



UNIVERSITÀ  
DEGLI STUDI  
FIRENZE

## FLORE

# Repository istituzionale dell'Università degli Studi di Firenze

### **Reticulated platelets and platelet reactivity in renal transplant recipients receiving antiplatelet therapy**

Questa è la Versione finale referata (Post print/Accepted manuscript) della seguente pubblicazione:

*Original Citation:*

Reticulated platelets and platelet reactivity in renal transplant recipients receiving antiplatelet therapy / M. Zanazzi; F. Cesari; G. Rosso; S. Farsetti; L. Caroti; A.M. Gori; G. Cerini; G. Cioni; E. Bertoni; R. Abbate; M. Salvadori. - In: TRANSPLANTATION PROCEEDINGS. - ISSN 0041-1345. - STAMPA. - 42(2010), pp. 1156-1157. [10.1016/j.transproceed.2010.03.042.]

*Availability:*

This version is available at: 2158/393412 since: 2018-02-28T14:23:18Z

*Published version:*

DOI: 10.1016/j.transproceed.2010.03.042.

*Terms of use:*

Open Access

La pubblicazione è resa disponibile sotto le norme e i termini della licenza di deposito, secondo quanto stabilito dalla Policy per l'accesso aperto dell'Università degli Studi di Firenze (<https://www.sba.unifi.it/upload/policy-oa-2016-1.pdf>)

*Publisher copyright claim:*

(Article begins on next page)



## Reticulated Platelets and Platelet Reactivity in Renal Transplant Recipients Receiving Antiplatelet Therapy

M. Zanazzi, F. Cesari, G. Rosso, S. Farsetti, L. Caroti, A.M. Gori, G. Cerini, G. Cioni, E. Bertoni, R. Abbate, and M. Salvadori

### ABSTRACT

**Introduction.** Renal transplant recipients are at increased risk of cardiovascular morbidity and mortality. We assessed platelet reactivity and reticulated platelets (RPs) in 90 recipients, 51 (56.6%) of whom were not receiving acetylsalicylic acid (ASA) therapy (group A) and 39 (43.3%) who were receiving ASA therapy, 100 mg (group B), and in 60 healthy controls (group C).

**Methods.** Reticulated platelets were measured using a hematology automated analyzer (XE-2100; Sysmex Corp, Kobe, Japan) and were expressed as the percentage of RPs in the total optical platelet count (immature platelet fraction [IPF]), as the percentage of highly fluorescent RPs, and as the absolute number of RPs (IPF#). Platelet function was assessed using optical aggregometry (platelet aggregation) induced using 1 mmol/L of arachidonic acid, 2 or 10  $\mu$ mol/L of adenosine diphosphate, or 2  $\mu$ g/mL of collagen.

**Results.** Group A demonstrated significantly higher values of RP compared with group B or group C. Group B demonstrated a substantially higher percentage of RPs compared with group C, which was significant only for the IPF parameter. Multiple regression analysis demonstrated that IPF and IPF# were significantly and positively related to collagen-induced platelet aggregation.

**Conclusion.** We documented the presence of higher concentrations of RPs in transplant recipients compared with a control population, and a significant association between RPs and platelet function.

OVER THE LAST YEARS, a number of studies have demonstrated the importance of some classic risk factors such as hyperlipidemia and hypertension in determining cardiovascular disease in renal transplant recipients; however, the presence of risk factors did not enable prediction of patient survival.<sup>1</sup> Various mechanisms can be responsible for cardiovascular complications in renal transplant recipients. Their platelets demonstrate enhanced thromboxane biosynthesis,<sup>2</sup> and some immunosuppression agents such as cyclosporine are associated with increased platelet procoagulant activity.<sup>3,4</sup> However, to our knowledge, no data on the presence of reticulated platelets (RPs), and in particular platelet activity, are available. The objective of the present study was to assess RPs and platelet aggregation (PA) in renal transplant recipients who were or were not receiving acetylsalicylic acid (ASA) therapy and in a population of healthy controls.

### METHODS

The study population included 90 renal transplant recipients observed according to American Society of Nephrology guide-

lines.<sup>5</sup> Fifty-nine patients were men, and 31 were women, with median (range) age of 55 (20–70) years. Group A included 51 recipients (56.6%) not receiving ASA therapy, and group B included 39 recipients (43.3%) receiving ASA therapy for at least 6 months posttransplantation. Group C (control group) included 60 healthy individuals. Forty-one were men, and 19 were women, with median (range) age of 52 (21–72) years, who were free of vascular and renal diseases. All 3 groups were comparable for age and sex.

Venous blood samples were obtained from each study participant in the morning, after an overnight fast, and were anticoagulated using 0.129 mol/L of sodium citrate, and examined using

From the Renal Unit, Department of Medical and Surgical Critical Care, Thrombosis Centre; Center for the Study at Molecular and Clinical Level of Chronic, Degenerative and Neoplastic Diseases to Develop Novel Therapies, University of Florence; and Careggi University Hospital (M.Z., F.C., G.R., S.F., L.C., G.C., G.C., E.B., R.A., M.S.), and Centro S. Maria agli Ulivi, Fondazione Don Carlo Gnocchi Onlus IRCCS, Impruneta (A.M.G.), Florence, Italy.

Address reprint requests to Maria Zanazzi, MD, Renal Unit, Careggi University Hospital, 18 Via le Pieraccini, 50134 Florence, Italy. E-mail: [mariazanazzi@libero.it](mailto:mariazanazzi@libero.it)

platelet aggregometry and ethylenediamine tetraacetic acid, 0.17 mol/L.

Turbidimetric PA was used to measure agonist-induced PA in response to various stimuli including 2 or 10  $\mu\text{mol/L}$  of adenosine diphosphate (ADP2-PA and ADP10-PA, respectively), 1 mmol of arachidonic acid (AA-PA), or 2  $\mu\text{g/mL}$  of collagen (Coll-PA), as previously described.<sup>6</sup>

Reticulated platelets were measured as previously described<sup>6</sup> using a hematology automated analyzer (XE-2100; Sysmex Corp, Kobe, Japan). They were expressed as a percentage of the total optical platelet count (immature platelet fraction [IPF]), the percentage of highly fluorescent RPs (H-IPF), or absolute number of RPs (IPF#).

Statistical analysis was performed using commercially available software (SPSS version 13.0 for Windows; SPSS, Inc, Chicago, Illinois). Data are given as median (range). The Mann-Whitney test was used to compare unpaired data between the various groups. A multivariate linear regression model adjusted for cardiovascular risk factors; hematocrit; ASA, erythropoietin, and cyclosporine therapy; and glomerular filtration rate was used to test independent associations of RPs with platelet reactivity.  $P < .05$  was considered significant.

## RESULTS

Group A demonstrated significantly higher values for RPs compared with groups B or C. Group B demonstrated a significantly higher percentage of RPs compared with group C, which was significant only for the IPF parameter.

To evaluate the influence of RPs on PA, we performed a linear regression analysis. In the univariate model, IPF was significantly and positively related to PA by arachidonic acid (AA) ( $\beta$  [SE], 1nAA and 1nIPF, 0.42 [0.16];  $P = .01$ ). However, in the multivariate model, after adjusting for age and sex; hypertension, dyslipidemia, and diabetes mellitus; smoking status; hematocrit; ASA, cyclosporine, and erythropoietin therapy; and glomerular filtration rate, the association lost its significance. Insofar as the association of RPs and Coll-PA, the univariate model demonstrated that IPF, H-IPF, and IPF# were positively and significantly related to Coll-PA ( $\beta$  [SE]: 1nColl and 1nIPF, 0.30 [0.06],  $P = .01$ ; 1nColl and 1nH-IPF, 0.18 [0.07]; 1nColl and 1nIPF#, 0.25 [0.07]). A multiple regression analysis adjusted for all confounding factors demonstrated that these associations remained significant ( $\beta$  [SE]: 1nColl and 1nIPF, 0.25 [0.06],  $P < .05$ ; 1nColl and 1nIPF#, 0.18 [0.07],  $P < .05$ ).

## DISCUSSION

This article provides new information about the presence of increased platelet turnover in renal transplant recipients and the relationship between the presence of RPs and platelet reactivity induced by AA or collagen. Reticulated platelets are immature platelets with a greater mass and greater prothrombotic potential compared with smaller

platelets. They aggregate more rapidly with collagen, and demonstrate a higher concentration of thromboxane  $A_2$  and increased concentrations of procoagulant surface proteins such as P-selectin and glycoproteins IIb and IIIa.<sup>7</sup> Moreover, RPs are associated with diminished antiplatelet effects of ASA and increased ASA resistance, possibly because of increased reactivity and the presence of uninhibited cyclooxygenase-1 and cyclooxygenase-2 activity.<sup>8</sup>

We documented the presence of the higher concentrations of RPs in renal transplant recipients compared with a control population of healthy individuals, and a significant association between RPs and platelet function.

The number of newly produced circulating platelets depends on stimulation of the thrombopoietic capacity of bone marrow and on the degree of platelet removal from the bloodstream via activation-dependent mechanisms that enhance platelet turnover. Both mechanisms may be important in determining the number of RPs. Some cytokines augment megakaryopoiesis quantitatively, and in renal transplant recipients, higher concentrations of tumor necrosis factor- $\alpha$ , a cytokine that can act to promote commitment along the megakaryocytic lineage to increased thrombopoiesis, have been reported.<sup>9</sup>

In conclusion, the presence of an increased percentage of RPs may be another mechanism involved in the increased cardiovascular risk profile documented in renal transplant recipients.

## REFERENCES

1. Kasiske BL, Chakkerla HA, Roel J: Explained and unexplained ischemic heart disease risk after renal transplantation. *J Am Soc Nephrol* 11:1735, 2000
2. Averna M, Barbagallo CM, Ganci A, et al: Determinants of enhanced thromboxane biosynthesis in renal transplantation. *Kidney Int* 59:1574, 2001
3. Malyszko J, Malyszko JS, Takada A, et al: Effects of immunosuppressive drugs on platelet aggregation in vitro. *Ann Transplant* 7:55, 2002
4. Tomasiak M, Rusak T, Gacko M, et al: Cyclosporine enhances platelet procoagulant activity. *Nephrol Dial Transplant* 22:1750, 2007
5. Kasiske BL, Vazquez MA, Harmon WE, et al: American Society of Transplantation: Recommendations for the outpatient surveillance of renal transplant recipients. *J Am Soc Nephrol* 11:S1, 2000
6. Cesari F, Marcucci R, Caporale R, et al: Relationship between high platelet turnover and platelet function in high-risk patients with coronary artery disease on dual antiplatelet therapy. *Thromb Haemost* 99:930, 2008
7. Tschöepe D, Roesen P, Kauffmann L, et al: Evidence for abnormal platelet glycoprotein expression in diabetes mellitus. *Eur J Clin Invest* 20:166, 1990
8. Guthikonda S, Lev EI, Patel R, et al: Reticulated platelets and uninhibited COX-1 and COX-2 decrease the antiplatelet effects of aspirin. *J Thromb Haemost* 5:490, 2007
9. Cottone S, Palermo A, Vaccaro F, et al: Inflammation and endothelial activation are linked to renal function in long-term kidney transplantation. *Transplant Int* 20:82, 2007