



# Perspective

## The Cardiovascular Safety of Diabetes Drugs — Insights from the Rosiglitazone Experience

William R. Hiatt, M.D., Sanjay Kaul, M.D., and Robert J. Smith, M.D.

The management of type 2 diabetes has been challenged by uncertainty about possible cardiovascular effects related to treatment intensity and choice of drug. Although the Food and Drug

Administration (FDA) considers a decrease in glycated hemoglobin an approvable end point, very intensive glycemic control is associated with increased cardiovascular and all-cause mortality.<sup>1</sup> The safety of specific drugs for type 2 diabetes — particularly the thiazolidinediones — has also been questioned. After rosiglitazone had been approved in the United States in 1999 and in Europe in 2000, a highly publicized meta-analysis in 2007 reported a 43% increase in myocardial infarction ( $P=0.03$ ) and a 64% increase in death from cardiovascular causes ( $P=0.06$ ).<sup>2</sup> This report and sub-

sequent FDA advisory committee reviews led to a boxed warning of myocardial ischemia in 2007 and highly restricted access to rosiglitazone in 2010. In 2010, the FDA placed a full clinical hold on the Thiazolidinedione Intervention with Vitamin D Evaluation (TIDE) trial (ClinicalTrials.gov number, NCT00879970), a large cardiovascular-outcome trial designed to evaluate the benefit of rosiglitazone and pioglitazone as compared with placebo (superiority hypothesis) and the safety of rosiglitazone as compared with pioglitazone (noninferiority hypothesis). In part owing to the rosiglitazone experience, the FDA

issued an updated Guidance for Industry in 2008 requiring that preapproval and postapproval studies for all new antidiabetic drugs rule out excess cardiovascular risk, defined as an upper bound of the two-sided 95% confidence interval for major adverse cardiovascular events (MACE) of less than 1.80 and less than 1.30, respectively.<sup>3</sup> Regardless of the presence or absence of preclinical or clinical signals of cardiovascular risk, the guidance has been applied broadly to all new diabetes drugs, creating substantial challenges in the drug development and approval process.

On June 5 and 6, 2013, the FDA held a joint meeting of the Endocrinologic and Metabolic Drugs Advisory Committee (on which we serve) and the Drug Safety and Risk Management Advisory Committee to further evaluate the car-

diovascular safety of rosiglitazone. When rosiglitazone was approved in Europe, the European Medicines Agency raised concern about the cardiovascular risks of the thiazolidinedione class, including fluid retention, heart failure, and increased levels of low-density lipoprotein cholesterol. This concern led to a postmarketing requirement that cardiovascular-outcome trials be conducted for both pioglitazone and rosiglitazone, and these were reviewed at subsequent FDA meetings. Although the results of the Rosiglitazone Evaluated for Cardiac Outcomes and Regulation of Glycaemia in Diabetes (RECORD) study (NCT00379769) did not suggest an increased risk of MACE,<sup>4</sup> issues with trial design and data integrity led the FDA to require the sponsor to perform an independent readjudication of the data. This extensive exercise, performed by the Duke Clinical Research Institute, had a minimal effect on the overall point estimates and confidence intervals for MACE, which remained at less than 1.30. The result was consistent with the FDA guidance and provided reassurance that rosiglitazone was not associated with excess cardiovascular risk.

Two groups of authors (Scirica et al. and White et al.) now report in the *Journal* the results of large, placebo-controlled, cardiovascular-outcome trials, these involving saxagliptin and alogliptin, members of the incretin drug class. Neither of these drugs had shown increased cardiovascular risk in its development program. Both trials were designed to first rule out excess cardiovascular risk by means of noninferiority testing; if that was shown, superiority testing followed, on the assumption

that better glycemic control might yield cardiovascular benefit. Both trials clearly met the FDA 2008 guidance for cardiovascular safety, but neither showed a reduction in cardiovascular events. Saxagliptin was associated with an unexpected increased risk of hospitalization for heart failure and a high frequency of hypoglycemia. Neither trial showed any increased risk of pancreatic adverse events, including cancer.

Before rosiglitazone, the cardiovascular safety of diabetes drugs had not been well studied. The initial concern with rosiglitazone arose from observational and case-control epidemiologic studies that generated a legitimate signal of possible cardiovascular harm, but every study had substantial methodologic shortcomings, including multiplicity, which meant that a statistically positive finding might be a false positive result.<sup>5</sup> Meta-analyses were also performed with preapproval studies that had been designed to show a positive glycemic effect as the primary end point. These studies enrolled patients at low cardiovascular risk, were short in duration, used both placebo and active controls, and did not prospectively adjudicate cardiovascular safety events. In such situations, comparison of a new drug with an active agent is challenged by the uncertain cardiovascular risk of the active comparator. In contrast, a placebo-controlled design may lead to imbalances in background therapy (as was the case with saxagliptin) that could influence the cardiovascular outcomes. Meta-analyses of these premarketing trials from phase 3 development programs were therefore relatively insensitive in assessing cardiovascular risk, making dedicated postmarketing cardiovas-

cular-outcome trials such as the RECORD study necessary to substantiate any risk signals. But the design of the RECORD study had substantial limitations that precluded a complete assessment of the cardiovascular safety of rosiglitazone.

In 2010, the FDA took a cautious stance and limited exposure to rosiglitazone, given the numerous alternative therapies that were available. But this position did not acknowledge the uncertainty of cardiovascular risk associated with other diabetes drugs on the market, and the FDA decision may have had unintended consequences. The intense publicity about the ischemic cardiac risk of rosiglitazone may have diverted attention from the better-established risk of heart failure that is common to the drug class. Restricted access led patients to switch from rosiglitazone to other diabetes drugs of unproven cardiovascular safety. Patients who had a myocardial infarction while taking rosiglitazone may have concluded that the drug was the cause, adversely affecting their perceptions of their doctor, drug companies, and the FDA. And placing a hold on the TIDE trial, although arguably justifiable, prevented any further clarification of the cardiovascular risks or benefits of the thiazolidinedione drug class. The rosiglitazone experience also raises the question of how to define a regulatory standard for withdrawing drugs from the market. New drug approvals are based on "substantial evidence" of drug safety and efficacy. But there is little guidance on what constitutes substantial evidence of harm that is sufficient to justify market withdrawal or the imposition of severe market restrictions.

What have we learned from the rosiglitazone experience? Clearly, the presumed cardiovascular risks of rosiglitazone led to a major change in FDA policy regarding the approval of all new diabetes drugs. From a cardiovascular perspective, rosiglitazone, saxagliptin, and alogliptin appear to be relatively safe. It is disappointing, however, that neither intensive glycemic control nor the use of specific diabetes medications is associated with any suggestion of cardiovascular benefit. Thus the evidence does not support the use of glycated hemoglobin as a valid surrogate for assessing either the cardiovascular risks or the cardiovascular benefits of diabetes therapy.

Patients with type 2 diabetes and their physicians currently have numerous treatment options, and additional drugs are in development. Perhaps the recent experience with rosiglitazone will allow

the FDA to become more targeted in its adjudication of the cardiovascular safety of new diabetes drugs, focusing the considerable resources needed to rule out a cardiovascular concern only on drugs with clinical or preclinical justification for that expenditure. New therapies targeting glycemic control may have cardiovascular benefit, but this has yet to be shown. The optimal approach to the reduction of cardiovascular risk in diabetes should focus on aggressive management of the standard cardiovascular risk factors rather than on intensive glycemic control.

Disclosure forms provided by the authors are available with the full text of this article at NEJM.org.

From the Division of Cardiology and Colorado Prevention Center Clinical Research, Department of Medicine, University of Colorado School of Medicine, Aurora (W.R.H.); the Division of Cardiology, University of California, Los Angeles, and Cedars-Sinai Medical Center, Los Angeles (S.K.); and the Ocean State Research Institute, Alpert

Medical School of Brown University, and Providence Veterans Affairs Medical Center, Providence, RI (R.J.S.).

This article was published on September 2, 2013, at NEJM.org.

1. The ACCORD Study Group. Long-term effects of intensive glucose lowering on cardiovascular outcomes. *N Engl J Med* 2011; 364:818-28.
2. Nissen SE, Wolski K. Effect of rosiglitazone on the risk of myocardial infarction and death from cardiovascular causes. *N Engl J Med* 2007;356:2457-71. [Erratum, *N Engl J Med* 2007;357:100.]
3. Guidance for Industry: diabetes mellitus — evaluating cardiovascular risk in new antidiabetic therapies to treat type 2 diabetes. Silver Spring, MD: Food and Drug Administration, 2008 ([www.fda.gov/downloads/Drugs/GuidanceComplianceRegulatoryInformation/Guidances/ucm071627.pdf](http://www.fda.gov/downloads/Drugs/GuidanceComplianceRegulatoryInformation/Guidances/ucm071627.pdf)).
4. Home PD, Pocock SJ, Beck-Nielsen H, et al. Rosiglitazone evaluated for cardiovascular outcomes in oral agent combination therapy for type 2 diabetes (RECORD): a multicentre, randomised, open-label trial. *Lancet* 2009;373:2125-35.
5. Kaul S, Diamond GA. Is there clear and convincing evidence of cardiovascular risk with rosiglitazone? *Clin Pharmacol Ther* 2011;89:773-6.

DOI: 10.1056/NEJMp1309610

Copyright © 2013 Massachusetts Medical Society.