Combination Therapy With Low-Dose Aspirin and Ticlopidine in Cerebral Ischemia

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We compared combination therapy with low-dose aspirin plus ticlopidine to therapy with aspirin alone or ticlopidine alone in patients suffering transient ischemic attack or cerebral infarction. In 17, 24, and 23 patients, respectively, 300 mg/day aspirin, 200 mg/day ticlopidine, and 81 mg/day aspirin plus 100 mg/day ticlopidine were administered orally. Aspirin alone markedly inhibited platelet aggregation induced by arachidonic acid, partially inhibited platelet aggregation induced by adenosine diphosphate, and did not inhibit platelet aggregation induced by platelet activating factor. Ticlopidine alone inhibited platelet aggregation induced by adenosine diphosphate and platelet activating factor, but did not inhibit platelet aggregation induced by arachidonic acid. Combination therapy with aspirin plus ticlopidine markedly inhibited platelet aggregation induced by all three agonists. Plasma concentrations of β-thromboglobulin and platelet factor 4 remained unchanged by aspirin alone, were slightly reduced by ticlopidine alone, and were markedly reduced by aspirin plus ticlopidine. Plasma concentration of thromboxane B2 was reduced by aspirin alone or with ticlopidine, but not by ticlopidine alone. The level of 6-ketoprostaglandin F1α was reduced only by aspirin alone. Bleeding time was significantly prolonged by aspirin alone and by ticlopidine alone, although the greatest prolongation was produced by aspirin plus ticlopidine. Our results indicate that the combination of aspirin plus ticlopidine is a potent antiplatelet strategy, although the clinical importance of the changes observed need to be determined by a properly designed and controlled prospective study. (Stroke 1989;20:1643-1647)
Concentrations of β-thromboglobulin (βTG) and platelet factor 4 (PF4) in all patients were quantified by radioimmunoassay (RIA) using kits (Kaken Seiyaku, Tokyo, Japan) and by turbidimetry as described previously. The extent of platelet aggregation in whole blood was measured by stimulation with 0.4 mM AA (Nakarai Kagaku, Tokyo, Japan), or 0.2 μM PAF (Funakoshi Yakuhin, Tokyo, Japan) to express as the percent change in light transmission 5 minutes after adding the agonist. Platelet aggregation in whole blood was measured by stimulation with 10 μM ADP, 1 mM AA, or 20 μM PAF using an impedance aggregometer (Chrono-Log C540, Haverton, Pennsylvania). The extent of platelet aggregation in whole blood was expressed as the impedance change (Ω) 5 minutes after adding the agonist. Platelet-aggregation was measured both before and 1 week after starting medication.

From all three groups with the Simplate device (Warner-Lambert, Morris Plains, New Jersey). These platelet function tests were performed both before and 1 week after starting medication.

Platelet survival and lysis were measured in 10 normal subjects and in four patients from each group using [111In]trospolone-labeled platelets both before and 2 weeks after starting medication. Forty-three milliliters of venous blood was collected in 7 ml acid citrate dextrose anticoagulant. The platelets were separated and labeled with indium-111 according to the method of Dewanjee et al. Nine milliliters of blood was collected in 1 ml EDTA 24, 48, 72, or 96 hours after the intravenous reinjection of the indium-111-labeled platelets. Radioactivity of the samples was determined with a gamma well counter (JDC-772, Aloka, Mitaka, Japan). Platelet survival was determined using a least-squares exponential curve-fitting program. Platelet lysis was calculated from the radioactivity of plasma-free indium-111 with respect to total indium-111 in samples of whole blood at 96 hours.

The results were expressed as the mean±1 standard deviation (SD) and were analyzed by Student’s dependent t test to compare results after medication with those before medication. In addition, one-way analysis of variance was used to compare the three treatment regimens.

Results

There were no significant differences in platelet aggregation or function before medication. In platelet-rich plasma, aspirin alone inhibited platelet aggregation induced by AA significantly more than did ticlopidine alone (p<0.01) but only partially inhibited platelet aggregation induced by ADP (p<0.05) and did not significantly affect platelet aggregation induced by PAF (Table 1). Ticlopidine alone markedly (significantly more than aspirin, p<0.01) inhibited platelet aggregation induced by ADP and PAF but did not significantly affect platelet aggregation induced by AA. Finally, aspirin plus ticlopidine inhibited platelet aggregation induced by all three agonists. No synergism or additivism between aspirin and ticlopidine was observed for the inhibition of platelet aggregation induced by any of the agonists because there was no significant difference in the inhibition of platelet aggregation induced by the combination of aspirin alone or ticlopidine alone and aspirin plus ticlopidine. Results obtained in whole blood were similar to those obtained in platelet-rich plasma, although the inhibition of platelet aggregation induced by ADP and PAF appeared to be less pronounced in patients treated with aspirin alone and more pronounced in patients treated with ticlopidine alone.

Plasma concentrations of βTG and PF4 remained unchanged by aspirin alone (Table 2), but both were significantly reduced by ticlopidine alone, and an additional effect of aspirin when used concomitantly with ticlopidine was observed for βTG (p<0.05) but not for PF4. Plasma TXB2 levels were...
by aspirin alone or with ticlopidine but not by ticlopidine alone (Table 2). No additional effect of ticlopidine was observed when used concomitantly with aspirin. Plasma 6-ketoPGF\(_1\alpha\) levels were significantly reduced only by aspirin alone. Bleeding time was significantly prolonged in patients treated with aspirin alone or ticlopidine alone, although the greatest prolongation was observed in patients treated with aspirin plus ticlopidine (\(p<0.05\) vs. single agent) (Table 2).

Platelet survival and lysis were not significantly altered by treatment with aspirin alone or ticlopidine alone, whereas both measures were significantly affected by treatment with aspirin plus ticlopidine (Table 3).

Hemorrhagic complications were observed in 13 patients. The complications included bruising in six, petechiae in two, epistaxis in two, hematuria in one, and hemorrhoidal and gingival bleeding in one patient each. Complications occurred in two patients treated with aspirin alone or ticlopidine alone, in three patients treated with aspirin plus ticlopidine alone, and in eight patients treated with aspirin plus ticlopidine. Hemorrhagic complications tended to occur sooner (range 46–220, average 102 days) after starting medication in patients treated with aspirin alone (157 and 206 days) or ticlopidine alone (172, 184, and 245 days). Bleeding time was prolonged (570–1,200 seconds) in all eight patients having hemorrhagic complications in whom it could be determined immediately. Platelet aggregation induced by ADP was inhibited in all eight patients with complications tested, whereas platelet aggregation induced by AA and PAF was inhibited in seven and six patients, respectively. The amount of blood lost was always small, and there was no significant fall of the hematocrit in any patient. No patient required a blood transfusion. The hemorrhagic complications subsided within a few days after discontinuation of the antplatelet agents, and there was no evidence of intracranial hemorrhage in any patient.

**Discussion**

It has been shown by American,\(^1\) Canadian,\(^2\) and French\(^3\) studies that aspirin can reduce the incidence of subsequent stroke and death in patients with TIA\(^1\)-\(^3\) or even cerebral infarction.\(^3\) The overview analysis of nine randomized trials (including those above) of aspirin for patients with ischemic stroke performed by the Antiplatelet Trialists’ Collaboration showed that the risk reduction in the incidence of stroke, myocardial infarction, or vascular death produced by aspirin was 22% (SD 5%). This limited efficacy of aspirin appears to be at least in part attributable to its limited inhibition of the multiple pathways leading to platelet aggregation.\(^7\),\(^8\) We demonstrate that aspirin completely blocks platelet aggregation induced by AA, while it only partially inhibits platelet aggregation induced by ADP and has very little effect on platelet aggregation induced by PAF.

<table>
<thead>
<tr>
<th>Antiplatelet agent(s)</th>
<th>Dose</th>
<th>Sample</th>
<th>n</th>
<th>Platelet aggregation induced by</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Adenosine diphosphate</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Before</td>
</tr>
<tr>
<td>Aspirin alone</td>
<td>300 mg</td>
<td>PRP (%)</td>
<td>17</td>
<td>54±24</td>
</tr>
<tr>
<td>Ticlopidine alone</td>
<td>200 mg</td>
<td>WB (Ω)</td>
<td>10</td>
<td>15±6</td>
</tr>
<tr>
<td>Aspirin plus ticlopidine</td>
<td>81 mg plus 100 mg</td>
<td>WB (Ω)</td>
<td>23</td>
<td>13±5</td>
</tr>
</tbody>
</table>

PRP, platelet-rich plasma; WB, whole blood. Data are mean±SD.

\(*t+\)p<0.05, 0.01, respectively, different from before by Student’s dependent t test.

| Table 2. Effects of Aspirin and/or Ticlopidine on Platelet Function |
|-----------------------|----------------|----------------|----------------|
| Platelet function test | Aspirin alone (300 mg) | Ticlopidine alone (200 mg) | Aspirin plus ticlopidine (81 mg plus 100 mg) |
| 6-Thromboglobulin (ng/ml) | 17 | 89±80 | 70±64 |
| Platelet factor 4 (ng/ml) | 17 | 48±43 | 38±39 |
| Thromboxane B\(_2\) (pg/ml) | 8 | 246±143 | 82±76† |
| 6-Ketoprostaglandin F\(_\text{I}_\alpha\) (pg/ml) | 8 | 40±17 | 24±15* |
| Bleeding time (sec) | 9 | 247±60 | 399±112* |

Data are mean±SD.

\(*t+\)p<0.05, 0.01, respectively, different from before by Student’s dependent t test.
Table 3. Effects of Aspirin and/or Ticlopidine on Platelet Survival and Lysis

<table>
<thead>
<tr>
<th>Platelet function test</th>
<th>Normal</th>
<th>Aspirin alone (300 mg)</th>
<th>Ticlopidine alone (200 mg)</th>
<th>Aspirin plus ticlopidine (61 mg plus 100 mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>Value</td>
<td>n Before</td>
<td>n Before</td>
</tr>
<tr>
<td>Platelet survival (days)</td>
<td>10</td>
<td>8.4±0.4</td>
<td>4 7.3±1.3</td>
<td>4 6.9±1.5</td>
</tr>
<tr>
<td>Platelet lysis (%)</td>
<td>10</td>
<td>3.7±2.8</td>
<td>4 7.6±2.7</td>
<td>4 7.3±2.8</td>
</tr>
</tbody>
</table>

Data are mean±SD.
*p<0.05 different from before by Student's dependent t test.

We previously performed the first trial of ticlopidine for the secondary prevention of TIA.5 The dose of ticlopidine used in that trial was 200 mg/day (one 100-mg tablet b.i.d.), which is the usual dose in Japan, enough to suppress platelet aggregation in the average Japanese.5 6 In that study we demonstrated that the incidence of ischemic events was reduced by ticlopidine as well as that platelet aggregation induced by ADP was inhibited in patients with multiple episodes of TIA or reversible ischemic neurologic deficit (RIND). That pilot study was followed by a double-blind multicenter trial with ticlopidine and aspirin in patients with single or multiple TIA.6 The reduction in the incidence of subsequent stroke and myocardial infarction was not different between patients treated with 200 mg ticlopidine and those treated with 500 mg aspirin until 6 months after entry into the trial, but the reduction was significantly greater in patients treated with ticlopidine than in those treated with aspirin 12 and 36 months after entry. Two very large multicenter studies on the efficacy of ticlopidine in patients with cerebral ischemia were recently performed in North America.7 8 One study involved >3,000 patients with TIA or RIND (Ticlopidine-Aspirin Stroke Study, TASS)9; 500 mg/day ticlopidine or 1,300 mg/day aspirin was administered in a double-blind trial for 2–6 (mean 3.3) years. The cumulative event rate for 3 years was significantly lower in the ticlopidine-treated group than in the aspirin-treated group. In the other large trial, 1,000 patients with a completed thromboembolic stroke received 500 mg/day ticlopidine or placebo for up to 3 (average 2) years (Canadian-American Stroke Study, CATS).10 11 12 A 30% risk reduction of stroke, myocardial infarction, and vascular death was observed in the ticlopidine-treated group compared with the placebo-treated group.

The mode of action of ticlopidine in inhibiting platelet aggregation is not as clearly understood as that of aspirin, which is known to inhibit cyclooxygenase, thereby inhibiting the synthesis of thromboxane A2, a potent platelet-aggregating substance. Ticlopidine has been reported to activate adenylate cyclase, increasing the concentration of cyclic adenosine monophosphate and leading to the inhibition of platelet aggregation20 or to produce a thrombathenic state by inhibiting the binding of fibrinogen to platelets.21 Ticlopidine can inhibit both primary and secondary platelet aggregation in response to ADP and PAF, but its inhibition of platelet aggregation in response to AA is not prominent since ticlopidine has no effect on cyclooxygenase.5 8 This was confirmed by our present study.

In our previous study23 we investigated the relationship between stroke recurrence and platelet aggregation in patients treated with aspirin or ticlopidine. Platelet aggregation induced by ADP was significantly inhibited after administration of these drugs in the group of patients without recurrence, but aggregation was not significantly inhibited in the group of patients who had a recurrent stroke. However, stroke still recurred despite the inhibition of platelet aggregation induced by ADP in some patients. One possible explanation for this discrepancy might be the presence of intact pathways for platelet aggregation via AA and/or PAF, although this could not be proven since platelet aggregation induced by AA and PAF was not measured in that study.

Therefore, we tried combination therapy with aspirin plus ticlopidine, which can inhibit all the pathways leading to platelet aggregation via ADP, AA, and PAF. The combination of aspirin plus ticlopidine inhibited platelet aggregation by all three agonists. Combination therapy also markedly reduced concentration of βTG and PF4, whereas aspirin alone or ticlopidine alone did not affect or only slightly reduced them.11 24 This shows that aspirin combined with ticlopidine can suppress in vivo platelet secretion, which cannot be suppressed when only one or two of the pathways leading to platelet aggregation are inhibited by aspirin alone or ticlopidine alone. In addition, the combination of aspirin plus ticlopidine produced a greater prolongation of bleeding time than did aspirin alone or ticlopidine alone. This is additional evidence that the combination can inhibit in vivo platelet function by inhibiting all pathways leading to platelet aggregation. Moreover, platelet survival was prolonged and platelet lysis was reduced after treatment with aspirin plus ticlopidine despite the fact that neither measure of platelet function was significantly altered after treatment with aspirin alone or ticlopidine alone. The correction of platelet survival and lysis by the combination therapy might reflect inhibition of the consumption and destruction of platelets in vivo. These results indicate that the combination of aspirin plus ticlopidine is a potent antiplatelet strategy, although the clinical importance of the changes that we observed need to be determined by a
properly designed prospective controlled study for the secondary prevention of ischemic stroke.

On the other hand, hemorrhagic complications were observed more frequently among patients treated with aspirin plus ticlopidine than among those treated with aspirin alone or ticlopidine alone, despite the smaller doses we used since the combination of 300 mg/day aspirin plus 200 mg/day ticlopidine had produced frequent hemorrhagic complications in a preliminary study. Optimal doses of aspirin and ticlopidine in combination should be determined by further investigations to minimize the hemorrhagic complications while preserving the antithrombotic effect.

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