Journal of Life Science and Biomedicine
JLSB ISSN 2251-9939
Volume 14, Issue 2: 38-44; June 25, 2024
DOI: https://dx.doi.org/10.54203/jlsb.2024.4

Morphometric study of peripheral blood in assessing the appropriateness of colloid use after mitral valve replacement

Ravshan Aliyevich IBADOV, Sukhrob Panjio'g'li ERGASHEV, and Sardor Khamdamovich IBRAGIMOV

State Institution "Republican Specialised Scientific and Practical Medical Centre for Surgery named after academician V.Vakhidov"., Tashkent, Uzbekistan

Corresponding author's Email: dr.sardor.ibragimov@gmail.com

RESEARCH ARTICLE
PII: S225199392400004-14
Received: February 19, 2024
Revised: June 12, 2024
Accepted: June 15, 2024

ABSTRACT: The study aimed to evaluate the morphological changes in erythrocytes following the administration of various solutions. Patients who underwent mitral valve (MV) replacement were divided into three groups: the first group received Hydroxyethylcellulose (HEC), the second received gelatin solution (4% succinylated gelatin solution), and the third received 0.9% sodium chloride solution. Blood samples were collected at 90 minutes, 24, and 48 hours post-resuscitation (ICU), and before discharge. Healthy patients' blood served as the control. The express technique of the "thick drop" (EMTD) was used to assess erythrocyte shape shifts, measuring the ratio of normal and pathological forms within 10-15 minutes using a DN-300M microscope. Before using the solutions, the pathological forms of erythrocytes were significantly higher in all groups compared to the control group. The control group had over 89.8% discocytes, while the number significantly decreased in MV patients pre-operation. Post-treatment with HEC, and gelatin solution, the number of discocytes increased slightly, whereas the third group (sodium chloride) showed no significant change. The number of echinocytes and stomatocytes varied across the groups, with the third group showing minimal improvement. The findings indicated that HEC and gelatin solution improved the ratio of discocytes to pathological forms better than sodium chloride. The most promising plasma-stimulating agents for surgical patients, particularly those with heart disease, are colloids and balanced crystalloid solutions. Their composition closely mimics blood plasma, providing optimal hemodynamic stability and tissue perfusion, thus supporting better postoperative recovery and critical care management.

KEYWORDS: Erythrocyte Morphology, Mitral Valve Replacement, Colloid Solutions, Crystalloid Solutions, Postoperative Hemodynamics

INTRODUCTION

Infusion therapy has become a major component in the treatment of critically ill patients in many areas of surgery [1, 2]. More than 30% of all hospitalized patients, or over 30 million people per year, receive intravenous solutions [3, 4]. However, despite almost a century of use of infusion solutions in medical practice, the dependence of the outcome in critically ill patients on their composition has only recently been demonstrated. At the same time, their potential negative effects have also become apparent [2]. This has led to the realization that infusion solutions are drugs that differ in pharmacodynamic and pharmacokinetic properties, efficacy and safety, and require an appropriate approach to selection, use and monitoring [1]. It has become clear that the choice of infusion solutions should be determined by the indications for use and individual characteristics of patients, and their unjustified use should be avoided [3]. Infusion solutions, like other drugs, must be administered in the optimal dose and for the optimal period of time [3].

The purpose of the study was to evaluate the characteristics of morphological changes in erythrocytes after the use of various solutions.

MATERIAL AND METHODS

To conduct the study, we divided patients after mitral valve replacement (MV) into 3 groups:

- The first group: patients received Hydroxyethylcellulose (HEC);
- The second group: received gelatin solution (4% succinylated gelatin solution) (also known as modified liquid gelatin);
- The third group received 0.9% sodium chloride solution (physiological or isotonic solution).

All collected blood samples were taken 90 minutes, 24 and 48 hours after resuscitation (ICU), as well as in the palate before the patient's discharge, after the introduction of the necessary fluids. Also, blood samples were taken from all three groups of patients before the introduction of solutions. This helped us to accurately assess the changes occurring in the peripheral blood after the introduction of solutions.

The blood of healthy patients with no history of diseases or surgical interventions was taken as a control group.

To assess the shape shifts of peripheral blood erythrocytes, we used a technique developed in the laboratory of pathological anatomy of the State Institution "RSSPMCS named after academician V.Vakhidov" of the Republic of Uzbekistan for studying discrete structures - the express technique of the "thick drop" (EMTD) for practical and scientific purposes. EMTD allows you to assess the ratio of normal and pathological forms of erythrocytes within 10-15 minutes. Based on this, it is possible to monitor the state of erythrocytes and assess the effectiveness of the measures taken. For this, 2 drops of blood are fixed for 3-4 minutes in 1 ml of 2.5% glutaraldehyde solution. Then a drop of fixed blood is placed on a glass slide. A cover glass is lowered horizontally onto it, under which a layer, a "thick drop", is formed, suitable for examination using a light microscope equipped with a digital camera. The ratio of erythrocyte shapes was calculated at a magnification of 10x60 with a sample of at least 1000 erythrocytes for each stage and series of the study, recording the results on a digital camera with subsequent data storage on a computer using Microsoft applications - "Windows 10 pro". Erythrocyte studies were conducted using a DN-300M microscope. Light-optical microphotographs were obtained on a DN-300M microscope coupled with a digital camera and a computer.

Table 1. Dividing patients into study groups

Groups	Number of patients (n)	Test solution
Control group	10	Group without infusion therapy
Group I	15	HEC
Group II	15	Gelatin solution (4% succinylated gelatin solution)
Group III	15	0.9% NaCl solution

RESULTS

According to the results of the study, it was found that the number of pathological forms of erythrocytes in the three above-mentioned groups is significantly higher compared to the control group before the use of various solutions. The calculations of the ratio of discocytes and pathological forms of erythrocytes in the peripheral blood of the control group (norm) showed that discocytes are the dominant type in the peripheral blood. They made up more than 89.8%. Echinocytes - 2.8%, Stomatocytes - 2.2%, erythrocytes with a crest - 3.7%, irreversible forms 1.5% (Figure 1, Table 2). When studying the forms of erythrocytes in patients with MV prosthetics, it was revealed that before the operation, all patients have a significant decrease in the number of discocytes to 76.5 ± 1.0%, which reflects an increase in the number of pathologically deformed erythrocytes by an average of 13.3 ± 1.5% of the permissible value (Figure 1).

At the 90th minute of the study

In group I (administration of the HEC solution): an increase in the number of discocytes was noted from 76.5±1% to 78.7±1% compared to the state before the solution was used. This indicator was from 76.5±1% to 79.5±1% in group II (administration of the Gelatin solution solution). In group III, it remained virtually unchanged.

It was found that the number of echinocytes in groups I and II decreased by an average of 1.24 times compared to the previous situation without the use of the solution. It can be noted that this indicator increased by 3.4 times compared to the control group. The number of stomatocytes increased from 4.4±0.4% to 5.7±0.4% in group I and from 4.4±0.4% to 4.8±0.4% in group II compared to the state before the solution was used. It was found that in group III it increased to 5.8±0.2%.

Citation: Ibadov RA, Ergashev SP, and Ibragimov SK. Morphometric study of peripheral blood in assessing the appropriateness of colloid use after mitral valve replacement. *J Life Sci Biomed,* 2024; 14(2): 38-44. DOI: https://dx.doi.org/10.54203/jlsb.2024.4

The number of erythrocytes did not change.

Irreversible forms in groups I and II decreased by 1.5 times (from 3.2±0.01% to 2±0.01%) compared to the previous situation without the use of solutions. In group III, this indicator remained unchanged (Table 2).

During this period, if we pay attention to the morphology of erythrocytes, we note the predominance of pathological forms of erythrocytes (PFE) in all three groups (Figures 2 and 3).

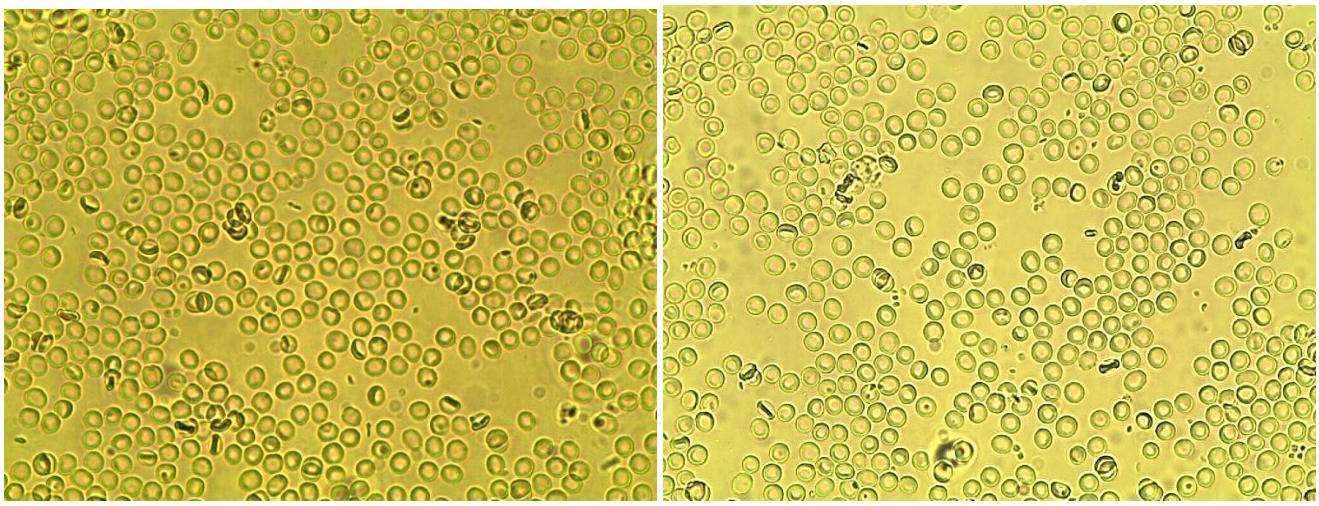

Figure 1. Erythrocytes in the norm, dominance of discocytes. EMTD. 10×10

Table 2. Morphological changes in peripheral blood (90 minutes) after the introduction of different solutions

Form of red blood cells	Norm, n=10	Group I, n=15	Group II, n=15	Group III, n=15
		90 minutes after applying the solutions		
Discocytes, %	89.8±0.5	78.7±1	79.5±1	75.3±1
Echinocytes, %	2.8±0.3	9.3±0.5	9.5± 0.1	10.7±0.1
Stomatocytes, %	2.2±0.05	5.7±0.4	4.8± 0.2	5.8±0.2
Red blood cells with a ridge, %	3.7±0.02	4.3±0.03	4.2±0.1	5.2±0.1
Irreversible forms, %	1.5±0.05	2±0.01	2±0.1	3±0.1

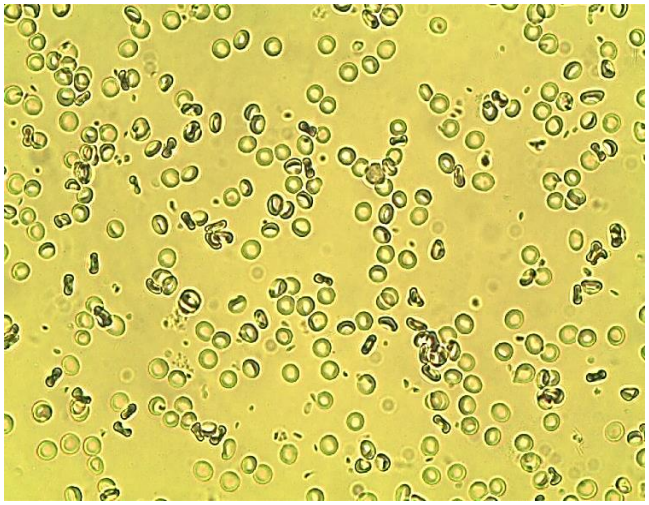

Figure 2. Relative predominance of PFE. The period after MV replacement. 90 minutes after infusion therapy. Group I. EMTC 10x10

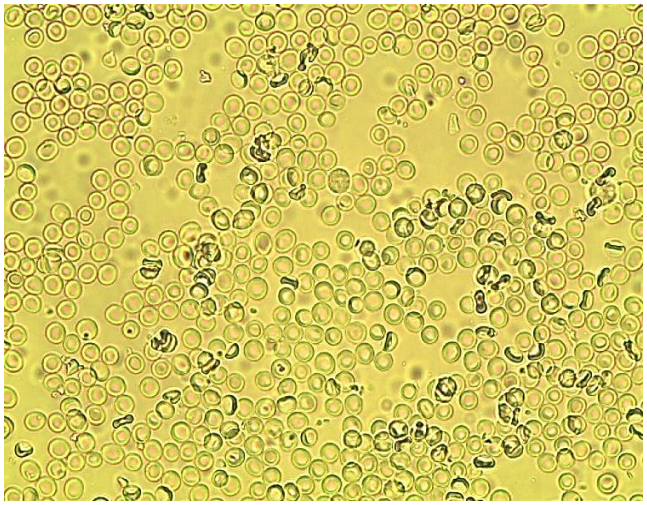

Figure 3. Relative predominance of PFE. The period after MV replacement. 90 minutes after infusion therapy. Group II. EMTC 10x10

At 24 hours of the study

In groups I and II: the number of discocytes improved compared to the previous state without the use of solutions and began to approach the indicators of the control group. In group III, these indicators remained close to the initial state without the use of solutions and amounted to 77.2 ± 1%. It was found that the number of echinocytes in groups I and II decreased on average by 0.76 times compared to the previous situation without the use of solutions. It can be noted that this indicator increased by 3.1 times compared to the control group. In group

III, these indicators remained close to the previous state without the addition of solutions. The number of stomatocytes increased from 4.4 ± 0.4% to 4.9 ± 0.4% in group I and from 4.4 ± 0.4% to 3.9 ± 0.4% in group II compared to the state before the use of solutions. But this decrease was observed compared to 90 minutes. In group III by this time it was 4.7±0.2%. This indicator was close to the indicators of groups I and II after 90 minutes of examination. The number of erythrocytes with a crest was close to the control group. Irreversible forms decreased by 1.45 times compared to the previous situation without adding solutions (Table 3).

By this time, the morphology of erythrocytes in group I, the ratio of D and PFE were relatively equal. In group II, an increase in the number of discocytes was noted compared to their pathological forms. But the pathological forms were more pronounced than in the control group (Figure 4, 5). In group III, the situation was close to that before the use of solutions, the prevalence of pathological forms of erythrocytes remained (Figure 6).

Table 2. Morphological changes in peripheral blood (after 24 hours) after the introduction of different solutions

Form of red blood cells	Norm. n=10	Group I. n=15	Group II. n=15	Group III. n=15
		24 hours after applying the solutions		
Discocytes. %	89.8±0.5	80.7±1	81.9±1	77.2±1
Echinocytes. %	2.8±0.3	8.3±0.5	8.7±0.5	11.8±0.1
Stomatocytes. %	2.2±0.05	4.9±0.4	3.9±0.4	4.7±0.2
Red blood cells with a ridge. %	3.7±0.02	3.3±0.03	3.3±0.03	3.2±0.1
Irreversible forms. %	1.5±0.05	2.8±0.01	2.2±0.01	3.1±0.1

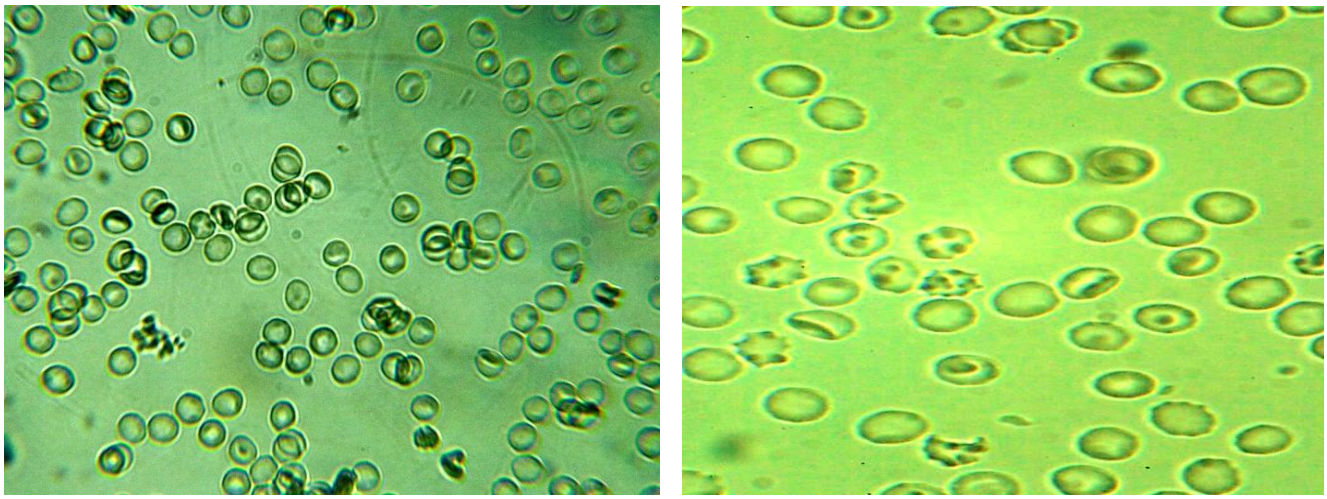

Figure 4. Significant decrease in PFE (pathological form of erythrocytes). Period after mitral valve (MV) prosthetics. 24 hours after infusion therapy. Group I. EMTD 10×10.

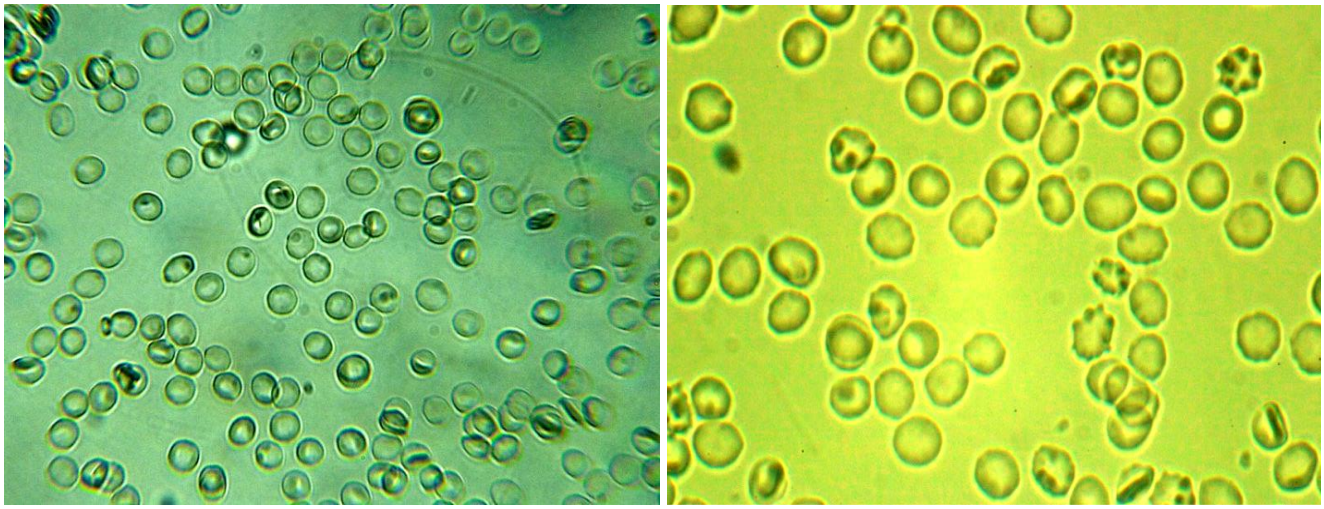

Figure 5. Equal ratios of the number of pathological and normal forms of erythrocytes. Reduction in the number of pathological forms of erythrocytes in peripheral blood. The period after MV prosthetics. 24 hours after infusion therapy. Group II. EMTD 10×60

Citation: Ibadov RA, Ergashev SP, and Ibragimov SK. Morphometric study of peripheral blood in assessing the appropriateness of colloid use after mitral valve replacement. *J Life Sci Biomed,* 2024; 14(2): 38-44. DOI: https://dx.doi.org/10.54203/jlsb.2024.4

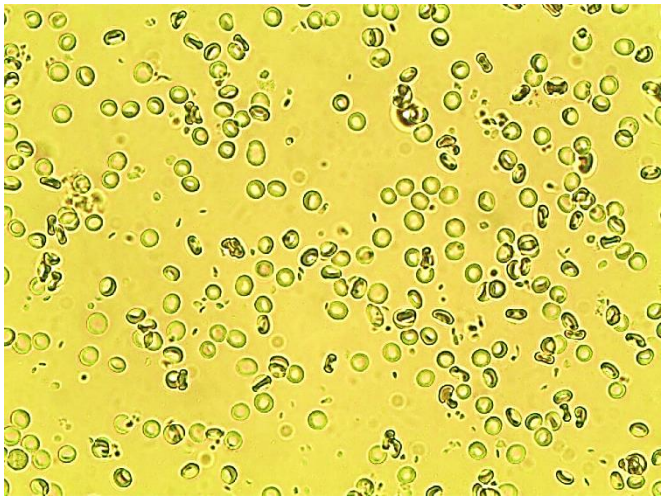

Figure 6. Signs of significant superiority of PFE. Period after MV replacement. 24 hours after infusion therapy. Group III. EMTC 10×10

Summarizing the results of the above analysis, it can be said that there is no doubt that infusion solutions are true drugs, this suggests an appropriate approach to their use.

As a result of our study:

- under the influence of GEC, the improvement of the D/PFE ratio in favor of discocytes began from the 24th hour of the experiment;

- in the group receiving gelatinol, it began from the 90th minute of the experiment and showed more pronounced changes after 1 day (after 24 hours) of testing.

- the improvement in the ratio of the number of discocytes in the blood to pathological forms in patients receiving 0.9% sodium chloride solution changed slowly for almost 2 days (after 48 hours). During these periods, the ratio of pathological forms of erythrocytes remained predominant compared to other groups.

The difference between the quantitative and qualitative ratios of erythrocytes in the studied groups proves that under the influence of 4% succinylated gelatinol solution (also known as modified liquid gelatin) the total volume of blood circulation, blood rheology, viscosity and their morphological state are improved.

Based on the results of the study of the morphology of peripheral blood in the aspect of assessing the effectiveness of the use of colloids after MV prosthetics, high information content of express monitoring of the shape of erythrocytes was determined as a non-specific method of morphological determination of the detection of violations of the volemic status and circulatory hypoxia caused by cardiac surgery, especially during the rehabilitation period after MV prosthetics.

DISCUSSION

As is known, blood is a non-Newtonian fluid: its viscosity decreases with increasing shear rate. At the level of microcirculation, where the blood flow velocity is minimal, viscosity decreases [4, 5]. With intravenous administration of colloids, hemodilution occurs, which reduces blood viscosity, despite an increase in plasma viscosity due to macromolecules. Plasma viscosity affects microcirculation: its decrease reduces vascular resistance, which increases venous return, cardiac output and improves tissue perfusion and oxygenation [6].

Restoration of microcirculation after cardiac surgery, including mitral valve replacement, is critically important for improving the patient's hemodynamic status. The volume of blood loss is compensated for by the use of blood components or blood substitutes with colloidal and crystalloid solutions [7]. Cardiac surgery, especially mitral valve replacement, causes changes in the shape of red blood cells from normal to pathological forms. Rapid restoration of normal cell shape facilitates successful rehabilitation [1]. Crystalloid solutions are often used for infusion therapy in emergency situations, maintenance and replacement therapy. Unlike colloids, they contain low-molecular compounds that diffuse into all fluid compartments of the body [5].

Colloids are more effective in restoring intravascular volume in emergency situations, although their advantage is not as great as previously thought. The ratio of their intravascular volume to the injected volume is on average 1:1.2. Balanced colloidal and crystalloid solutions are recommended for resuscitation, especially in patients with severe hypovolemia [8]. Sodium chloride solution 0.9% increases interstitial volume, which can cause organ edema and peripheral edema. It is suitable for small infusions or as a solvent for injection drugs [9].

As a result of our studies, the improvement in the ratio of the number of discocytes in the blood to pathological forms in patients receiving 0.9% sodium chloride solution changed slowly in periods up to 48 hours after surgery. During these periods, the ratio of pathological forms of erythrocytes remained predominant compared to other groups.

CONCLUSION

The most promising plasma-stimulating agents for use in surgical patients, especially those with heart disease, including cardiac surgery patients in both their postoperative and critical conditions, are colloids and balanced crystalloid solutions. These solutions are preferred due to their composition, which closely mimics that of blood plasma, thereby enhancing both efficiency and safety. Colloids, due to their ability to effectively restore intravascular volume, and balanced crystalloids, with their low-molecular-weight ions and electrolytes that ensure better diffusion across fluid compartments, provide optimal hemodynamic stability and tissue perfusion. This balance helps minimize complications and supports better postoperative recovery and critical care management.
Future studies should focus on comparing assessing which is more effective and safer for cardiac surgery patients, examining the lasting impact on cardiovascular health and recovery, developing tailored fluid management strategies based on individual patient needs and exploring new plasma-stimulating agents and their potential benefits.

DECLARATIONS

Corresponding author

Correspondence and requests for materials should be addressed to Sardor Kh. Ibragimov, MD, PhD, Senior Research Fellow, Intensive Care Unit, Republican Specialized Scientific and Practical Medical Center for Surgery named after academician V. Vakhidov, Tashkent, Uzbekistan.

Phone: +99-890-327-92-89;
E-mail: dr.sardor.ibragimov@gmail.com;
ORCID: https://orcid.org/0000-0003-2876-411X

Acknowledgements

This work was supported by State Institution "Republican Specialized Scientific and Practical Medical Center for Surgery named after academician V.Vakhidov", Uzbekistan.

Authors contributions

All authors contributed equally to this work.

Funding support

None.

Competing interests

All authors declare that they have no conflict of interest.

Ethical approval

The review board and ethics committee of Republican Specialized Scientific and Practical Medical Center for Surgery named after academician V. Vakhidov approved the study protocol and informed consents were taken from all the participants.

REFERENCES

[1] Kirov MY, Kuzkov VV, Lapin KS. Volumetric Monitoring and Extravascular Lung Water in Perioperative Setting and Critically Ill. Turk J Anaesthesiol Reanim. 2021 Jun;49(3):201-210. doi: 10.5152/TJAR.2021.21382.

[2] Casey JD, Brown RM, Semler MW. Resuscitation fluids. Curr Opin Crit Care. 2018 Dec;24(6):512-518. doi: 10.1097/MCC.0000000000000551.

[3] Al-Ghamdi AA. Intraoperative fluid management: Past and future, where is the evidence? Saudi J Anaesth. 2018 Apr-Jun;12(2):311-317. doi: 10.4103/sja.SJA_689_17.

[4] Simmons JW, Dobyns JB, Paiste J. Enhanced Recovery After Surgery: Intraoperative Fluid Management Strategies. Surg Clin North Am. 2018 Dec;98(6):1185-1200. doi: 10.1016/j.suc.2018.07.006.

[5] Ushkalova EA, Zyryanov SK, Zatolochina KE, Butranova OI. Infusion fluids: a clinical pharmacologist's view. Russian Journal of Anesthesiology and Reanimatology. 2021;(6):100-106. (In Russ.). https://doi.org/10.17116/anaesthesiology2021061100

[6] Mkalaluh S, Szczechowicz M, Dib B, Szabo G, Karck M, Weymann A. Outcomes and predictors of mortality after mitral valve surgery in high-risk elderly patients: The Heidelberg experience. Med Sci Monit. 2017;23:6193-6200. doi:10.12659/msm.906003

[7] Silva-Jr JM, Menezes PFL, Lobo SM, de Carvalho FHS, de Oliveira MAN, Cardoso Filho FNF, Fernando BN, Carmona MJC, Teich VD, Malbouisson LMS. Impact of perioperative hemodynamic optimization therapies in surgical patients: economic study and meta-analysis. BMC Anesthesiol. 2020 Mar 31;20(1):71. doi: 10.1186/s12871-020-00987-y

[8] Lewis SR, Pritchard MW, Evans DJ, Butler AR, Alderson P, Smith AF, Roberts I. Colloids versus crystalloids for fluid resuscitation in critically ill people. Cochrane Database Syst Rev. 2018 Aug 3;8(8):CD000567. doi: 10.1002/14651858.CD000567.pub7.

[9] Malbrain ML, Marik PE, Witters I, Cordemans C, Kirkpatrick AW, Roberts DJ, Van Regenmortel N. Fluid overload, de-resuscitation, and outcomes in critically ill or injured patients: a systematic review with suggestions for clinical practice. Anaesthesiol Intensive Ther. 2014 Nov-Dec;46(5):361-80. doi: 10.5603/AIT.2014.0060.