Clinical Focus

The TRITON versus PLATO trials: Differences beyond platelet inhibition

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Summary

Clopidogrel monopoly as an exclusive oral antiplatelet agent used in combination with aspirin or as a monotherapy for treatment or and prevention of occlusive thrombotic vascular events has been recently challenged. Based on the indirect comparison of TRITON and PLATO trial data, ticagrelor is clearly superior to prasugrel in a population of patients with acute coronary syndrome (ACS) because of absolute mortality reduction, realistic second myocardial infarction (MI) prevention, growing over time vascular outcome benefit, fewer haemorrhagic fatalities, potentially less coronary artery bypass graft (CABG)-related bleeding events, and lack of cancer risks. Despite an unfavourable immediate safety profile, ticagrelor has a lot of room to compensate for agitation, dyspnea, and ventricular pauses, if used in appropriate patients. It will be naïve and wrong to assume that ticagrelor will completely substitute clopidogrel, especially considering higher discontinuation rates after ticagrelor, generic competition, and other health economics issues. However, unless the regulatory authorities discover some unexpected serious flaws with PLATO, the ticagrelor will substantially change the present landscape of oral antiplatelet therapy, especially in high-risk patients, diabetics, and those with repeated vascular events including stent thrombosis. In contrast, a too exclusive trial design, a lack of persistent vascular benefit despite issues with event adjudication, growing-over-time bleeding complications, an issue with cancer, and finally an increase in mortality risk among unstable angina and non ST-elevated myocardial infarction will likely prevent a broad prasugrel implementation, unless more reassuring evidence becomes available.

Keywords

Prasugrel, ticagrelor, clopidogrel, clinical trials, outcomes

The era of clopidogrel monopoly as an exclusive oral antiplatelet agent used in combination with aspirin or as a monotherapy for treatment or and prevention of occlusive thrombotic vascular events has been recently challenged. Large inter-individual response variability, delayed onset of action, two-step hepatic metabolisation, and potential link of inadequate response and worsened vascular outcomes triggered the development of new antiplatelet options. Two studies, namely, TRIal to assess Improvement in Therapeutic Outcomes by optimizing platelet InhibitionN with prasugrel (TRITON) (1), and PLATElet Inhibition and Clinical Outcomes (PLATO) (2) trials were phase 3, randomised, double blind, parallel-group, multinational, clinical studies. Both trials compared head-to-head the efficacy of antiplatelet agents: third generation thienopyridine, ticagrelor (formerly known as AZD6140, to be marketed as Effient™), and a pioneer cyclopentyl-triazolo-pyrimidine, prasugrel (formerly known as CS-747, marketed as Effient™), and a pioneer cyclopentyl-triazolo-pyrimidine, ticagrelor (formerly known as AZD6140, to be marketed as Brilinta™) versus standard care with clopidogrel. There are substantial differences between ticagrelor and prasugrel. Being a pyrimidine, ticagrelor differs from thienopyridines (ticlopidine, clopidogrel and prasugrel) by reversible nature of P2Y12 blockade, exhibiting direct antiplatelet properties with no dependence on complicated hepatic metabolism. Ticagrelor plasma levels are maintained for no longer than 12 hours, requiring twice daily oral use. In contrast, prasugrel undergo one-step CYP3A4 hepatic metabolism, targets the cell for the life span of platelet, irreversibly binding to P2Y12 receptors, and subjected to potentially harmful drug-drug interactions. Although no direct platelet inhibition studies among prasugrel, ticagrelor, and clopidogrel are available, in both trials the antiplatelet potency of ticagrelor was similar to prasugrel (about 65–70% inhibition) compared to approximately 40% platelet inhibition achieved after clopidogrel. Importantly, we should be careful in cross-comparing differently designed studies, some assumptions and considerations seem appropriate. Both trials were relatively large, with the identical primary efficacy endpoints (combination of the first occurrence of cardiovascular death, non-fatal myocardial infarction, and stroke), with a relatively long follow up. Patients demographics, antecedent treatment patterns, inclusion of diabetics were very similar between studies among prasugrel, ticagrelor, and clopidogrel are available, in both trials the antiplatelet potency of ticagrelor was similar to prasugrel (about 65–70% inhibition) compared to approximately 40% platelet inhibition achieved after clopidogrel. Importantly, we should be careful in cross-comparing differently designed studies, some assumptions and considerations seem appropriate. Both trials were relatively large, with the identical primary efficacy endpoints (combination of the first occurrence of cardiovascular death, non-fatal myocardial infarction, and stroke), with a relatively long follow up. Patients demographics, antecedent treatment patterns, inclusion of diabetics were very similar between trials. However, there were some notable differences in the trial designs which are outlined in Table 1. In order to match more closely, numbers in the clopidogrel arm were exclusively used in Table 1.

Comparison of baseline characteristics between the two trials revealed that PLATO sample size was about 30% larger, with the higher overall ischemic burden than in TRITON. Allowing pretreatment, and higher than 300 mg loading with clopidogrel, in

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combination with the inclusion of high-risk coronary artery bypass graft (CABG) patients makes PLATO much more relevant to the real-life clinical scenarios than TRITON, in which multiple exclusions have been implemented. Importantly, platelet GP IIb/IIIa inhibitors were used twice more common in TRITON, and prasugrel loading dose (60 mg) was six times higher than maintenance (10 mg) than in PLATO where loading and daily maintenance regimens were equal (180 mg). Both trials unfortunately decided not to continue the follow-up of their patients as a registry after unblinding; however, PLATO patients were allowed to remain treated with either ticagrelor or clopidogrel at physician’s discretion, when all prasugrel-treated patients in TRITON were mandatory switched to clopidogrel. Both trials failed to continue the follow-up in the frame of the open-label registry despite the claims of late stent thrombosis prevention. This fact is understandable for the exit strategy in TRITON, where the bleeding risks, and cancer-related deaths among unstable angina and non-ST-elevated myocardial infarction (MI) patients (4). However, excess in bleeding fatalities (21 vs. 5), and four extra cancer-related deaths after prasugrel dilute the benefit almost completely. Moreover, final FDA notes from the Prasugrel Action Package revealed more deaths after prasugrel (5 vs. 2) in patients lost in follow-up without primary endpoints (4). In short, while the entire prasugrel benefit in TRITON is exclusively attributed to the reduction of non fatal MIs, in PLATO, the mortality reduction (107 deaths) numerically exceeds the MI prevention benefit (89 events), making it a hitherto unmatchable achievement (5), and representing the major clinical outcome difference between the two trials.

**Myocardial infarction.** At a first glance, the overall nonfatal MI reduction looks more impressive in TRITON than in PLATO. Indeed, the benefit of prasugrel in MI reduction in TRITON is 23.2%, while second MI prevention benefit of ticagrelor in PLATO was “only” 16%. However, there is an important difference between trials. The PLATO MI rates are realistic, match well with other similar studies like CURRENT (6) and ACUITY (7), in contrast to TRITON, where MI adjudication is a matter of considerable controversy due to massive inclusion of extra events (8, 9), half of which were enzymatic or “chemical” MIs rather than real clinical events not identified by investigators, but still adjudicated (3, 4). Therefore, MI prevention in PLATO and TRITON should be judged not only by the absolute difference between the treatment arms both favouring novel antiplatelet agents, but also acknowledging that MI adjudication in PLATO was handled utilising realistic, strict universal acute MI definition (10) rather than inflated assessment of MIs adding enzymatic leaks and almost every ischaemic episode to the totality of evidence. Indeed, following the recent worldwide trend towards lower MI rates (11), a reduction from 6.9% in the clopidogrel arm to 5.8% after ticagrelor – especially late in the trial – unquestionably represents a solid achievement over both clopidogrel and prasugrel.

**Timing of benefit** in PLATO looks ideal for long-term therapy, in contrast to the TRITON outcome curves. The benefit after ticagrelor is somewhat delayed, what is not surprising considering lack of loading; growing slowly, but constantly over the entire time of the trial (2). The largest outcome benefit is observed at the end of the follow-up, ultimately justifying a chronic treatment regimen with ticagrelor. TRITON, however, revealed early periprocedural benefit of prasugrel over clopidogrel, with lack of additional advantage thereafter (3, 4).

**Heart surgery** cohort shows a slight advantage of ticagrelor, in contrast to prasugrel inferiority over clopidogrel with regard to the

### Table 1: Baseline differences in TRITON and PLATO trials.

<table>
<thead>
<tr>
<th>Clinical variable</th>
<th>TRITON</th>
<th>PLATO</th>
</tr>
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<tbody>
<tr>
<td>Sample size (n)</td>
<td>6,795</td>
<td>9,291</td>
</tr>
<tr>
<td>ST-elevated MI (%)</td>
<td>26</td>
<td>38</td>
</tr>
<tr>
<td>Inclusion: defined coronary anatomy</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>CABG (%)</td>
<td>1</td>
<td>4.7</td>
</tr>
<tr>
<td>Pretreatment with clopidogrel (%)</td>
<td>0</td>
<td>46.1</td>
</tr>
<tr>
<td>Clopidogrel loading dose 600 mg+ (%)</td>
<td>0</td>
<td>&gt;19.6</td>
</tr>
<tr>
<td>Loading regimen for experimental agent</td>
<td>Yes, 6:1</td>
<td>No, 1:1</td>
</tr>
<tr>
<td>Glycoprotein IIb/IIIa inhibitor use (%)</td>
<td>55</td>
<td>26.8</td>
</tr>
<tr>
<td>Follow-up (months)</td>
<td>6–15</td>
<td>12</td>
</tr>
<tr>
<td>Switching to clopidogrel at the end of follow-up</td>
<td>Mandatory</td>
<td>Discretion of physician</td>
</tr>
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### Table 2: Clinical outcomes in TRITON versus PLATO trials.

<table>
<thead>
<tr>
<th>Outcome measure</th>
<th>TRITON</th>
<th>PLATO</th>
</tr>
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<tbody>
<tr>
<td>All-cause mortality reduction (%)</td>
<td>4.57 or less</td>
<td>21.15</td>
</tr>
<tr>
<td>Cardiovascular mortality reduction (%)</td>
<td>11.33</td>
<td>21.14</td>
</tr>
<tr>
<td>Non fatal MI reduction (%)</td>
<td>9.5 to 7.3*</td>
<td>6.9 to 5.8*</td>
</tr>
<tr>
<td>Fatal bleeding events versus clopidogrel (n)</td>
<td>21/5</td>
<td>20/23</td>
</tr>
<tr>
<td>Timing of benefit</td>
<td>Early</td>
<td>Growing over time</td>
</tr>
<tr>
<td>Any malignancy during treatment in active arm (%)</td>
<td>1.59</td>
<td>1.25</td>
</tr>
</tbody>
</table>

* – first number represents the outcome in the clopidogrel arm, second number is for the experimental agent.
CABG-associated bleeding risks. However, the anticipated benefit of bleeding reduction due to the reversible nature of P2Y12 platelet receptor blockade after ticagrelor was clearly exaggerated, and was not achieved in PLATO. It turns out that theoretical considerations did not yield the desired benefit challenging the reversibility hypothesis, and practicality of twice daily maintenance ticagrelor regimen. Since heart surgeons are usually discontented to operate on patients with clopidogrel on board (12), ticagrelor may offer a slightly better alternative with regard to bleeding risks, in comparison to prasugrel, causing 3.5 times higher CABG-associated bleeding events than clopidogrel in TRITON.

Cancer risks after prasugrel in TRITON are growing over time, especially in women, and results in 27% increase in colorectal, lung, and breast solid malignancies is alarming (3, 4, 13). Although unaudited, the cancer rates in PLATO trended lower after ticagrelor (n=132; 1.4%) than after clopidogrel (n=155; 1.7%) (2). Based on the CAPRIE (14), and CHARISMA (15) trials, the FDA found no evidence that clopidogrel promotes cancer (3), therefore, lack of a cancer signal in PLATO with ticagrelor is reassuring, and will be an additional argument for future chronic use. If confirmed by regulatory agencies, differences in cancer risks will represent an extremely important finding favoring ticagrelor over prasugrel.

Side events profile of ticagrelor is clearly inferior to prasugrel, and clopidogrel. In contrast to all thienopyridines, classical consequences of adenosine overload such as transitory bronchoconstriction causing dyspnea (16); arrhythmogenic hazards resulting in ventricular asystole or pauses (17); and metabolically-induced anxiety manifesting as agitation or panic attacks (18) are commonly observed after ticagrelor. Impaired purine catabolism due to increased adenosine levels may cause elevated serum creatinine and uric acid (19), which were observed with ticagrelor in PLATO, the phenomenon not attributed to clopidogrel or prasugrel. Importantly, both creatinine and uric acid return to pretreatment values after ticagrelor discontinuation (1), suggesting that the alterations in purine metabolism is a real phenomenon, rather than a play of chance.

In summary, based on the indirect comparison of TRITON and PLATO trial data, ticagrelor is clearly superior to prasugrel, and clopidogrel. In contrast to all thienopyridines, classical consequences of adenosine overload such as transitory bronchoconstriction causing dyspnea (16); arrhythmogenic hazards resulting in ventricular asystole or pauses (17); and metabolically-induced anxiety manifesting as agitation or panic attacks (18) are commonly observed after ticagrelor. Impaired purine catabolism due to increased adenosine levels may cause elevated serum creatinine and uric acid (19), which were observed with ticagrelor in PLATO, the phenomenon not attributed to clopidogrel or prasugrel. Importantly, both creatinine and uric acid return to pretreatment values after ticagrelor discontinuation (1), suggesting that the alterations in purine metabolism is a real phenomenon, rather than a play of chance.

In summary, based on the indirect comparison of TRITON and PLATO trial data, ticagrelor is clearly superior to prasugrel for chronic preventive use because of absolute mortality reduction, realistic second MI prevention, growing over time vascular outcome benefit, fewer haemorrhagic fatalities, potentially less CABG-related bleeding events, and lack of cancer risks. Despite an unfavourable immediate safety profile, ticagrelor has a lot of room to compensate for agitation, dyspnea, and ventricular pauses, if used in appropriate patients. It will be naïve and wrong to assume that ticagrelor will completely substitute clopidogrel, especially considering higher discontinuation rates after ticagrelor, generic competition, and other health economics issues. Obviously, favourable safety profile and acceptable bleeding risks after clopidogrel represent a major driving force for broad use of this agent in a wide spectrum of patients with underlying vascular disease. However, unless the regulatory authorities discover some unexpected serious flaws with PLATO, the ticagrelor will substantially change the present landscape of oral antiplatelet therapy, especially in high-risk patients, diabetics, and those with repeated vascular events including stent thrombosis. Importantly, both PLATO and TRITON trials included exclusively acute coronary syndrome (ACS) patients. Data for both new agents in stable coronary disease, or for elective stenting are very limited. In conclusion, based on the indirect and admittedly intricate comparison of the TRITON and PLATO trial data, ticagrelor appears superior to prasugrel in the populations of ACS studied.

Disclosure
Dr. Serebruany is listed as an inventor and received compensation for the U.S. Patent Application P-17232 “Method for treating vascular diseases with prasugrel” assigned to Lilly. He received funding for research studies with both clopidogrel and prasugrel, but not with ticagrelor, but received speakers honoraria from Astra Zeneca.

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