Inhibition of Human Platelet Glycoprotein IIb/IIIa Binding to Fibrinogen by Tumor Cell Membrane Proteins

Mikio Kamiyama, Karen Chen, Jean Lynch, and Yale S. Arkel

**Blood Research Institute, Saint Michael's Medical Center, Newark, New Jersey 07102 [M. K., K. C., J. L., Y. S. A.], and Seton Hall University School of Graduate Medical Education, South Orange 07079 [M. K., Y. S. A.], New Jersey.**

In brief, we report that GPIIb/IIIa is involved in tumor cell adhesion. Monoclonal antibodies directed against GPIIb/IIIa complex and peptides that inhibit cellular binding to fibronectin were found to inhibit tumor cell growth and colony formation. These results suggest that tumor cells which have immunological and/or structural similarities to platelets may affect hemostasis and coagulation in vivo.

**Introduction**

There have been several reports showing immunological similarities between tumor cell membrane proteins and platelet membrane glycoproteins (1-6). Tumor cell-induced platelet aggregation (6-13) and tumor cell adhesion to platelets (14-17) have also been reported. These reports indicate that GPIIb/IIIa 3 is involved in tumor cell adhesion. Monoclonal antibodies directed against platelet GPIIb/IIIa and peptides that inhibit cellular binding to fibronectin were found to inhibit tumor cell growth and colony formation (12, 18). Pearlstein et al. (8) reported the isolation of PAM from tumor cells. To investigate immunological and functional similarities between tumor cell membrane proteins and human platelet glycoproteins, we used a two in vitro cultured tumor cell lines, a breast adenocarcinoma cell line (BT-20) and a lung adenocarcinoma cell line (A549). The immunological properties of BT-20 had previously been well characterized by one of the authors (19). In this paper we report on a) the platelet-aggregating activity of the tumor cell membrane proteins, (b) the immunological similarity between the tumor cell membrane proteins and platelet glycoproteins as determined by monoclonal antibodies to human platelet glycoprotein Ib, IIb, and IIIa, and (c) TAA isolated from the tumor cell lines on in vitro binding of GPIIb/IIIa to fibrinogen.

**Materials and Methods**

**Materials.** NP-40 was purchased from Bethesda Research Laboratories (Bethesda, MD). Human fibrinogen (Fraction I, type I) was obtained from Sigma Chemical (St. Louis, MO). Monoclonal antibodies against human platelet GPIb (CD42b), GPIIIa (CD41b), GPIIIa (CD61), and GPIIIIa complex (CD41a) were obtained from-AMAC, Inc. (Westbrook, ME). Microtiter plates for enzyme-linked immunosorbent assay (96-well flat-bottomed microtitr plates; Nunc-Immuo Plate MaxiSorp, Nunc, Inc.) were obtained from Accurate Chemical and Scientific Co. (Westbury, NY).

**Tumor Cell Lines.** Human breast adenocarcinoma (ATCC HTB 19, BT-20) and lung adenocarcinoma (ATCC CCL185, A549) were obtained from the American Type Culture Collection (Rockville, MD). PAM and TAA. PAM was extracted from the cultured cell lines with 1 M urea in veronal buffer, dialyzed, and concentrated as described by Pearlstein et al. (8). TAA were isolated from the cell lines and processed as described earlier (19). To summarize the isolation procedures, membrane-bound TAA were solubilized with 0.5% Nonidet P-40 in PBS at room temperature. The extracts were then filtered on a Bio-Gel A-50 column. The elution pattern showed two well-separated peaks. The first peak contained the TAA. In the second peak were concentrated by pressure filtration and lyophilized.

**Platelet Aggregation.** Platelet aggregation was determined by a platelet aggregometer from Chrono-Log Co. (Haverstown, PA) using PRP.

**Platelet Extraction.** Fresh platelets were obtained from healthy donors. Blood was drawn into a 10 ml-plastic tube containing 0.9 ml of 3.8% sodium citrate. PRP was harvested by centrifugation at 200 × g for 15 min, and the platelet number was counted. Platelets were pelleted by centrifuging the PRP at 1000 × g for 15 min. The platelets were washed 3 times with platelet washing buffer consisting of 10 mN Tris-HCl (pH 7.0), 6 mM EDTA, 150 mM NaCl, 30 mN N-ethylmaleimide, and 1 mM phenylmethylsulfonyl fluoride. The platelet concentration was adjusted to 2 × 10^9/ml with 1.0% NP-40 in 10 mM NaCl, 30 mN N-ethylmaleimide, and 1 mM phenylmethylsulfonyl fluoride. The platelet concentration was adjusted to 2 × 10^9/ml with 1.0% NP-40 in 10 mM PBS (pH 7.4), and the extraction mixture was allowed to stand for 30 min at room temperature with occasional stirring. The mixture was centrifuged at 27,000 × g for 30 min, and the supernatant was then divided into smaller portions and kept frozen at -20°C until used.

**Immunoblotting.** The harvested tumor cells were washed with PBS and extracted with 0.5% NP-40, 2 mM KCI, or 8 mM urea and reduced with 2% β-mercaptoethanol and 1% SDS at 95°C for 5 min prior to SDS-PAGE. SDS-PAGE was performed at 20 mA/gel for 1 h, and membrane glycoproteins were transferred to a nitrocellulose membrane in a trans/entr chamber for 3 h at 20 mA/gel. Glycoproteins on nitrocellulose membranes were blocked with 3% gelatin in 0.02 M Tris-buffered saline and incubated with 500-fold diluted monoclonal antibodies to GPIb, GPIIIa, or GPIIIIa in Tris-buffered saline for 3 h or overnight at room temperature. The nitrocellulose strips were further incubated with the 1:100 dilution of alkaline phosphatase-gent (Fab) antibodies against mouse IgG for 2 h at room temperature, and subsequently color was developed with 5-bromo-4-chloro-3-indolyl phosphate and p-nitro blue tetrazolium chloride.

**Binding Assays of GPIIIa/IIb to Fibrinogen.** The effect of tumor cell membrane glycoproteins on platelet GPIb/IIa binding to fibrinogen was measured by an enzyme-linked immunosorbent assay described previously (20). Fibrinogen (type I; Sigma Chemical) was coated to microtiter plates by placing 100 μl of a fibrinogen solution at a concentration of 50 μg/ml of PBS in each well. Prior to use, the plates were washed with PBS with 0.05% Tween-20. Approximtely 100 μg of tumor extracts were delivered to the first rows, followed by a 1:2 serial dilution with PBS, and then a constant amount of the platelet extract (50 μg) in 50 μl of PBS containing 10% fetal calf serum, 5.0 μM MgCl2, and 5.0 μM CaCl2 was added to each well. The plates were incubated for 2 h at 37°C and washed 3 times with PBS-Tween 20 with 0.05% FCS. Membranes were washed with PBS containing 0.05% Tween-20 with 0.05% FCS.

**Materials and Methods**

**Materials.** NP-40 was purchased from Bethesda Research Laboratories (Bethesda, MD). Human fibrinogen (Fraction I, type I) was obtained from Sigma Chemical (St. Louis, MO). Monoclonal antibodies against human platelet GPIb (CD42b), GPIIIa (CD41b), GPIIIa (CD61), and GPIIIIa complex (CD41a) were obtained from-AMAC, Inc. (Westbrook, ME). Microtiter plates for enzyme-linked immunosorbent assay (96-well flat-bottomed microtitr plates; Nunc-Immuo Plate MaxiSorp, Nunc, Inc.) were obtained from Accurate Chemical and Scientific Co. (Westbury, NY).
TUMOR CELL MEMBRANE GLYCOPROTEINS

μl containing 10% FCS were added to each well, and the plates were further incubated for 2 h at 37°C and washed with PBS-FCS-Tween-20. The plates were then incubated with 50 μl of 1:5000 dilutions of horseradish peroxidase anti-mouse IgG antibodies in PBS-FCS for 2 h at 37°C for color development.

Results

Aggregation of Human Platelets. Platelet aggregations were measured in an aggregometer using fresh PRP within 2 h after preparation. Aggregability of the platelets was confirmed by testing with ADP or collagen. Neither breast nor lung tumor cell fractions, either (a) whole cells, (b) crude extracts with NP-40 (dialyzed to ensure removal of detergent or salts), (c) purified TAA, or (d) the PAM fraction (8) induced platelet aggregation.

Detection of Tumor Glycoproteins by Monoclonal Antibodies to Human Platelet Glycoprotein. The breast tumor cell membrane proteins transferred to nitrocellulose membranes after SDS-PAGE were incubated separately with monoclonal antibodies against GPIb, GPIIb, and GPIIIa, and then color was developed with the alkaline phosphatase-conjugated second antibodies. Fig. 1 shows that the breast adenocarcinoma cells had three main proteins with approximate molecular weights of 125,000, 94,000, and 68,000, which were detectable by monoclonal antibodies against GPIb, GPIIb, and GPIIIa. In contrast, the lung cancer proteins were not recognized by these monoclonal antibodies, even though both tumor cell membranes contained several protein bands as revealed by SDS-PAGE (data not shown). When the strips containing the breast tumor cell membrane proteins were incubated with 20-fold dilution of sera from a patient with systemic lupus erythematosus and a patient with immune thrombocytopenic purpura who were known to have anti-platelet antibodies, serum anti-platelet antibodies were noted to bind to the tumor cell proteins (data not shown).

Inhibition of Platelet GPIIb/IIIa Binding to Fibrinogen by Tumor Cell Membrane Extracts. The binding of platelet GPIIb/IIIa to immobilized fibrinogen was inhibited by TAA isolated from the breast tumor cells. As shown in Fig. 2, a mixture containing equal amounts of the breast TAA and platelet extract showed approximately 40% inhibition of GPIIb/IIIa binding. The lung TAA had almost no effect on the binding.

Discussion

In the past few years, several reports have been published which demonstrate (a) the presence of glycoproteins on tumor cell membranes which are detectable with antibodies against platelet glycoproteins (1-5, 14-17) and (b) platelet aggregation induced by tumor cells or PAM isolated from tumor cells (6, 8-13). Glycoproteins on some tumor cells have been found to be immunologically related to platelet GPIIb/IIIa complex (IR-GPIIb-IIIa) (4, 14, 16). To study immunochemical and functional similarities between tumor cell membrane proteins and human platelet glycoproteins, we used a lung tumor cell line and a breast tumor cell line which had been characterized earlier by one of the authors. Tested at various dilutions, neither the breast nor the lung tumor cell materials induced platelet aggregation. Tumor cell membrane glycoproteins immunologically related to platelet GPIIb/IIIa may mediate the interaction among tumor cells, platelets, and endothelial cells. Monoclonal antibodies to GPIIb/IIIa have been shown to inhibit human melanoma cell adhesion to fibronectin (15) and tumor cell-induced platelet aggregation (14). There have been reports showing that monoclonal antibodies to GPIIb/IIIa reduced carcinoma metastasis (12) and inhibited the growth of human melanoma cells implanted in nude mice (18).

In our experiment, three proteins in the BT-20 cell extract were recognized by monoclonal antibodies against human platelet GPIb, GPIIb, and GPIIIa. In addition, anti-platelet antibodies in sera from patients with systemic lupus erythematosus and immune thrombocytopenic purpura bound to tumor cell membrane proteins on nitrocellulose strips. These data suggest that there is a certain structural similarity between the membrane proteins of the breast tumor cells

![Fig. 1. Recognition of the breast adenocarcinoma cell membrane glycoproteins by monoclonal antibodies to platelet glycoproteins. Lane 1, anti-GPIb; Lane 2, anti-GPIIb; Lane 3, anti-GPIIIa.](image_url)
and human platelet glycoproteins. The presence of Ib/IIa-like glycoproteins on the tumor cell membranes may be interpreted as the aberrant expression of antigens which occurs during the process of malignancy (2), although the exact nature of these Ib/IIa-like glycoproteins remains to be determined. The TAA isolated from BT-20 cells markedly inhibited the GPIIb/IIIa binding to fibrinogen, whereas the lung TAA had no effect on the binding. These results suggest that tumor cells carrying glycoproteins immunologically related to human platelet glycoproteins may affect hemostasis and coagulation in vivo.

References


Inhibition of Human Platelet Glycoprotein IIB/IIIA Binding to Fibrinogen by Tumor Cell Membrane Proteins


Updated version
Access the most recent version of this article at:
http://cancerres.aacrjournals.org/content/53/2/221

E-mail alerts
Sign up to receive free email-alerts related to this article or journal.

Reprints and Subscriptions
To order reprints of this article or to subscribe to the journal, contact the AACR Publications Department at pubs@aacr.org.

Permissions
To request permission to re-use all or part of this article, contact the AACR Publications Department at permissions@aacr.org.