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Review

Molecular blood grouping of donors

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ABSTRACT

For many decades, hemagglutination has been the sole means to type blood donors. Since the first blood group gene cloning in the early 1990s, knowledge on the molecular basis of most red blood cell, platelet and neutrophil antigens brought the possibility of using nucleotide-based techniques to predict phenotype. This review will summarized methodologies available to genotype blood groups from laboratory developed assays to commercially available platforms, and how proficiency assays become more present. The author will also share her vision of the transfusion medicine future. The field is presently at the crossroads, bringing new perspectives to a century old practice.

Contents

1. Introduction

Blood transfusion has been part of medicine for centuries, although the first reported human to human blood transfusion dates back only to 1818 [1]. Transfusions were not tolerated by all recipients and fatal reactions were common. This phenomenon remained a mystery until 1901, when Karl Landsteiner discovered the ABO blood group system. Since then, the practice of blood transfusion has evolved dramatically. For red blood cells only, the International Society of Blood Transfusion acknowledges 33 blood group systems comprising over 300 antigens [2]. A 34th blood group will soon be added to this list. Earlier last year,

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Table 1
Blood group systems recognized by the International Society of Blood Transfusion [78].

No.	Name (symbol)	Gene name(s)	No. of antigens
001	ABO	*ABO*	4
002	MNS	*GYPA, GYPB*	46
003	P1PK	*A4GALT*	3
004	Rh (RH)	*RHD, RHCE*	54
005	Lutheran (LU)	*LU*	20
006	Kell (KEL)	*KEL*	35
007	Lewis (LE)	*LE (FUT3)*	6
008	Duffy (FY)	*FY (DARC)*	5
009	Kidd (JK)	*JK (SLC14A1, HUT11A)*	3
010	Diego (DI)	*DI (SLC4A1, AE1, EPB3)*	22
011	Yt (YT)	*YT (ACHE)*	2
012	Xg (XG)	*XG (PBDX)*	2
013	Scianna (SC)	*SC (ERMAP)*	7
014	Dombrock (DO)	*DO (ART4)*	8
015	Colton (CO)	*CO (AQP1)*	4
016	Landsteiner-Wiener (LW)	*LW (ICAM4, CD242)*	3
017	Chido-Rodgers (CH/RG)	*CH (C4B), RG (C4A)*	9
018	H (H)	*H (FUT1)*	1
019	Kx (XK)	*XK*	1
020	Gerbich (GE)	*GE (GYPC)*	11
021	Cromer (CROM)	*CROM (DAF)*	18
022	Knops (KN)	*KN (CR1)*	9
023	Indian (IN)	*IN (CD44)*	4
024	Ok (OK)	*OK (BSG, EMPRIN)*	3
025	Raph (RAPH)	*RAPH (CD151)*	1
026	John Milton Hagen (JMH)	*JMH (SEMA7A, CD108, SEMA-L)*	6
027	I (I)	*I (GCNT2, IGnT)*	1
028	Globoside (GLOB)	*GLOB (B3GALNT1)*	1
029	Gill (GIL)	*GIL (AQP3)*	1
030	Rh-associated glycoprotein (RHAG)	*RHAG*	4
031	FORS (FORS)	*FORS (GBGT1, A3GALNT)*	1
032	JR (JR)	*JR (ABCG2)*	1
033	Lan (LAN)	*LAN (ABCB6)*	1
034[a]	Vel (VEL) [3–5]	*VEL (SMIM1)*	1

[a] The Vel blood group has not been officially approved by the ISBT.

SMIM1, a new blood group gene, was proven responsible for the Vel antigen expression [3–5] (Table 1). Although, platelet and neutrophil antigens are not subject to as many publications as red blood cells, nonetheless they play an important role in transfusion The ISBT set up working parties to address issues regarding those cells. Tables 2 and 3 list recognized platelet and neutrophil antigens.

Transfusion reaction results from a complex immune response against antigens present on the transfused red blood cells, and lacking on the recipient's. This immune response can be mild, moderate or strong. It can happen immediately or be delayed. In rare cases, the reaction is fatal. The produced antibody in the process is problematic, causing donor/patient transfusion incompatibility and materno-fetal incompatibility during subsequent pregnancies [6].

The most clinically significant red blood cell antigens are within ABO, Rh and Kell blood group systems. Other antigens can also stimulate antibody production and these include Dombrock, Kidd and MNS. In certain populations, specific antibodies are more often seen. This is due to the different antigen frequency observed within populations [7]. For example, Africans tend to develop more antibodies against the MNS and Duffy systems, while Polynesians develop antibodies mostly against the Kidd system [8].

To avoid transfusion reactions and hemolytic disease of the fetus and newborn, Anstee published three simple and sensible rules to be followed: (1) transfuse only ABO-

Table 2
Platelet antigens [79].

Antigen	Glycoprotein	Gene name
HPA-1	GPIIIa	*ITGB3*
HPA-2	GPIba	*GP1BA*
HPA-3	GPIIb	*ITGA2B*
HPA-4	GPIIIa	*ITGB3*
HPA-5	GPIa	*ITGA2*
HPA-6w	GPIIIa	*ITGB3*
HPA-7w	GPIIIa	*ITGB3*
HPA-8w	GPIIIa	*ITGB3*
HPA-9w	GPIIb	*ITGA2B*
HPA-10w	GPIIIa	*ITGB3*
HPA-11w	GPIIIa	*ITGB3*
HPA-12w	GPIbb	*GP1BB*
HPA-13w	GPIa	*ITGA2*
HPA-14w	GPIIIa	*ITGB3*
HPA-15	CD109	*CD109*
HPA-16w	GPIIIa	*ITGB3*
HPA-17w	GPIIIa	*ITGB3*
HPA-18w	GPIa	*ITGA2*
HPA-19w	GPIIIa	*ITGB3*
HAP-20w	GPIIb	*ITGA2B*
HPA-21w	GPIIIa	*ITGB3*
HPA-22bw	GPIIb	*ITGA2B*
HPA-23bw	GPIIIa	*ITGB3*
HPA-24bw	GPIIb	*ITGA2B*
HPA-25bw	GPIa	*ITGA2*
HPA-26bw	GPIIIa	*ITGB3*
HPA-27bw	GPIIb	*ITGA2B*
HPA-28bw	GPIIb	*ITGA2B*