Advances in Diabetes Care Technologies

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Advances in Diabetes Care Technologies

1979

Placing insulin-pump needle under skin

Puzzling Ailment
Hope for juvenile diabetics

2015

THRESH Suspend

National Association of Clinical Endocrinologists
Introduction

• Roughly 20% - 30% of patients with T1DM and fewer than 1% of insulin-treated patients with T2DM use an insulin pump
• In 2007, the US FDA estimated that the number of patients with T1DM using CSII was ~375,000
• By 2050, up to one-third of US residents may have T2DM; many of these individuals will be insulin-requiring
• Therefore, more clinicians must develop a comprehensive understanding of these devices

U.S. FDA. General Hospital and Personal Use Medical Devices Panel. 2010

T1DM: type 1 diabetes mellitus
T2DM: type 2 diabetes mellitus
FDA: U.S. Food and Drug Administration
CSII: continuous subcutaneous insulin infusion
Why We Do It
Better Control Reduces Complications

76% Risk Reduction
59% Risk Reduction
39% Risk Reduction
54% Risk Reduction
64% Risk Reduction

Cumulative Incidence (%)

Retinopathy Progression
Laser Rx¹
Microalbuminuria²
Albuminuria²
Clinical Neuropathy³

Insulin Pumps Reduce Incidence of DR Vs MDI In Pts. With Similar A1Cs

Followed incidence of DR in 1604 adolescents with T1DM ages 12-20 x 20 years. Incidence of DR declined by 38% as more patients were transitioned to MDI and CSII vs twice daily injections. A1Cs were identical in all cohorts suggesting that reduction in GV influenced progression towards DR.

Downie, et al Diabetes Care 2011;34:2368-73
Improved Control: Decreased Hypoglycemia

Type 1 Diabetes

• A 2010 Cochrane review compared the use of CSII vs. MDI insulin regimens (23 randomized studies involving 976 patients with T1DM)
  – A significant difference was documented in HbA$_{1c}$ response, favoring CSII
  – CSII users demonstrated greater improvements in quality of life measures
  – Severe hypoglycemia appeared to be reduced in CSII users


CSII: continuous subcutaneous insulin infusion
MDI: multiple daily injection
T1DM: type 1 diabetes mellitus
Basal Bolus Regimen with Glargine and Lispro

Insulin Effect

- **lispro**
- **Glargine**

B L S HS B
Continuous Subcutaneous Insulin Infusion

Insulin Effect

Bolus
Basal

B L S HS B
Pharmacokinetics of CSII vs MDI

• Uses only immediate acting insulin
  – More predictable absorption
• Uses one injection site
  – Reduces variations in absorption
• Eliminates most of the subcutaneous insulin depot
• Closest match with physiologic needs

* Lauritzen: Diabetologia 1983; 24:326-9
Advantages of Pump Therapy

• Improved blood glucose control
  – Improved AIC’s
  – Decreased hypoglycemia and hyperglycemia
  – Delay in incidence and progression of complications
• Precise dosage delivery
• Improved control for pre-conception and pregnancy
• Management of dawn phenomenon
• Increased flexibility in lifestyle
• Improved control during exercise
• Improved gastroparesis management
## Array of options

<table>
<thead>
<tr>
<th>Insulin Pumps on the Market</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Accu-Chek Combo System</strong></td>
</tr>
<tr>
<td>Roche Health Solutions</td>
</tr>
</tbody>
</table>
## Indications and Contraindications for CSII

**Indications:**
- Failure to achieve targeted A1c with MDI
- Hypoglycemia unawareness
- Athletes and patients who incorporate exercise into daily routines
- Persistent fasting hyperglycemia ("Dawn phenomena")
- Pregnancy
- Frequent travel
- Shift workers
- Poorly adherent DKA prone adolescent patients
- Insulin resistant patients
- Females in whom glycemic control is lost during menstruation

**Contraindications:**
- Uncontrolled psychiatric disorders (until corrected or stabilized)
- History of lack of adherence to prescribed treatment regimen (pumps do NOT cure diabetes)
  - However, some insulin is better than no insulin. Some non-adherent patients may do better on a pump than MDI
- Lack of financial ability to pay for pump and supplies

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Unger, J. Diabetes Management in Primary Care. 2nd Ed. Lippincott. 2012.
Current Continuous Sensors Available in the US
Continuous Glucose Sensors Available Outside US
What is CGM?

• Consists of a sensor inserted through the skin that measures interstitial glucose levels every 5 minutes
  – About 9 minute lag behind blood glucose values, which can differ by up to 20%

• Useful for identifying blood glucose trends

• Is NOT a replacement for SMBG
  – Still requires 2-4 blood sugar checks daily
  – Should not use the values for calculating insulin dosing
Types of CGM

• Professional
  – Blinded, retrospective
  – Reviewed in clinic typically by MD, although often can also be reviewed by CDE

• Personal
  – Monitor shows real time (RT) glucose levels with trends
Benefits of CGM?

- A1C lowering with less hypoglycemia
  - 0.5% for adults with type 1 DM
- Hypoglycemia warning for individuals with hypoglycemia unawareness
Drawbacks to CGM

- Can be overwhelming for some patients
- Alarms can be annoying, discontinued
- Cost; not covered by Medicaid or Medicare
- Comfort
- Accuracy
- Frustration - analog (fast) insulin is slow!
Who can benefit from CGM?

• Patients with type 1 diabetes
  – With A1C <7.0% to maintain control with lower risk of hypoglycemia
  – With A1C above goal, if they can use it on a daily basis
  – Severe hypoglycemia unawareness

• Intermittent, retrospective CGM useful in certain situations
  – Concern for nocturnal hypoglycemia
  – Dawn phenomena
  – Post-prandial hyperglycemia
Continuous Glucose Monitor Use in Clinical Practice- Real World Experience

- Retrospective review of university based clinical practice patient base
- Review of 30 months of clinical encounters
- Severe hypoglycemia defined as needing assistance to treat
- Continuous CGM use versus intermittent (defined as <2/3 of time)
- All on pump therapy
Reduction in Hypoglycemia

Table 2. Results of CGM use.

<table>
<thead>
<tr>
<th></th>
<th>Continuous Users</th>
<th>Intermittent Users</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>HbA1c baseline</td>
<td>7.5%</td>
<td>7.7%</td>
<td>7.6%</td>
</tr>
<tr>
<td>HbA1c on CGM</td>
<td>7.2%</td>
<td>7.3%</td>
<td>7.2%</td>
</tr>
<tr>
<td>P value</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Rate of Severe Hypoglycemia (per 100 pt. years)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>baseline</td>
<td>66.4</td>
<td>44.8</td>
<td>58.9</td>
</tr>
<tr>
<td>on CGM</td>
<td>22.3</td>
<td>29.0</td>
<td>23.6</td>
</tr>
<tr>
<td>odds ratio</td>
<td>0.34</td>
<td>0.65</td>
<td>0.40</td>
</tr>
<tr>
<td>CI</td>
<td>0.19-0.59</td>
<td>0.24-1.78</td>
<td>0.24-0.65</td>
</tr>
</tbody>
</table>

CGM data

Overall 24 hour blood sugar patterns over days are displayed:

• look for overlap patterns at same time of day
• Look for hypoglycemia- frequency, time of day
• Check timing of insulin injections, meal choice effect
• Check for effect of increased physical activity
Interpreting the data to

• Look for patterns
  – Highs and lows occurring at the same time each day

• Fix lows first

• Basal insulin
  – Start overnight, then progress through the day

• Bolus insulin
  – Look at glucose response to meals and to correction doses

• Now practice!
Sensor Linked to Pump

- Glucose trends visible on pump or PDA
- Pump suspend feature available on one system
- Integration of insulin delivery and realtime glucose trends
Pump + CGM patterns

• Adds information regarding blood sugar trends between checks, after boluses and overnight
Vintage Blood Glucose Meters

DextroStix, Ames, 1965

Reflomat (Boehringer-Mannheim), 1974
Traditional Glucometers on the market...
Accuracy of Glucometers

FDA guidance (non-binding):

+/- 15% for OTC self-monitoring devices
+/- 10% for clinical use meters

Acceptable to measure only as low as 50mg/dl for self-monitoring devices

2013 ISO Standards:

95% of blood glucose results
- below 100 mg/dl need to be within 15 mg/dl of reference
- above 100 mg/dl need to be within 15% of reference

At least 30% of glucometers do not meet ISO 2013 standards!

FDA draft guidance issued January 2014
AACE Consensus Conference of Glucose Monitoring, 2014
When finger-stick testing is more reliable than HbA1c measurement

- Several anemias due to low Hb values
- High red cell turnover states
  - E.g. Hemolytic anemias, Splenectomy, Hemochromatosis requiring frequent phlebotomy
- CKD on erythropoietin-analogue therapies until stable HCT is reached
- Pregnancy
- Some ethnic groups

Glucometers for the Blind

Glucometers that have:

• Speech output
• Capillary traction
• No need for test strip coding
Are there needle-free glucometers?

Glucowatch Biographer:
- Released in 2002
- Needed 3 hour ‘warm-up period’
- Skin irritation
- Discontinued by manufacturer

In development:

- Temporary sensor ‘tatoo’
  - Tested in 7 patients at UCSD
- ‘Smart’ Contact Lens Project
Does monitoring lead to better outcomes?

- Several studies suggest a relationship between more frequent monitoring and improved glucose control.
- Increased frequency of monitoring reduces hypoglycemia in patients with Type 1 and 2 DM.
- There are ongoing trials on the effect of SMBG on provider and patient outcomes in non-insulin patients with Type 2 DM.

Diabetes Care June 2003 vol. 26 no. 6 1759-1763
AACE Consensus Conference of Glucose Monitoring, 2014

SMBG: Self-Monitoring of Blood Glucose
Connected health strategies to increase effective monitoring

• Some systems allow checking glucose and managing data generate directly from a phone

• Other systems pair the glucose meter with a mobile phone for a data sync
Glucose data in EHR platforms
Glucose monitoring apps

Several apps for both Android and iOS are available to facilitate data tracking, trending and communication with providers.

BG Monitor  BlueLoop  OnTrack Diabetes

-Some studies suggest positive results using mobile phone based interventions for DM contro
- Apps specific for the needs of minorities with diabetes are needed

Diabetes Technol Ther. 2011 May;13(5):563-9
Will enhanced monitoring increase patient engagement? *For which patients?*
Conclusions and Final Notes

• An increasing number of patients treated with intensive insulin therapy has led to widely available diabetes technology, and clinicians will see more patients who use diabetes tech for self-management.

• There is an array of available insulin pumps on the market, each with unique features. Patients require education from knowledgeable clinicians on special features, insurance coverage and details of use. Insulin pump therapy is highly interactive, not passive.

• Continuous Glucose Monitoring (CGM) is accessible to more patients with type 1 diabetes and allows for more accuracy and safety with insulin dosing. It is an interactive tool patients and providers need to learn and master for optimal effectiveness. Integrated pumps with CGM and the promise of closed loop insulin delivery systems are transforming the landscape of intensive insulin therapy.

• Glucose monitoring advances include connected health platforms and allowing for “Patient Dashboard” glucose management. Patient selection and new models of care delivery are two important elements for successful implementation.

• Patients still have to perform fingersticks to know what their glucose level is.