Clinical care of patients using diabetes technologies such as insulin pumps and continuous glucose monitors is often poorly standardized. The American Diabetes Association’s insulin pump standards of care emphasize the importance of skilled, consistent providers to care for patients who utilize diabetes technologies to manage their disease. Recognizing the need for a unique clinic that focused on people with diabetes who use technology to effectively manage the disease, Mayo Clinic in Rochester, Minnesota, founded the Diabetes Technology Clinic (DTC) in 2006. The clinic continues to grow and is now staffed by five physicians, two nurse practitioners and four certified diabetes educators that care for patients who currently use or are interested in using an insulin pump, a continuous glucose monitor, or a combined insulin pump and continuous glucose monitor.

Yogish C. Kudva, M.B.B.S., an endocrinology consultant at Mayo Clinic’s campus in Rochester, Minnesota, says: “In 2010, an estimated 400,000 people were using insulin pumps. The estimate for 2015 is that 525,000 people are using insulin pumps, according to statistics shared by Halozyme Therapeutics during the J.P. Morgan 29th Healthcare Conference in 2011. More sophisticated diabetes technologies continue to emerge, including sensor-augmented insulin pumps and low-glucose insulin suspend models, the latter representing the first step of a closed-loop glucose insulin control system.”

With the goal of better meeting the needs of an anticipated increasing number of patients using diabetes technologies, the Mayo Clinic DTC partnered with a health systems engineer from Mayo Clinic Systems and Procedures to complete several voice-of-the-customer exercises to better understand the needs of DTC patients.

Dr. Kudva explains: “These needs were solicited utilizing several tools. Internal stakeholders such as DTC staff — nurses, nurse practitioners, physician assistants, physicians, desk staff and others — as well as referring providers were interviewed to learn about their experiences with the DTC. Patient and patient family input was solicited via a satisfaction survey.” Patient feedback was centered on the following themes:

**Education.** Survey respondents expressed a strong desire to continue to learn more about the diabetes technology they currently use as well as new developments. Education was suf-
icient when they were new to the technology, but respondents felt there was much they could learn about using the technology more efficiently and expressed interest in continuing education. There was also interest in additional education on topics such as exercise and pregnancy.

Communication. Survey respondents appreciated advance notice when tests were required and clearly understandable test results.

Visit frequency and appointment access. Patients want to understand the expectations for follow-up care and visit frequency and were concerned that appointment access was insufficient.

Care team. Patients stated a preference to see the same provider at each DTC visit.

Between-visit care. There was a desire to clearly understand the contact information and process for care required between visits to the DTC.

As a result of patient feedback, several DTC enhancements were implemented, including:

- An increase in the number of providers focused on meeting the needs of patients and ensuring sufficient training for them, to meet expectations and practice growth
- Creation of additional patient education materials specific to diabetes technology on topics such as diabetes technology and exercise, diabetes technology and pregnancy, traveling with an insulin pump, and uploading insulin pumps at home
- Expansion of DTC appointment access to five days a week to ensure patient appointment availability
- Implementation of the DTC provider of the day role to ensure access to a diabetes technology-focused provider, to support patient needs between visits and respond to referring provider questions
- Development of an education assessment to be completed by the certified diabetes educator at each patient visit to identify knowledge gaps and inform the DTC team of potential patient education needs
- Development of a model of caring for community patients currently using or interested in using diabetic technologies in partnership with primary care providers
- Creation of a DTC overview video to provide an overview of the clinic for new patients, posted to YouTube

Dr. Kudva adds: “Improvement efforts also included developing a standard patient visit process to ensure a consistent patient experience. At each patient visit, the DTC care team reviews the patient’s medical history to understand the patient’s health and diabetes management concerns. The DTC team develops a plan with the patient to effectively and safely manage his or her devices. This plan may include working with a certified diabetes educator, a dietitian or both to address specific concerns the patient may have. If the patient already uses diabetes technology, the team will review device download information, determine if the device settings require adjustment and answer any questions the patient may have. The patient and DTC care team partner to determine DTC visit frequency.”

Dr. Kudva concludes: “The care of patients who currently use or have an interest in using technology to manage their diabetes is a field that continues to evolve based on advances in available technologies. The Mayo Clinic DTC continues to identify opportunities to best meet the needs of this patient population.”

For more information


A Case From the Endocrine Teaching Clinics

Endocrine Manifestations of Erdheim-Chester Disease — A Rare Cause of Diabetes Insipidus

A 60-year-old man was in his usual state of health until one year prior to his presentation at Mayo Clinic in Rochester, Minnesota. It was at that point that he started noticing asymmetric ankle edema, with the left greater than the right. He also developed left ankle pain when walking. He was initially treated with diuretics and indomethacin with minimal relief. His
symptoms worsened to the point that he started limping. His past medical history was notable for nephrolithiasis, hyperlipidemia and a right shoulder benign bone tumor excision. On physical examination the patient had tenderness of the left ankle (pain intensity of 8 out of 10) with 1+ edema.

A plain radiograph of his left lower extremity showed diffuse soft tissue swelling around the calf, ankle and foot. There was a heterogeneous lucency involving the left distal tibial diaphysis and midmetaphysis with cortical irregularity, in addition to mild periosteal reaction along the distal left tibial diaphysis. An MRI scan showed an extensive bone marrow abnormality involving the left distal tibia and, to a lesser degree, the fibula as well as the talus, with a mild to moderate tibial-talar joint effusion. A bone scan (Figure) showed symmetrical intense uptake in the distal femurs and tibias bilaterally. In addition, there was abnormal uptake in the left facial bone attributed to chronic left maxillary sinusitis. The patient underwent left distal tibia bone biopsy that revealed fibrohistiocytic proliferation, and immunohistochemical studies showed that the neoplastic cells were positive for CD68 and negative for BRAFV600E — findings suggestive of Erdheim-Chester disease.

At the subsequent endocrine consultation, the patient admitted to a 40-year history of urinating almost hourly and passing up to 6 liters of dilute urine daily. He had a constant sense of thirst and enjoyed ice-cold drinks. Following an overnight fast, the serum sodium concentration was 148 millimoles per liter and the serum osmolality was 296 milliosmoles per kilogram (mOsm/kg) with a simultaneously obtained urine osmolality of 182 mOsm/kg. Further laboratory testing showed normal blood tests for thyroid function, prolactin, insulin-like growth factor-I, sex steroids, cortisol, corticotropic, glucose and calcium. He was not taking medications that could contribute to his symptoms. A pituitary-directed MRI showed absence of the posterior pituitary bright spot, but no other abnormalities. The patient was diagnosed with diabetes insipidus and responded well to oral desmopressin with clinical and biochemical resolution of his symptoms.

Erdheim-Chester disease is a rare hematologic disorder manifesting as granulomatous or fibrotic infiltration of long bones and nonskeletal tissues by non-Langerhans foamy histiocytic cells. Paget’s disease also may present with sclerotic bony lesions; however, patients with Paget’s disease typically lack the systemic manifestations of Erdheim-Chester disease and do not incorporate a symmetrical predilection for the diaphysis of the appendicular long bones. The majority of patients with Erdheim-Chester disease are diagnosed between the ages of 40 and 70 years and there is a male predominance.

The number of patients with Erdheim-Chester disease has increased dramatically over the last 10 years due to increased recognition. The clinical presentation can be diverse, ranging from asymptomatic bone involvement to multisystemic, life-threatening disease. Nonskeletal endocrine manifestations seen in patients with Erdheim-Chester disease include central diabetes insipidus, primary and secondary hypothyroidism, primary and secondary adrenal insufficiency, primary and secondary hypogonadism, growth hormone deficiency, and hyperprolactinemia. Radiographically, the pituitary gland, pituitary stalk and hypothalamic-pituitary axis may be normal; alternatively, enlargement or abnormal enhancement may be noted.

It is not uncommon for diabetes insipidus to present many years, sometimes over a decade, before the bony presentation of Erdheim-Chester disease. Various therapies for Erdheim-Chester disease have been reported (for example, interferon-alpha, interleukin-1 receptor antagonists, cladribine, tyrosine kinase inhibitors and corticosteroids). Pre-existing diabetes insipidus and endocrinopathies typically persist despite systemic treatment, even with radiographic regression of the disease.

Fifty-five patients with Erdheim-Chester disease have been evaluated in Hematology/Oncology and Endocrinology at Mayo Clinic in Rochester, Minnesota, since 1990. Members of this Mayo multidisciplinary team suggest that Erdheim-Chester disease should be included in the differential diagnosis of central diabetes insipidus and hypothalamic-pituitary dysfunction. Endocrinologists are key members of the multidisciplinary team in the diagnosis and treatment of Erdheim-Chester disease.

**Key message**

The nonskeletal endocrine manifestations of Erdheim-Chester disease should be kept in mind in patients with sclerotic bone lesions suggestive of this diagnosis.
Management of Hyperglycemia in the Hospital

Reliable management of hyperglycemia in a hospitalized patient requires concerted efforts from hospital food service workers, dietitians, laboratory technicians, pharmacists, nurses, providers and, most of all, the patient. Reliable management also requires substantial resources. Such resources are available with varying ease depending on the size and complexity of the institution.

Pankaj Shah, M.D., an endocrinology consultant at Mayo Clinic’s campus in Rochester, Minnesota, says: “Mayo Clinic and Mayo Clinic Health System include a wide variety of institutions. On one end of the spectrum are institutions with a large variety and number of resources available (Table 1). On the other end of the spectrum are institutions that may have very sparse resources. Some of our institutions have detailed protocols and order sets for specific clinical situations faced during management of hyperglycemia. These resources would be expected to increase the uniformity of care and also the access for surveillance and possibility of improvement in quality of care. Other institutions rely on providers to write out the order sets on each patient, leading to a possibility of an inconsistency of care.

“At Mayo Clinic, we recognized the importance of providing the same high-quality care to each patient, no matter where the patient presents — at the smallest hospitals in rural Wisconsin, at a multispecialty hospital such as Mayo Clinic Hospital in Florida or at a destination center such as Mayo Clinic Hospital — Rochester. In order to achieve this consistency, we embarked on harmonizing protocols and order sets to standardize the care patients with hyperglycemia receive in our various institutions.”

In 2009, a project was launched with an aim to develop, disseminate and implement enterprise-wide standardized guidelines and processes of care for management of diabetes and hyperglycemia for adult, nonobstetric inpatients. Dr. Shah explains: “This project is run collaboratively by quality improvement specialists, laboratory pathologists and technicians specializing in laboratory medicine, inpatient diabetes nurse specialists, pharmacists, and endocrinology and diabetes providers.

“As needed, the group collaborates with other specialists — for example, intensivists specializing in diabetic ketoacidosis or intravenous insulin infusion protocol and nutrition specialists (endocrinologists and gastroenterologists). Nurses specializing in information technology were critical for translation of the guidelines into usable protocols and order sets. Representatives from Mayo Clinic’s campuses in Rochester, Minnesota, Scottsdale, Arizona, and Jacksonville, Florida, plus Mayo Clinic Health System sites in the Midwest participated in multiple, regularly scheduled telephone, video and face-to-face meetings.

Table 1. Unique practice patterns in various institutions affiliated with Mayo Clinic.

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<table>
<thead>
<tr>
<th>Group A. (Example: Mayo Clinic Hospital — Rochester, Minn.)</th>
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</thead>
<tbody>
<tr>
<td>• Endocrinologist on call</td>
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<tr>
<td>• Intensivist in-house</td>
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<tr>
<td>• Diabetes-specialized nurse practitioners</td>
</tr>
<tr>
<td>• Diabetes educators</td>
</tr>
<tr>
<td>• Diabetes pump nurses</td>
</tr>
<tr>
<td>• Trained nurses in the hospital to manage hyperglycemia based on protocols</td>
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<tr>
<td>• Nurse specialist dedicated for inpatient hyperglycemia management</td>
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<tr>
<td>• Nurses trained to check glucose</td>
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<tr>
<td>• Laboratory technicians available at short notice</td>
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<tr>
<td>• Quick turnaround time for laboratory results, even for sophisticated tests</td>
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<tr>
<td>• Patients who are well-established and have undergone years of extensive training in the management of diabetes</td>
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<tr>
<td>• Detailed order sets</td>
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<td>• Nurse-driven protocols</td>
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<table>
<thead>
<tr>
<th>Group B. (Example: Mayo Clinic Hospital, Jacksonville, Fla.)</th>
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</thead>
<tbody>
<tr>
<td>• Endocrinologist on call</td>
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<tr>
<td>• Intensivist in-house</td>
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<table>
<thead>
<tr>
<th>Group C. (Example: Mayo Clinic Health System Hospital, Red Wing, Minn.)</th>
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<tbody>
<tr>
<td>• One person responsible for blood tests and blood draws after office hours.</td>
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<tr>
<td>• Laboratory is not capable of doing tests such as beta-hydroxybutyrate in-house; therefore, the results are not available in a timely fashion to direct treatment.</td>
</tr>
<tr>
<td>• Nurses taking care of hospitalized patients in these centers are often not specialized.</td>
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Amy J. Koenigs, APRN, C.N.P.; Charles T. Bingham, M.D.; Curtiss B. Cook, M.D.; Pankaj Shah, M.D.
### Subcutaneous insulin therapy in adults

**Plan:** Basal insulin (1–2 doses/d) + meal bolus insulin (~3 doses, with meal if eating) + correction bolus (with the 3 meal bolus doses; see below).

Include orders for glucose monitoring.

- If patient on insulin at home: Review the home plan and adjust if needed.
- If new to insulin, starting total daily dose is: 0.2–0.5 U/kg/d; ½ basal, ½ bolus (divided in 3 and taken with meals).

If patient is NPO, use only the basal component.

Adjust by the effect of insulin (after ruling out confounders), for example:

- Declining basal glucose: decrease glargine
- High noon glucose: increase morning meal bolus

### Correction scale insulin

**Purpose** of “correction insulin doses” is to correct unexpected glucose excursions.

Use only rapid- or short-acting insulin; the same used for meal bolus doses.

Given with the meal and the meal dose (if any).

Lower dose given to those who are prone to hypoglycemia, hypoglycemia-related complications or both.

Rule of 1700 is used to determine the correction scale, e.g. if total daily dose (TDD) is appropriate (that is, 1 unit of insulin will correct 1700/TDD mg/dL of glucose):

- **Appropriate** as stand-alone plan: only for a day or two, and if only mild hypoglycemia < 180 mg/dL.
- **Inappropriate** as stand-alone plan for DM1 or DM2 on insulin at home or significant hypoglycemia.

### Carbohydrate counting in the hospitalized patient

**Insulin to gram of carbohydrate ratio** rule of 500 is used if appropriate (that is, 1 unit for 500/TDD g of carbohydrates).

If patient is using carbohydrate counting at home: consider the same plan/ratio, or clarify if patient is using exchange or gram (15 g of carbohydrate = 1 exchange).

Create a system:

1. **Dietary staff** calculating appropriate carbohydrate content
2. **Nursing staff** calculating the grams of carbohydrates eaten
3. **Plan for adjusting** insulin infusion or both to maintain glucose at 150-250 mg/dL.

Diabetes care providers should continue to monitor the appropriateness of the insulin to carbohydrate ratio. Carbohydrate counting is not used if the patient is on correction scale insulin only, on basal insulin + correction only, or snacks frequently between meals.

### Hypoglycemia

**Nurse-driven protocol** is activated with ordering anti-diabetic medications that can cause hypoglycemia.

Indication to use the protocol:

- Adrenergic symptoms
- Mental status changes suggestive of hypoglycemia, and/or
- Glucose is < 70 mg/dL

Follow the rule of 15: Treat with 15 g (or 30 g), wait for 15 min and retest; repeat till in target met twice, 15 min apart.

Treatment:

- **Glucose or other sugar** – 15–30 g (more if glucose < 50 mg/dL)
  - PO: 5 sugar packets; 4 glucose tabs, 4 oz. juice (without fat/protein), as they retard glucose absorption and prolong hypoglycemia
  - IV: 25 mL 50% dextrose (12.5 g) when there is IV access and patient cannot swallow safely or
  - Glucagon 1 mg SQ once when patient cannot swallow safely and there is no IV access

Patient is advised to take next meal soon. Ongoing therapy is provided if the cause of hypoglycemia is ongoing (for example, NPH/long-acting insulin or insulin secretagogues).

Floor nurse should call the service after treating the patient if hypoglycemia was severe or before the next dose of insulin if not severe.

### Diabetic ketoacidosis and hyperosmolar hyperglycemic state (DKA/HHS)

**DKA/HHS** order sets outlines the criteria for diagnosis.

Therapy includes:

- Fluids: NS or 10%NS and transition to D5 or D51NS
- Insulin bolus (if insulin < 0.14 U/kg/hr)
- Continuous insulin infusion (0.1-0.14 U/kg/hr)
- There should be:
  - A provision for increasing insulin rate if there is an inadequate decline in glucose concentration and decreasing insulin rate if glucose decline is too rapid (> 100 mg/dL over 1 hr).

**Plan IV to SQ insulin transition** (see below). IV insulin is discontinued after acidosis resolves.

- Plans for meal time insulin when eating.
- Plan for potassium replacement: before (if hypokalemia), with or after (if hyperkalemia) insulin.
- Plan for adjusting glucose, insulin infusion or both to maintain glucose at 150-250 mg/dL.

Bicarbonate and phosphate are almost never needed.

Identify, treat and prevent the proximate cause of DKA/HHS.

Monitoring, including point-of-care glucose and periodically other blood tests.

### Intravenous insulin infusion therapy for hyperglycemia

There should be a glucose threshold to start IV insulin with a provision to allow prescribers to choose the goal.

Exclusions:

- Eating
- Receiving bolus tube feedings
- Diagnosis of diabetic ketoacidosis

Include orders for hourly point-of-care glucose testing.

Start at a moderate dose and modify:

- If BG > 150 x 2 hr and decline < 50 over next 2 hr: upscale if 3rd hr > 150
- If BG < 150 x 4 hr: downscale if 5th hr < 150

Anticipate the response:

- Increase if glucose decline is inadequate
- Reduce if glucose decline is rapid
  - Restart at a lower rate, if tolerated
  - Reconsider plan if glucose < 100 mg/dL
- Treat if glucose < 70 mg/dL: Have a protocol

Plan if patient going off the unit of care for test

Plan for a transition from IV to SQ insulin

Plan for IV glucose infusion if continuous tube feeding or parenteral nutrition is withheld while on IV insulin

If nurse-driven protocol

Triggers for notifying the provider for further action, for example:

- If the lowest set of rates is too much (causing glucose to go below target)
- If the highest set of rates is too little (causing glucose to stay above target)

### Transitioning from IV insulin to SQ insulin therapy

Consider transition when:

- IV insulin infusion rates stable
- Vasopressors are off
- Patient stable, and is going to start eating
- There is no anticipated procedure or need for NPO in the next 24 hr
- IV insulin not needed anymore

Order GID (AC/NS): point-of-care glucose check plus correction plan (for 48 hr) in all.

If the patient was on insulin at home (DM1 or DM2), consider home plan.

If not DM (known or newly diagnosed):

- Rate ≤ 2 U/hr: correction scale only with meals
- Rate > 2 U/hr
  - TDD ascertained by calculating the hourly rate over the last 4-8 hr of steady state
  - 30–80% of the estimated dose as basal

Hourly point-of-care glucose and IV insulin for at least 2 hr monitored

Nurse to notify if IV insulin is discontinued without a correction plan

### Self-management of multiple daily insulin (MDI) plan

**This protocol is for patients who are already using basal bolus plan or insulin pump at home.**

Consult diabetes/endocrinology service if available.

Evaluate for appropriateness of home plan.

Evaluate if patient capable of self-management. Reassess regularly.

Have a patient agreement.

Use the hospital point-of-care glucose for clinical decision-making.

Store medications per hospital policy.

Contraindication, discontinue if started:

- Altered state of consciousness
- DKA/HHS
- Critical illness/ICU

| Suicide risk | Inability/Unwilling | Other reasons thought to be a hindrance for self-management of diabetes while in the hospital |
| Interpretation: | Continuously aware of the plan of action, that is: | Test | Need to remain fasting for testing | Transfer to another place | Plan of dismissal from hospital |
|---------------|---------------------|----------------------------------|

**Table 2. Summary document for management of hyperglycemia in the hospital.**
The project started by identifying areas requiring convergence through a collaborative discussion between various centers (Table 2). Work groups were created for each of these areas. Each work group created a summary document after looking at the existing protocols and order sets in the various institutions and reviewing the literature and existing guidelines. Each summary document highlighted the problem at hand, the current status of the order sets and a brief review of literature and proceeded with recommending a treatment plan. Special considerations for unique clinical settings also were highlighted.

Dr. Shah summarizes: “Each work group brought its summary and recommendations to the whole committee, and the topic was discussed extensively before finalizing the document. After the documents were finalized, they were translated into a series of care process models. These care process models are accessible to all the providers, nurses and students through the intranet portal called AskMayoExpert. An example of one of the care process model components is shown in the Figure.”

Artificial Endocrine Pancreas: Past, Present and Near Future

The concept of automated, algorithmic feedback control of blood glucose with insulin delivery to close the loop in patients with type 1 diabetes was conceived and implemented with the Biostator device more than four decades ago, with significant contributions from Robert A. Rizza, M.D., a consultant in Endocrinology, and F. John Service, M.D., Ph.D., an emeritus endocrinology specialist, at Mayo Clinic in Rochester, Minnesota. The Biostator device was distinctly immovable, measured intravenous glucose, and also delivered insulin and glucose through the intravenous route. Though early success in glucose control was established, the impracticality of the apparatus precluded use in daily living.

Ananda Basu, M.B.B.S., M.D., an endocrinology consultant at Mayo Clinic’s campus in Rochester, Minnesota, says: “With the advent of the electronic age and consequent miniaturization of devices (that is, insulin pumps, continuous glucose monitors, and electronic platforms such as phones and tablets), and development of sophisticated computerized control algorithms, the concept of closing the loop using subcutaneous glucose sensing and insulin delivery with automated artificial pancreas has once again been rekindled. The pace of clinical research in this area has accelerated exponentially, catalyzed by statutory funding from federal agencies such as the National Institutes of Health in the United States, the European Union,
nongovernmental organizations, and foundations such as the Leona M. and Harry B. Helmsley Charitable Trust, Juvenile Diabetes Research Foundation (JDRF) and others.

“Furthermore, in 2008, the Food and Drug Administration accepted the type 1 diabetes mellitus (T1DM) simulator, created by scientists at the University of Padova, Italy, and the University of Virginia, Charlottesville, Virginia, as an alternative to preclinical animal studies, thus shortening the path to final approval of a device system for clinical use by at least a decade. It is indeed noteworthy that the data used to create the T1DM simulator was generated by current team members of Endocrinology at Mayo Clinic in Rochester, Minnesota, more than a decade ago.”

Recently published clinical trials have variously demonstrated improved nocturnal and daytime glucose control and reduced rates of hypoglycemia with closed-loop control when compared with open-loop control — the usual therapy with an insulin pump and a continuous glucose monitor, or so-called sensor-augmented pump therapy — in nonpregnant adults and adolescents with type 1 diabetes. Dr. Basu explains: “These studies have been conducted in clinical research units, in diabetes camps, at hotels and in people’s homes under carefully controlled conditions, and also during free living (research participants going about their usual customary day-to-day activities). Most of the trials conducted have utilized a single hormone (that is, insulin only) closed-loop system; dual hormone closed-loop clinical trials (insulin and glucagon) also have demonstrated superiority in glucose control compared with open-loop therapy as far as hypoglycemic events and duration of both hypoglycemia and hyperglycemia are concerned. The lengths of the trials have varied from a day to several weeks.”

Since 2009, clinical investigators from Endocrinology at Mayo Clinic in Rochester, Minnesota, have contributed to inform and improve existing closed-loop control algorithms with physiological experiments conducted in volunteers with type 1 diabetes. Dr. Basu highlights: “These studies have sought to understand changes in insulin sensitivity during conditions of daily living — for example, diurnal pattern of postprandial insulin sensitivity, during activity and exercise, dawn phenomenon, and those resulting from changes in gastric emptying. Information on changes to insulin sensitivity and also glucagon responsivity gleaned from these experiments is now being incorporated into control algorithms and tested in closed-loop control clinical trials, by creating the next versions of control algorithms.

“Additionally, definitive physiological studies have been conducted investigating the kinetics of glucose transport from the vascular to the abdominal interstitial compartment, as well as other confounders of glucose sensing (such as drug interference) that promises to help improve the precision and accuracy of next-generation continuous glucose monitors — the afferent arm of any closed-loop control system.

“Furthermore, in an effort to re-create, to the extent possible, an artificial islet, where the normal beta cell cosecretes insulin and amylin in response to rising blood glucose levels and the normal alpha cell secretes glucagon to declining blood glucose levels, we are conducting experiments in volunteers with type 1 diabetes using a multihormonal tactic. This approach seeks to coinfuse insulin and the amylin analogue pramlintide for rising blood glucose (for example, with meals) while utilizing glucagon as a rescue mechanism for impending hypoglycemia (for example, with exercise). In addition, we are also seeking active participation in an international closed-loop control trial consortium.”

What is the near future for the artificial pancreas?

Dr. Basu answers: “Clinical at-home trials are currently underway or being designed for application of the artificial pancreas during free living, for longer duration with clinical endpoints such as hemoglobin A1C, with the understanding of the extent to which we all recognize its relevance as a risk marker for development of diabetic microvascular complications. That said, future longer term trials are needed to test the safety and efficacy of the artificial pancreas approach for amelioration of hard microvascular and macrovascular outcomes. The research into faster acting insulin analogues, designer insulins, stable glucagon formulations, and more sophisticated and reliable hardware and machine-learning algorithms promises much for the future of the artificial endocrine pancreas. If I read the tea leaves correctly, it will not be long, perhaps indeed within the turn of this decade, before a patient with type 1 diabetes can receive a prescription for an artificial pancreas system from his or her endocrinologist.”
Education Opportunities

19th Annual Mayo Clinic Endocrine Update 2016
Feb. 29–March 4, 2016, at Hyatt Regency Maui Resort and Spa in Lahaina, Hawaii
Designed for endocrinologists and interested internists and surgeons, this course addresses gaps in medical knowledge and barriers in clinical practice to improve the outcomes of patients with endocrine and metabolic disorders. Topics span the full range of endocrinology through lectures, debates, panel discussions, clinicopathologic sessions, clinical pearls sessions, informal breakfast roundtable discussions and small-group discussions with experts. Attendees have plenty of opportunity for interaction with the course faculty, who are selected for their expertise and clinical acumen. To ensure accommodations at the discounted rate at the Hyatt Regency Maui Resort and Spa, make your reservations directly with the hotel by calling 888-421-1442 (toll-free). Identify yourself as a participant of the Mayo Clinic Endocrine Update Course. For more information, visit https://ce.mayo.edu/endocrinology/node/4006 or call 800-323-2688 (toll-free).

16th Annual Mayo Clinic Nutrition and Wellness in Health and Disease 2016
Sept. 30–Oct. 1, 2016, at InterContinental Hotel, Chicago
Nutrition, physical activity and other healthy lifestyle behaviors are vital components in the promotion of health and the treatment of disease. This course — designed for endocrinologists and interested internists and surgeons, this course addresses gaps in medical knowledge and barriers in clinical practice to improve the outcomes of patients with endocrine and metabolic disorders. Topics span the full range of endocrinology through lectures, debates, panel discussions, clinicopathologic sessions, clinical pearls sessions, informal breakfast roundtable discussions and small-group discussions with experts. Attendees have plenty of opportunity for interaction with the course faculty, who are selected for their expertise and clinical acumen. To ensure accommodations at the discounted rate at the Hyatt Regency Maui Resort and Spa, make your reservations directly with the hotel by calling 888-421-1442 (toll-free). Identify yourself as a participant of the Mayo Clinic Endocrine Update Course. For more information, visit https://ce.mayo.edu/endocrinology/node/4006 or call 800-323-2688 (toll-free).

Resources
MayoClinic.org/medicalprofs
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