Closer Look

Diabetes Technology Meeting 2013

October 31-November 1, 2013: Burlingame, CA Day #2; Highlights - Draft

Executive Highlights

Hello from sunny California! We're back with our highlights of day #2 from the Diabetes Technology Meeting. Friday's sessions had plenty on the artificial pancreas (four hours worth!), lots on mHealth, two wonderful awards, a keynote, and a notable WellDoc poster.

The clear highlights of the day came during two jam-packed sessions on the artificial pancreas. Dr. Bruce Buckingham (Stanford University, Stanford, CA) presented data from his 20-patient overnight closed-loop study at a diabetes camp this past summer. Campers on the closed loop spent significantly more time in range (70-150 mg/dl) vs. those on open loop (~63% vs. ~50%), less time in hypoglycemia (0% vs. ~7%, respectively), and had less glucose variability. These results are very impressive when one considers that the camp setting is very far from the real world type 1 diabetes care most patients receive. We wish the study showed time in range and time in hypoglycemia for "usual care" as well! They would undoubtedly be lower and higher, respectively. Dr. Kenneth Ward (Oregon Health and Science University, Portland, OR) shared new results from a bi-hormonal 30-hour outpatient partially outpatient closed-loop experiment, highlighting that when the closed loop was down ≤ 10% of the time (connectivity issues plagued the study), median glucose was 130 mg/dl with only 13 minutes per day spent <70 mg/dl and only 30 seconds spent <60 mg/dl - he had lots of praise for the Dexcom G4 Platinum, a theme we've heard in many talks in this conference. Dr. Claudio Cobelli's (University of Padova, Padova, Italy) presentation on the currently-running AP@home two-day transition study mirrored these positive results as well - less time spent in hypoglycemia and more time in target. We took particular note of his Christmas wish list item: a Dexcom Gen 5. He isn't alone!

On the algorithm side, device expert Dr. Patrick Keith-Hynes (University of Virginia, Charlottesville, VA) showed what closed-loop control might look like on Google Glass - very innovative! See inside for more on this. We also enjoyed a talk from the charismatic Dr. Francis Doyle III (University of California Santa Barbara, Santa Barbara, CA), who discussed MPC control algorithm improvements and shared interim data from four patients in the in-progress NIH DP3 grant funded Ambulatory Control project.

Aside from the artificial pancreas, we were also pleased to see mHealth taking a more central role at this year's DTM. A WellDoc poster on predicting hypoglycemia in patients with type 2 diabetes drew considerable interest - the model needs 10 SMBG values within seven days. Notably, it was more accurate than the predictions of three endocrinologists. We also heard from the great Dr. Viswanathan Mohan (Madras Diabetes Research Foundation, Chennai, India), winner of the prestigious Diabetes Technology Society Leadership Award. We were very impressed with his work using a satellite-linked "telediabetology van" to remotely diagnose and care for patients in rural India. A keynote speech from pediatric endocrinologist Dr. Jennifer Dyer (EndoGoddess, Columbus, OH) was also of note - her talk provided a great overview of apps and mHealth, with plenty of opinion (and the drawbacks) of Sanofi's iBGStar, Glooko's universal cable/app, iGlucose, Telcare's BGM, WellDoc's Diabetes Manager, Ginger.io (behavioral analytics), and Bant (a social app for diabetes). While many are holding out for slam-dunk data on telemedicine, we are optimistic that it works if applied correctly and in the proper patient population and setting. The keys will be obtaining reimbursement, rolling it out to the populations that need it most, and scaling it from there.

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Introduction

David Klonoff, MD (Mills-Peninsula Health Services, San Mateo, CA)

Dr. David Klonoff opened the meeting with a summary of extensive activity happening at the Diabetes Technology Society:

- ***Journal of Diabetes Science and Technology*:** *JDST* is transitioning to Sage publications, which will bring it to more medical libraries. Additionally, Dr. Klonoff has appointed two new

associate editors: Drs. Boris Kovatchev and Claudio Cobelli ("to emphasize our commitment to the artificial pancreas"). Indeed, the November edition of the JDST is a special issue on the artificial pancreas.

- **Error Grid Project:** DTS has been working for the past year, along with other organizations (ADA, Endocrine Society, AAMI, FDA) to develop a new error grid for determining the clinical accuracy of BGMs. The article outlining the grid will be submitted to a medical journal in the next month and should be published in early 2014. Dr. Klonoff called it, "A real advance in terms of understanding the clinical accuracy of BGMs." See our Day #1 report for a description.
- **Proposed Post-market BGM Surveillance Program:** At the DTS September 9 meeting, Dr. Klonoff presented a surveillance program that would assess the accuracy of strips in the post-market setting (see our report here). Currently, DTS is getting the surveillance program organized and starting to hammer out details with the steering committee.
- **Certified Diabetes Technology Clinician:** At the Clinical DTM this past April (read our report), DTS certified close to 200 clinicians. This program recently continued in Frankfurt, Germany, at a European version of the meeting. The meeting will be back in the US in April in Los Angeles.
- **Tissue Response to Implanted Active Medical Devices Meeting:** DTS just announced this meeting, which will focus on implanted sensors and drug delivery (both diabetes and non-diabetes applications). It has been developed in cooperation with Duke University, Georgia Tech University, Massachusetts Institute of Technology Lincoln Laboratory, and California Institute of Technology and will take place May 9-10 in Herndon, VA. See the schedule here.
- **DTM 2014:** Next year's Diabetes Technology Meeting will take place in Bethesda, MD, from November 6-8. We are very excited it will not take place over Halloween again!

Artificial Pancreas - Clinical Outcomes

CLOSED-LOOP CONTROL IN CHILDREN AND ADOLESCENTS WITH TYPE 1 DIABETES AT DIABETES CAMP

Bruce Buckingham, MD (Stanford University, Stanford, CA)

Dr. Bruce Buckingham shared "exciting new data" from a 20-patient overnight closed-loop study conducted this past summer at a diabetes camp. Participants were randomized to open loop (pump and CGM) or closed loop control overnight (54 nights in total). The trial used the Dexcom G4 Platinum, a Bayer Next glucometer, the UVa DiAs control algorithm running on an Android phone, and a Tandem t:slim insulin pump (all connected with help of a USB Bluetooth LE relay device and an Xperia phone to send Dexcom data to the DiAs controller - a reminder of how much connectivity can improve!). Compared to control nights, patients on overnight closed loop spent significantly more time between 70 and 150 mg/dl (~63% vs. ~50%), significantly less time <70 mg/dl (0% vs. ~7%), and had noticeably less variability (not quantified, but very clear from the graphs). Overall mean glucose was not significantly different between the open-loop and closed-loop groups - this was not terribly surprising to us given the excellent care patients receive at diabetes camp. However, it was also an important reminder of why mean glucose does not tell the full story, given the huge improvement in time spent in hypoglycemia during closed loop. Concluding, Dr. Buckingham asserted that overnight closed loop with the DiAs system is safe, feasible, and effective in reducing nocturnal hypoglycemia and increasing time in range compared to sensor-augmented pump therapy. The team is "planning to move forward to further studies." We hope they go in-home!

- **This study enrolled 20 patients (mean A1c: 8.1%; mean age: 15 years; mean duration of diabetes: 6 years).** Closed loop used UVa's United Safety System as the control algorithm. The algorithm's hypoglycemia module aimed to keep glucose values above 110 mg/dl. The hyperglycemia module shot for a target around 160 mg/dl, which dropped to 120 mg/dl around 4-5 am. Maximum delivery was capped at three times the basal rate. System setup required entry of patient height, weight, and basal rates.

- **Closed loop began before bedtime and could only start if glucose was 80-250 mg/dl and if the sensor was within 20% of the meter glucose (mandated by the FDA** - we wonder if this requirement might be built into a commercial product, such that overnight closed loop could only be initiated after confirming the sensor is running accurately). Meter glucose checks occurred at midnight, 3 am, and 6am. Hypoglycemia was treated when glucose <50 mg/dl (in these cases, closed loop was stopped). On open-loop control nights, alarms were set at 70 mg/dl and 250 mg/dl. Standard hypoglycemia treatment was given for glucose levels <70 mg/dl, and patients were cared for by camp physicians. There was no remote monitoring on open-loop nights (two counselors were in each cabin).
- **Overnight closed loop was commenced on 54 nights, and on 76% of nights, closed loop lasted more than six hours.** It was stopped on 13 nights (24% of the time) due to sensor errors over 20% or lost sensor (12%); infusion set failure (7%); pump failure (2%); software failure (2%); hypoglycemia <50 mg/dl (2%). This reinforces the clear areas for improvement - CGM reliability and infusion sets.
- **Interestingly, the Dexcom G4 Platinum performed worse than expected in the camp setting:** a MARD of 17.5% at camp vs. a MARD of 11% observed in the in-clinic feasibility study. Dr. Buckingham attributed this to less accurate blood glucose calibration in the camp setting (e.g., dirty hands causing inaccurate readings). We've also heard that adhesive is a challenge at diabetes camp - this may have contributed to worse accuracy as well.

NEW ALGORITHMS FOR CLOSED-LOOP STUDIES

Claudio Cobelli, PhD (University of Padova, Padova, Italy)

Dr. Claudio Cobelli discussed the past, present, and future of outpatient trials for the closed-loop artificial pancreas, providing an overview of three trials to happen within the next year. In future outpatient studies, the system will include an Accu-Chek pump, UVa's DiAs mobile platform, and the Dexcom G4 Platinum CGM; while this system is more streamlined from the original protocols, Dr. Cobelli lamented the need to go wireless because the "major limitation" in the closed-loop is the USB cord. Current studies are 19-hour overnight, closed-loop trials with dinner and breakfast. Looking at preliminary results from the currently-running AP@home two-day transition study, Dr. Cobelli demonstrated that compared to open-loop therapy, patients spend less time in hypoglycemia (<70 mg/dl) for both dinner and night control (~2% vs. ~9%for both), and spent more time in target (70-180 mg/dl) during the night compared to open loop (~90% vs. ~70%). Turning to the future, three studies will expand on the two-day study to include one-week, three-month, and five-week studies. Dr. Cobelli also highlighted the importance of physiological studies of type 1 diabetes, providing an update of current research on the diurnal patterns of insulin action, moderate intensity exercise, hepatic plasma glucagon sensitivity, and time lag of glucose transport from vascular to interstitial space.

- **Dr. Cobelli outlined three future closed-loop studies: 1) a one-week (five days at home) study of open loop vs. "hybrid" closed loop (n=24); 2) a three-month (two months at home) open loop vs. "hybrid" closed loop (n=36); and 3) a five-week (three weeks at home) open loop vs. mixed "hybrid" and "all-day" closed loop (n=24).** Participants will use the closed loop only from dinner to wake-up ("hybrid") for the first two studies. In this third study, participants will use the "hybrid" system for the first week, and the "all-day" closed-loop for weeks two and three. The first and third studies are slated to begin in January 2014 and the second in February 2014. The preliminary endpoint for all is percentage of time spent in target range (70-180 mg/dl).
- **Coming into type 1 diabetes research, Dr. Cobelli was "surprised by the lack of mechanistic physiological studies being done in type 1 diabetes" compared to those done in prediabetes and type 2 diabetes.** Although Dr. Cobelli believes there is a dearth of research being done, some of the current work in type 1 diabetes physiology includes: 1) diurnal pattern of insulin action; 2) the effects of gastric emptying (pramlintide); 3) the effects of daily

activities on glucose levels; 4) the effects of moderate exercise; 5) the effects of hepatic plasma glucagon sensitivity; 6) the dawn phenomenon; 7) the response to mental stress; and 8) the time lag of glucose transport from vascular to interstitial space. Dr. Cobelli emphasized that understanding the physiology of type 1 diabetes will help the development of devices.

- **Diurnal pattern of insulin action:** Dr. Cobelli highlighted that researchers are examining the one-month trend of insulin sensitivity in patients.
- **Time lag of glucose transport from vascular to interstitial space:** Although Dr. Cobelli did not divulge too many details, he did note that results will be presented at ATTD (which we are excited to hear!), and a paper is currently in publication.
- **"I don't know if it's too optimistic to hope that Santa will bring us a wireless Dexcom Gen 5"** Dr. Cobelli joked as he emphasized that the USB is the major limitation the current closed loop.

LOW-DOSE GLUCAGON IN TYPE 1 DIABETES

W. Kenneth Ward, MD (Oregon Health and Science University, Portland, OR)

Dr. Kenneth Ward discussed automated bi-hormonal closed-loop control, highlighting background research and sharing fresh data from an outpatient study. He had a handful of main takeaways from the work at OHSU: 1) in the fasting state, to maximize subcutaneous glucagon effectiveness for doses of 175 ug or less, insulin levels should ideally be <40 uU/ml - this result was obtained from studies in which various doses of glucagon were given at each of three steady state insulin infusion rates; 2) repeated use of low dose glucagon is unlikely to cause depletion of liver glycogen in people with type 1 diabetes who are eating normally (their group measured liver glycogen by magnetic resonance spectroscopy; historically, this has been a concern of bi-hormonal skeptics); 3) CGM devices are increasingly accurate and egregious errors are very rare (he highlighted the more than four-fold improvement in such errors with the Dexcom G4 Platinum vs. the Seven Plus); and 4) the improvement in sensor accuracy contributes to lower rates of hypoglycemia. Dr. Ward also shared results from a bi-hormonal 30-hour closed-loop experiment (n=11 in-clinic, n=18 in hotel setting) - results showed very low rates of hypoglycemia, though connectivity was a significant issue that contributed to worse system performance (smartphone to USB and OmniPod PDM to pods). This contributed to Dr. Ward's last slide on the two key areas for improvement: connectivity and a pumpable glucagon formulation.

- **Dr. Ward discussed a bi-hormonal 30-hour closed-loop experiment (n=11 in-clinic, n=18 in hotel setting)**. The study used two OmniPod pumps (insulin and glucagon), an OmniPod PDM, two Dexcom G4 Platinum sensors with receivers (for redundancy), a Motorola smartphone controller, batteries, a cable, and a USB hub - a clear reminder of how much there is to improve on the connectivity and device burden front! Novo Nordisk glucagon was used and changed out every eight hours. Physicians monitored patients via a cloud service. Meals were announced and patients estimated their size to the nearest 20 g of carbs. Control was otherwise fully automated.
  - **Dr. Ward noted that in many cases, patients did not need any glucagon to avoid hypoglycemia.** When glucagon was given, the goal was to keep the dose as low as possible.
  - **When closed loop was down ≤10% of the time, median glucose was 130 mg/dl (mean: 141 mg/dl). For the recent studies carried out with the Dexcom G4 sensors, there were only 30 seconds per day with blood glucose <60 mg/dl.** When closed loop was down >10% of the time (due to connectivity issues), median glucose was a much higher 160 mg/dl (mean: 179 mg/dl).
  - **Dr. Ward underscored the accuracy improvements with the G4 Platinum.** For the overall study (721 hours of control), 13 minutes per day were spent <70 mg/dl and four minutes were spent <60 mg/dl. For the G4 Platinum only (498 hours), only eight minutes per day were spent <70 mg/dl and only 30 seconds per day were spent <60 mg/dl. (Dr.

Ward did not specify, but we assume the Seven Plus was the other CGM used prior to the G4 Platinum.)

- **The Oregon team will transition to using a single CGM sensor - historically, they have used two or more sensors to improve accuracy and reduce errors.** In this closed-loop study, the G4 Platinum had an impressive MARD of 9.3% with two sensors (calibrating every six hours), which "would probably be one point higher if you chose one sensor." The frequency of egregious errors (>50%) was just 0.4% vs. 1.5-2% in previous studies of the Seven Plus.

- **Dr. Ward noted that glucagon can be stabilized by avoiding water (Xeris), increasing the pH to 9-10, creating analogs of glucagon (DiMarchi et al, Roche), increasing solubility at a neutral pH (Steiner et al., Biodel), and interestingly, adding curcumin (Oregon Health and Science University).** The latter approach appears to reduce fibrillation. Dr. Ward showed results of curcumin-stabilized glucagon in pigs - pharmacodynamic results were very similar between fresh and aged glucagon.

DREAM PROJECT: WHERE ARE WE TODAY?

Moshe Phillip, MD (Institute for Endocrinology and Diabetes, Petah Tikva, Israel)

Dr. Moshe Phillip provided an update on the DREAM Project, highlighting that, to date, the project has accrued an impressive ~15,000 hours of closed-loop operation in 179 patients and 858 nights at home. Notably, Dr. Phillip provided interim results of the DREAM 4+ pilot study, a single center six-week at-home crossover study (n=30) of the overnight MD-logic artificial pancreas system (MDLAP). Participants using the MD-logic system experienced significantly lower ($p < 0.05$) overnight median blood glucose values vs. control (141 mg/dl vs. 161 mg/dl, respectively). He also noted that participants had lower blood glucose levels in the morning, and some of the study effects of the control group are starting to disappear. We look forward to hearing results of the full study, which we would expect to hear at ATTD 2014 or ADA 2014. Turning to the future, Dr. Phillip remarked that DREAM 5 and 6 are closed loop, full 24-hour sessions, and there will be multicenter, multi-national studies in 2014. Wow!

- **Average insulin delivery did not vary significantly between the MD-Logic and control group (8.5 units vs. 7.7 units, respectively).**

Artificial Pancreas - Algorithms

BEYOND SMARTPHONES: WEARABLE COMPUTING, ALGORITHMS, AND THE ARTIFICIAL PANCREAS

Patrick Keith-Hynes, PhD (University of Virginia, Charlottesville, VA)

Dr. Patrick Keith-Hynes, an artificial pancreas hardware and software expert, provided an excellent overview of next-generation devices that could be added to the closed loop. He began with Google Glass (!), which he wore around the hotel lobby before his talk. He showed several slides with point-of-view pictures of the lobby taken from Glass, adding in the Diabetes Assistant closed-loop user interface in the heads-up display's top right corner (hypoglycemia and hyperglycemia traffic lights, sensor glucose, trend; see the picture on twitter). Very futuristic! It was also notable to hear that UVa is releasing a second version of its Diabetes Assistant (its Android phone-based closed-loop platform, first unveiled at DTM 2011) - the update will include additional software modules and new devices (Dexcom's ANT+ wireless [presumably for the Gen 5 mobile platform], Roche's Accu-Chek Combo pump, Tandem's t:AP [the closed-loop version of Tandem's pump that includes slight modifications, such as Bluetooth], and an AP Alarm Clock configuration for Dexcom Share). It's impressive to see the roadmap to connectivity with so many next-gen devices already. Dr. Keith-Hynes discussed the concept of networks and cloud services in some detail as well, noting the importance of safely designing the AP for connectivity/link failures (e.g., spreading the algorithm across multiple system components).

- **Dr. Keith-Hynes showed examples of what closed-loop control might look like on Google Glass - see the picture on twitter.** As background, Google Glass is worn like eyeglasses, has a heads up display, a camera, private audible feedback and alerts, and voice control. Dr. Keith-Hynes showed the DiAs interface onscreen, noting that the display is quite visible and it's "easy to see what you're doing." The closed-loop DiAs display could be minimized and only appear with a risk of hypoglycemia or another event.
    - **A "DiAs Glass companion" could talk directly to the CGM sensor and insulin pump** (the screen showed the Dexcom G4, the Tandem t:slim pump, and the Roche Accu-Chek Combo pump). Such a system would allow voice activation to send boluses.
    - **Dr. Keith-Hynes believes Glass could also be used as a patient training tool for the artificial pancreas.** Patients could watch training videos and Glass would also offer a first-person perspective for tech support, as well as simplified device pairing through QR codes.
- **Dr. Keith-Hynes mentioned some other interesting mobile platforms that could be incorporated into the artificial pancreas:** Sony's Smartwatch2, Samsung's Galaxy Gear, and Recon's Jet.
- **"AP systems are inherently networked. It's impossible to build one without some degree of networking."** Dr. Keith-Hynes emphasized that closed-loop control means a wireless signal is involved, so developers must consider the coordination between multiple devices. On the plus side, this presents "tremendous opportunities" to take advantage of rapidly evolving mobile platforms. Developers can combine the best pumps, glucose sensors, apps, and other biometric devices in a single system (i.e., like a modularized software model). This approach will enable the creation of an ecosystem of software apps for blood glucose control.
- **That said, closed-loop control presents several challenges from a engineering standpoint.** Chief among them is connectivity ("this is the first thing you run up to when building an AP system"). This is sentiment we've heard at every major diabetes technology meeting this year, particularly April's FDA/NIH/JDRF Artificial Pancreas Workshop. Dr. Keith-Hynes also highlighted network-algorithm interactions (i.e., link failure, human-machine interactions, safety, privacy/security, regulatory approval). He called the recent FDA guidance on mobile medical apps "extremely helpful."
- **"Links will fail and the system must degrade gracefully."** Right now, algorithms are all loaded into the smartphone, putting a lot of stock into one device. Ideally, the algorithm could be spread across the network - for example, the safety part of the system could be on the pump, while other modules could be put on the smartphone or in the cloud.
- **"If connectivity from the smartphone to the pump fails, the pump must know it."** In this case, there needs to be a transfer of control authority to the pump. Alternatively, if the CGM signal is lost, the system should shift to open-loop mode. This is what happens with Dr. Ed Damiano's bionic pancreas as well. His approach also reverts to a control-algorithm-informed open-loop basal.

ALGORITHMS FOR PATIENT CUSTOMIZATION IN THE OUTPATIENT SETTING

Francis Doyle III, PhD (University of California Santa Barbara, Santa Barbara, CA)

Dr. Francis Doyle III provided an update on the development of his research group's model predictive control (MPC) algorithm and shared interim results from an outpatient study of the model's most recent iteration. Updates to the MPC algorithm include a variable target zone (which can help patients stay clear of nocturnal hypoglycemia) and an adjustment to the hyperglycemia and hypoglycemia cost functions to prevent overcorrections that result in a over-delivery of insulin. An adaptive function allows the system to use CGM, pump, and patient data to produce a customized baseline for each patient, allowing the controller to focus more on transient effects and disturbances. A similarly customizable feature allows the algorithm to

calculate an estimate of insulin sensitivity, which in turn allows it to optimize bolus dosages - given the transient increases in insulin sensitivity in type 1 diabetes (e.g., stress, illness, exercise), this is a great addition. Dr. Doyle shared interim data from four patients in the NIH DP3 grant funded Ambulatory Control project, which is still in progress. The 24-hour outpatient study includes sleep and exercise periods, and allows patients to consume meals based on their normal diets. The few CGM traces Dr. Doyle displayed showed that the updated "adaptive" algorithm provided tighter control than the "control" algorithm without the aforementioned improvements - the reduction in overcorrections to hyperglycemia and hypoglycemia was a very evident change (a soft landing - quite hard to do with open-loop therapy). For background on MPC and its development, read our coverage of Dr. Doyle's talk at last year's DTM on page two of our collection of DTM 2012's Most Memorable Talks.

- **Dr. Doyle began by discussing extensions to UCSB's core model predictive control (MPC) algorithm.** Some features were included to improve safety in the outpatient setting, while others are centered on improving patient customization.
    - **A major update is the ability to set a variable target zone.** As background, the zone MPC algorithm utilizes a target zone rather than a single set-point. If the algorithm predicts an excursion from the zone (generally set from 80-140 mg/dl) it will adjust insulin infusion accordingly. Dr. Doyle argued that this zone approach is more medically relevant than a single set-point. The new variable zone feature allows the algorithm to shift its set point, for example overnight, when hypoglycemia is a greater concern.
    - **Another update is the ability to set asymmetric cost functions for hyperglycemia and hypoglycemia.** Dr. Doyle noted that excursions below the target range should be associated with a high cost function in order to expedite recovery from hypoglycemia, while hyperglycemia should be associated with a lower cost function in order to protect against over-delivery of insulin (which could quickly push patients into severe hypoglycemia).
    - **An adaptive advisory system allows the algorithm to produce a patient-adapted baseline.** This "basal initialization" system receives input from the sensor, the pump, and the patient diary. The adaptive baseline allows the controller to focus on transient effects and disturbances. Another adaptive feature also combines data from the patient, CGM, and pump to estimate insulin sensitivity, which can be used to optimize bolus delivery.
- **Excitingly, Dr. Doyle shared interim data from the NIH DP3 grant-funded Ambulatory Control project,** which UCSB is performing in collaboration with the University of Virginia, Mayo Clinic, and Sansum Diabetes Research Institute. The outpatient study is currently in progress and involves a 24-hour period in which patients are completely under the control of the updated MPC algorithm or a control version of the model without the aforementioned improvements. The study design included an unannounced exercise session of 30-60 minutes if the subject was accustomed to exercise, as well as an overnight phase (during which time the target zone was elevated to 110-170 mg/dl). Study participants consumed "real-life" meals based on their normal diet, and were allowed to snack or otherwise self-treat hypoglycemia. Dr. Doyle noted that only four patients have completed the trial at present, and that the results displayed should not be accepted as broadly generalizable.
    - **The predictive algorithm appeared to perform better than the "control" version in a number of ways.** In one patient, the system's nocturnal target zone elevation kept blood glucose around 150 mg/dl, well clear of hypoglycemia. In another patient that experienced a period of hypoglycemia at the beginning of the night, the asymmetric cost functions eliminated the overcorrections seen in the "control" version of the algorithm. Instead, glucose levels recovered quickly from hypoglycemia but leveled off in the lower half of the target zone. The predictive function appeared to work well: in one

illustrative example in which a patient was exercising, the algorithm suspended insulin delivery while blood glucose levels were above range, because it predicted a sharp drop.

REVISITING THE USE OF CONTINUOUS GLUCOSE MONITORS TO EFFECT TIGHT GLYCEMIC CONTROL IN THE ICU

Garry Steil, PhD (Boston Children's Hospital, Boston, MA)

Dr. Garry Steil's presentation focused on tight glycemic control (TGC) in the ICU - he reviewed the previously published SPECS trial (NEJM 2012), where TGC showed no benefit on outcomes (read our report). More importantly, he highlighted the just-started HALF PINT trial (Heart and Lung Failure Pediatric Insulin Titration; 35 sites, nine currently enrolling). This was particularly interesting, as it is assessing TGC in a larger and sicker population of patients (n=1,880 vs. 980 in the SPECS trial). Dr. Steil shared interesting commentary on how the research team decided which CGM to use in HALF PINT - they began with Medtronic's Enlite sensor, though experienced an 81% failure rate on the first day and a MARD of 17.8%. They switched back to the Sof-Sensor (used in SPECS), though still experienced a 44% failure rate (MARD: 13.8%). Using the Dexcom G4 Platinum, however, there was no early failure on the first day and a MARD of 11.7% ("better than ambulatory studies"). Dr. Steil concluded with several examples of sample dilution and inaccurate calibration, which he believes is an underappreciated issue. We certainly agree, especially as CGM gets more and more accurate and comparable to blood glucose meter accuracy.

ARTIFICAL PANCREAS AWARD

David Klonoff, MD (Mills-Peninsula Health Services, San Mateo, CA)

Dr. David Klonoff presented this year's DTS Artificial Pancreas Award to Medtronic's Drs. John Mastrototaro and Francine Kaufman, a selection motivated by the recent FDA approval of Medtronic's MiniMed 530G - as a reminder, this is the first system to gain approval under the FDA's new "artificial pancreas device system" product classification. Dr. Klonoff noted that this was a special year, as this is the first time the award has gone to industry, demonstrating the major progress that has been achieved in making the artificial pancreas available to patients. As a reminder, the MiniMed 530G features a threshold suspend feature and was approved in the US four years after it launched in 2009. In his brief remarks, Dr. Mastrototaro remarked that "this is the very beginning, and we are going to launch many more stages of the product before we get to the fully automated artificial pancreas." We look forward to hearing how the early reception has been when Medtronic reports earnings on November 19. Kudos to the two leaders!

PANEL DISCUSSION

Q: Is there any quantification you can give us on the failure rate in the system as you have gone from DiAs 1 to DiAs 2, in terms of linking?

Dr. Patrick Keith-Hynes (University of Virginia, Charlottesville, VA): I don't have any quantitative measures for you, but I can tell you that the results are pretty dramatic. We're on a pretty steep curve. In the first systems we had had multiple boxes, and each of the links between boxes was prone to failure. This year with the new version, we'll have a cellphone talking directly to a pump with no boxes in between, and we expect reliability to go up.

Q: How are you providing nutrition in the ICU?

Dr. Garry Steil (Boston Children's Hospital, Boston, MA): All patients are on IV feeds. Once they can choose food or bolus feeds, they are off the algorithm and may be more automatic. We do a little bit of a division around six years old because the glucose turnover is so fast. The turnover rate is about 5 mg/dl/minute, about twice of most of you in the audience. That's a little harder to control.

Q: You showed data on acetaminophen, but what sensor was being used?

Dr. Steil: It was the Dexcom sensor.

Q: So the Medtronic sensor did not react to acetaminophen?

Dr. Steil: No we did not see a response there.

Dr. Jeffrey Joseph (Thomas Jefferson University, Philadelphia, PA): In the hospital setting we have seen it affect both Medtronic and Dexcom. Oral was not clinically significant but now that the IV is being used more often, you get higher peak levels and it becomes an issue.

Q: There are lots of telemetry protocols; do you have a preference for some over others?

Dr. Hynes: Bluetooth is where things are going. At the present time, Bluetooth is robust, but it burns battery quickly. We're using Dexcom receiver so we have high hopes for that.

Q: For the closed-loop results, how did you deal with the challenges that meals introduce? The closed loop performed better in every way. Does the body release insulin before food hits the stomach, or does it wait for the glucose to rise? If the insulin is released prior to food hitting the stomach, would you mimic that in the next closed loop?

Dr. Nick Oliver (Imperial College London, London, UK): We use a meal announcement strategy. I wouldn't claim that's a biological cue, but you just get better prandial control when you give insulin with a meal announcement. We are doing it because postprandial insulin has a longer tail; this is a pragmatic rather than biological solution.

Comment: Did you give boluses?

Dr. Oliver: Yes.

Q: What is the ideal CGM sampling interval?

Dr. Francis Doyle (University of California, Santa Barbara, Santa Barbara, CA): A five-minute sampling interval is the right one. When you're checking, you're responding to the earliest sample - you can use a one-minute sampling size for finer resolution.

Dr. Steil: In the ambulatory work we're doing, we've been using one-minute interval samplings. It is hard to make it through the meal when you are only doing five-minute samplings. In the ICU it's a bit interesting. We're making changes to insulin delivery every hour, but the question of whether one-minute would help over five is interesting. We do see glucose levels changing 2 ml/dl/min. When you look at the sensor value, we were looking at it just before it was about to change, and it would be 15 mg/dl later because it was moving at 3 mg/dl/min.

Q: In the ICU have you seen any interference from other drugs? There is some in vitro data that suggests that drugs like beta-blockers alter glucose sensing. Have you seen any sort of similar drug interference?

Dr. Steil: I haven't noticed anything, but we may be underpowered; there are companies that are doing much more extensive testing and are going through a gauntlet of drugs that might possibly intervene. We are going to try to properly control these, and we'll provide p-values to show we saw an effect.

Comment: At ATTD we'll be presenting data that uses microdialysis and looks at the difference.

Q: We've seen closed-loop data, and despite our best efforts, we're seeing episodes of mild hypoglycemia and hyperglycemia. How will the approval of rapid acting insulins help us in the closed loop? Is it the rapid onset that is the benefit, or is it the lack of residual subcutaneous depot? How might that help closed-loop control?

Dr. Doyle: The engineering interpretation is that the delay is the issue, whether it's the sensor or the pump. If you eliminate the latency in one, you will still have the other. We were expecting dramatic improvements with faster insulin, and it was good, but we still have slow sensing. You really have two sources of delay.

Dr. Steil: I agree with that. There are many closed-loop algorithms we don't have optimized, and I believe we could get rid of much of the postprandial hypoglycemia after breakfast if we have the algorithm tuned to deliver all insulin in the first 15 minutes. It is doable in simulation but not in clinic yet.

Q: Do you think this can be done with a single hormone or do you think you will need glucagon?

Dr. Steil: I think I would stay with a single hormone until I am compelled to believe otherwise. I wouldn't just start glucagon. If someone came to me and said we would not be able to achieve our goals without glucagon, then I would start to pursue that option. But I just don't think we know at this point.

Dr. Doyle: I remain to be convinced.

Dr. Oliver: I think it depends on the patient. From a clinician's perspective, there are some patients that have a little bit of a glucagon reserve that they can rely on. For those that have lost all of that reserve, I think there is a compelling argument for adding glucagon.

Q: We heard about acetaminophen, but what about hypotension and hypoxia and other issues in ICU settings? What's been your experience regarding those?

Dr. Steil: I'm still a defender of the subcutaneous site, but there are all kinds of speculations that something might not work. You saw me put up the data on the subcutaneous sensor in hyposensitive kids, and if you have a sensor that works well, many arguments go away. At these meetings we used to blame everything on interstitial fluid, but as the sensors get better, all those issues go away. Someone brought up a delay of 15 minutes, but there can't be that delay with a MARD of 11%.

Posters

TYPE 2 DIABETES HYPOGLYCEMIA PREDICTION USING SMBG DATA & PROBABILISTIC METHODS

Bharath Sudharsan, MS; Malinda Peeples, RN, MS, CDE; Mansur Shomali, MD (WellDoc, Baltimore, MD)

This poster outlined an interesting mathematical model developed by WellDoc to predict hypoglycemia in patients with type 2 diabetes. Notably, the model needs only ten SMBG data points taken in a seven-day period to predict whether hypoglycemia will occur on day eight. The researchers developed and tested the approach (a probabilistic model using machine learning algorithms) via several real-world SMBG data sets. The final version had a striking 92% sensitivity and 70% specificity for predicting hypoglycemia, better than the performance of three real endocrinologists (a mean of 53% sensitivity and 80% specificity). The poster concludes that the model's performance is sufficient to off-load hypoglycemia blood glucose analysis from human experts - a major goal of mHealth/telemedicine in diabetes. As we understand it, WellDoc is considering incorporating the model into its mobile prescription therapy (BlueStar), though going forward, the company will need to define the regulatory path. The goal would be to use the model's predictions to provide patients with real-time interventions and education to manage or prevent hypoglycemia. That would be quite impressive, especially if it can help patients avoid severe hypoglycemia (particularly critical in this era of cost-containment). There was a lot of buzz about this poster during the poster session - as we understand it, the most common attendee question was "When will this be launched commercially?" Further studies will test the model when used in real time.

- **The model is grounded in a key assumption: most type 2s are not CGM users or high frequency testers.** As a result, this model was designed to work based on a very real-world testing frequency observed in type 2 patients. Indeed, we think a model based on one test per day is pretty magical from a clinical and commercial relevancy standpoint. The hypoglycemia prediction is especially relevant in type 2s, where there are more patients on hypoglycemia-causing agents than there are type 1s in total.
- **A probabilistic model using machine learning algorithms was trained with de-identified, SMBG data from a randomized controlled trial** (Quinn et al., *Contemp Clin Trials* 2009). For each patient, 10 SMBG data points were used from the week prior to a hypoglycemia event (<70 mg/dl). Then, SMBG data, excluding the hypoglycemia data point, was

applied to test and validate the model. Next, using additional data sets, the model was iterated over three generations to optimize performance.

- **The poster showed how the model's predictions outperformed three endocrinologist's predictions.** The data provided to the model and human experts were blinded to occurrence of hypoglycemia on day eight. The model had 92% sensitivity and 70% specificity for predicting hypoglycemia, better than the performance of the endocrinologists (a mean of 53% sensitivity and 80% specificity).
- **The poster provided an example of how the model would work in practice.** In the example below, the model correctly predicted hypoglycemia, but the human experts did not.

10 SMBG Values in Seven Days									
111 mg/dl	141 mg/dl	110 mg/dl	116 mg/dl	113 mg/dl	142 mg/dl	99 mg/ dl	148 mg/dl	210 mg/dl	142 mg/dl
7 AM	12 PM	3 PM	6 AM	5 PM	1 PM	10 PM	8 PM	6 AM	12 PM

Day Eight Prediction	
Model	Hypoglycemia
Human Expert (Endocrinologists)	No Hypoglycemia

Day Eight Actual	
65 mg/dl	Hypoglycemia

- **Interestingly, ten SMBG data points in a seven-day period provided the most accurate predictions of hypoglycemia.** Five SMBGs had a hypoglycemia prediction accuracy of 87%, which rose to a high of 97% with ten data points. More data did not appear to improve the accuracy of the model - 15 SMBGs had an accuracy of 95%, and 20 SMBGs had an accuracy of 88%.
- **The model is robust to different populations and times of the week.** The team calibrated the model to deal with weeks where the SMBGs are not spread out evenly during the seven-day period (e.g., five tests on day one, then five the rest of the week). Additionally, four SMBG data sets were used with sample sizes ranging from 1,037-6,686, demonstrating robustness to different populations.

Keynote

MEDICAL APPS: EVIDENCE-BASED STRATEGY

Jennifer Dyer, MD, MPH (Pediatric Endocrinologist; EndoGoddess, LLC, Columbus, OH)

Pediatric endocrinologist Dr. Jennifer Dyer provided a great overview of apps and mHealth, sharing her opinions (and the drawbacks) of Sanofi's iBGStar, Glooko's universal cable/app, iGlucose, Telcare's BGM, WellDoc's Diabetes Manager, Ginger.io (behavioral analytics), and Bant (social app for diabetes). She spent the most time discussing her own app in development, EndoGoal. The product stemmed from her experience texting patients, a strategy that worked for a few months until motivation dropped off. Consequently, EndoGoal seeks to motivate patients to check their blood glucose over the long term through financial rewards. It's certainly an interesting approach and one definitely worth exploring, though we wonder if motivation can be sustained through such extrinsic rewards. Time will tell!

- **"My number one strategy in clinical practice is to align app advantages with the clinical goal."** In other words, individualize the app based on what is challenging a patient -

connectivity and downloading data (iBGStar, Glooko, Telcare, iGlucose), dosing guidance (WellDoc), behavioral issues (Ginger.io), social isolation (Bant), or motivation (EndoGoal).

- **EndoGoal:** Dr. Dyer focused much of her discussion on the app/web-based cash rewards program she is developing to motivate glucose checks. The purpose of EndoGoal is to help overcome an obstacle many patients face - "I don't feel like checking my blood glucoses." Patients earn points over time, and friends and family members make monetary donations. Patients get a weekly prepaid Visa card ($10 per week) or a Target gift card. Said Dr. Dyer, "At least if you have diabetes, you can get some rewards for it." She has used a crowd-funding platform to raise money for the product.
    - **We wonder if patient motivation can be stoked and sustained through extrinsic rewards.** Bestselling author Dan Pink argues in *Drive* (see a great TED talk here) that extrinsic motivators are often not that effective (and can even be detrimental) in motivating people. The key is the difficulty of the task - extrinsic motivation can work for very simple tasks, but it should be avoided for complex tasks that require more cognitive skills (for the latter, he argues that we must encourage intrinsic motivation by fostering autonomy, mastery, and purpose). One could argue that SMBG is a simple and straightforward task, so financial incentives may be enough to motivate patients to test more often. However, there's also a degree of complexity and a feedback loop that makes glucose testing more complicated. As a result, we look forward to seeing how Dr. Dyer's approach works in practice.
- **iBGStar: "**In my practice, patients really like this meter. It doesn't look like a medical device. They feel less diabetic. It has a magical feel about it and a really great user interface." The one drawback mentioned by Dr. Dyer is that it only connects to the iPhone 4, not the iPhone 5. (We'd note this is not entirely accurate, as the iBGStar can use the Lightning adapter to connect to the iPhone. That said, this solution is a bit clunky and not in line with the product's original sleekness and seamless integration with the iPhone.)
- **Glooko**: Dr. Dyer likes that patients using the Glooko cable for downloading meter data don't have to carry around an old-fashioned logbook (though she admitted that carrying around the cable is still a downside). She complimented the app's "really great interface."
- **iGlucose:** This cable connecter for downloading meter data has a "great user interface for graphs."
- **Telcare:** Dr. Dyer called the wireless-enabled meter a "really exciting product" that is "covered by some insurers." She highlighted the real-time transfer of blood glucose data to the cloud, particularly appealing for parents. Dr. Dyer also noted a completed study of Telcare's meter from Dr. Charlene Quinn and the University of Maryland (ClinicalTrials.gov Identifier: NCT01341587). She explained that data from the randomized controlled trial "should be released soon." The page was last updated on January 25, 2013.
- **WellDoc Diabetes Manager:** Dr. Dyer briefly discussed WellDoc's 2008 study (Quinn et al., *DT&T*), which showed "great evidence that outcomes are affected." We were surprised she did not mention the company's more recent 2011 study (Quinn et al., Diabetes Care) or the FDA cleared BlueStar product (limited launch in 2013; read our report). See below for WellDoc's interesting poster on predicting hypoglycemia, which garnered lots of buzz during the poster session.
- **Ginger.io:** Dr. Dyer described this as "an analytics app that detects behavior patterns" through surveys and mobile glucose/meal/mood logging. Users can see patterns in their diabetes care and how they change with moods. Dr. Dyer noted a post about Ginger.io on the blog "Cranky Pancreas."
- **Bant:** This product incorporates a Bluetooth-connected meter - kids check their blood glucose, which is transmitted wirelessly to the Bant app. On the app itself, users can interact on a social platform and receive rewards. Dr. Dyer noted the "great data visualization." See Dr. Cafazzo's talk in session one for more specifics on the system.

Questions and Answers

Q: $100 is not going to take patients that far. How do you plan to continue the motivation?

Dr. Dyer: My experience so far hasn't been long-term. It would be $10 a week that each patient would get. That sustains motivation for kids to do their chores! It's the chronicity of diabetes that frustrates patients, and hopefully, the chronicity of the rewards will help motivate them.

Q: What about working with an insurance company?

Dr. Dyer: I have to start somewhere, and I'm too small for insurance companies right now.

mHealth Wireless Technology

USING TELEMEDICINE TO DELIVER DIABETES CARE TO THE RURAL POOR IN INDIA

Viswanathan Mohan, MD, PhD (Madras Diabetes Research Foundation, Chennai, India)

Dr. Viswanathan Mohan introduced attendees to the Madras Diabetes Research Foundation's (MDRF) Rural Diabetes Telemedicine Project, a collaborative effort with the World Diabetes Foundation (WDF) and the Indian Space Research Organization (ISRO). As background, Dr. Mohan noted that India has the second-largest diabetes population in the world with over 62 million patients (and an additional 77 million with prediabetes). Rural areas face the greatest unmet need, as 72% of India's population is rural but 75% of certified doctors reside in cities. The telemedicine project centers on a "telediabetology van," which has screening equipment for diabetes and its complications and a satellite link (courtesy of the ISRO). The van's staff includes no physicians; rather, staffers are formerly unemployed local individuals who receive training at the Madras Diabetes Research Foundation headquarters. The staff and van screen patients in their local communities, and diagnosed patients can receive a complete screening for microvascular complications and teleconference with doctors at MDRF's headquarters. This strikes us as a terrific way to keep costs low and maximize the reach of limited doctors. Indeed, it's really the holy grail of telemedicine and healthcare in general: lower cost, higher quality care to a greater number of patients. MDRF coordinates follow-up visits with local doctors.

- **The most recent published data (Mohan et al., *JDST* 2012) from the three-year history of the project is impressive:** the van has screened over 23,000 individuals, diagnosed and/or cared for over 1,100 diabetes patients and 3,400 prediabetes patients, and helped reduce the mean A1c for the diabetes patients from 9.3% to 8.5% within one year (Dr. Mohan noted that the most current mean A1c value is actually closer to 8.0%). Telemedicine has garnered increasing interest within the diabetology community in recent years, especially as a way to reach underserved rural patients, and we hope healthcare system innovators take note of the success of Rural Diabetes Telemedicine Project as a model of effective, sustainable telemedicine.

DESIGN AND DEVELOPMENT OF BANT: AN MHEALTH APP FOR SELF-MANAGEMENT

Joseph Cafazzo, PhD (University of Toronto, Toronto, Ontario, Canada)

Dr. Joseph Cafazzo detailed the Bant app, a social media tool aimed at helping teenagers manage their diabetes, and highlighted the 50% increase in frequency of daily testing by app users (although we are unsure of the initial starting frequency or clinical outcomes associated with the increased testing). The app tracks blood glucose values via Bluetooth and the cloud, allows teenagers to interact in a closed Twitter forum, and gives users iTunes-redeemable points based on their performance (with bonus points for checking at school or more than five times a day). The interface is user-friendly, with color-coded meal points along a daily calendar and easy-to-set reminders; one component also features a road map-like progress chart so patients can visually see how they are doing - the trail fills with blue as users progress. Dr. Cafazzo also discussed the newest generation of the app, which is currently in a randomized controlled trial. The most significant change is a more sophisticated trend wizard that prompts users to consider why they experience certain blood glucose patterns - what a great way to closed the feedback loop. However, Dr. Cafazzo emphasized that the wizard does not tell users what to do, which he noted was critical for teenagers who may already be rebelling (in these cases, it remains to be seen how many of these patients would even download the app in the first place). The new app also has less of an emphasis on rewards, placing more

focus on a leaderboard where users can compare their ranking - we think there is a lot of potential for gamification in diabetes, though it certainly won't be for everyone. The app is compatible with Microsoft HealthVault via Bluetooth, as well as the OneTouch UltraMini and iBGStar meters.

- **The new version of Bant focuses on a leaderboard where users can compare rankings against each other.** Noting the potential for this feature to negatively impact those at the bottom of the leaderboard, Dr. Cafazzo remarked that they are examining whether or not these low-ranking users experience poorer results.
- **Dr. Cafazzo called for manufacturers to "step up their game" to create products that could easily integrate with iPhones.** Currently, Bant is only available with the OneTouch UltraMini (via an adapter) and Sanofi's iBGStar. Eventually, he hopes that there will be a commercially available Bluetooth meter. Things are certainly moving in the right direction on this front - LifeScan's OneTouch VerioSync is approved (thought not yet launched) and iHealth Labs just launched its similarly designed Bluetooth-connected meter. Additionally, Glooko's pipeline includes a universal Bluetooth adapter.
- **Dr. Cafazzo and his group are also working to develop apps for patients with type 2 diabetes**. One of his students is working to incorporate the FitBit with the Bant app so that patients with type 2 diabetes will gain awareness for how activity levels can affect blood glucose levels. A randomized controlled trial will begin in the winter.

PANEL DISCUSSION

Q: I would love for you to comment on the subsequent talks after your own that evaluated web-based devices; particularly, we heard that the experience at Kaiser has not been as positive as we would have liked.

Dr. Jennifer Dyer (EndoGoddess, LLC, Columbus, Ohio): Unfortunately, I am not surprised that engagement at Kaiser is low. There was a piece in Forbes recently that discussed how very few health apps achieve over 500 downloads after six months, and very few are actually used in the consumer space after six months. We really need to look at what makes apps and web-programs sticky in the social space. My hypothesis is that we can create that stickiness by paying patients. We know that financial incentives do work with difficult behavioral changes such as weight loss. I believe that stickiness comes from real rewards and rewards that enhance someone's life - maybe the financial incentives allow the patient to save up for a new pair of earrings or a new basketball.

Q: A few years ago in Oregon I was asked to help with a program to screen rural Oregonians for diabetes and associated complications. It's still going, there are now two vans, and the program is supported by nonprofit organizations and hospitals. The program is considered successful but it never achieved the rate of patient cooperation that you received; I believe you screened over 80% of the local population? How did that happen?

Dr. Viswanathan Mohan (Madras Diabetes Research Foundation, Chennai, India): The response rates in the rural areas are better than in the urban areas in India because in cities there is a choice of healthcare options between hospitals and clinics. In rural areas, all they have is one primary health center for each cluster of villages. In Tamil Nadu these centers provide a basic level of diabetes care, but in other states there is no diabetes care at primary care centers. We used skits, street plays, videos, and demonstrations of healthy cooking to help get the buy-in from people. When we remind people that our care is free, we generally get great response rates.

Q: As an endocrinologist who has to see a lot of patients to make a living and survive, we need some sort of accountability documentation in our workflow; I need something that I can enter into the electronic health records (EHR) so that I can get reimbursement, and also so that I can justify getting insulin pumps and continuous glucose monitors (CGM) for patients. This information seems to get lost in the cloud - the cloud is build for information but not for documentation, so that is something else to consider when developing Bant.

Dr. Joseph Cafazzo (University of Toronto, Toronto, Ontario, Canada): You are right. It is a real issue, and we don't have a real answer. One of the reason we are looking to establish informatics standards is to liberate data, make it more accessible, and hopefully integrate information from different manufacturers. This problem is it is not just a diabetes technology problem, but an EHR problem. We try to circumvent this problem; at our hospital, we are having kids print out what has been done from the last visit, and then we scan it in to the EHR; it takes too long to enter it into the system. We are really just circumventing the problem, but the manufacturers need to step up. The new standards have been out for 18 months, and to my knowledge only one company has adopted it.

Q: It seems like telemedicine is dependent on transportation infrastructure and patient willingness to participate. Do you think that this strategy is applicable to other parts of the world?

Dr. Mohan: Willingness depends on the population, especially its education. But you are right that in some areas, the roads are not sufficient to get the large van to the people, and a smaller van would be needed. In Tamil Nadu, the roads are in relatively good shape. But you could always park the van somewhere else and transport people to the van. Some infrastructure is needed, such as roads, but most of India is getting there.

Q: Have you looked at the use of social media for chronic disease management across age groups and baseline technical literacy? How does that play out?

Dr. Cafazzo: The data on social media is pretty weak. What we have introduced to measure this is an analytics package in Bant. This will, hopefully, figure out how people are using social media. We know that there are many people who can be engaged but no host; measuring how often someone posts is not a good measure of social media use because there are lurkers who are on the social media feed but they are only reading and not posting - however, they follow the forum and are therefore engaged in social media. This area of data collection is new, and I would love to come back in a year and report on what we have learned. In terms of the baseline values, we are evaluating patients between the ages of 12 and 16 and A1c levels above 8%. Numeracy and other data will be reported in the future.

Q: I'm concerned about using gamification to get kids to check their blood sugar levels and have certain behaviors. There is a great amount of literature in psychology and education that discusses how extrinsic rewards extinguish internal rewards. Although we know that we can get kids to do things because of extrinsic rewards, at a certain point, kids may decide one day that they don't care and the extrinsic rewards are not enough. What are your thoughts?

Dr. Dyer: I agree that some of the literature is contraindicated. I find as an endocrinologist, using fear does not work at all. I think considering extrinsic rewards in the context of a great doctor-patient relationship is key. These extrinsic rewards are one tool to help behavior change.

Ms. Enid Hunkeler (Kaiser Permanente Medical Care Program, Oakland, CA): We have a philosophy in the projects we develop at Kaiser that patients should be scientists about their own care. We should help them see what behaviors benefit them and what behaviors don't. The patients who have the most awareness about their experience of the disease have the best chance of living a productive life. Everything I do is geared in that direction, even for kids. The way I try to involve kids is by making the process something that happens online in a very interactive way. I'm trying to hook the kid on the tech-y part, which is a different approach.

Comment: It was exciting to see Dr. Cafazzo show technology for blood pressure control. I want to remind the audience that cardiovascular disease is the leading cause of death in the country, and it is especially concerning for people with long-term diabetes; I believe there needs to be more emphasis on cardiovascular end points. There is an interesting analogy between blood pressure time in range and glucose time in range; if patients amble around with a blood pressure cuff, they are in range of only a small part of the time, and there is some research that shows if you titrate cardiovascular medication in response to real-time data, there is better control. It would be great to see some device development in this area, as well.

Comment: We've heard about the lack of connectivity between diabetes technologies. I've been working with a number of medical device companies on those types of issues; some don't know how to develop the wireless technologies, while some want improved range. They are dealing with the most basic level of connectivity challenges. There's also a higher level of issues such as connecting the apps and the cloud. What I would like to see from this society is a working group on communications, which is so fundamental to what we're doing.

Dr. Cafazzo: I would encourage anyone who's interested to look at the ad-hoc voluntary groups being done on this. I also look to Howard Look, who is working on making an ecosystem around this. I'm happy to facilitate at the DTS level to see if there is interest.

Comment: Is there a central person that everyone can look to for a coordinated effort? People have been talking about getting something done for several years.

Dr. David Klonoff (Mills-Peninsula Health Services, San Mateo, CA): That is a really good suggestion, and I would like to invite anyone who is interested in this topic to meet with me at the break, and we will talk about whether or not this can happen.

Dr. Larry Hirsch (BD Diabetes Care, Franklin Lakes, NJ): In EndoGoal, where does the money come from?

Dr. Dyer: The money comes from family and friends. Each patient recruits or crowd-funds for themselves from family and friends. The patients therefore feel accountable to their supporters, which is responsible for improving their behavior.

Dr. Jan Wojcicki (Polish Academy of Sciences, Warsaw, Poland): After 23 years of development, we have tools that we can use now; we have mobile phones and the Internet and many other tools. However, when we compare metabolic control with usual care groups, the answer is that these groups using these technological tools the answer is not so bright, only about a 0.1% or 0.2% difference. This means that we have the tools, but we need to a better system and new models. I hope that next year we will have a presentation showing an intervention system with real-time feedback and excellent results.

Dr. Robert Burk (Albert Einstein College of Medicine, Bronx, NY): What I'm taking from the session is that there is a great heterogeneity of need; there is not one system that will meet all the needs of all the patients. There is an absolute necessity for standards, and this is an area where we need computer scientists, psychologists, engineers, and many others to move this field forwards.

New Metrics Assessed by Continuous Glucose Monitors

DIABETES TECHNOLOGY SOCIETY LEADERSHIP AWARD

David Klonoff, MD (Mills-Peninsula Health Services, San Mateo, CA)

Dr. David Klonoff presented the highest award of the DTS, the Diabetes Technology Society Leadership Award, to Dr. Viswanathan Mohan (Madras Diabetes Research Foundation & Dr. Mohan's Diabetes Specialties Center, Chennai, India). Dr. Klonoff noted the impressive scope of Dr. Mohan's clinic - "No one in the world has 300,000 patients with diabetes." See Dr. Mohan's talk ("Using Telemedicine to Deliver Diabetes Care to the Rural Poor in India") in our coverage of session one ("mHealth Wireless Technology"). The likes of Mr. Al Mann, Drs. Lutz Heinemann, Boris Kovatchev, John Pickup, William Tamborlane, and Robert Vigersky have received the award in the past. Last year, it was presented to the FDA's CDRH division (accepted by Director Dr. Jeffrey Shuren).

--by Adam Brown, Hannah Martin, Manu Venkat and Kelly Close