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Association between scar formation in patients undergoing cardiac surgery and ABO blood group association of ABO blood group with scar formation

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Abstract

The aim of this study was to investigate whether scar formation in the chest region following cardiac surgery differs according to blood groups. A total of 581 patients who underwent cardiac surgery between 2015 and 2025 were included in the study. Among them, 240 had blood group A, 200 blood group O, 100 blood group B, and 41 blood group AB. Patients who presented to the Cardiovascular Surgery outpatient clinic at least six months after their operation were evaluated, and their chest incisions were assessed using the Vancouver Scar Scale (VSS). The scores were recorded and compared according to the ABO blood group system. In addition, the relationship of Rh blood group, diabetes mellitus (DM), hypertension (HT), and age with scar formation was also analyzed. There were no statistically significant differences between the groups in terms of Rh factor, DM, HT, or age ($p > 0.05$). When evaluated according to VSS, scar formation was significantly higher in patients with blood groups B and AB compared with those with blood groups A and O ($p<0.001$). No statistically significant difference was observed between blood groups B and AB or between A and O. Our study demonstrated an association between ABO blood group and chest scar formation following cardiac surgery. The observed relationship between blood group and scar development may contribute to scar management in both diagnostic and therapeutic contexts.

Keywords: ABO blood group, vancouver scar scale, cardiac surgery

Introduction

Scar formation is an important clinical and cosmetic problem that can follow surgery, trauma, or burns. Worldwide, scarring negatively affects millions of people by causing structural deformities, functional impairment, cosmetic concerns and associated psychosocial burdens. Pathologic scars are often palpable, elevated, erythematous, and may be itchy or painful; these features arise from an exaggerated inflammatory response and aberrant collagen deposition during wound repair [1,2].

Hypertrophic scars are commonly categorized as linear—typically developing after surgical incisions or localized trauma—or widespread, which are more frequently seen after major burns, extensive soft-tissue injury, or infection. Unlike keloids, hypertrophic scars remain confined to the original wound boundaries and can partially regress over time [3,4].

A variety of methods exist to evaluate scar appearance and severity. While objective instruments provide measurable parameters, subjective methods depend on examiner judgment; to increase consistency, semi-quantitative scoring systems have been developed. The Vancouver Scar Scale (VSS), first proposed by Sullivan in 1990, is among the most commonly used tools and assesses four domains: vascularity, thickness (height), pliability and pigmentation [5].

The ABO blood group system with phenotypes A, B, AB and O is determined by the ABO glycosyltransferase gene on chromosome 9 (9q34.1–9q34.2). Prior research has associated ABO types with various disease processes, including thrombotic and vascular disorders, colorectal cancer, coronary artery disease, diabetes, and outcomes after transplantation [6–12].

In this context, the current study was designed to examine whether ABO blood group and selected demographic factors are related to VSS scores of sternal scars in patients who underwent

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cardiac surgery. This study aims to examine the potential relationship between genetically determined blood groups and scar formation, with the goal of informing follow-up strategies and therapeutic interventions.

Material and Methods

This retrospective cross-sectional study included patients who underwent cardiac surgery at the Faculty of Medicine Hospital of Kahramanmaraş Sütçü İmam University University after 2015 and who presented to the outpatient clinic at least six months postoperatively. During physical examination, the sternal scars of the included patients were evaluated and scored according to the VSS. Patients were classified based on their blood groups determined prior to cardiac surgery.All patients who underwent coronary artery bypass grafting, valve, and aortic root replacement via median sternotomy were included in the study. A full sternotomy extending from the jugular notch to the xiphoid process was performed in all patients. Patients with postoperative sternal dehiscence, mediastinitis, surgical site infection, previous cardiac surgery, or dermatological disorders were excluded. All surgeries and evaluations were performed by the same surgical team.

The VSS remains one of the most commonly applied tools for the clinical assessment of scar characteristics in humans. It evaluates four major features vascularity, height (thickness), pliability, and pigmentation each scored individually. The cumulative score ranges from 0 to 13, with higher values indicating more pronounced or severe scarring.

Scar Characteristic	Description	Score
Vascularity	Normal	0
	Pink	1
	Red	2
	Purple	3
Pigmentation	Normal	0
	Hypopigmentation	1
	Hyperpigmentation	2
Pliability	Normal	0
	Supple	1
	Yielding	2
	Firm	3
	Banding (fibrotic scar)	4
	Contracture	5
Height	Flat	0
	< 2 mm	1
	2–5 mm	2
	> 5 mm	3
Total Score		**Maximum: 13**

Statistical Analysis

The normality of quantitative variables was assessed using the Shapiro–Wilk test. For data that deviated from a normal distribution, comparisons between two independent groups were performed using the Mann–Whitney U test, whereas comparisons among more than two groups were evaluated with the Kruskal–Wallis H test. When significant differences were observed, Dunn–Šidák post hoc analyses were applied to determine pairwise group differences. Correlations between continuous variables were examined using the Spearman rank correlation coefficient.

A p-value less than 0.05 was regarded as statistically significant. Descriptive data were summarized as mean ± standard deviation, median (interquartile range, IQR: 1st–3rd quartile), or as frequency and percentage values, according to the measurement type. All statistical analyses were carried out using IBM SPSS Statistics for Windows, Version 22.0 (IBM Corp., Armonk, NY, USA).

Results

A total of 581 patients who underwent cardiac surgery between 2015 and 2025 and were subsequently monitored in the outpatient clinic were enrolled in this study. The distribution of ABO blood groups among participants was as follows: 240 (41.3%) individuals with group A, 200 (34.4%) with group O, 100 (17.2%) with group B, and 41 (7.1%) with group AB. Of the total cohort, 471 (81.1%) were Rh-positive, whereas 110 (18.9%) were Rh-negative. Demographic variables including age, diabetes mellitus (DM), hypertension (HT), and blood group characteristics are detailed in Table 1.

Table 1. Distrubution of patients, blood group, age, DM and HT

Age, Mean±SD		**61.40**	**±9.71**
DM	negative, n(%)	287	49.57
	pozitive, n(%)	292	50.43
HT	negative, n(%)	340	58.52
	pozitive, n(%)	241	41.48
ABO blood group	0 RH	200	34.4%
	A RH	240	41.3%
	B RH	100	17.2%
	AB RH	41	7.1%
Rh blood group	negative	110	18.9%
	pozitive	471	81.1%

DM: diabetes mellitus, HT: hypertension

The mean ages of patients according to ABO blood groups are presented in Table 2. No statistically significant differences were observed in mean age among the different blood groups (p>0.05).

Table 2. Age distribution according to ABO blood groups

		Age		Statistics	p
		Mean±SD	**Median(Q1-Q3)**		
ABO blood group	0 RH	62.17±9.58	62.00(55.00-69.00)	4.185	0.242
	A RH	60.84±9.62	60.00(55.00-68.50)		
	B RH	61.60±10.75	62.00(54.00-69.00)		
	AB RH	60.51±8.10	60.00(53.00-65.00)		
Rh blood group	negatif	60.73±9.10	61.50(55.00-67.00)	24808.000	0.489
	pozitif	61.56±9.85	61.00(55.00-69.00)		

Kruskal Wallis h test;Mann Whitney u test;a:0.05

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Since the demographic data did not meet the assumption of normality, regression analysis was not suitable for assessing the potential influence of confounding variables such as age, DM, and HT on scar formation. Therefore, the Spearman rank correlation test was used to evaluate possible associations between these variables and VSS. The results revealed no significant correlation between age, DM, or HT and VSS (Table 3), indicating that these parameters did not exert a statistically significant association effect on scar severity.

The relationship between patients' gender and VSS is presented in Table 4. According to the data, no statistically significant association was observed between postoperative scar formation and gender (p>0.05).

The associations between ABO blood groups, Rh factor, and VSS are illustrated in Tables 5 and 6. The comparison of Rh-positive and Rh-negative groups showed no significant difference in VSS values (p>0.05). In contrast, when evaluating the ABO system, patients with blood groups B and AB exhibited significantly higher VSS scores compared with those possessing groups A and O (p<0.001) (Figure 1). However, no statistically significant differences were detected between groups A and O or between groups B and AB (p>0.05).

Table 3. Relationship between ABO blood group and Vancouver Scar Scale

Demographic Characteristics	Vancouver Scar Scale	
	r	p
Age	-0.057	0.171
DM	0.025	0.543
HT	-0.039	0.342

DM: diabetes mellitus, HT: hypertension, Spearman Korelasyon testi;a=0.05; r correlation coefficient

Table 4. Relationship between gender and Vancouver Scar Scale

Sütun başliği ekleyiniz	Gender					
	Male		Female		Statistical Test	P-value n
	Mean±SD	Median(Q1-Q3)	Mean±SD	Median(Q1-Q3)	MW-U	p
Vancouver scar scale	3.68±2.27	3.00(2.00-5.00)	3.56±2.23	2.00(2.00-5.00)	33052.500	0.694

Mann Whitney u test;a:0.05

Table 5. Relationship between ABO blood group and Vancouver Scar Scale

ABO blood group	Vancouver Scar Scale	
	Mean±SD	Median(Q1-Q3)
0 RH	3.36±1.93	2.50(2.00-5.00)
A RH	3.20±2.17	2.00(2.00-4.00)
B RH	4.72±2.34	5.00(2.00-7.00)a,b
AB RH	5.05±2.62	5.00(3.00-7.00)a,b
Kw-h	59.129	
p	p<0.001*	

Kruskal Wallis H test; a:0.05; Post-hoc: Dunn Sidak test; * the difference between the groups is statistically significant; a the difference with the 0 RH group is significant; b the difference with the A RH group is significant

Table 6. Relationship between Rh status and Vancouver Scar Scale

Rh blood group		Vancouver Scar Scale	
		Mean±SD	Median(Q1-Q3)
Rh group	Negative	3.61±2.36	2.00(2.00-5.00)
	Pozitive	3.65±2.23	3.00(2.00-5.00)
	Mw-u	26.907	
	p	0.507	

Mann Whitney u test; a:0.05

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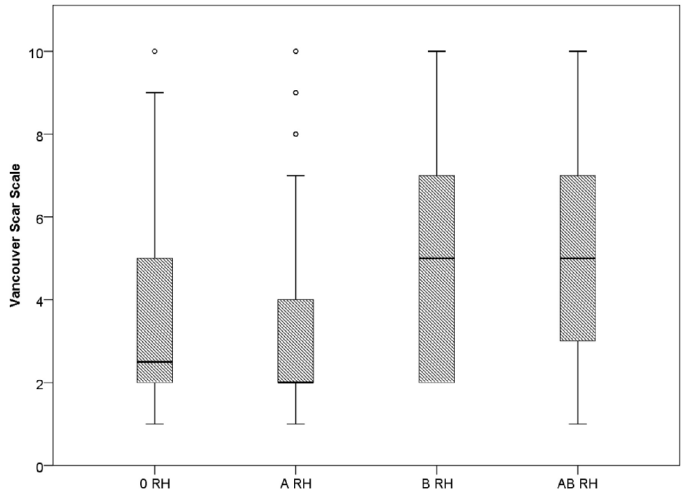

Figure 1. Relationship between ABO blood group and Vancouver Scar Scale

Discussion

The main purpose of this research was to determine whether post-sternotomy scar deformities following cardiac surgery vary according to patients' blood group types.

Wound healing and scar formation progress through three overlapping yet distinct phases: inflammation, proliferation, and remodeling. The inflammatory phase begins immediately after tissue damage, triggered by capillary rupture and activation of coagulation cascades. Plasma leakage and platelet aggregation result in the formation of a fibrin-based clot, which serves as a temporary extracellular scaffold supporting the migration of immune and reparative cells.

The proliferative phase, generally starting around the fourth or fifth day, is characterized by fibroblast migration into the wound site. Between two and four weeks, fibroblast activity peaks, gradually replacing fibrin networks with a dense collagen matrix. As the wound matures, the elastic fiber framework diminishes, producing the characteristic rigidity and reduced elasticity of scar tissue [13]. Concurrently, epithelialization occurs as keratinocytes migrate inward from wound edges, while wound contraction typically begins around days 10–12, though the timing may vary depending on tissue injury severity and patient condition [14].

The remodeling phase, which usually starts about three weeks after injury, involves a reduction in fibroblast density, regression of neovascularization, and enhanced collagen cross-linking. Continuous collagen synthesis and degradation persist for several months, reaching equilibrium around six months post-injury, at which point the scar's structure stabilizes. Notably, this phase determines the final appearance and texture of the scar—where even a fine surgical incision can evolve into a prominent, disfiguring scar [15].

Hypertrophic scarring often arises in wounds subjected to high mechanical tension. To standardize the evaluation of such scars, the VSS was introduced by Sullivan et al. in 1990, providing a semi-quantitative framework for assessing vascularity, thickness, pliability, and pigmentation [16]. It remains one of the most reliable and widely used clinical scales in scar assessment.

Growing evidence suggests that the ABO blood group system may be linked to various pathological and physiological processes [17–19]. These associations have raised interest in whether genetic variations influencing blood group antigens might also modulate wound healing and scarring. Since ABO phenotypes are genetically determined and differ among individuals, they offer a useful biological model for studying genetically influenced tissue responses.

Both genetic and environmental factors contribute to variations in scar formation. Bayat et al. reported that familial predisposition plays a significant role in keloid formation, with a higher frequency observed in twins [20]. Pathological scarring is believed to follow an autosomal dominant inheritance pattern, and its prevalence is notably greater in individuals of African and Asian descent compared with Caucasians [21]. The incidence of keloidal scarring among African populations ranges from 4.5% to 16% [22].

On a molecular level, Teofili et al. demonstrated that dysregulated expression of apoptotic and proliferative markers such as Bcl-2, p53, Ki-67, c-jun, and c-fos contributes to abnormal collagen synthesis and pathological scar formation [23]. Likewise, Larson et al. compared fetal and adult wound healing and found that the superior regenerative capacity in fetuses was linked to differences in collagen organization, hyaluronic acid content, extracellular matrix composition, platelet function, and cytokine activity [24]. Together, these findings emphasize the critical role of genetic and molecular pathways in determining scar outcomes.

While only a few studies have explored the association between ABO blood groups and scarring, Shaheen et al. reported that keloid formation varied according to age, sex, scar cause, family history, anatomical site, and blood type, identifying blood group A as more prone to keloid development, whereas the Rh factor showed no significant relationship [25]. Conversely, Mouhari-Toure et al. conducted a case–control study and observed no significant association between keloid formation, ABO blood type, or Rh status [26]. Saleem et al. reported that keloid formation after cardiac surgery was more frequent in women than in men [27]. In our study, however, no statistically significant difference was observed between gender and scar formation.

In alignment with the hypothesis that genetic background influences wound-healing outcomes, our study revealed that individuals with blood groups B and AB demonstrated higher VSS scores, indicating more pronounced scar formation. The absence of a relationship between VSS and demographic variables such as age, diabetes mellitus, or hypertension, combined with a significant correlation with ABO blood group, supports the notion that genetic determinants play a role in scar

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development. These results suggest that the observed differences in post-sternotomy scarring across ABO groups may reflect underlying genetic variations affecting collagen remodeling and wound-repair mechanisms. The GREMCIQ (Group for Multicenter Studies in Keloids and Hypertrophic Scars) has recognized silicone gel sheeting as one of the widely used methods for the prevention of hypertrophic scars and keloids. It is recommended to be applied soon after suture removal, while the scar is still in the immature phase [28,29]. Based on the results of our study, it is suggested that patients with B and AB blood groups receive more intensive and prolonged medical treatment to prevent scar formation after cardiac surgery.

The limitations of this study include the inability to incorporate patients' body mass index, smoking status, type of cardiac surgery, and sternal tension, as well as its single-center design, which prevented performing multivariate analysis.

Conclusion

Research examining the link between ABO blood group and scar formation remains limited. In the present study, a significant association was identified between ABO phenotype and sternal scar characteristics in patients who had undergone cardiac surgery. To confirm and expand upon these findings, large-scale, multicenter studies are necessary to clarify the mechanisms connecting blood group antigens with wound healing and tissue remodeling. A deeper understanding of this relationship may pave the way for personalized preventive and therapeutic strategies in scar management, ultimately improving postoperative recovery and patient quality of life.

Conflict of Interests
The authors declare that there is no conflict of interest in the study.

Financial Disclosure
The authors declare that they have received no financial support for the study.

Ethical Approval
The study was approved by the Medical Research Ethics Committee of Kahramanmaraş Sütçü İmam University (Approval No: 2025-197/10, Date:16.06.2025)

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