The discovery of citrate anticoagulant in the 1920s and the development of plastic packs for blood collection in the 1960s laid the groundwork for platelet transfusion therapy on a scale not previously possible. A major limitation, however, was the finding that platelet concentrates prepared from blood anticoagulated with citrate were unsuitable for transfusion because of platelet clumping. We found that this could be prevented by simply reducing the pH of platelet-rich plasma to about 6.5 prior to centrifugation. We used this approach to characterize platelet kinetics and sites of platelet sequestration in normal and pathologic states and to define the influence of variables such as anticoagulant and ABO incompatibility on post-transfusion platelet recovery. The “acidification” approach enabled much wider use of platelet transfusion therapy until alternative means of producing concentrates suitable for transfusion became available.

The identification of platelets as a distinct cellular element of blood with a critical role in hemostasis in the late 1800s (1) inevitably led to speculation about platelet transfusion as a treatment for bleeding in patients with thrombocytopenia. The realization of this goal was delayed for many years by technical barriers. Development of citrate-based anticoagulants in the 1920s and flexible plastic blood containers in the 1950s–1960s made it feasible to collect blood in a plastic pack containing standard acid-citrate-dextrose (ACD) anticoagulant, centrifuge it slowly, and express the supernatant platelet-rich plasma (PRP) into a plastic side-pack for convenient transfusion. Early studies showed that platelets from multiple units of blood were needed to achieve a therapeutic effect in a bleeding patient. To prevent volume overload, this required that platelets be concentrated before being transfused. The obvious way to accomplish this was to centrifuge PRP at high speed, remove the supernatant plasma, and suspend the pelleted platelets in a small volume by gently massaging the plastic pack. It soon became apparent that concentrates prepared in this way almost invariably contained large and small platelet aggregates and few single platelets. Not surprisingly, clinicians were reluctant to transfuse these preparations.

It was known at this time that platelets isolated from blood that had been anticoagulated with EDTA could be pelleted from PRP by centrifugation and dispersed without difficulty. To meet the growing demand for platelet transfusions, the Fenwal Company developed the “EDTA Platelet Pack,” consisting of a plastic collection bag containing EDTA and an attached satellite bag into which PRP could be expressed, concentrated by centrifugation into a pellet, and suspended in a small volume of plasma. Red cells were returned to the donor to enable repeated platelet donations.

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Blood platelet kinetics and platelet transfusion

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major sites of platelet deposition. The linear clearance pattern suggested that under normal circumstances, platelets die as a consequence of “senescence,” rather than being randomly utilized (5).

Freireich and his colleagues at the National Cancer Institute soon confirmed the superiority of platelet concentrates prepared from acidified ACD blood in producing sustained platelet increases in thrombocytopenic patients (6). Over the next few years, this simple maneuver facilitated much wider use of platelet transfusions, especially in patients being treated for hematologic malignancies. We used the new methodology to characterize platelet clearance and sites of sequestration in normal individuals (5, 7) and in patients with platelet destruction mediated by alloantibodies (8) and autoantibodies (9), as well as to more fully define the role of anticoagulants and ABO incompatibility on recovery and survival of transfused platelets (10). We also demonstrated that “hypersplenic” thrombocytopenia is largely caused by pooling of a significant fraction of the total circulating platelet mass in an enlarged spleen, rather than being a consequence of suppressed platelet production or premature platelet destruction (11).

Although acidifying citrated blood or PRP to prepare platelet concentrates for transfusion represented a significant improvement over what was previously possible, other advances soon followed. Mourad found that platelet concentrates prepared from nonacidified ACD blood could be manually suspended with little clumping, provided the platelet pellet was allowed to rest for some time at room temperature before manipulation (12). Other key developments were the finding by Murphy et al. that platelet viability is best maintained by storage at room temperature (13) and the evolution ofpheresis systems for isolating large quantities of platelets from single donors.

To my knowledge, reversible aggregation of platelets pelleted from citrated PRP is still not fully understood, but it seems almost certain that fibrinogen binding to partially activated \(\alpha_{IIb}\beta_3\) integrin (GP IIb/IIIa) is involved, since fibrinogen-dependent platelet aggregation is markedly inhibited at pH 6.5 (6, 14). The EDTA-induced structural changes in platelets were well characterized by White (15). The “swirling” of platelets was shown to be a consequence of their normal discoid shape and to correlate fairly well with post-transfusion viability (16).

Figure 1
Survival of autologous “citrate platelets” after transfusion to a normal subject. Approximately 75% of labeled platelets were recovered in the circulation immediately after being transfused. The red area denotes the range of blood platelet radioactivity after the injection of Cr\(^{51}\)-labeled “EDTA platelets” on 10 occasions in 7 normal subjects. Adapted from ref. 5.

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