

Human platelet antigens polymorphisms: Association to primary immune thrombocytopenia in the Iranian patients

Mojgan Shaiegan PhD¹, Ali Ghasemi PhD², Maryam Zadsar MD^{3,*}, Jahangir Ahmadi MD⁴, Shahram Samiee MSc⁴, Tahereh Madani MSc⁴

1. Blood Transfusion Research Center /High Institute for Research & Education in Transfusion Medicine, Immunohematology Department, Tehran, Iran.

2. Department of Biochemistry and Hematology, Faculty of Medicine, Semnan University of Medical Sciences, Semnan, Iran.

3. Blood Transfusion Research Center/High Institute for Research & Education in Transfusion Medicine, Microbiology Department, Tehran, Iran.

4. Iranian Blood Transfusion Organization Research Center, Tehran, Iran.

*Corresponding author: Dr Maryam zadsar, Blood Transfusion Research Center/High Institute for Research & Education in Transfusion Medicine, Immunohematology Department, Tehran, Iran. Email: maryam.zad@gmail.com. ORCID ID: 0000-0001-9519-4853

Received: 19 August 2020

Accepted: 20 November 2020

Abstract

Background: Human platelet antigens (HPAs) are part of platelet GP complexes have the potential to contribute to the autoantibody production. Moreover, these antigens demonstrate different patterns of distribution on different ethnic groups and variation in some types of diseases. This study was objected to determine the incidence of HPA-1 to -5 and -15 polymorphisms in the Iranians suffering from primary Immune thrombocytopenic purpura (ITP).

Materials and Methods: In this case-control investigation, 30 patients by definite primary ITP were randomly selected and enrolled in the study. HPA genotyping was performed implicating by the Single Specific Primer PCR (SSP-PCR). For the control group, data of recently published gene polymorphism among Iranian Blood donors were deployed for comparison.

Results: The incidence of HPA-1 to -5 and -15 polymorphisms in the Iranian patients with primary ITP was found to be: HPA-1a/1a: 0.933, HPA-1a/1b: 0.067, HPA-2a/2a: 0.133, HPA-2a/2b: 0.867, HPA-3a/3a: 0.2, HPA-3a/3b: 0.533, HPA-3b/3b: 0.267, HPA-4a/4a: 1, HPA-5a/5a: 0.967, HPA-5a/5b: 0.330, HPA-15a/15a: 0.166, HPA-15a/15b: 0.667 & HPA-15b/15b: 0.167.

Conclusion: This study provides special new data on the distribution of HPA allele among the Iranians ITP patients. Furthermore, it might useful to characterize understanding more precisely about ITP and HPA distribution. However, further studies concerning platelet immunology are needed to do help on best practice on management of immune diseases triggered by platelet antibodies.

Keywords: Antigens, Blood Platelets, Human Platelet, Purpura, Thrombocytopenic

Introduction

Immune thrombocytopenic purpura (ITP) is a heterogeneous acquired disease (1). In the serum of patients with ITP, there are immunoglobulin G antibodies that are produced against glycoproteins (PSGs) on the platelet surface (2). Platelets sensitized by these autoantibodies are removed by the reticuloendothelial system and cleared from the bloodstream (3). ITP may be categorized according to the duration of diagnosis as: newly diagnosed (up to three months), perpetual ITP (up to twelve

months), and chronic (longer than twelve months) (4).

Till now, factors and mechanisms contributing to the occurrence of ITP have not been fully identified (5). It seems that some environmental and genetic factors including specific infections (6) and vaccination (7), specific human leukocyte antigens (HLAs) and HPAs might play a role (3). However, the association between ITP and polymorphisms of some genes encoding cytokines and chemokines have been shown (8, 9). Some HPAs, including HPA-1, -2, -3, and -5 are part of the

structure of PSGs and might have been a particular autoepitope (3) and formation of autoantibodies with antiplatelet function.

In HPA systems, HPA-1 to -5 and -15 are two allelic antigens whereas other systems are monoallelic (10). To date, the expression of 35 platelet-specific alloantigens (HPAs) on different platelet glycoproteins have been shown (11). Moreover, it is declared that severity of clinical complications among patients by different races exist due to antibodies against different HPAs systems (12). Besides, the development of alloantibodies against HPAs has been described in many conditions such as platelet refractoriness (PTR), fetal immune thrombocytopenia (FIT) (13), outcomes of HCV infection (14, 15) and increased risk of HCV infection (16).

In the other hand, there are many evidences which shows that the frequencies of HPAs allele in different ethnic populations are different. Thus, HPAs genotyping could be used for the management of clinical situations which mentioned above (17). Though the frequency of HPAs varies among different racial groups (18, 19) and no information is available about the abundance of HPAs genes on Iranian patients with immune thrombocytopenia, this study was arranged to provide data on the frequencies of HPA-1 to -5 and -15 systems in Iranian primary chronic ITP patients.

Materials and Methods

Thirty chronic primary ITP patients were randomly selected and enrolled in the study.

Inclusion criteria were as follows: platelet count less than $100 \times 10^9/L$, normal or increased megakaryocytes in bone marrow without dysplasia in the absence of disorders that may be associated with thrombocytopenia (20) such as lymphoproliferative disorders, transfusion or taking some medications (21).

Peripheral blood samples were then collected in ethylenediaminetetraacetic acid.

Samples of patients were collected from Shariati Hospital in Tehran.

Genomic DNA was prepared from mononuclear cells by a commercial kit (Qiagen, Milan, Italy). Genomic DNA was amplified using PCR sequence-specific primers (Bhatti et al., 2010) (22). The sequence of primers and product size is displayed in Table 1. An internal control was used in all PCR runs. An example of the results of electrophoresis on 2% agarose gel is illustrated in Figure 1.

The distribution of gene frequencies in the HPAs was calculated by Hardy-Weinberg equilibrium test. We made use of data from a recently published article about HPAs gene polymorphism among Iranian blood donors as a typical group (23).

The code of ethics for this study is IR.TMI.REC.1396.005.

Statistical analysis

SPSS software (version 15) was used to identify the relationship between the variables.

Results

A total of 30 patients, 18 (60 %) females and 12 (40 %) males, participated in this study. The mean \pm SD age of all of these primary ITP patients was 42.5 ± 12 years; they were between 20 and 65 years old. Average monitoring period was 18 months (ranging from 6 to 25 months) and all were in a treatment protocol.

In both patients and control subjects, the frequency of "a" allele in the studied HPA-1, -2, -4, and -5 found higher in comparison to "b" allele.

Moreover, the allele abundance of HPA-3b appeared to be higher than the "a" allele in primary ITP patients. It was also higher than the "a" allele in blood donors.

In HPA-1, -4 & -5 systems, the prevalence of homozygous "aa" genotypes proved to be higher than that of heterozygous "ab" genotype, besides the homozygous "bb" genotype was far rarely observed. In HPA-3 & -15 systems, the abundance of heterozygous "ab" genotype was greater than that of homozygous "aa" genotype

while the homozygous "bb" genotype was intermittent.

The results of genotyping of HPAs for blood donors and patients with primary ITP are presented in Table 2.

The frequencies of HPAs genotypes in total subjects were determined as follows: HPA-1a/1a: 95.3%, HPA-1a/1b: 4.6%, HPA-2a/2a: 9.2%, HPA-2a/2b: 90.7%, HPA-3a/3a: 11.5%, HPA-3a/3b: 65.3%, HPA-3b/3b: 23%, HPA-4a/4a: 100%, HPA-5a/5a: 98.5%, HPA-5a/5b: 1.5%, HPA-15a/15a: 14.6%, HPA-15a/15b: 66.9%, and HPA-15b/15b: 18.4%. The frequencies of homozygous HPA-1a/a and HPA-5a/5a was 95.3% and 98.5%, respectively.

The abundance of heterozygous types of HPA-2, HPA-3 & HPA-15 were detected to be 90.7%, 65.3% and 66.9%, respectively, thus indicating a greater

frequency compared to the homozygous (a/a or b/b) forms. The homozygous "b" allele, however, was not found in HPA-4. No homozygous "bb" genotype was also identified in HPA-1, HPA-2 and HPA-5.

The abundance of HPA-3aa/bb genotype showed to be higher in ITP patients than that observed in the blood donors; however, the abundance of HPA-3ab genotype was lower in ITP patients compared to the control group.

The odds ratio with the 95% CI revealed that individuals with HPA-1b, -5b & -15a allele phenotypes are at greater risk for the disease by odds of 1.714 (95% CI 0.298-9.853), 3.414 (95% CI 0.207-56.281) and 1.173 (95% CI 0.397-3.462), respectively (Table 3). The Hardy Weinberg equilibrium calculation result was also presented in the Table 4.

Table I. HPAs gene primers sequence & product size for SSP-PCR.

Gene	Specificity	Sequences of primers	Product size (bp)
HPA-1	1a	5' TCA CAG CGA GGT GAG GCC A 3'	90
	1b	5' TCA CAG CGA GGT GAG GCC G 3'	
	Common	5' GGA GGT AGA GAG TCG CCA TAG 3'	
HPA-2	2a	5' GCC CCC AGG GCT CCT GAC 3'	258
	2b	5' GCC CCC AGG GCT CCT GAT 3'	
	Common	5' TCA GCA TTG TCC TGC AGC CA 3'	
HPA-3	3a	5' GGG GGA GGG GCT GGG GA 3'	267
	3b	5' GGG GGA GGG GCT GGG GC 3'	
	Common	5' GGC CCT GGG ACT GTG AAT G3'	
HPA-4	4a	5' CTG GCC ACC CAG ATG CG 3'	120
	4b	5' CTG GCC ACC CAG ATG CA 3'	
	Common	5' GGT AGA AAG GAG CTA TAG TTT GGC 3'	
HPA-5	5a	5' AGA GTC TAC CTG TTT ACT ATC AAA G 3'	246
	5b	5' AGA GTC TAC CTG TTT ACT ATC AAA A 3'	
	Common	5' CTC TCA TGG AAA ATG GCA GTA CA 3'	
HPA-15	15a	5' TTC AAA TTC TTG GTA AAT CCT CG 3'	225
	15b	5' TTC AAA TTC TTG GTA AAT CCT CT 3'	
	Common	5' ATG AAC CTT ATG ATG ACC TAT TC 3'	
HGH	Forward	5' GCC TTC CCA ACC ATT CCC TTA 3'	429
	Reverse	5' TCA CGG ATT TCT GTT GTG TTT 3'	

HPA; human platelet antigen, HGH; human growth hormone

Table II. Allelic and genotypic frequencies for HPAs

HPA alleles	Allele frequency			Allele phenotype frequency			HPA genotypes	Genotype frequency		
	ITP ^a (%)	Bd ^b (%) [*]	P	ITP (%)	Bd (%) [*]	P		ITP (%)	Bd (%) [*]	P
HPA-1a	58 (96.7)	196 (98)	0.834	30 (100)	100 (100)	-	1aa	28 (93.3)	96 (96)	0.542
							1ab	2 (6.7)	4 (4)	0.542
HPA-1b	2 (3.3)	8 (2)		2 (6.7)	4 (4)	0.621	1bb	0	0	-
HPA-2a	34 (56.7)	108 (54)	0.716	30 (100)	100 (100)	-	2aa	4 (13.3)	8 (8)	0.376
HPA-2b	26 (43.3)	92 (46)		26 (87.6)	92 (92)	0.376	2ab	26 (86.7)	92 (92)	0.376
							2bb	0	0	
HPA-3a	28 (46.7)	87 (43.5)	0.665	22 (73.3)	78 (78)	0.595	3aa	6 (20)	9 (9)	0.098
							3ab	16 (53.3)	69 (69)	0.114
HPA-3b	32 (53.3)	113 (56.5)		24 (80)	91 (91)	0.098	3bb	8 (26.7)	22 (22)	0.595
HPA-4a	60 (100)	200 (100)	-	30 (100)	100	-	4aa	30 (100)	100	-
							4ab	0	0	-
HPA-4b	0	0		0	0	-	4bb	0	0	-
HPA-5a	59 (98.3)	199 (99.5)	0.364	30 (100)	100	-	5aa	29 (96.7)	99 (99)	-
							5ab	1 (3.3)	1 (1)	-
HPA-5b	1 (1.7)	1 (0.5)		1 (3.3)	1 (1)	0.362	5bb	0	0	-
HPA-15a	30 (50)	95 (47.5)	0.734	25 (83.3)	81 (81)	0.773	15aa	5 (16.6)	14 (14)	0.717
							15ab	20 (66.7)	67 (67)	0.409
HPA-15b	30 (50)	105 (52.5)		25 (83.3)	86 (86)	0.717	15bb	5 (16.7)	19 (19)	0.773

^a ITP: Immune thrombocytopenic purpura; ^b Blood donors; ^{*}Data reported by Data reported by Shaiegan et al. (2019: ISBT Science Series, in press). HPA; human platelet antigen.

Table III. OR of HPAs genotypes in ITP patients and blood donors.

Allele phenotype	ITP patients		Blood donors*		OR	95% CI OR	
	Allele present (%)	Allele absent (%)	Allele present (%)	Allele absent (%)		Lower	Upper
HPA-1a	30 (100)	0	100 (100)	0	-	-	-
HPA-1b	2 (6.7)	28 (93.3)	4 (4)	96 (96)	1.714	0.298	9.853
HPA-2a	30 (100)	0	100 (100)	0	-	-	-
HPA-2b	26 (87.6)	4 (12.4)	92 (92)	8 (8)	0.565	0.158	2.026
HPA-3a	22 (73.3)	8 (26.7)	78 (78)	22 (22)	0.776	0.304	1.980
HPA-3b	24 (80)	6 (20)	91 (91)	9 (9)	0.396	0.128	1.221
HPA-4a	30 (100)	0	100	0	-	-	-
HPA-4b	0	30 (100)	0	100	-	-	-
HPA-5a	30 (100)	0	100	0	-	-	-
HPA-5b	1 (3.3)	29 (96.7)	1 (1)	99 (99)	3.414	0.207	56.281
HPA-15a	25 (83.3)	5 (16.7)	81 (81)	19 (19)	1.173	0.397	3.462
HPA-15b	25 (83.3)	5 (16.7)	86 (86)	14 (14)	0.814	0.267	2.480

ITP; Immune thrombocytopenic purpura, HPA; human platelet antigen. *Data reported by Shaiegan et al. (2019: ISBT Science Series, in press).

Table IV. The calculation of the gene abundances of HPAs by Hardy-Weinberg equilibrium test.

Genotypes	Blood donors (n=100)			ITP patients (n=30)			
	EN	ON	p-Value	EN	ON	p-Value	
HPA-1	aa	96	96	0.979	28	28	0.982
	ab	3.9	4		1.9	2	
	bb	0	0		0	0	
HPA-2	aa	29.2	8	0.100	9.6	4	0.115
	ab	49.7	92		14.7	26	
	bb	21.2	0		5.6	0	
HPA-3	aa	18.9	9	0.285	4.9	6	0.746
	ab	49.2	69		18.2	16	
	bb	31.9	22		16.9	18	
HPA-4	aa	100	100	1.000	30	30	1.000
	ab	0	0		0	0	
	bb	0	0		0	0	
HPA-5	aa	99	99	0.998	29	29	0.995
	ab	1	1		1	1	
	bb	0	0		0	0	
HPA-15	aa	22.6	14	0.102	7.5	5	0.188
	ab	49.9	67		15	20	
	bb	27.6	19		7.5	5	

ITP; Immune thrombocytopenic purpura, HPA; Human platelet antigen. ON: Observed number; EN: Expected number. * Data reported by Shaiegan et al. (2019: ISBT Science Series, in press).

Table V. The results of the abundance of HPAs in the study population & other populations.

Population	HPA-1		HPA-2		HPA-3		HPA-4		HPA-5		HPA-15	
	a	b	a	b	a	b	a	b	a	b	a	b
Croatian (27, 28)	0.85	0.14	0.89	0.11	0.57	0.42	–	–	0.89	0.1	0.53	0.47
Macedonian (29)	0.86	0.13	0.85	0.14	0.57	0.42	–	–	0.9	0.09	–	–
Lebanese (30)	0.81	0.19	–	–	–	–	–	–	–	–	–	–
Indian (31)	0.92	0.07	0.99	0	0.01	0.99	0.99	0	0.95	0.04	–	–
Han Chinese (32)	0.99	0	0.95	0.04	0.59	0.4	0.99	0	0.98	0.01	0.53	0.46
Pakistani (22)	0.88	0.11	0.92	0.08	0.69	0.31	1	0	0.9	0.1	0.59	0.41
Bahrainian (33)	0.76	0.24	0.77	0.23	0.57	0.43	0.93	0.07	0.86	0.13	–	–
Egyptians (34)	0.76	0.23	0.75	0.24	0.7	0.29	1	0	0.72	0.27	–	–
Thai (17)	0.98	0.01	0.95	0.04	0.56	0.44	1	0	0.96	0.03	0.49	0.5
Saudis (11)	0.8	0.2	0.71	0.29	0.65	0.35	0.99	0.01	0.8	0.2	0.47	0.52
Iran (This study)	0.99	0.01	0.55	0.45	0.44	0.56	1	0	0.99	0	0.48	0.52
Malay (35)	0.97	0.02	0.96	0.03	0.5	0.49	0.99	0	0.95	0.05	0.51	0.48
Malaysian Chinese (35)	1	0	0.96	0.03	0.57	0.42	0.99	0	0.98	0.01	0.49	0.5
Malaysian Indian (35)	0.88	0.11	0.96	0.04	0.62	0.38	0.99	0	0.94	0.06	0.4	0.59
Argentinean (36)	0.87	0.12	0.87	0.12	0.61	0.38	1	0	0.92	0.07	0.51	0.48
Amerindian Toba (36)	1	0	0.94	0.05	0.38	0.61	1	0	1	0	0.68	0.31
Algerian (37)	0.83	0.16	0.83	0.16	0.62	0.37	1	0	0.83	0.15	0.53	0.47
Beninese (38)	0.89	0.1	0.7	0.29	0.67	0.32	1	0	0.81	0.18	0.64	0.35
Cameroonian (38)	0.9	0.09	0.76	0.23	0.61	0.38	1	0	0.74	0.25	0.69	0.3
Congolese (38)	0.9	0.09	0.77	0.22	0.59	0.4	1	0	0.73	0.26	0.7	0.29
Central African (38)	1	0	0.6	0.39	0.5	0.5	1	0	0.59	0.4	0.69	0.3

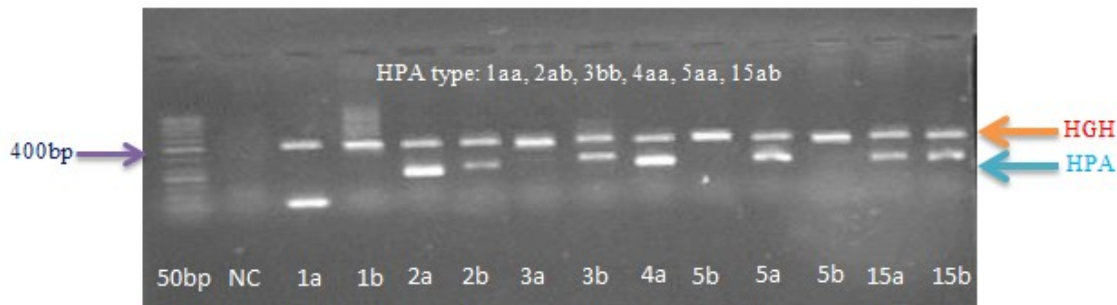


Figure 1. Results related to genotyping of a patient; NC, negative control; HGH, human growth hormone

Discussion

The present research has revealed that the phenotype of HPA3b abundance was lower in ITP patients compared to blood donors, but the homozygous 3aa/3bb genotype abundance was higher in ITP cases compared to control group. The findings of this study the clinical studies related to platelet disorders, and it can be assumed as the first step creating a database on platelet antigen polymorphisms among Iranians.

As ITP is a heterogeneous and acquired disease of unidentified etiology, it could be useful to study HPAs systems for gathering comprehensive data on population genetics (24).

In addition, T. K. Eyada et al. reported HPA-2b allele phenotype showed a significantly higher frequency in Egyptian patients compared to normal blood donors. They also reported the genotype of HPA-2b showed considerably higher prevalence in case group compared to blood donors (19).

Furthermore, Tang LJ et al. identified that the special HPAs polymorphisms can associate to the possibility of ITP in Chinese Guangxi area (25). Besides, another study reported that the HPA-2b has revealed a significantly higher frequency in Macedonian patients compared to blood donors and thus authors recommended that it is likely that HPA-2b be involved in the formation of a specific autoepitope in this ethnicity (3).

In addition, Carmo JC et al. declared that allele abundances of the HPA-2, -4, -6 to -9, -11, and -15 were undistinguishable among patients with PTR and blood donors in the northern Brazil, hence suggesting that the allele of HPA-1a, -3b, & -5b might be considered as ITP-particular autoepitopes (26).

This study, in contrast, revealed no substantial dissimilarity between blood donors and ITP patients regarding the HPA-1 to -5 & -15 allele and genotype abundances. Accordingly, we suggest that global variation in the abundance of autoepitopes among ITP subjects can take place in response to the genetic inheritance of HPA polymorphisms.

The HPA-1 to -5 & -15 frequencies in this study and other populations are shown in Table- 5 for comparison.

Conclusion

In conclusion, the present investigation reports that individuals with HPA-1b, -5b & -15a allele phenotypes are more likely to be affected by the ITP by odds of : 1.714, 3.414 & 1.173 times respectively; however, this was not statistically significant. HPA-4b was absent and there was not any homozygosity for HPA-1b/1b, HPA-2b/2b and HPA-5b/5b. Moreover, no HPA-1b/b, HPA-2b/b, and HPA-5b/b homozygosity were found. Therefore, it seems that HPA-1a, -2a, -4a & -5a polymorphisms do not involved in the

autoimmunity related to the primary ITP in Iranian population. Further studies are recommended to help the prevention and management of immune diseases engendered by platelet antibodies. This study provides comprehensive information on the HPA allele distribution among the Iranians with ITP.

Acknowledgement

We appreciate IBTO research center for funding this project. The authors wish to acknowledge Jahangir Ahmadi, Zohreh Atarchi, Shahnaz Valmohammadi and Zahra Ataee as well.

Conflict of interest

The authors declare no conflict of interest.

References

1. Zufferey A, Kapur R, Semple JW. Pathogenesis and therapeutic mechanisms in immune thrombocytopenia (ITP). *JCM* 2017; 6 (2); 16: 1-21.
2. Schmidt DE, de Haan N, Sonneveld ME, Porcelijn L, van der Schoot CE, de Haas M, et al. IgG-Fc glycosylation before and after rituximab treatment in immune thrombocytopenia. *Scientific Reports* 2020; 10(1): 1-8.
3. Pavkovic M, Stojanovic A, Karanfilski O, Cevreska L, Spiroski M. Association of polymorphisms in human platelet antigens with idiopathic thrombocytopenic purpura in Macedonians. *MASA* 2012; 33(1): 1-1.
4. Rodeghiero F, Stasi R, Gernsheimer T, Michel M, Provan D, Arnold DM, et al. Standardization of terminology, definitions and outcome criteria in immune thrombocytopenic purpura of adults and children: report from an international working group. *Blood* 2009; 113 (11): 2386-2393.
5. Neunert CE. Current management of immune thrombocytopenia. *ASH Education Program* 2013; 2013(1): 276-282.
6. Moulis G, Palmaro A, Montastruc J-L, Godeau B, Lapeyre-Mestre M, Sailler L. Epidemiology of incident immune thrombocytopenia: a nationwide population-based study in France. *Blood* 2014; 124 (22): 3308-3315.
7. Vickers NJ. Animal Communication: When I'm Calling You, Will You Answer Too? *Curr Biol* 2017; 27(14): 713-715.
8. Wu KH, Peng CT, Li TC, Wan L, Tsai CH, Lan SJ, et al. Interleukin 4, interleukin 6 and interleukin 10 polymorphisms in children with acute and chronic immune thrombocytopenic purpura. *BJH* 2005; 128 (6): 849-852.
9. Pehlivan M, Okan V, Sever T, Balci SO, Yilmaz M, Babacan T, et al. Investigation of TNF-alpha, TGF-beta 1, IL-10, IL-6, IFN-gamma, MBL, GPIA, and IL1A gene polymorphisms in patients with idiopathic thrombocytopenic purpura. *Platelets* 2011; 22(8): 588-595.
10. Silvestre APA, Zacarias JMV, Guelsin GAS, Visentainer JEL, Sell AM. Genetic polymorphisms of human platelet antigens in Euro-African and Japanese descendants from Parana, Southern Brazil. *Platelets* 2017; 28(6): 607-610.
11. Al-Ouda S, Al-Banyan A, Abdel Gader A, Bayoumy N, Al-Gahtani F. Gene frequency of human platelet alloantigens-1 to-6 and-15 in Saudi blood donors. *Transfus Med* 2016; 26 (3): 220-224.
12. Ghevaert C, Rankin A, Huiskes E, Porcelijn L, Javela K, Kekomaki R, et al. Alloantibodies against low-frequency human platelet antigens do not account for a significant proportion of cases of fetomaternal alloimmune thrombocytopenia: evidence from 1054 cases. *Transfusion* 2009; 49(10): 2084-2089.
13. Tamatani T, Takamaru N, Ohe G, Nakagawa T, Kurio N, Kudou K, et al. The clinicopathologic roles of SOX2 and Oct4 expressions in stage 1 and 2 oral

- squamous cell carcinoma. *AACR* 2018; 3061-3061.
14. Ghasemi A, Zadsar M, Shaiegan M, Samiei S, Namvar A, Rasouli M, et al. Human platelet antigens polymorphisms; association to the development of liver fibrosis in patients with chronic hepatitis C. *JMV* 2020; 92(1): 45-52.
 15. Verdichio-Moraes CF, Toralles-Pereira C, Grotto RMT, Silva GF, Pardini MIDMC. Allelic frequencies of HPA-1 to 5 human platelet antigens in patients infected with hepatitis C virus. *JMV* 2009; 81(4): 757-759.
 16. Salem AH, Han K, Batzer MA. Allele frequencies of the human platelet antigen-1 in the Egyptian population. *BMC res notes* 2009; 2(1): 90-94.
 17. Kupatawintu P, Nathalang O, O-Charoen R, Patmasiriwat P. Gene frequencies of the HPA-1 to 6 and Gov human platelet antigens in Thai blood donors. *Immunohematology* 2005; 21(1): 5-9.
 18. Castro V. Human platelet antigens and primary immune thrombocytopenia. *RBHH* 2017; 39(2): 95-97.
 19. Eyada TK, Amin DG, Samih I, Khedr SM. Human platelet antigen 1, 2 and 5 gene polymorphisms in Egyptians and their potential association with susceptibility to immune thrombocytopenic purpura in Egyptian patients. *Hematology* 2018; 23(2): 111-116.
 20. Michel M, editor *Immune thrombocytopenia nomenclature, consensus reports, and guidelines: what are the consequences for daily practice and clinical research?* *hematology* 2013; 50: 50-54.
 21. Moulis G, Palmaro A, Montastruc J-L, Godeau B, Lapeyre-Mestre M, Sailler L. Epidemiology of incident immune thrombocytopenia: a nationwide population-based study in France. *Blood* 2014; 124(22): 3308-3315.
 22. Bhatti F, Uddin M, Ahmed A, Bugert P. Human platelet antigen polymorphisms (HPA-1,-2,-3,-4,-5 and-15) in major ethnic groups of Pakistan. *Transfus Med* 2010; 20(2): 78-87.
 23. Shaiegan M, Ghasemi A, Madani T, Samiee S, Bayat B, Mohammadi S, et al. Gene frequencies of human platelet antigen-1 to-5 and-15 in the Iranian population. *ISBT* 2020; 15(2): 273-280.
 24. Muhiddin R, Nurulita A, Harjianti T, Hatta M, Arif M. Analysis of Human Platelet Antigen (HPA) in Thrombocytopenia Patients. *IJPHRD* 2019; 10 (10): 1570-1575.
 25. Tang L, Zhou X, Bin Q, Huang X, Luo J. Analysis of HPA gene Polymorphisms in Children with Acute or Chronic ITP. *JXH* 2016; 24(5): 1518-1522.
 26. Carmo JcD, Klippel PdS, Cordeiro SdC, Fernandes ÂMdS, Pinto RM, Weber SS, et al. Molecular typing of human platelet antigens in immune thrombocytopenia patients in northern Brazil. *RBHH* 2017; 39(2): 122-126.
 27. Tomicic M, Bingulac-Popovic J, Drazic V, Hundric-Haspl Z. Frequency of HPA-15a and HPA-15b (Gov a/b) human platelet alloantigens in the Croatian population. *AMR* 2006; 37 (1): 172-174.
 28. Pavic M, Zadro R, Coen Herak D, Radic Antolic M, Dodig S. Gene frequencies of platelet specific antigens in Croatian population. *Transfus Med* 2010; 20 (2): 73-77.
 29. Pavkovic M, Petlichkovski A, Strezova A, Arsov T, Trajkov D, Spiroski M. Gene frequencies of human platelet antigens in the Macedonian population. *Tissue antigens* 2006; 67 (3): 241-246.
 30. Sabbagh A, Taher A, Zaatari G, Mahfouz R. Gene frequencies of the HPA-1 platelet antigen alleles in the Lebanese population. *Transfus Med* 2007; 17(6): 473-478.
 31. Kulkarni B, Mohanty D, Ghosh K. Frequency distribution of human platelet antigens in the Indian population. *Transfus Med* 2005; 15 (2): 119-124.
 32. Feng M, Liu D, Shen W, Wang J, Guo Z, Zhang X, et al. Establishment of an

HPA-1-to-16-typed platelet donor registry in China. *Transfus Med* 2006; 16(5): 369-374.

33. AlSubaie AM, Al-Absi IK, Al-Ola K, Saidi S, Fawaz NA, Almawi WY. Gene frequencies of human platelet alloantigens in Bahraini Arabs. *AJH* 2007; 82(3): 242-244.

34. Salem AHA, Hamed AESA, Abdalla EM, Almawi W. Gene frequencies of human platelet alloantigens 1-5 in two Arab populations. *Blood Transfusion* 2014; 12 (Suppl 1): 281-285.

35. Tan J-Y, Lian L-H, Nadarajan VS. Genetic polymorphisms of human platelet antigens-1 to-6, and-15 in the Malaysian population. *Blood Transfusion* 2012; 10(3): 368-376.

36. De La Vega Elena C, Nogues N, Fernandez Montoya A, Chialina S, Blanzaco P, Theiller E, et al. Human platelet-specific antigens frequencies in the Argentinean population. *Transfus Med* 2008; 18(2): 83-90.

37. Brouk H, Halle L, Bertrand G, Neche F, Ouelaa H, Kaplan C. Human platelet antigen allele frequencies in different Algerian populations. *Tissue Antigens* 2010; 75 (6): 673-678.

38. Halle L, Bigot A, Mullen-Imandy G, M'bayo K, Jaeger G, Anani L, et al. HPA polymorphism in sub-Saharan African populations: Beninese, Cameroonians, Congolese, and Pygmies. *Tissue Antigens* 2005; 65 (3): 295-298.