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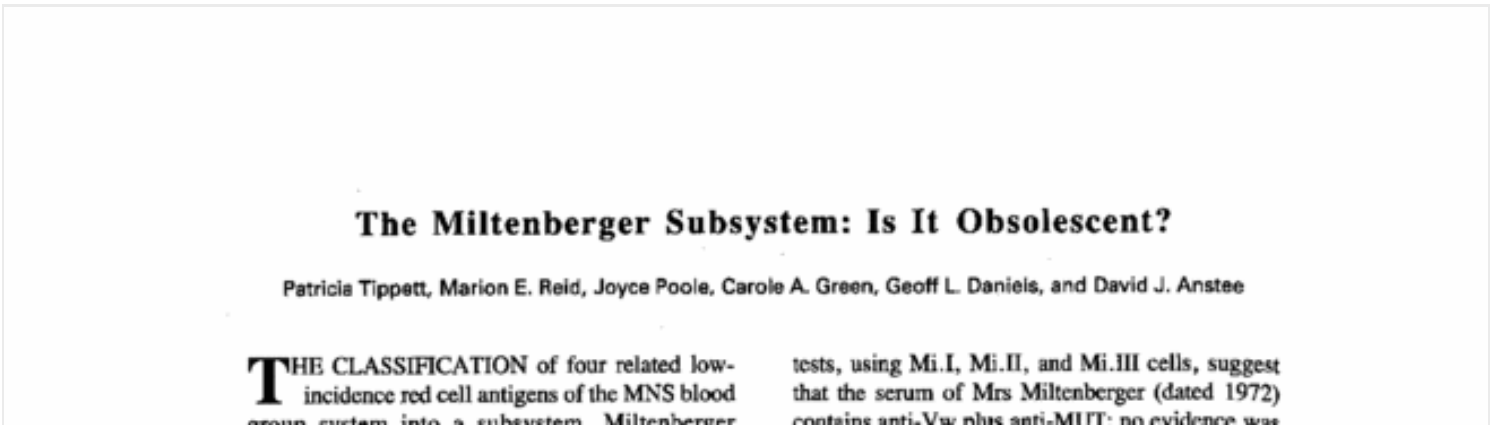

The Miltenberger Subsystem: Is It Obsolescent?

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THE CLASSIFICATION of four related low-incidence red cell antigens of the MNS blood

tests, using Mi.I, Mi.II, and Mi.III cells, suggest that the serum of Mrs Miltenberger (dated 1972)

group system into a subsystem, Miltenberger (Mi.), was first proposed by Cleghorn in 1966.[1] Studies with several sera in various laboratories were collated and extended by Cleghorn.[1] Four cell classes (Mi.I, Mi.II, Mi.III, and Mi.IV) were defined by their reactions with four type sera called Verweyst (Vw), Miltenberger (Mi^a), Murrell (Mur) and Hill (Hil). These cell classes were related by their positive reactions with the serum of Mrs Miltenberger (Table 1). A new class, Mi.V, was added to describe a red cell sample that was negative with Mrs Miltenberger's serum but positive with anti-Hil.[2] The Mi. subsystem was further expanded to eight phenotypes and reassessed by Giles in terms of antigenic determinants, instead of reactions with type sera.[3] The associated low-incidence antigens have subsequently been numbered by the International Society of Blood Transfusion Working Party for the Terminology of Red Cell Antigens.[4] A ninth class was added recently.[5] These antigens are summarized in Table 1. Several other cell samples that react with antibodies positive with Mi.III and Mi.IV cells do not fit into the recognized phenotypes and will be discussed later.

From the beginning, doubts were cast on the specificity of anti-Mi^a because Miltenberger sera appeared to be heterogeneous.[1] Anti-Mi^a was found to be polyspecific with separable and cross-reactive antibodies.[1,3,6] Giles speculated that "if the Miltenberger complex exists as an entity then Mi^a as a determinant probably does not."[3] This view was also held by Anstee.[7] Clarification of the relationships between the Mi. determinants was handicapped by the rarity of appropriate red cells and lack of "monospecific" sera because most reagents were polyspecific with cross-reactive components. The results of recent adsorption/elution found for a separable anti-Mi^a (C. Green, unpublished observations). There is little evidence for Mi^a as a discrete determinant. The majority of sera, like that of Mrs Miltenberger, have separable anti-Vw plus anti-MUT and/or anti-Mur and/or anti-Hut (J. Poole, unpublished observations). Therefore, Mi^a as a determinant will not be considered further.

The MN and Ss antigens are carried by glycophorin A (GPA) and glycophorin B (GPB), the major sialic acid-rich glycoproteins on red cells.[8-11] Immunoblotting with anti-GPA and anti-GPB of red cell membrane components separated by sodium dodecyl sulfate–polyacrylamide gel electrophoresis showed the apparent relative molar mass (M_r) of monomeric GPA to be 42,000 and that of monomeric GPB to be 25,000. The amino acid sequences of GPA and GPB have been determined:[12,13] GPA^M has serine and glycine and GPA^N has leucine and glutamic acid at residues 1 and 5, respectively. Amino acid residues 1-26 of GPB are the same as those of GPA^N; the Ss polymorphism of GPB depends on a single amino acid substitution at residue 29: methionine in GPB^{NS} and threonine in GPB^{Ns}.

The genes encoding GPA and GPB are closely linked and have been assigned to chromosome 4.[14] Cloning of these genes showed them to have considerable homology and confirmed their close linkage and chromosomal assignment.[15-19] The gene for GPA has seven exons, five of which (exons A2 to A6) encode the protein. The gene for GPB has five exons, three of which (exons B2 to B4) encode the protein. Four exons are the same in both genes (Fig 1). Exon 1 of both genes contains the 5′ noncoding sequence and part of the signal sequence.[18] Intervening sequences between exons B2 and B3 (intron B2) contain a sequence, called by Blumenfeld and coworkers the pseudoexon (denoted ψB in Fig 1). The pseudoexon is similar to exon A3 but unexpressed because of inactivation of the 5′ splicing signal sequence caused by a single nucleotide substitution. During investigation of the genes for GPA and GPB, a third related gene

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