ARTÍCULO DE INVESTIGACIÓN / RESEARCH ARTICLE

Rev Med Chile 2026; 154(2): 190-200. DOI: 10.4067/s0034-98872026000200190

The Effect of ABO Blood Groups and Rhesus Factor on Cardiac Surgery Performed with Cardiopulmonary Bypass

[1]Department of Perfusion, Faculty of Health Sciences, Harran University, Sanliurfa, Turkey.
[2]Department of Cardiovascular Surgery, Bursa Yuksek Ihtisas Training and Research Hospital, University of Health Sciences, Bursa, Turkey.
[3]Department of Cardiovascular Surgery, Şanlıurfa Mehmet Akif Inan Training and Research Hospital, University of Health Sciences, Şanlıurfa, Turkey.

Bişar Amaç[1,], Mesut Engin[2], Alaa Hijazi[3], Mustafa Abanoz[3].*

Efecto de los grupos sanguíneos ABO y del factor Rhesus en la cirugía cardiaca realizada con bypass cardiopulmonar

ABSTRACT

In cardiac surgery operations with cardiopulmonary bypass (CPB), patients are connected to a heart-lung machine and the patient's blood comes into contact with nonphysiological extracorporeal circulation equipment. ***Aims:*** *In this retrospective study, we investigated the effect of the interaction of ABO and Rh blood groups with extracorporeal circulatory equipment on transfusion requirements and perioperative outcomes in patients undergoing CPB-guided cardiac surgery.* ***Methods:*** *The study data were obtained retrospectively. Demographic and descriptive data of the patients were recorded. Haemogram and biochemistry parameters and other variables measured in the perioperative period were also collected. The relationships between ABO and Rh blood groups and these variables were statistically analysed.* ***Results:*** *A total of 913 patients were included in the study, mean age was 62.6±10.4 years, mean BSA was 1.87±0.2 m², and 59.5% of the patients were male. The most common surgical procedures were CABGx3 (35.0%) and CABGx4 (31.5%). There was no significant difference between blood groups and pre/postoperative haematological parameters and clinical outcomes (p>0.05). However, intensive care unit duration was significantly longer in AB Rh(+) and AB Rh(-) groups (p<0.001). According to the ABO system, ICU duration was longer in the AB group than in the other groups (p<0.001). The need for inotropes (p= 0.035) and ICU duration (p<0.001) were higher in Rh negative patients.* ***Conclusions:*** *This study showed that ABO and Rh blood groups may have an effect on ICU duration and the need for*

**Corresponding author: Bişar Amaç, PhD, Assist. Prof. / amacbisar@gmail.com Department of Perfusion, Faculty of Health Sciences, Harran University, Sanliurfa, Turkey. Osmanbey Campus, Sanliurfa-Mardin Highway 18 Km, Gulveren Neighbourhood, 63050 Haliliye, Sanliurfa, Turkey.*

Funding: This work received no funding.

The authors declare no conflict of interest.

Received: May 16, 2025.
Accepted: October 15, 2025.

inotropic support in patients undergoing CPB. In particular, it was found that ICU duration was prolonged in patients with AB blood group and Rh negative factor and the rate of inotrope use was higher in Rh negative patients.
Keywords: *ABO Blood-Group System; Cardiopulmonary Bypass; Perfusion; Rh-Hr Blood-Group System.*

RESUMEN

En las operaciones de cirugía cardíaca con circulación extracorpórea (CEC), los pacientes están conectados a una máquina de circulación extracorpórea y la sangre del paciente entra en contacto con un equipo de circulación extracorpórea no fisiológico. ***Objetivo:*** *En este estudio retrospectivo, investigamos el efecto de la interacción de los grupos sanguíneos ABO y Rh con el equipo de circulación extracorpórea sobre las necesidades de transfusión y los resultados peroperatorios en pacientes sometidos a cirugía cardiaca guiada por CEC.* ***Métodos:*** *Los datos del estudio se obtuvieron de forma retrospectiva. Se registraron los datos demográficos y descriptivos de los pacientes. También se recogieron los parámetros hemográficos y bioquímicos y otras variables medidas en el periodo perioperatorio. Se analizaron estadísticamente las relaciones entre los grupos sanguíneos ABO y Rh y estas variables.* ***Resultados:*** *Un total de 913 pacientes fueron incluidos en el estudio, la edad media fue de 62,6±10,4 años, el BSA medio fue de 1,87±0,2 m², y el 59,5% de los pacientes eran varones. Los procedimientos quirúrgicos más frecuentes fueron CABGx3 (35,0%) y CABGx4 (31,5%). No hubo diferencias significativas entre los grupos sanguíneos y los parámetros hematológicos pre/postoperatorios y los resultados clínicos (p>0,05). Sin embargo, la duración de la unidad de cuidados intensivos fue significativamente mayor en los grupos AB Rh(+) y AB Rh(-) (p<0,001). Según el sistema ABO, la duración de la UCI fue mayor en el grupo AB que en los demás grupos (p<0,001). La necesidad de inotrópicos (p= 0,035) y la duración de la UCI (p<0,001) fueron mayores en los pacientes Rh negativo.* ***Conclusiones:*** *Este estudio demostró que los grupos sanguíneos ABO y Rh pueden tener un efecto sobre la duración de la UCI y la necesidad de soporte inotrópico en pacientes sometidos a CEC. En concreto, se observó que la duración de la UCI fue más prolongada en los pacientes con grupo sanguíneo AB y factor Rh negativo y que la tasa de uso de inotrópicos fue mayor en los pacientes Rh negativo.*
Palabras clave: *Sistema del Grupo Sanguíneo ABO; Derivación Cardiopulmonar; Perfusión; Sistema del Grupo Sanguíneo Rh-Hr (Factor Rh).*

Cardiac surgery with cardiopulmonary bypass (CPB) requires an immobilised and bloodless area. For this reason, the heart must be stopped. In order to stop the heart, the heart and lung functions must be disabled. For this purpose, the patient is connected to the heart-lung machine and the patient's blood contacts the nonphysiological extracorporeal circulation equipment[1]. However, this may cause various changes and damages in blood parameters. This leads to the need for transfusion of blood and blood products. Blood management in cardiovascular surgery has cost-effectiveness and budget implications. In addition, more complications may develop when blood or blood products transfusion is required[2,3,4].

Blood groups can be categorised according to different systems, such as the ABO blood group system and the Rhesus (Rh) blood group system. The ABO blood group system is the most common system[5].

ABO blood group antigens were first identified by Karl Landsteiner at the beginning of the 20th century and categorised into four main groups: A, B, AB, O. Since then, associations between certain ABO groups and susceptibility to cardiovascular diseases and infections have been reported. Since then, associations between some ABO groups and susceptibility to cardiovascular diseases and infections have been reported. In particular, O group individuals have a lower risk of thromboembolism, pulmonary embolism and myocardial infarction. This is attributed to lower levels of coagulation factor VIII (FVIII) and von Willebrand factor (vWF) in O group individuals. High levels of vWF and FVIII are associated with thrombotic risk; low levels may increase bleeding tendency[6,7,8,9].

The Rh blood group system was described about 85 years ago when a woman who had stillbirth due to erythroblastosis foetalis had a severe reaction following a blood transfusion from her husband; her serum agglutinated erythrocytes from her husband and 80% of Caucasian ABO-compatible donors. The following year Landsteiner and Wiener showed that sera from rabbits and guinea pigs immunised with erythrocytes from Macaca mulatta monkeys agglutinated 85% of human erythrocytes. Although it was initially thought that these reactions occurred against a common 'Rh factor' in human and animal red blood cells, it was later realised that this was not true, but terms such as 'Rh factor' and 'anti-Rh' continued to be widely used despite being misnomers; the heteroantibody was called 'anti-LW' and the human-derived alloantibody was called 'anti-D'. The Rh system is the most polymorphic human blood group system containing at least 45 independent antigens and is one of the most important systems in transfusion medicine together with ABO; cDNA cloning and sequencing of Rh genes have provided an understanding of the molecular basis of some antigens, and serologically determined phenotypes have been a valuable resource for molecular studies[10].

The aim of this retrospective study was to evaluate the effects of ABO blood groups and Rh blood group system interactions with extracorporeal circulation (heart-lung machine / extracorporeal circulation equipment / tubing sets etc.) equipment on blood and blood products transfusion and peroperative outcomes in patients undergoing CPB-guided cardiac surgery.

Methods

This study is a retrospective clinical research.

Ethical Dimension of the Research

In this study, approval was obtained from the institutions and the local ethics committee (Harran University Clinical Research Ethics Committee) (Date: 24.03.2025 - Approval no: HRÜ/25.06.01). The study was conducted following the principles of the Declaration of Helsinki. Since only anonymized patient data was used and there was no risk or impact on patient care, informed consent was not required. This consent waiver was approved by the Institutional Review Board and Ethics Committee and complies with regulatory and ethical guidelines for retrospective studies.

Research Design and Data Collection

The study retrospectively included the data of patients who underwent CPB-guided cardiac surgery and who did not undergo any additional surgery in the last three years from the date of

ethics committee approval (January 2022-January 2025). Study data were obtained retrospectively from hospital records and patient files. Descriptive data including blood groups, age, gender, height, weight, body surface area (BSA), blood flow, ejection fraction percentage (EF%), aortic cross clamp time, total perfusion time, and type of surgery (number of coronary artery bypass grafts, aortic valve, mitral valve, etc.) were recorded. Routine haemogram and biochemistry parameters and perioperative variables were recorded. The relationship between ABO blood groups and Rh factor of the patients and other variables were compared.

Exclusion and Inclusion Criteria

Patients treated with anticoagulant drugs preoperatively, patients with bleeding and coagulation disorders, patients with preoperative haematocrit level <30, patients treated with amiodarone preoperatively, patients who underwent emergency cardiac surgery, patients who planned additional cardiac surgery such as aortic aneurysm, dissection, patients with known systemic inflammatory disease, patients who underwent cardiac surgery again, chronic haemodialysis patients, patients with haematological diseases were excluded.

Patients who underwent similar surgical technique were included in the study consecutively after the exclusion criteria were applied (Conventional CPB techniques and those using blood cardioplegia). The included patients were adults aged between 18 and 85 years who underwent conventional cardiac surgery under CPB guidance.

Statistical Analyses

The patient data collected within the scope of the study were analysed with IBM Statistical Package for the Social Sciences 25 (IBM SPSS Statistics 25®) (IBM Corporation, Armonk, NY, USA). Means and standard deviations were calculated for continuous data. Frequency and percentage analyses were performed for nominal data. One way ANOVA test was used to evaluate the significance of the groups. In post-hoc analysis, Tukey HSD test was used to define between which groups the significance was between. A "p" value less than 0.05 was considered statistically significant.

Results

Demographic and descriptive data of 913 patients included in the study are presented in Table 1. In this study, preoperative and postoperative haematocrit, haemoglobin, platelet, erythrocyte and leukocyte values of the blood groups were similar ($p>0.05$). In addition, the early clinical data of intraoperative and postoperative drainage, intraoperative fluid administration, intraoperative urine volume, intraoperative and postoperative blood and blood products transfusion, inotrope requirement, intracardiac defibrillation requirement, intra-aortic balloon pump (IABP) requirement, mechanical ventilation support time and hospital stay were similar ($p>0.05$). However, there was a significant difference between the intensive care unit (ICU) time data of the groups ($p<0.001$) (Table 2).

Table 2 shows the relationship between blood groups and ICU time. Table 3 shows which groups are responsible for this relationship: AB Rh(+) group showed longer ICU time compared to other Rh positive groups such as A Rh(+), B Rh(+), 0 Rh(+) ($p= 0.001$; $p= 0.006$; $p<0.001$ respectively). AB Rh(-) patients also showed significantly longer ICU duration compared to A Rh(+), B Rh(+) and 0 Rh(+) groups ($p<0.001$; $p= 0.001$; $p<0.001$). The differences between 0 Rh(+) - AB Rh(+) and 0 Rh(+) - AB Rh(-) groups were also significant ($p<0.001$ and $p<0.001$). No significant difference was observed between the other groups.

In the comparisons made according to ABO system only in Table 4, the AB group was associated with significantly longer ICU duration compared to the A, B and 0 groups:

- AB - O: Difference= 0.606 days, $p<0.001$.
- AB - A: Difference= 0.470 days, $p<0.001$.
- AB - B: Difference= 0.479 days, $p<0.001$.

In Table 5, various intraoperative and postoperative clinical parameters were compared between Rh positive and negative groups. Inotrope requirement was significantly higher in the Rh negative group ($p= 0.035$). The most significant difference was in ICU duration: ICU duration was significantly longer in Rh negative patients (mean: 2.98 days vs. 2.67 days, $p<0.001$). No statistically significant difference was found in other parameters (blood drainage, fluid requirement, urine output, ventilation time, IABP requirement, etc.) ($p>0.05$).

Table 1. Descriptive and demographic data.

Variable	A Rh(+) (n= 205)	B Rh(+) (n= 173)	AB Rh(+) (n= 140)	O Rh(+) (n= 219)	A Rh(-) (n= 62)	B Rh(-) (n= 44)	AB Rh(-) (n= 38)	O Rh(-) (n= 32)	Total (n= 913)	P
Age (years), mean±SD	62.85±7.90	61.56±9.35	62.38±8.38	63.53±8.19	61.02±9.40	64.98±9.08	62.89±8.37	61.72±8.57	62.64±8.56	0.127
Height (cm), mean±SD	168.42±10.03	167.01±10.23	166.96±10.91	167.92±10.86	169.69±9.46	168.73±10.64	168.66±11.13	167.56±7.79	167.89±10.37	0.625
Weight (kg), mean±SD	78.49±12.99	79.72±15.02	79.80±14.53	77.47±14.85	80.45±12.96	79.41±14.23	78.42±14.71	81.66±19.99	78.97±14.47	0.620
BSA (m^2), mean±SD	1.88±0.19	1.87±0.19	1.88±0.19	1.85±0.19	1.88±0.20	1.86±0.18	1.85±0.20	1.88±0.22	1.87±0.19	0.654
Flow (L/min), mean±SD	4.54±0.29	4.52±0.35	4.49±0.31	4.48±0.34	4.51±0.30	4.55±0.25	4.53±0.36	4.56±0.32	4.51±0.32	0.592
EF (%), mean±SD	50.40±8.69	49.92±8.74	50.13±8.55	50.25±8.41	50.11±8.60	49.83±8.52	49.75±8.70	49.88±8.66	50.02±8.61	0.218
ACCe (min), mean±SD	63.61±19.87	66.67±19.54	66.49±20.45	66.29±18.97	63.05±20.46	65.36±19.54	68.45±25.14	65.97±20.54	65.60±19.95	0.676
TPT (min), mean±SD	97.69±25.52	93.51±20.67	100.43±24.70	96.55±23.98	94.65±22.91	100.64±28.34	102.71±30.62	93.41±21.89	97.04±24.31	0.140
Serum Creatinine (mg/dL)	0.90 ± 0.20	0.92 ± 0.22	0.94 ± 0.21	0.89 ± 0.18	0.88 ± 0.19	0.91 ± 0.20	0.93 ± 0.19	0.85 ± 0.17	0.90 ± 0.20	0.620
AST (U/L), mean±SD	30.2 ± 9.5	31.0 ± 9.8	32.5 ± 10.1	29.8 ± 9.2	30.5 ± 9.7	31.2 ± 10.0	32.0 ± 10.3	29.5 ± 8.9	30.7 ± 9.8	0.450
Total Bilirubin (mg/dL), mean±SD	0.75 ± 0.28	0.77 ± 0.30	0.80 ± 0.32	0.73 ± 0.26	0.74 ± 0.27	0.76 ± 0.29	0.79 ± 0.31	0.71 ± 0.25	0.76 ± 0.29	0.560
INR, mean±SD	1.08 ± 0.13	1.09 ± 0.14	1.10 ± 0.15	1.07 ± 0.12	1.08 ± 0.13	1.09 ± 0.14	1.10 ± 0.15	1.06 ± 0.11	1.08 ± 0.13	0.720
Gender, Male, n (%)	123 (22.7%)	102 (18.8%)	81 (14.9%)	130 (23.9%)	33 (6.1%)	27 (5.0%)	25 (4.6%)	22 (4.0%)	543 (59.5%)	0.882
Gender, Female, n (%)	82 (22.2%)	71 (19.2%)	59 (15.9%)	89 (24.1%)	29 (7.8%)	17 (4.6%)	13 (3.5%)	10 (2.7%)	370 (40.5%)	
CABGx2, n (%)	28 (23.9%)	28 (23.9%)	13 (11.1%)	29 (24.8%)	8 (6.8%)	5 (4.3%)	4 (3.4%)	2 (1.7%)	117 (12.8%)	0.471
CABGx3, n (%)	85 (26.6%)	52 (16.3%)	59 (18.4%)	61 (19.1%)	25 (7.8%)	17 (5.3%)	13 (4.1%)	8 (2.5%)	320 (35.0%)	
CABGx4, n (%)	52 (18.1%)	61 (21.2%)	41 (14.2%)	70 (24.3%)	18 (6.3%)	17 (5.9%)	13 (4.5%)	16 (5.6%)	288 (31.5%)	
CABGx5, n (%)	28 (20.7%)	22 (16.3%)	20 (14.8%)	44 (32.6%)	7 (5.2%)	4 (3.0%)	6 (4.4%)	4 (3.0%)	135 (14.8%)	
AVR, n (%)	10 (27.8%)	5 (13.9%)	4 (11.1%)	11 (30.6%)	3 (8.3%)	1 (2.8%)	1 (2.8%)	1 (2.8%)	36 (3.9%)	
MVR, n (%)	2 (11.8%)	5 (29.4%)	3 (17.6%)	4 (23.5%)	1 (5.9%)	0 (0.0%)	1 (5.9%)	1 (5.9%)	17 (1.9%)	
Smoking, Yes, n (%)	53 (24.7%)	41 (19.1%)	31 (14.4%)	48 (22.3%)	13 (6.0%)	13 (6.0%)	8 (3.7%)	8 (3.7%)	215 (23.5%)	0.937
Smoking, No, n (%)	152 (21.8%)	132 (18.9%)	109 (15.6%)	171 (24.5%)	49 (7.0%)	31 (4.4%)	30 (4.3%)	24 (3.4%)	698 (76.5%)	
Hypertension, Yes, n (%)	114 (22.6%)	96 (19.0%)	73 (14.5%)	124 (24.6%)	32 (6.3%)	25 (5.0%)	22 (4.4%)	19 (3.8%)	505 (55.3%)	0.985
Hypertension, No, n (%)	91 (22.3%)	77 (18.9%)	67 (16.4%)	95 (23.3%)	30 (7.4%)	19 (4.7%)	16 (3.9%)	13 (3.2%)	408 (44.7%)	
COPD, Yes, n (%)	5 (15.6%)	3 (9.4%)	8 (25.0%)	10 (31.3%)	3 (9.4%)	1 (3.1%)	2 (6.3%)	0 (0.0%)	32 (3.5%)	0.421
COPD, No, n (%)	200 (22.7%)	170 (19.3%)	132 (14.9%)	209 (23.7%)	59 (6.7%)	43 (4.9%)	36 (4.1%)	32 (3.6%)	881 (96.5%)	
Diabetes Mellitus, Yes, n (%)	79 (22.5%)	69 (19.7%)	55 (15.7%)	79 (22.5%)	24 (6.8%)	14 (4.0%)	14 (4.0%)	17 (4.8%)	351 (38.5%)	0.722
Diabetes Mellitus, No, n (%)	126 (22.4%)	104 (18.5%)	85 (15.1%)	140 (24.9%)	38 (6.8%)	30 (5.3%)	24 (4.3%)	15 (2.7%)	562 (61.5%)	
Hyperlipidemia, Yes, n (%)	72 (23.5%)	59 (19.2%)	44 (14.3%)	67 (21.8%)	28 (9.1%)	11 (3.6%)	17 (5.5%)	9 (2.9%)	307 (33.6%)	0.244
Hyperlipidemia, No, n (%)	133 (22.0%)	114 (18.8%)	96 (15.8%)	152 (25.1%)	34 (5.6%)	33 (5.4%)	21 (3.5%)	23 (3.8%)	606 (66.4%)	

BSA: Body surface area, EF: Ejection fraction, ACC: Aortic cross clamp, TPT: Total Perfusion Time, AST: Aspartate aminotransferase, INR: International normalized ratio, CABG: Coronary artery bypass graft, AVR: Aortic valve replacement, MVR: Mitral valve replacement, COPD: Chronic obstructive pulmonary disease.

Table 2. Evaluation of significance data of groups.

ANOVA Between Groups	Sum of Squares	Mean Square	F	P value
Preoperative Haematocrit (%)	391.80	55.97	1.099	0.362
Preoperative Haemoglobin (g/dL)	13.46	1.92	0.646	0.718
Preoperative Platelets (103)	27961.50	3994.50	1.364	0.217
Preoperative Erythrocyte (106uL)	2.29	0.32	0.806	0.583
Preoperative Leukocyte (103µl)	73.70	10.52	1.143	0.334
Postoperative Haematocrit (%)	822.63	117.51	1.502	0.163
Postoperative Haemoglobin (g/dL)	14.24	2.03	0.281	0.961
Postoperative Platelets (103)	9774.30	1396.32	0.429	0.884
Postoperative Erythrocyte (106uL)	2.88	0.41	0.936	0.478
Postoperative Leukocyte (103µl)	100.91	14.41	0.945	0.471
Intraoperative Drainage	105121.17	15017.31	1.044	0.398
Postoperative Drainage	539280.01	77040.00	0.678	0.691
Intraoperative Fluid	969649.45	138521.35	1.046	0.397
Intraoperative Urine	620787.18	88683.88	0.673	0.695
Intraoperative Transfusion (unit)	19.59	2.79	1.878	0.070
Postoperative Transfusion (unit)	4.75	0.67	0.355	0.928
Inotrope Requirement	1.62	0.23	1.707	0.104
Intracardiac Defibrillation Requirement	0.57	0.08	0.403	0.901
IABP Requirement	0.20	0.02	0.964	0.456
Mechanical Ventilation Support Time (hours)	30.03	4.29	1.057	0.389
ICU time (days)	44.46	6.35	6.526	<0.001
Hospital Stay (days)	35.78	5.11	0.394	0.906

IABP: Intra-aortic balloon pump, ICU: Intensive care unit.

Table 3. Comparison of ICU Duration Differences between ABO and Rh Blood Groups (Multiple Comparisons with Tukey HSD Test).

Tukey HSD	(I) Blood groups	(J) Blood groups	Multiple Comparisons Mean Difference (I-J)	P value	95% Confidence Interval Lower Bound	Upper Bound
ICU Time (days)	A Rh (+)	B Rh (+)	-0.03059	1.000	-0.3420	0.2808
		AB Rh (+)	-0.44443*	0.001	-0.7751	-0.1137
		0 Rh (+)	0.18209	0.560	-0.1110	0.4752
		A Rh (-)	-0.20456	0.847	-0.6418	0.2326
		B Rh (-)	-0.07040	1.000	-0.5716	0.4308
		AB Rh (-)	-0.78691*	<0.001	-1.3197	-0.2542
		0 Rh (-)	-0.55335	0.068	-1.1267	0.0200
	B Rh (+)	A Rh (+)	0.03059	1.000	-0.2808	0.3420
		AB Rh (+)	-0.41383*	0.006	-0.7567	-0.0709
		0 Rh (+)	0.21269	0.412	-0.0941	0.5195
		A Rh (-)	-0.17397	0.937	-0.6205	0.2725
		B Rh (-)	-0.03981	1.000	-0.5491	0.4695
		AB Rh (-)	-0.75631*	0.001	-1.2967	-0.2159
		0 Rh (-)	-0.52276	0.113	-1.1032	0.0577
	AB Rh (+)	A Rh (+)	0.44443*	0.001	0.1137	0.7751
		B Rh (+)	0.41383*	0.006	0.0709	0.7567
		0 Rh (+)	0.62652*	<0.001	0.3001	0.9529
		A Rh (-)	0.23986	0.760	-0.2203	0.7000
		B Rh (-)	0.37403	0.365	-0.1473	0.8954
		AB Rh (-)	-0.34248	0.561	-0.8942	0.2093
		0 Rh (-)	-0.10893	0.999	-0.7000	0.4821
	0 Rh (+)	A Rh (+)	-0.18209	0.560	-0.4752	0.1110
		B Rh (+)	-0.21269	0.412	-0.5195	0.0941
		AB Rh (+)	-0.62652*	<0.001	-0.9529	-0.3001
		A Rh (-)	-0.38665	0.122	-0.8206	0.0473
		B Rh (-)	-0.25249	0.786	-0.7508	0.2458
		AB Rh (-)	-0.96900*	<0.001	-1.4991	-0.4389
		0 Rh (-)	-0.73545*	0.002	-1.3063	-0.1646
	A Rh (-)	A Rh (+)	0.20456	0.847	-0.2326	0.6418
		B Rh (+)	0.17397	0.937	-0.2725	0.6205
		AB Rh (+)	-0.23986	0.760	-0.7000	0.2203
		0 Rh (+)	0.38665	0.122	-0.0473	0.8206
		B Rh (-)	0.13416	0.997	-0.4604	0.7288
		AB Rh (-)	-0.58234	0.085	-1.2038	0.0391
		0 Rh (-)	-0.34879	0.742	-1.0054	0.3078
	B Rh (-)	A Rh (+)	0.07040	1.000	-0.4308	0.5716
		B Rh (+)	0.03981	1.000	-0.4695	0.5491
		AB Rh (+)	-0.37403	0.365	-0.8954	0.1473
		0 Rh (+)	0.25249	0.786	-0.2458	0.7508
		A Rh (-)	-0.13416	0.997	-0.7288	0.4604
		AB Rh (-)	-0.71651*	0.026	-1.3845	-0.0485
		0 Rh (-)	-0.48295	0.420	-1.1838	0.2179

...continue table 3.

Multiple Comparisons					
Tukey HSD	**(I) Blood groups**	**(J) Blood groups**	**Mean Difference (I-J)**	**P value**	**95% Confidence Interval**
				Lower Bound	**Upper Bound**
	AB Rh (-)	A Rh (+)	0.78691*	<0.001	0.2542	1.3197
		B Rh (+)	0.75631*	0.001	0.2159	1.2967
		AB Rh (+)	0.34248	0.561	-0.2093	0.8942
		0 Rh (+)	0.96900*	<0.001	0.4389	1.4991
		A Rh (-)	0.58234	0.085	-0.0391	1.2038
		B Rh (-)	0.71651*	0.026	0.0485	1.3845
		O Rh (-)	0.23355	0.977	-0.4902	0.9573
	0 Rh (-)	A Rh (+)	0.55335	0.068	-0.0200	1.1267
		B Rh (+)	0.52276	0.113	-0.0577	1.1032
		AB Rh (+)	0.10893	0.999	-0.4821	0.7000
		0 Rh (+)	0.73545*	0.002	0.1646	1.3063
		A Rh (-)	0.34879	0.742	-0.3078	1.0054
		B Rh (-)	0.48295	0.420	-0.2179	1.1838
		AB Rh (-)	-0.23355	0.977	-0.9573	0.4902

*The mean difference is significant at the 0.05 level.
ICU: Intensive care unit.

Table 4. Differences in ICU Duration between ABO Blood Groups.

Dependent Variable Tukey HSD	**(I) ABO GRUBU**	**(J) ABO GRUBU**	**Mean Difference (I-J)**	**P value**	**95% Confidence Interval**	
					Lower Bound	**Upper Bound**
ICU Time	O	A	-0.13583	0.413	-0.3626	0.0909
		B	-0.12699	0.520	-0.3661	0.1121
		AB	-0.60587*	<0.001	-0.8586	-0.3531
	A	O	0.13583	0.413	-0.0909	0.3626
		B	0.00884	1.000	-0.2269	0.2446
		AB	-0.47004*	<0.001	-0.7196	-0.2205
	B	O	0.12699	0.520	-0.1121	0.3661
		A	-0.00884	1.000	-0.2446	0.2269
		AB	-0.47887*	<0.001	-0.7397	-0.2181
	AB	O	0.60587*	<0.001	0.3531	0.8586
		A	0.47004*	<0.001	0.2205	0.7196
		B	0.47887*	<0.001	0.2181	0.7397

*The mean difference is significant at the 0.05 level.
ICU: Intensive care unit.

Table 5. Association of Rh Factor with Perioperative and Postoperative Clinical Outcomes.

		Group Statistics			
	Rh Factor	**N**	**Mean**	**Std Deviation**	**P value**
Intraoperative Drainage	Positive	737	157.29	119.96	0.067
	Negative	176	175.71	119.08	
Postoperative Drainage	Positive	737	749.78	336.88	0.143
	Negative	176	708.35	334.94	
Intraoperative Fluid	Positive	737	627.18	363.54	0.107
	Negative	176	676.42	364.37	
Intraoperative Urine	Positive	737	492.52	355.57	0.819
	Negative	176	499.48	391.53	
Intraoperative Transfusion (unit)	Positive	737	1.27	1.23	0.699
	Negative	176	1.23	1.19	
Postoperative Transfusion (unit)	Positive	737	1.87	1.36	0.904
	Negative	176	1.88	1.42	
Inotrope Requirement	Positive	737	0.78	0.41	0.035
	Negative	176	0.84	0.35	
Intracardiac Defibrillation Requirement	Positive	737	0.27	0.44	0.292
	Negative	176	0.31	0.46	
IABP Requirement	Positive	737	0.02	0.16	0.436
	Negative	176	0.03	0.19	
Mechanical Ventilation Support Time (hours)	Positive	737	6.95	2.01	0.252
	Negative	176	7.14	2.02	
ICU Time (days)	Positive	737	2.67	0.96	<0.001
	Negative	176	2.98	1.21	
Hospital Stay (days)	Positive	737	11.14	3.53	0.876
	Negative	176	11.09	3.82	

IABP: Intra-aortic balloon pump, ICU: Intensive care unit.

Discussion

In this study, the effects of ABO blood groups and Rh factor interactions with extracorporeal circulation (heart-lung machine) equipment on blood and blood products transfusion and postoperative outcomes in CPB-guided cardiac surgery were evaluated. In our study, it was observed that the ICU length of stay was significantly longer in patients with AB blood group than in patients with A, B and 0 blood groups. This finding has been associated with the fact that AB group has an immunologically different profile and may show a stronger systemic inflammatory response in previous studies. In particular, the fact that AB blood group lacks both anti-A and anti-B antibodies may lead to a different course of some infectious and inflammatory responses. In the analyses performed according to Rh factor, ICU stay was found to be significantly longer in Rh-negative patients and inotropic requirement was significantly higher in these patients. The fact that the immunological structure of Rh-negative individuals differs from that of Rh-positive individuals and is associated with more prominent inflammatory responses in some cases may explain these findings. There are also hypotheses that Rh-negativity may be associated with lower oxygen carrying capacity in some populations. These data show the superiority of our study[11].

In the literature, ABO blood groups are associated with susceptibility to many diseases such as cancer, cardiovascular diseases, infections, metabolic and haematological disorders, cognitive decline and malaria[12]. All these findings suggest that ABO blood groups may be an important genetic marker for susceptibility to infectious and non-infectious diseases, but more research is needed to elucidate the mechanisms, especially at the molecular level. However, the effects of ABO and Rh blood groups on CPB-guided cardiac surgery are not clearly known.

In a study in the literature investigating the relationship between ABO blood groups and cardiac surgery in CPB-guided cardiac surgery, patients with blood group AB require less blood transfusion compared to other blood groups, especially during emergency operations. However, patients with blood group AB are reported to have a higher mortality rate due to secondary cardiovascular complications. The postoperative prognosis of these patients is worse due to the increased incidence of fatal cardiovascular complications. Perioperative myocardial ischaemia due to graft occlusion is the most likely explanation for this. Therefore, more stringent anticoagulation therapy should be considered in patients with blood group AB[8]. In another study, the procoagulant phenotype of blood group AB was associated with less transfusion and improved late survival after cardiac surgery[9]. In some studies, it was reported that there was no relation between blood groups and the incidence or results of surgery, including bleeding, postoperative complications and survival[13,14]. In our study, it was observed that individuals with blood group AB, both in Rh positive and Rh negative status, required longer ICU follow-up in the postoperative period. In addition, it is shown that the AB group is statistically significantly more negatively affected than the other ABO groups in terms of ICU duration. This may be related to the difference in the immunological profile, antigen structure or blood components of the AB group.

When studies outside cardiac surgery were analysed, it was found that O blood group was associated with obesity and high body mass index in pregnant women. However, no significant association of Rh factors with obesity was found in the same study[15]. In another study, the relationship between ABO blood groups and pre-eclampsia was investigated. As a result, it was reported that O blood group decreased the risk of late-onset preeclampsia and increased the risk of early-onset preeclampsia[16]. In a study examining the relationship between blood group and myocardial damage in patients undergoing non-cardiac surgery, it was determined that factors such as hypertension, diabetes or coronary artery disease did not play a mediating role in this relationship. The findings suggest that blood group B may be associated with an increased risk of myocardial damage. However, the potential mediating mechanisms underlying this association need to be further investigated[17]. In a study investigating the relationship between ABO blood groups and cardiovascular

disease in type 1 diabetics according to diabetic nephropathy status, it was reported that blood group A was a risk factor for ischaemic heart disease in individuals with type 1 diabetes and microalbuminuria[18]. In our study, the relationship between ABO and Rh blood groups and CPB, that is, non-physiological extracorporeal circulatory equipment, was discussed.

Limitations of this study include its retrospective design, limited evaluation of biomarker levels and uneven distribution of blood groups. However, the data obtained indicate that blood group may be a variable that should be considered not only in terms of transfusion but also in the management of postoperative clinical processes.

This study evaluated the effects of ABO and Rh blood groups on postoperative clinical outcomes in patients undergoing CPB-guided cardiac surgery. The findings revealed that patients with AB and Rh-negative blood groups had a significantly longer intensive care period and the need for inotropic support was higher in Rh-negative individuals. These results suggest that blood groups may have an effect on the clinical recovery process after CPB.

In addition, these results suggest that taking into account an innate and unchangeable feature such as blood groups in preoperative evaluation may contribute to individualisation of risk prediction, CPB and perfusion management and postoperative management.

References

1. *Ismail A, Semien G, Sharma S, Collier SA, Miskolczi SY. Cardiopulmonary Bypass. In: StatPearls. Treasure Island (FL): StatPearls Publishing; August 12, 2024.*
2. *Zhang Q, Zhao W, Gao S, Yan S, Diao X, Wang Y, et al. Quality Management of a Comprehensive Blood Conservation Program During Cardiopulmonary Bypass. Ann Thorac Surg. 2022; 114(1): 142-150.*
3. *Şanal L, Günaydın S, Tatar M. Cost-Effectiveness and Budget Impact Analyses of Patient Blood Management in a Cardiovascular Surgery Department at Ankara Bilkent City Hospital in Turkey. Adv Ther. 2024; 41(2): 716-729.*
4. *Menkis AH, Martin J, Cheng DC, Fitzgerald DC, Freedman JJ, Gao C, et al. Drug, devices, technologies, and techniques for blood management in minimally invasive and conventional cardiothoracic surgery: A consensus statement from the International Society for Minimally Invasive Cardiothoracic Surgery (ISMICS) 2011. Innovations (Phila). 2012; 7(4): 229-241.*
5. *Liu FH, Guo JK, Xing WY, Bai XL, Chang YJ, Lu Z, et al. ABO and Rhesus blood groups and multiple health outcomes: An umbrella review of systematic reviews with meta-analyses of observational studies published correction appears in BMC Med. 2024; 22(1): 291. doi: 10.1186/s12916-024-03520-x. BMC Med. 2024; 22(1): 206.*
6. *Höglund J, Karlsson T, Johansson T, Ek WE, Johansson Å. Characterization of the human ABO genotypes and their association to common inflammatory and cardiovascular diseases in the UK Biobank. Am J Hematol. 2021; 96(11): 1350-1362.*
7. *Eastlund T. The histo-blood group ABO system and tissue transplantation. Transfusion. 1998; 38(10): 975-988.*
8. *Masseli F, Veseli A, Pfohl M, Hoch J, Treede H, Schiller W. Blood group AB is associated with reduced blood loss but also elevated cardiovascular mortality in aortocoronary bypass surgery. J Thromb Thrombolysis. 2024; 57(3): 512-519.*
9. *Welsby IJ, Phillips-Bute B, Mathew JP, Newman MF, Becker R, Rao S, et al. ABO blood group influences transfusion and survival after cardiac surgery. J Thromb Thrombolysis. 2014; 38(3): 402-408.*
10. *Avent ND, Reid ME. The Rh blood group system: A review. Published correction appears in Blood 2000; 95(7): 2197. Blood. 2000; 95(2): 375-387.*
11. *Butler EA, Parikh R, Grandi SM, Ray JG, Cohen E. ABO and Rh blood groups and risk of infection: Systematic review and meta-analysis. BMC Infect Dis. 2023; 23(1): 797.*
12. *Abegaz SB. Human ABO Blood Groups and Their Associations with Different Diseases. Biomed Res Int. 2021; 2021: 6629060.*
13. *Welsby IJ, Jones R, Pylman J, Mark JB, Brudney CS, Phillips-Bute B, et al. ABO blood group and bleeding after coronary artery bypass graft surgery. Blood Coagul Fibrinolysis. 2007; 18(8): 781-785.*
14. *Nozohoor S, Ahmad K, Bjurbom M, Hansson EC, Heimisdottir A, Jeppsson A, et al. ABO blood group does not impact incidence or outcomes of surgery for acute type A aortic dissection. Scand Cardiovasc J. 2020; 54(2): 124-129.*
15. *Bashir AO, Hassan AA, Mahdi ELB, Adam GK, AlHabardi N, Adam I. The association between blood groups, Rhesus factors, body mass index and obesity among pregnant women at Gadarif Maternity Hospital, Eastern Sudan. BMC Pregnancy Childbirth. 2023; 23(1): 801.*
16. *Mahasub N, Boriboonhirunsarn D. Relationship between ABO blood groups and preeclampsia. Hypertens Pregnancy. 2020; 39(3): 348-353.*
17. *Li J, Li W, Li L, Yang S, Zhao G, Li K. Association between blood groups and myocardial injury after non-cardiac surgery: A retrospective cohort study. Sci Rep. 2024; 14(1): 14028.*
18. *Parente EB, Harjutsalo V, Lehto M, Forsblom C, Sandholm N, Groop PH, et al. Relationship between ABO blood groups and cardiovascular disease in type 1 diabetes according to diabetic nephropathy status. Cardiovasc Diabetol. 2020; 19(1): 68.*