DOI:10.34084/bshr.1331273 e-ISSN 2587-1641

Journal of Biotechnology and Strategic Health Research

Araştırma Makalesi /Research Article

http://dergipark.org.tr/tr/pub/bshr

Evaluation of Current Professional Practices of Perfusionists: Survey Study

Perfüzyonistlerin Güncel Mesleki Uygulamalarının Değerlendirilmesi: Anket Çalışması

Bişar Amaç[1], Murat Ziya Bağış[2]

[1] University of Health Sciences, Sanliurfa Mehmet Akif Inan Training and Research Hospital, Department of Perfusion, Sanliurfa, Türkiye

[2] University of Health Sciences, Sanliurfa Mehmet Akif Inan Training and Research Hospital, Department of Cardiovascular Surgery, Sanliurfa, Türkiye

ORCID ID: Bişar Amaç: https://orcid.org/0000-0003-0320-4239, Murat Ziya Bağış: https://orcid.org/0000-0002-4088-7510

***Sorumlu Yazar / Corresponding Author:** Bişar Amaç, **e-posta / e-mail:** amacbisar@gmail.com

Geliş Tarihi / Received : 22-07-2023 **Kabul Tarihi / Accepted:** 17-12-2023 **Yayın Tarihi / Online Published:** 31-12-2023

Amaç B., Bağış MZ. Evaluation of current professional practices of perfusionists: Survey study, J Biotechnol and Strategic Health Res. 2023;7(4):239-248

Abstract

Aim Cardiac surgical procedures performed with extracorporeal circulation or perfusion techniques retain their importance in treating heart disease and often represent an alternative method. This survey aimed to identify and evaluate the current practice of perfusionists in cardiovascular surgery clinics in Turkey.

Material and Method This study is a prospective and descriptive etiological study. Surveys regarding the current practices of perfusionists were created as part of the study. The created surveys were sent to perfusionists in Turkey voluntarily through the application "Google Forms", and the data were collected. The data obtained from the surveys were statistically analyzed.

Results In this study, 80 perfusionists from 28 centres participated in the survey. Thirty-four participants were under 30 years old, 12 were between 31 and 35 years old, 16 were between 36 and 40 years old, and 18 were over 40 years old. Of the participants, 46 were female and 34 were male. The study collected descriptive data, information on cardiac clinics, cardiopulmonary bypass practices, use of cardioplegia, and other assistive devices.

Conclusion There have been significant advances and changes in cardiac surgery surgeries performed with cardiopulmonary bypass over approximately 70 years from the past to the present. However, we believe that there are ongoing or pending issues.

Keywords Cardiopulmonary bypass, Current Practices, Perfusionist, Survey

Özet

Amaç *Ekstrakorporeal dolaşım teknikleri veya perfüzyon teknolojisi kullanılarak gerçekleştirilen kardiyak cerrahi, kalp hastalıklarının tedavisinde önemini korumakta ve çoğu zaman alternatifi olmayan bir yöntemdir. Bu anket çalışmasında, Türkiye'de kalp damar cerrahisi kliniklerinde çalışan perfüzyonistlerin güncel uygulamamalının belirlenmesi ve değerlendirilmesi amaçlandı.*

Gereç ve Yöntem *Bu araştırma prospektif ve tanımlayıcı nitelikte etyolojik bir çalışmadır. Çalışmada, perfüzyonistlerin güncel uygulamaları ile ilgili anket soruları oluşturuldu. Oluşturulan anket soruları "Google Forms" uygulaması üzerinden Türkiye'deki perfüzyonistlere elektronik ortamda gönüllülük esasına göre gönderildi ve veriler toplandı. Anketten elde edilen veriler istatistiksel olarak analiz edildi.*

Bulgular *Yapılan bu çalışma anketine 28 merkezden toplam 80 perfüzyonist katıldı. Katılımcıların 34'dü 30 yaş ve altı, 12'si 31-35 yaş aralığında, 16'sı 36-40 yaş aralığında ve 18'sı 40 yaş üstündeydi. Katılımcıların 46'sı kadındı ve 34'ü erkekti. Bu çalışmada; tanımlayıcı veriler, kalp kliniklerine ait bilgiler, kardiyopulmoner bypass uygulamalarına ait bilgiler, kardiyopleji kullanımı ve diğer yardımcı ekipmanlara ait bilgiler elde edildi.*

Sonuç *Kardiyopulmoner bypass eşliğinde yapılan kalp cerrahisinde, geçmişten günümüze yaklaşık 70 yıllık bir süreçte önemli ilerlemeler ve değişiklikler olmuştur. Ancak hala devam eden veya çözülmesi gereken sorunlarında olduğunu düşünmekteyiz.*

Anahtar Kelimeler *Kardiyopulmoner bypass, Güncel Uygulamalar, Perfüzyonist, Anket*

INTRODUCTION

Cardiac surgery procedures performed using extracorporeal circulation techniques (cardiopulmonary bypass (CPB) in cardiac surgery) retain their importance in treating heart disease and are often an alternative method. CPB is defined as the temporary cessation of cardiac and pulmonary functions during cardiac and aortic surgical procedures and the continuation of these functions by the heart-lung machine.[1] The existence of the heart-lung machine is the result of many developments. Despite the first investigators who designed the circuit to an oxygenator outside the body and pumped it to perform intracardiac surgery are unknown, the 1885 publication by Frey and Gruber is a notable early attempt to build a gas exchange machine.[2] The primitive pump and oxygenator designs that emerged from the work of physiologists and engineers in the late 19th century were the precursors to the great work of DeBakey in developing roller pumps and of Gibbon in developing oxygenators.[2] The advent of the CPB machine and its ability to allow blood flow made open heart surgery possible in humans. On May 6, 1953, the first successful use of the heart-lung machine was performed by Dr Gibbon (John Heysham Gibbon, Jr.) on an 18-year-old woman named Cecilia Bavolek.[3]

Today, perfusionists are responsible for the management of the heart-lung machine. They also play an important role in managing extracorporeal circulation devices. Nevertheless, in the early years of CPB, the heart-lung machines were managed by surgeons (usually assistants) and laboratory technicians in research laboratories. Later, this task was gradually taken over by "technicians" from various fields trained "on the job.".4 In 1964, a group of "perfusionists" (a designation attributed to Bennett Mitchell) met, and in 1968 they formed the American Society of ExtraCorporeal Technology (AmSECT). In the late 1960s and early 1970s, the need for perfusionists increased dramatically with the advent of coronary artery surgery and more successful valve surgery.[4] In 1974 AmSECT established the American Board of Cardiovascular Perfusion (ABCP). The first undergraduate perfusion program was founded by James Dearing at Ohio State College in 1969, and Charles Reed founded the famous Texas Heart Institute School of Perfusion in 1971. In 1991, the European Cardiovascular Perfusion Board was established.[4] In Turkey, on the other hand, the law enacted in 2011 created the legal basis for the perfusionist profession.[5] However, organizational structuring in Turkey began with establishing of the Perfusionist Association in 1997.[6] Even though the development of cardiovascular perfusion historically arose from the need for CPB, the recent development of extracorporeal assist technology or perfusion technology has led to its expansion beyond the traditional field.[1,7,8] The profession of perfusionist will retain its importance soon. Developments in science and technology will bring absolute changes in the practice of the perfusionist. The qualification, knowledge, duties and responsibilities of the clinical perfusionist and the professional profile of the perfusionists are in a clear and current evolution in terms of competence.[7,8]

This review study aims to identify and evaluate the current practice of perfusionists working in cardiovascular surgery clinics in Turkey. This study is a prospective and descriptive etiological study.

MATERIALS and METHODS

This research is a prospective and descriptive etiological study. Approval was obtained from the Clinical Research Ethics Committee of Harran University for this study without drugs (date: 11.14.2022 - approval number: HRÜ/22.22.16). Voluntary informed consent was obtained from all participants prior to the study. This study was conducted under the principles of the Declaration of Helsinki.

Data Collection Tools and Data Analysis

Current practice surveys were created in this study. The created surveys were sent to the perfusionists in Turkey voluntarily in an electronic environment (on the Internet) between January 19 and February 02, 2023, using the

"Google Forms" application, and the data were collected. The data obtained from the surveys were recorded and analyzed by statistical analysis. The statistical analyzes in our study were performed using the SPSS® computer program. Frequency and percentage analyzes were performed for nominal data.

Inclusion and Exclusion Criteria

Those having the Perfusionist profession authority specified in the Law of the Republic of Turkey, numbered 1219, on the style of the practice of medicine and medical arts, and those working as active perfusionists in the public or private sector in Turkey at the time of the survey were included in the study voluntarily.

RESULTS

In this study, 80 perfusionists from 28 centres participated in the survey. Thirty-four participants were under 30 years old, 12 were between 31 and 35, 16 were between 36 and 40, and 18 were over 40. Of the participants, 46 were female and 34 were male. Information on their educational attainment status, the institution they work for, and their years of employment can be found in Table 1.

Number of perfusionists in the clinic, number of perfusionists involved in the cases, presence of written CPB protocol in the clinic, make/model of cardiopulmonary machine used, type of arterial pump head of cardiopulmonary machine, type of tubing set/oxygenator used, integrated cardiopulmonary machine, presence of online blood gas/electrolyte tracking system, presence of cardiopulmonary machine, electronic venous occlusion, and information on CPB safety systems used are given in Table 2.

Table 1. Descriptive data (Demographic information)

		N	%
Number of perfusionists surveyed		80	100
Number of heart centres of participating perfusionists		28	100
Age range (Year)	**≤30**	34	42.5
	31-35	12	15
	36-40	16	20
	>40	18	22.5
Gender	**Male**	34	44.5
	Female	46	57.5
Education certificate status	**Bachelor's degree in perfusion**	20	25
	Perfusion graduate diploma	52	65
	Perfusionist authorization certificate	8	10
Institution Employed	**MH Training and Research Hospital**	54	67.5
	MH Public Hospital	8	10
	MH Heart Branch Hospital	2	2.5
	University Hospital	10	12.5
	Private Hospital	6	7.5
Working time as a perfusionist (Year)	**≤1**	10	12.5
	2-5	32	40
	6-10	14	17.5
	>10	24	30

Table 2. Cardiac clinic information			
		N	%
Number of perfusionists in the clinic	**≤1**	4	5
	2-5	36	45
	6-10	36	45
	>10	4	5
How many perfusionists enter cases in the clinic	**1 Person**	24	30
	2 Persons	56	70
Presence of written CPB protocol in the clinic	**Available**	40	50
	None	40	50
Heart-lung machine brand/model used	**Stockert S3**	6	7.5
	Stockert S5	38	47.5
	Corin C5	18	22.5
	Quantum	2	2.5
	Terumo system1	4	5
	Maquet HL 20	8	10
	Maquet HL 40	4	5
CAM artery pump head type	**Roller pump**	80	100
	Centrifugal pump	0	0
Type of tubing set/oxygenator used	**Membrane oxygenator with integrated arterial filter**	72	90
	Membrane oxygenator with non-integrated arterial filter	8	10
Presence of CAM integrated online blood gas/electrolyte tracking system	**Available**	10	12.5
	None	70	87.5
Presence of CAM electronic venous occlusion	**Available**	68	85
	None	12	15
CPB security systems used (Multiple options selected)	**Level sensor**	80	100
	Bubble sensor	54	67.5
	Flowmeter	12	15
	Pressure gauge	46	57.5
N: Number; %:Percentage ratio; CPB: Cardiopulmonary bypass; CAM: Heart-lung machine.			

The routinely used primary solution, crystalloid solution, natural colloid solution, artificial colloid solution, the content of the primary solution, the temperature at which priming is performed, the status of reduction of the crystalloid or colloid solution, and the amount of red blood cell suspension (ES) added to the primary solution, The status of changing the primary solution according to the patient's comorbidities, the routine use of the carbon dioxide flash method, the CPB initial hematocrit value (Hct), the CPB minimum initial value ACT, the frequency of active clotting time (ACT) and blood gas monitoring during CPB, and the CPB application temperature are given in Table 3.

Cardioplegia delivery method, cardioplegia delivery method/route, routinely used cardioplegia solution, combined cardioplegia use, cardioplegia frequency time, hemocondenser, cytokine filter, cell saver, extracorporeal membrane oxygenation (Extracorporeal membrane oxygenation.) membrane oxygenation=ECMO) and minimally invasive extracorporeal circulation (minimally invasive extracorporeal circulation=MiECC), the type of MiECC and the most common problems during CPB are given in Table 4.

Table 2. Cardiac clinic information

		N	%
The premium solution used routinely	**Crystalloid**	62	77.5
	Colloids	8	10
	Crystalloid-Colloid	10	12.5
The crystalloid solution used routinely	**Ringer's Lactate**	24	30
	Isolayte M	42	52.5
	Isolayte S	6	7.5
	Isotonic	6	7.5
	None	2	2.5
The natural colloidal solution used routinely	**Albumin**	12	15
	Fresh Frozen Plasma	10	12.5
	None	58	72.5
The artificial colloidal solution used routinely	**Voluven**	22	27.5
	Gelofusine	2	2.5
	Dextran 40	0	0
	Dextran 70	0	0
	None	56	70
Routine premium solution content	**Mannitol %20**	80	100
	(Multiple options selected)	80	100
	Heparin	80	100
	Cefazolin	42	52.5
	Magnesium	6	7.5
	Prednol	2	2.5
The temperature at which Prime operation is performed	Hot 37 °C	68	85
Cold 32 oC	**Cold 32 °C**	12	15
Crystalloid or colloid solution reduction status as much as the amount of ES added to the prime solution	**Yes**	52	65
	No	28	35
Prime solution change status according to the comorbidities of the patient	**Yes**	60	75
	No	20	25
Use of carbon dioxide flash method in routine	**Yes**	18	22.5
		62	77.5
CPB input Hct value	**Hct< 20%**	0	0
	Hct< 24%	18	22.5
	Hct< 28%	58	72.5
	From patient to patient	4	5
CPB minimum input ACT value	**400**	2	2.5
	450	8	10
	480	70	87.5
Frequency of ACT and blood gas monitoring during CPB	**Every 20 minutes**	34	42.5
	Every 30 minutes	44	55
	By case	2	2.5
CPB application temperature	**Normothermic**	8	10
	Hypothermic 32 oC	52	65
	Hypothermic 30 oC	14	17.5
	Hypothermic 28 oC	4	5
	Varies by case	2	2.5

N: Number; %:Percentage ratio; CPB: Cardiopulmonary bypass; ES: Erythrocyte suspension; Hct: Hematocrit; ACT: Active clotting time); NaHCO3: Sodium bicarbonate.

Table 4. Information on the use of cardioplegia and other assistive devices

			N	%
Method of applying cardioplegia	**With a pressure bag from the anaesthesia**		36	45
	By pressure bag from perfusion		24	30
	CAM's mini-pumps		20	25
Cardioplegia administration method/way	**Antegrade**		46	57.5
	Redrograde		20	25
	Antegrade - Redrograde		14	17.5
Cardioplegia solution used routinely	**Del Nido**		20	25
	(Multiple options selected)		0	0
	Plejisol (St. Thomas)		2	2.5
	Microplegia		4	5
	Blood cardioplegia		56	70
Combined use of cardioplegia	**Yes**		28	35
	No		52	65
Duration of cardioplegia frequency	**Every twenty minutes**		58	72.5
	Other		2	2.5
	Initial/Single dose		20	25
Use of hemocondenser	**Yes, routine**		6	7.5
	Yes, if there is an indication		48	60
	No		26	32.5
Using a cytokine filter	**Yes, routine**		0	0
	Yes, if there is an indication		20	25
	No		60	75
Cell-saver usage	Yes, routine		4	5
	Yes, if there is an indication		28	35
	No		48	60
ECMO usage	**Yes**		52	65
	No		28	35
If you use MiECC in cardiac surgery, what type of MiECC do you use?	**Yes**	Type I	2	2.5
		Type II	2	2.5
		Type III	0	0
		Type IV	2	2.5
	No		74	92.5
What are the most common problems during CPB? (Asked as an open-ended question)	**Failure to pull the valve**		14	17.5
	Heart not emptying		14	17.5
	Reservoir level low/insufficient		6	7.5
	Venous return problem/insufficiency		6	7.5
	Air embolism		14	17.5
	Line pressure height		14	17.5
	Hypotension		6	7.5
	Dislocation of cannulas		6	7.5

N: Number; %: Percentage ratio; CAM: Heart-lung machine; HTK: Histidine-tryptophan-ketoglutarate solution; ECMO: Extracorporeal membrane oxygenation; MiECC: Minimally invasive extracorporeal circulation; CPB: Cardiopulmonary bypass.

DISCUSSION

When the current practices of perfusionists in Turkey are studied, it is found that the practices are similar in both open heart surgery and extracorporeal circulation. This study aimed to evaluate the current practices of perfusionists. The benefits of this study include the cardiopulmonary machines used by perfusionists today, primary solutions, cardioplegia solutions used and routes of administration, CPB and safety equipment, other extracorporeal circulation devices, and evaluation of problems encountered.

In the 1980 survey of 811 perfusionists practising in North America (United States and Canada), Hessel et al.[4] evaluated the current perfusion practice 25 years after its introduction. As a result of the survey studies, they found that 68% of perfusionists received their on-the-job training, and 76% of them were certified. They found that disposable bubble oxygenators were used in more than 90% of cases, roller pumps in 94%, and arterial filters in 64%. They found that perfusionists used low-level sensors in 45% of cases, oxygen sensors in 26%, and bubble sensors in 10%. They found that two-thirds of perfusionists performed heparinization with ACT before starting CPB, most used moderate hypothermia (26-30oC), and 84% added carbon dioxide to the oxygenator; cold cardioplegia was administered in 99% of cases. Cardioplegia was administered with a pressure bag in 50% of cases (usually by an anesthesiologist).[4] In our study, we tried to determine the current practices of cardio technicians in Turkey 70 years after the introduction of CPB. Although there are serious developments and changes in current practices, it is felt that many problems still await resolution.

In the review study by Hessel et al.[9] on innovations in CPB (It examined the studies carried out between 2017-2018), he noted that some of the issues affecting innovations in CPB are temperature management, anticoagulation, perfusion administration, use of transesophageal echocardiography during CPB, optimal mean arterial pressure, vasoplegia, bleeding, perioperative anaemia, postcardiac transfusion, acute kidney injury, delirium and cognitive decline, CPB during pregnancy, pulmonary management, radial-femoral arterial pressure, gradients during CPB, prophylactic perioperative intra-aortic balloon pump, del Nido cardioplegia, antibiotic prophylaxis, and use of levosimendan in cardiac surgery.[9] In our study, it is seen that perfusionists most frequently face problems such as non-ventilation, low level, venous return, air embolism, pressure rise, and hypotension.

In the article by Kulat et al.10, the American Board (The American Society of ExtraCorporeal Technology (AmSECT)) developed 12 survey questions in 2016, and the survey questions included demographic information, education levels, years of clinical experience, recertification requirement satisfaction. and professional activity requirement satisfaction. They also stated that he conducted a survey in 2017; they stated that this survey focused primarily on perfusionist demographics and staffing issues in the respondents' operating rooms, as well as the respondents' ECMO and ventricular assist device (VAD) staffing situations. The results of both surveys noted that 38.2% and 38% of perfusionists would retire in the next 10 years, respectively. They noted that the workforce is getting older, 29% of the respondents are between 50 and 59 years old, and 15.3% are 60. They also stated positive workforce growth in clinical perfusion, however, this situation should be closely monitored in the future. They stated that supply and demand in perfusion employment are complex, and additional measurements are needed.[10] Our study shows that 77.5% of perfusionists in Turkey are in the age group of 40 years and below, and it is a young population.

It should be noted that cardioplegia solutions (e.g., del Nido) and the MiECC method are among the newest issues that concern perfusionists in CPB surgery. In our survey, we found that a small proportion of participants (approximately 25% del Nido) used single-dose cardioplegia solution, microplegia (approximately 5% microplegia), and MiECC (approximately 7.5% MiECC).

Modern cardiac perfusion technologies' main challenge is achieving optimal biocompatibility for extracorporeal circuits (ECC). Undesirable pathophysiological side effects of conventional CPB circuits on organ systems are triggered by activation of the complement system via foreign surfaces, hemodilution due to priming volume, blood-air contact, and negative and positive reservoir pressures. MiECC circuits have emerged over the last 20 years as an alternative to the more traditional ECC circuits to overcome these effects. The use of MiECC circuits is now increasing.[11] These systems offer several potential advantages by reducing the systemic inflammatory response and subsequent organ dysfunction. To be uniquely characterized as MiECC, the system's major components must include a closed CPB circuit. It should have biologically inert blood contact surfaces, reduced filling volume, a cardioplegia system, a venous bubble trap/air trap, and a blood spill management system.[11] MiECC circuits are classified into four different types with modular components. The classification of MiECC circuits provides a clear description of the different systems and also allows a clear distinction between traditional ECC and MiECC. MiECC provides a physiologically based perfusion strategy rather than just another CPB circuit or a specific product. Therefore, a multidisciplinary approach is essential. Close collaboration and teamwork between surgeons, anesthesiologists, and perfusionists are essential to safely and efficiently implement MiECC concepts.[11,12] Effective teamwork is critical for safe and high-quality care in the operating room. However, it is argued that teamwork interventions do not consistently result in the expected improvements in patient safety or surgical culture.[12] To optimize OR teamwork in a targeted, evidence-based manner, a comprehensive, theory-based assessment of barriers and facilitators from an interprofessional perspective must first be undertaken.[12] In our review study, we hypothesize that the very low rate of MiECC use is due to other reasons that are independent of the individual competencies of perfusionists.

The basic requirement for a good surgical outcome in cardiac surgery is optimal myocardium protection. Microplegia has been studied in isolated coronary artery bypass grafting, heart valve surgery, and more complex procedures. Studies demonstrating the safety and efficacy of microplegia over Buckberg cardioplegia (4:1 blood cardioplegia) revealed that the simplified microplegia technique offers several advantages over Buckberg cardioplegia without compromising myocardial protection or safety during complex, multicomponent surgery with prolonged aortic clamping times.[13] Furthermore, cardioplegia strategies used in adult cardiac surgery cannot be directly applied to pediatric hearts. Pediatric micro plegia, similar to calafiore cardioplegia used in adult cardiac surgery, offers safe myocardial protection without hemodilution. The use of concentration-dependent pediatric microplegia is new to clinical practice. Adapted to the needs of pediatric myocardium, microplegia provides a simple technique for perfusionists while avoiding hemodilution.[14] Our review study shows that microplegia is used to a very small extent (about 5%) in Turkey. We believe technological advances and developments will be much faster in perfusion applications soon. Cardioplegia is an essential and fundamental method for protecting the myocardium of patients of all ages during cardiac surgical procedures requiring cardiac arrest. Additionally, many cardioplegia solutions and application methods have been developed. The Del Nido cardioplegia solution is also increasingly used in today's practice. Del Nido Cardioplegia Solution has been used at Boston Children's Hospital for many years. It consists of a unique formulation of four parts crystalloid and one part whole blood and is typically used as a single dose. Although the formulation was originally developed for pediatric and neonatal patients, it is increasingly used in adult cardiac surgery.[15] Our study shows its use is widespread in adult cardiac surgery in Turkey. It is one of the most commonly used cardioplegia solutions after blood cardioplegia. We believe that single-dose cardioplegia solutions will soon be more widely used, and their volume will be further reduced.

CONCLUSION

Over the past 70 years, significant advances and changes in cardiac surgical procedures performed with CPB have occurred. Nonetheless, we believe that there are still persistent or pending problems. In this review study, it is clear that modern applications (single-dose cardioplegia, microplegia, and MiECC, etc.) are being used in addition to current conventional CPB methods. We believe modern applications will become more widespread, and new developments will emerge shortly.

Ethical Approval

Approval was obtained from the Clinical Research Ethics Committee of Harran University for this study without drugs (date: 11.14.2022 - approval number: HRÜ/22.22.16). Voluntary informed consent was obtained from all participants prior to the study. This study was conducted under the principles of the Declaration of Helsinki.

Peer-review

Externally and internally peer-reviewed.

Authorship Contributions

Concept: B.A., M.Z.B., Design: B.A., M.Z.B., Data collection or Processing: B.A., M.Z.B., Analysis or interpretation: B.A., M.Z.B., Literature Search: B.A., M.Z.B., Writing: B.A., M.Z.B.

Conflict of Interest

The authors declare that they have no conflict of interest.

Funding

This study received no financial support.

References

1. Passaroni AC, Silva MA, Yoshida WB. Cardiopulmonary bypass: development of John Gibbon's heart-lung machine. Rev Bras Cir Cardiovasc. 2015;30(2):235-245. doi:10.5935/1678-9741.20150021
2. Holman WL, Timpa J, Kirklin JK. Origins and Evolution of Extracorporeal Circulation: JACC Historical Breakthroughs in Perspective. J Am Coll Cardiol. 2022;79(16):1606-1622. doi:10.1016/j.jacc.2022.02.027
3. Theruvath TP, Ikonomidis JS. Historical perspectives of The American Association for Thoracic Surgery: John H. Gibbon, Jr (1903-1973). J Thorac Cardiovasc Surg. 2014;147(3):833-836. doi:10.1016/j.jtcvs.2013.11.007
4. Hessel EA 2nd. History of cardiopulmonary bypass (CPB). Best Pract Res Clin Anaesthesiol. 2015;29(2):99-111. doi:10.1016/j.bpa.2015.04.006
5. T.C. Cumhurbaşkanlığı Mevzuat Bilgi Sistemi. https://www.mevzuat.gov.tr/mevzuat?MevzuatNo=1219&MevzuatTur=1&MevzuatTertip=3 (Erişim Tarihi:17.01.2023)
6. Perfüzyonistler Derneği. http://www.perfuzyon.org.tr/TR,530/dernek-hakkinda.html (Erişim tarihi: 17.01.2023)
7. Bauer A, Benk C, Thiele H, et al. Qualification, knowledge, tasks and responsibilities of the clinical perfusionist in Germany. Interact Cardiovasc Thorac Surg. 2020;30(5):661-665. doi:10.1093/icvts/ivaa005
8. Nicoletti AM, Zamberlan C, Miranda RCK, Marques C, de Moraes CB. Current status of perfusionists in Brazil: a 2018 survey. Perfusion. 2019;34(5):408-412. doi:10.1177/0267659119826491
9. Hessel EA 2nd. What's New in Cardiopulmonary Bypass. J Cardiothorac Vasc Anesth. 2019;33(8):2296-2326. doi:10.1053/j.jvca.2019.01.039
10. Kulat B. Perfusionist Manpower Survey. J Extra Corpor Technol. 2019;51(1):P2-P4.
11. Jenni H, Heinisch PP, Eberle B, Gisler F, Kadner A, Carrel T. From minimal invasive extracorporeal circulation type I to type III: the perfusionist's view. J Thorac Dis. 2019;11(Suppl 10):S1515-S1518. doi:10.21037/jtd.2019.01.47
12. Etherington C, Burns JK, Kitto S, et al. Barriers and enablers to effective interprofessional teamwork in the operating room: A qualitative study using the Theoretical Domains Framework. PLoS One. 2021;16(4):e0249576. doi:10.1371/journal.pone.0249576
13. Borden RA 2nd, Ball C, Grady PM, et al. Microplegia vs 4:1 Blood Cardioplegia: Effectiveness and Cost Savings in Complex Cardiac Operations. Ann Thorac Surg. 2020;110(4):1216-1224. doi:10.1016/j.athoracsur.2020.02.006
14. Münch F, Kwapil N, Teske A, et al. Microplegia in paediatric hearts. Perfusion. 2022;2676591221127926. doi:10.1177/02676591221127926
15. Matte GS, del Nido PJ. History and use of del Nido cardioplegia solution at Boston Children's Hospital. J Extra Corpor Technol. 2012;44(3):98-103.