові; корекція мітральної вади.

### Abstract

**Objective.** Investigation of modern possibilities of the bloodless technique of surgical treatment of the mitral valve failure (MVF) in environment of artificial blood circulation (ABC).

**Materials and methods.** There were examined 727 patients, suffering MVF. All the patients were divided into two groups: the main and a comparative one. The main group have consisted of 637 patients, in whom various variants of the blood preservation without its transfusion were applied, without application of a cell-saver, hemoconcentrating columns and the blood ultrafiltration; and a comparative one group have consisted of 90 patients, to whom the blood preparations were transfused. The procedure depicted have provided the anesthesia and the perfusion measures during operation of the mitral valve change, including as well the peculiarities of the intraoperative infusion therapy management in the ABC conditions.

**Results.** In the main group of patients the rate of postoperative infectious complications have constituted 1.2%, while in a comparative one – 9.9%. Median duration of stay on the artificial pulmonary ventilation have constituted  $(6.7 \pm 2.3)$  and  $(12.3 \pm 8.4)$  hours accordingly. The average duration of stay in reanimation department was  $(58.4 \pm 12.4)$  and  $(116.3 \pm 45.2)$  hours, accordingly ( $p < 0.05$ ). The intraoperative blood loss volume in the main group was significantly lesser, than in a comparative one:  $(261.2 \pm 33.8)$  and  $(533.1 \pm 131.6)$  ml, accordingly ( $p < 0.05$ ).

On all stages of the operation and in postoperative period the level of hemoglobin have persisted in a compensation period range, what constitutes a safe level of the blood oxygen capacity.

**Conclusion.** Introduction of intraoperative variants of the autologous blood reservation without application of the donor's blood, cell-saver and hemoconcentration columns is not accompanied with lowering of the oxygen delivery and consumption, as well as development of lactate-acidosis.

The improved procedure of anesthesiological support consisted of the infusion-transfusion therapy conduction with stimulation of diuresis, the water balance control, applying combination of an acute normovolemic hemodilution with ABC, and lowering of hemodilution due to retrograde filling of oxygenator by autologous blood. As well there were applied various methods of the autologous blood exsufflation and its components combinations, change of tactics in the infusion hemostatic therapy; a central venous pressure control and support of median arterial pressure.

Introduction of the procedure depicted have guaranteed a good clinical effect without complications of transfusion on a hospital stage of the patients' management.

**Keywords:** artificial blood circulation; procedure of the blood preservation without application of the donor's blood; correction of mitral failure.

### Introduction

Transfusion of components of donor blood and its components is, essentially, a transplantation of a foreign tissue and is connected to the risk of developing diverse reactions after the transfusion and to the immunological and non-immune complications [1, 2]. There is a risk of contracting infectious or viral diseases (hepatitis, AIDS, cytomegalovirus, syphilis, transfusion mononucleosis, alaria, and others), which numbers grow every year [3]. The fact of immunosuppressive effect of allogeneic transfusions on the recipient has been proven [4]. Clinicians have been facing ethical and legal problems more and more often, lately, connected to patients' refusals of allogeneic transfusions due to either religious beliefs or doubts regarding safety or components of donor blood.

It should also be noted the low functional efficiency of the donor erythrocyte mass in connection with the sequestration of 25–30% of transfused erythrocytes and a reduced content of 2,3-diphosphoglycerate in them (2,3-DPG). In this connection, hemoglobin, although it adds oxygen, but gives it to tissues rather weakly. That is why transfused donor blood only slightly improves oxygen transport to tissues. In this regard, the question raised in this article regarding the possibilities of bloodsaving technologies is extremely relevant [5 – 8].

Objective. The purpose is to study the modern possibilities of bloodless technique of surgical treatment of mitral heart disease (MIA) in conditions of artificial blood circulation (SHK).

### Materials and methods

It was possible to completely abandon the use of donor blood and its components throughout the entire hospitalization period for all 627 patients, from 01.01.2000 to 01.01.2017. Thanks to the developed by us blood-saving technologies which very used in the department of surgical treatment of acquired heart diseases in the NICVS AMS, utilized during surgical treatment of acquired valvular pathology in conditions of artificial circulation. In this group of patients, nether hemoconcentration of blood cells nor cell-savers were used.

All studied patients were divided into 2 groups: main group– 627 patient with mitral malformations, who had surgery with without the use of donor blood preparations and its components. Different kinds of bloodsaving methods were used in this group, and no preparations of donor blood and its components were done at all stages of postoperative period.

The comparison group– 90 patients with the same pathology, who did not use any bloodsaving techniques and the patients used donor blood and its components both in the in-

tra- and postoperative period. The main group consisted of 627 patients, including 237 (37,4%) men and 390 (62,6%) women from 18 to 70 years old, average age is (54,3 ± 9,2) years old. The comparison group consisted of 90 patients, including 40 (44,4%) men and 50 (55,6%) women from 18 to 70 years old average age (47,6 ± 9,3) years old. All of them had corrections of MM under conditions of AC.

In 398 (63,5%) patients of the main group, as in 71 (78,9%) patients of the comparison group, a procedure of placing an isolated mitral valve prosthesis (Prosthetic Mitral Valve or PMV) prevails, without accompanying procedures.

In the main group, methods were developed and implemented that aimed at bloodsaving technologies. Careful monitoring of hemodynamics as well as an evaluation of gas states were conducted, to rule out any complications at all stages of an operation. An important element in the main group was the stimulation of diuresis, which started with the start of the operation at a dose of 1 mg/kg of furosemide and (0.15 – 0.3) g/kg of mannitol. The following administration was performed intravenously for half an hour at an initial anesthesia. If the hematocrit was more than 0,4, then it created an opportunity blood deposition on citrate before the beginning of the artificial circulation (bloodsaving option "A").

Therefore, in 297 (47,5%) patients it was possible to deposit blood on citrate at a dose of 400 ml or more before the beginning of the AC, replenishing the volume with a 10% solution of Amylum hydroxaethylicum to blood 1: 1 (bloodsaving option "A"). Reservation of autoblood in the preperfusion stage was (465.2 ± 119.9) ml, i.e. (11.4 ± 3.2)% of the volume of circulating blood (VCB). After autoblood effusion, hemoglobin decreased from (139.2 ± 15.2) g/l to (129.4 ± 15.3) g/l, hematocrit – from 0.43 ± 0.03 to 0.38 ± 0.04, and the protein – from (73.2 ± 6.7) g/l to (59.2 ± 7.2) g/l, which was safe and did not significantly reduce the oxygen capacity of the blood.

After aortic cannulation, a procedure called retrograde autologous priming (RAP) was performed in 96 patients (blood-saving option "B"). This was possible with stable hemodynamics, with a patient weight of 80 kg and more and at a hematocrit value (in the last analysis) of at least 0.36. Meanwhile, heparinized blood was collected from the CPB pump arterial line, in which the patient's blood was collected in the oxygenator reservoir, displacing the original bloodless perfusate collected by the perfusiologist in a separate reservoir.

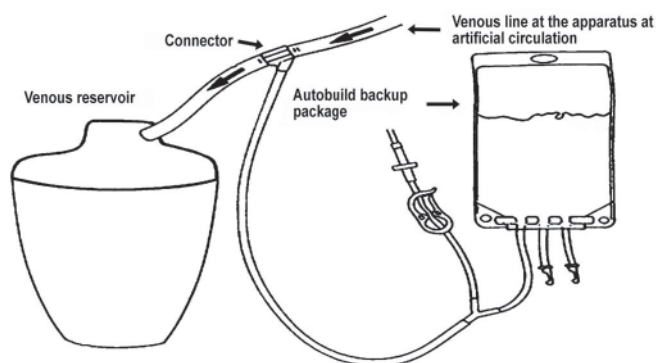
The main goal of this stage is to minimize the hemodilution value after the start CPB by filling up the CPB pump reservoir with the patient's own blood. This procedure is performed under strict hemodynamic control for approximately 9 – 10 minutes, that is why the use of any drugs that significantly lower AP (such as propofol), should be ruled out at this stage.

Before blood test the beginning of CPB determined a hematocrit of at least 0.4 and with a patient weight of at least 80 kg, then at the start of the perfusion and the presence in the oxygenator of a level of more than 1500 ml it was possible to perform the option "C" autoblood reservation (Figure).

This procedure was performed seperately in 84 patients and in 201 patients in combination with other options – "A" or "B".

At the same time, through the venous port of the oxygenator, the autoblood perfusate exfusion was (472.8 ± 128.3) ml (10.3 ± 3.4)% of the bcc calculated volume (4.3 ± 0.5) L.

After autoblood effusion at this stage, hemoglobin decreased from (134.5 ± 10.2) g/l to (97.3 ± 11.8) g/l, hema-



*Deposit of perfusate in the CPB pump from the venous trunk during perfusion. Bloodsaving option "C".*

tocrit – from  $(0.39 \pm 0.03)$  to  $(0.29 \pm 0.03)$ , and the protein from  $(70.8 \pm 6.2)$  g/l to  $(55.5 \pm 4.5)$  g/l, which was safe and did not significantly reduce the oxygen capacity of the blood.

Thus, the maximum discharge of autoblood at the stages of the operation was  $1427.2 \pm 413.7$  ml ( $28.2 \pm 6.7\%$  of blood volume circulation) with the variant “A + B + C”, and the minimum with isolated variants of “A” ( $403.7 \pm 92.7$ ) ml and “B” –  $(462.8 \pm 135.8)$  ml.

The most widely used as a method of exfusion in 293 (46.7%) isolated patients, or in conjunction with other methods exfusion in 538 (85.8%) patients was the option “A”. Isolated option “C” was used on 70 (11.2%) patients. The backup options “B” and “B + C” did not find a proper application in isolation.

All operations were performed under conditions of CPB and moderate hypothermia ( $32 - 35$  °C). Myocardial protection was carried out on the basis of a modified crystalloid solution of St. Thomas with the addition of 22.0% autoblood, as well as a solution of Custadiol. Administering cardioplegia typically performed by applying a retrograde cardioplegia in combination with external cooling heart.

During the CPB, the following parameters were monitored: coagulogram, blood gas analysis (PaO<sub>2</sub> 100–300 mm Hg), SvO<sub>2</sub>, plasma electrolytes, glucose and lactate, hemoglobin, hematocrit, protein), depth of anesthesia, diuresis (200 ml / hr) with hemodilution, temperature, CVP (negative), mean BP (50 – 90 mmHg).

After completion of the correction of the defect and stopping the apparatus, the remaining contents of the CPB pump reservoir were returned to the patient, filling the BCC under strict control of the hemodynamics, keeping the preload in the maximum physiological limits. Typically, at this stage is actively used izoket ( $0.5$  mkr/kg/min) in order to compensate for the maximum aortic trunk perfusate from the oxygenator to the patient. If this procedure is limited in its capabilities, the remaining perfusate of the oxygenator was going into the vials, then immediately poured to the patient. Irreversible blood loss at this stage (the remainder in the CPB pump reservoir) of the operation was minimized to 20–25 ml. Careful surgical hemostasis was carried out at all stages of the operation.

The time of CPB was  $(96.2 \pm 20.4)$  min, the time of clamping of the aorta was  $62.3 \pm 15.5$  min. in the main group, and it was  $(96.5 \pm 14.2)$  min. and  $(62.3 \pm 15.2)$  min. ( $p > 0.05$ ) in the comparison group.

One of the principles of bloodless surgery with CPB is the absence of pronounced hemodilution at all stages of performing a correction. This allowed to maintain the water balance of the water balance of the liquid prior to perfusion within  $0 + 300,0$ , pouring Amylum hydroxaethylicum only 10% at a dose of about 400 ml (as replenishment for blood sampling) and leaving almost zero water balance by the end of the operation. It is very important to minimize the water preload in the

preperfusion stage. In most cases, 10% solution of 400 ml Amylum hydroxaethylicum was quite enough for this purpose.

At the stage of artificial circulation and at the end of perfusion, the water balance the liquid was not more than  $+1500.0$  ml, and at the end of the operation, due to active diuresis, the fluid balance was usually reduced to zero. The protamine sulfate was administered at the calculated dose. To improve hemostasis, gordox was administered at the end of the operation at a dose of 20 000 – 30 000 units/kg of weight, and epsilon-aminocaproic acid 200 mg/kg, as well as etamzilate at a dose of 30 mg/kg.

### Results

The absence of allogeneic transfusions in the patients of the main group contributed to a reduction in the number of postoperative infectious complications in relation to the comparison group from 9,9% to 1,2%, and the duration of stay on artificial ventilation from  $(12,3 \pm 8,4)$  hours to  $(6,7 \pm 2,3)$  hours. The length of stay in the intensive care unit decreased from  $(116.3 \pm 45.2)$  hours to  $(58.4 \pm 12.4)$  hours ( $p < 0.05$ ). Thus, the proposed methods of bloodsparing allowed to improve the results of surgical correction of mitral defects in the main group.

Reduction of intraoperative blood loss is one of the main tasks of bloodless operations. In the course of the comparative analysis of the volume of intraoperative blood loss, we found out that in the main group these indices were significantly less than in the comparison group:  $261,2 \pm 33,8$  ml and  $533,1 \pm 131,6$  ml ( $p < 0,05$ ). Data on the volume of blood loss are presented in *Table 1*.

In the comparison group, donor blood and plasma were used at all stages of the operation in 90 (100%) patients and in the intensive care unit in 48 (53,3%) patients. At the same time, in the comparison group, 24052 ml of erythrocyte mass were transfused in the operating room, which is 267.2 ml per person, and 30585 ml of fresh frozen plasma, which also corresponds to 340 ml per person. A total of 32317 ml of erythrocyte mass were used in this group, which in terms of 359 ml per patient and 44510 ml of fresh frozen plasma, which translates into 495 ml per patient.

An important criterion for the oxygen capacity of the blood was the level of hemoglobin at the correction stages. The dynamics of changes in hemoglobin indices at all stages in both the main group and in the comparison group is presented in *Table 2*.

As follows from the data of *Table 2*, in all groups at all stages of correction, the hemoglobin value was adequate and corresponded to the safe level of oxygen capacity of blood, as evidenced by the absence of multi-organ failure and clinically significant complications at the hospital stage. There were no lethal cases in the analyzed groups at the hospital stage.

**Table 1. Intraoperative blood loss in cardiosurgical patients and drainage exudation in ICU**

	Main group (n=227)	% of BCC	Comparative group (n=90)	% of BCC
Intraoperative blood loss (ml)	185,5±34,4	4,1±0,6	421,1±83,5*	8,9±1,8
Exudation by drainage (ml)	75,7±39,4	1,3±0,5	112,0±48,1	2,3±1,0
Total (ml)	271,2±33,8	5,4±1,5	533,1±131,6*	11,2±2,8
* – p<0,05				



**Table 2. Dynamics of changes in Hb (g/l) in the reservation and comparison groups at all stages**

Groups	Stages						
	start of anesthesia	start of operation	start of CPB	end of CPB	end of operation	2 days after the operation	discharge
Option «A» (n=293)	135,5±16,0	130,5±16,8	96,2±16,0 *	90,2±13,7	108,3±14,4*	115,5±18,9*	110,9±13,0
Option «A+B» (n=46)	131,2±15,3	128,7±16,6	99,5±11,2*	95,1±12,2	115,4±9,7*	128,4±16,9*	107,0±18,0
Option «A+C» (n=143)	139,8±16,1	132,2±14,8	99,5±11,9*	95,1±11,8*	109,5±11,9*	127,2±16,0*	110,8±13,1
Option «A+B+C» (n=56)	140,4±12,1	131,3±15,9	103,1±14,6*	96,1±9,2*	116,3±9,8*	131,5±18,6*	120,0±10,9
Option C» (n=70)	133,8±11,8	133,9±17,6	98,7±10,5*	93,4±10,4*	110,4±8,1*	124,6±19,5*	109,1±11,1
Comparison group (n=90)	136,0±15,7	130,1±11,7	90,1±12,5	87,2±11,4	102,9±12,0	111,1±9,8	111,8±14,7

**Discussion**

Routinely introduced into clinical practice the above-described technique of bloodless surgery in MPI compensation under CPB allowed us to get a good clinical effect, without transfusion complications during hospital stay. The probability of its use is reduced in patients with a weight of 60 kg or less, the presence of anemia (hemoglobin 110 g / L and less) and in the older age group (65 years and older). With sufficient caution should be used bloodless technique in patients with multiple organ failure, the initial significant brain damage after previous impaired cerebral circulation.

The criterion indication for reserving intraoperative autologous blood during surgical correction operations mitral defects under CPB are:

a) anamnestic – no history of anemia and withdrawal of drugs that affect blood clotting 7 days before surgery;

b) initial laboratory parameters: hemoglobin  $\geq 120$  g / l, hematocrit  $\geq 40$ , platelets  $\geq 170 \times 10^9$  / l, erythrocytes  $\geq 4,0 \times 10^{12}$  / l, protein  $\geq 60$  g / l;

c) indicators of hemodynamics after the initial anesthesia: CVP  $\geq 4$  mm Hg.t. and mean BP  $\geq 90$  mm Hg, with initial bcc  $\geq 4.4 \pm 0.7$  l.

The applied variants of intraoperative redundancy of autoblood in surgical correction of mitral defects in conditions of infarction in complex with other methods have shown their effectiveness, which made it possible to abandon the use of donor blood and its components. The most optimal indicators were observed with the “A + B + C” reservation option and a statistically significant increase in the platelet count at the time of discharge was 20.4% compared to baseline data (p <0.05).

Exfusion of blood in the volume of 10–29% of the bcc during surgical correction of mitral heart defects in CPB conditions does not lead to a reduction in oxygen delivery and consumption and the development of lactic acidosis. The hemodynamic parameters remained stable.

Indices of BGA of autoblood collected on glucuricide are much better than BGA of donor blood. In the exfused autoblood, as a result of leaving the vascular bed and entering non-physiological storage conditions in a sodium citrate-based medium, as in donor EB, primary abnormalities occur that differ sharply from the physiological norm. Perfuzate reserved after heparinization in a container without citrate anticoagulant is stored in more physiological conditions. The absence of allogemotransfusions in the patients of the main group contributed to a reduction in the number of postoperative infectious complications from 7.7% to 1.2% relative to the comparison group.

The duration of mechanical ventilation and the length of stay in the ICU in the main group relative to the comparison

group decreased (p <0.05). All these indicators and a significant decrease in intraoperative and postoperative blood loss in the main group relative to the comparison group improved the results of surgical correction of mitral defects.

**Conclusion**

The blood saving methods of during open heard surgery was improved:

– for infusion–transfusion therapy (stimulation of diuresis, control of water balance, combination of ONG and CPB, and reduction of hemodilution due to autograft retrograde filling of the oxygenator);

– perfection of autoblood exfusion methods and their combination, change in the tactics of infusion hemostatic therapy;

– monitoring of CVP and maintenance of MAP with various methods of autoblood exfusion – all this increased the quality of surgical treatment of MD in conditions of CPB.

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