

Comparison of Insulin Dose Adjustments by Primary Care Physicians and Endocrinologists

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■ **IN BRIEF** Insulin dose adjustment decisions in 20 simulated patients by nine primary care physicians (PCPs) and nine endocrinologists were compared to the algorithms used in a diabetes program in a large safety-net clinic. The number of dose changes was similar in the PCP and endocrinologist groups; however, the amounts of the dose changes in the PCP group were significantly closer to the diabetes program algorithms than the amounts in the endocrinologist group. Time constraints, rather than lack of ability, seem to be the major barrier to PCPs treating patients with insulin.

In type 2 diabetes, insulin secretion is depressed ~50% at the time of diagnosis and progressively decreases (1) regardless of treatment (2). Because of this, noninsulin therapies eventually fail, and insulin treatment becomes necessary. Approximately 30% of Caucasians and African Americans and 22% of Mexican Americans with diabetes are currently taking insulin (this includes the 5% of patients with type 1 diabetes, all of whom require insulin) (3).

Primary care physicians (PCPs), who care for >90% of people with diabetes (4), have agreed that decisions regarding insulin initiation should not be made exclusively by endocrinologists (5). Yet, they are reluctant to start insulin (6) and, once initiated, to intensify the regimen. In one study (7), 21% of PCPs never initiated or modified insulin doses, and 37% believed that only specialists should intensify insulin therapy. In one report (8), one-third of physicians regarded insulin as a treatment of last resort and withheld it until it was “absolutely necessary.” According to one report (9), once insulin was started in patients with type 2 diabetes, the dose or dosing

frequency was increased in only 23%, and insulin was discontinued in 27%. In another study (10), only 31% of patients started on basal insulin had their treatment intensified, and, in 32%, it was discontinued. Although most PCPs recognize the effectiveness of insulin, they still regard the initiation of insulin therapy as one of the most difficult aspects of managing patients with type 2 diabetes (11). The reasons stated for their reluctance to start or intensify insulin included lack of time and experience (4,5), as well as patient reluctance to use insulin and the potential for hypoglycemia.

Three-fourths of patients who are >80% adherent in taking their multiple oral medications have A1C levels exceeding the American Diabetes Association’s target level of <7.0% for most patients (12). The reluctance on the part of PCPs to start insulin, even in industrialized countries (e.g., the United States, Canada, and the United Kingdom), is also reflected in the length of time during which patients’ type 2 diabetes remains out of control before insulin is prescribed. In patients with A1C levels >8.0% who receive two or three oral antidiabetic drugs, the median

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time to starting insulin was ~7 years (13,14), and, even then, only 22% of the patients received insulin (13). In another study (15) in patients whose diabetes control was poor while taking multiple oral antidiabetic drugs, only 25% of patients started insulin within 1.8 years, and, in half of the patients, it took 5 years before insulin was started. In yet another study (16) in patients who had A1C levels >8.0% and were on two available oral antidiabetic drugs, only 42% started insulin, and it took nearly 3 years for them to do so. In various studies, the average A1C level when insulin therapy was initiated ranged from 8.9 to 9.8% (13,14,17,18). Furthermore, the mean A1C in patients taking insulin ranged from 7.9 to 9.3% (17,19,20). Almost two-thirds of insulin-treated patients fail to reach the target goal of <7.0% (21). Yet, clinical trials have shown that if insulin doses were adjusted every 1–4 weeks, the majority of patients would reach that goal (21).

From the PCPs' perspective, there are two general reasons why they may be reluctant to start or intensify insulin. The first is the structure of medical practice, in which lack of time is a major factor. Teaching patients to use insulin and to test their blood glucose levels reliably is time-consuming, although, in many practices, support staff carry out these tasks. However, increased frequency of visits is usually necessary as insulin doses are initially increased, and analyzing glucose results always takes a considerable portion of the usual 10- to 20-minute visit. There is also often a necessary increase in communications with patients outside of office visits regarding possible hypoglycemia and other questions concerning their insulin therapy.

The second reason may be hesitation because of PCPs' own perceived lack of ability to adjust insulin doses appropriately. This study tests this ability by comparing insulin dose adjustment decisions by PCPs and by endocrinologists to the decisions made by algorithms used in the dia-

betes program at the Martin Luther King, Jr., Outpatient Clinic of Los Angeles County, Calif.

Methods

For the past 35 years, the first author has taught and supervised mid-level health care providers (registered nurses, nurse practitioners, physician assistants, and clinical pharmacists) in caring for patients with diabetes using his detailed treatment algorithms. Part of these step-by-step plans include insulin dose adjustment algorithms (22), which have been very effective. For example, a registered nurse trained by the first author was placed in a family medicine clinic, where she was supervised by the PCPs. The PCPs referred 178 patients with diabetes to her, of whom 111 were taking insulin at referral. Using these algorithms, the nurse was able to decrease A1C levels of $11.0 \pm 2.1\%$ at referral to $7.3 \pm 1.0\%$ 9–12 months later in these insulin-requiring patients (23).

These insulin dose adjustment algorithms have recently been computerized and served as the arbitrarily termed "gold standard" against which the decisions of nonacademic PCPs ($n = 9$) and endocrinologists ($n = 9$) were compared. Seven of the PCPs worked in safety-net clinics and two worked at a Veterans Administration hospital. Three of the endocrinologists were faculty members at other institutions; the remaining six were in private practice. There were 11 male and 7 female physicians. The average number of years (range) after graduation from medical school was 22.3 (5–44) and 37.9 (13–54) for the PCPs and endocrinologists, respectively.

Twenty simulated cases were prepared using actual data downloaded from glucose meters over a 1-month period (28–34 days) from patients cared for by Anne L. Peters, MD, director of the University of Southern California's clinical diabetes program. Information available to the physicians included the simulated patients' height, weight, sex, insulin regimen (type of insulin, when injected, and

doses), range of time when meals were eaten, and pre- and postprandial glucose targets. The physicians also received not only measured glucose values with the dates and times they were measured, but also the distribution of these values in a scattergram. An example of a simulated patient on a self-mixed/split regimen is shown in the online appendix to this article. The 20 simulated cases included 3 with basal insulin alone, 4 with a basal/bolus insulin regimen, 6 with self-mixed/split regimens, 5 with premixed insulins, 1 with U-500 regular insulin, and 1 with delayed peaking of NPH insulin. Physicians were not allowed to discontinue an insulin preparation and substitute another one (a quantitative analysis would not be feasible in that case) but could add at another time a preparation that was already being given at one time or start a short- or rapid-acting insulin preparation if it as not already part of the insulin regimen.

Comparisons were made in three ways. First, the number of times that the gold-standard algorithms made a change in an insulin dose in the 20 cases was compared to the average number of times that the PCPs and the endocrinologists also made a change. Second, when both the gold-standard algorithms and the PCPs and/or endocrinologists made a change in a specific dose, the actual changes in the dose were compared and expressed as change by gold standard minus change by PCPs and/or endocrinologists (\pm SD). Third, the number of times that the gold-standard algorithms did not make a change in an insulin dose in the 20 cases was compared to the number of times the PCPs and endocrinologists also did not make a change. The differences between the gold standard and the PCPs were compared to the differences between the gold standard and the endocrinologists by the Wilcoxon rank-sum test. The two-tailed 5% significance level was used throughout.

This study was approved by the institutional review board of the

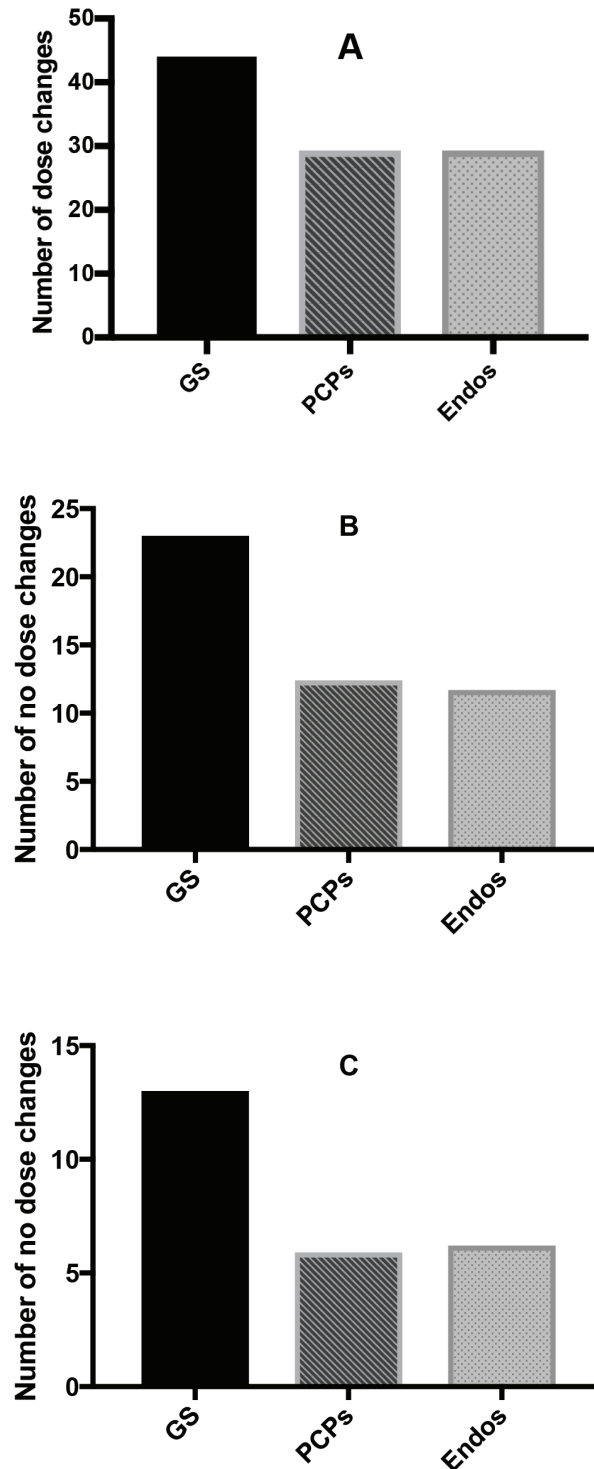
Los Angeles County Department of Public Health.

Results

Each component of the insulin regimen has a maximal effect during one of four specific periods of the 24-hour day/night cycle (i.e., overnight, morning, afternoon, or evening). The gold-standard algorithms make a specific recommendation of change or no change in the dose for each component of the insulin regimen based on the glucose values in the corresponding period. For example, rapid-acting insulin injected before breakfast mainly affects glucose concentrations between breakfast and lunch, whereas a basal insulin whenever injected mainly affects the longest period of time in which no food is eaten, usually overnight.

The gold-standard algorithms recommended 44 insulin dose changes for the 20 cases. The average number of changes made for the 20 cases by the PCPs and the endocrinologists at the same times were both 29.3 (67%) (Figure 1A). The identical number of changes in the two groups does not necessarily imply that the changes were always made under the same circumstances. The difference in dose changes compared to the gold-standard algorithms was -1.2 ± 6.3 units and -5.1 ± 12.3 units by the PCPs and the endocrinologists, respectively ($P < 10^{-4}$). The negative differences indicate that, in both groups, the mean changes in insulin doses were greater than in the gold-standard algorithms, but recommendations by the PCPs were significantly closer to the gold-standard recommendations than those by the endocrinologists. The large SDs reflect the variability in insulin dosing, with more variability by the endocrinologists than by the PCPs (although not significantly so).

There were 23 instances in the 20 cases where the gold-standard algorithms did not recommend an insulin dose change in a component of the insulin regimen. The average num-



■ **FIGURE 1.** Decisions regarding insulin dose adjustments by the gold-standard (GS) algorithms, PCPs, and endocrinologists (Endos). The figure shows *A*) the number of dose changes at the requisite times, *B*) the total number of no dose changes at the requisite times, and *C*) the total number of no dose changes at the requisite times eliminating instances for which too few glucose values dictated no change by the gold-standard algorithms. See Results for a definition of “requisite times.”

ber of no changes in those instances was 12.4 (54%) by the PCPs and 11.7 (52%) by the endocrinologists (Figure 1B). Again, the similar number of no changes in the two groups does not necessarily imply that the lack of a change occurred under the same circumstances.

The gold-standard algorithms made no change in insulin dose under two circumstances: if the appropriate glucose values were within the target range or if there were too few of them. The PCPs and endocrinologists may have disagreed with the appropriate number of glucose values that would allow a change and thus made a change with fewer values than the gold-standard algorithms would have. This would decrease the level of agreement between the results of the gold-standard algorithms and the individual physicians. However, if the 10 instances in the 20 cases where the gold-standard algorithms would not have made a change because of too few values were eliminated, leaving 13 instances where no change was made because of values in the target range, the average number of no changes in those instances was 5.9 (45%) by the PCPs and 6.2 (48%) by the endocrinologists (Figure 1C). Thus, eliminating this possible source of disagreement did not change the level of agreement between the gold-standard algorithms and the two physician groups.

Discussion

There is no one right way to adjust insulin doses. As long as appropriate dose changes are made at appropriate intervals (e.g., more frequently when doses are being titrated and less frequently when more stable doses are reached), diabetes control should improve and, in many cases, be satisfactory. The number of times that the PCPs and the endocrinologists changed or did not change the insulin dose compared to the gold-standard algorithms did not differ between the two groups. When adjustments were made by both the gold-standard al-

gorithms and the PCPs or endocrinologists, the average dose changes by the PCPs (-1.2 ± 6.3 units) were significantly closer to the gold-standard algorithms than those made by the endocrinologists (-5.1 ± 12.3 units). There was also less variability in the changes made by the PCPs than by the endocrinologists.

Given the similarity of the responses of PCPs and the endocrinologists compared with the gold-standard algorithms, it would seem that PCPs should be able to adjust insulin doses appropriately if they took the opportunity to do so. This suggests that the time constraints of the current medical system play an important role in the reluctance of PCPs to start and intensify insulin therapy.

Telemedicine is a potential solution to this problem. Several studies have shown the effectiveness of telemedicine programs in which remote glucose monitoring values were sent to providers, with clinical decisions regarding insulin adjustments made either directly by endocrinologists or by nurses supervised by endocrinologists (24–28). Our results strongly suggest that PCPs could also carry out telemedicine adjustments of insulin doses appropriately. The lack of a face-to-face interaction is not an issue for telemedicine adjustments of insulin doses because dose change recommendations based only on glucose readings (independent of known clinical parameters) were just as effective as recommendations made by endocrinologists who knew the patients (21).

Using reports generated by these (or similar) computerized insulin dose adjustment algorithms after meters are downloaded in the office or remotely will save PCPs time and, if done remotely, decrease face-to-face visits. The latter telemedicine approach is economically feasible because of a recently instituted Centers for Medicare &

Medicaid Services monthly fee of \$42 for telemedicine “visits.”

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Duality of Interest

No potential conflicts of interest relevant to this article were reported.

Author Contributions

M.B.D. planned the study, obtained the glucose data, and wrote the manuscript. P.D. carried out the study, entered the data, and reviewed the manuscript. S.J.D. helped plan the study, developed the case studies, and reviewed the manuscript. M.L. suggested the statistical analysis, carried out the statistical analysis, and reviewed the manuscript. M.B.D. is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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