INSULIN PUMP THERAPY FROM THE PRIMARY CARE PERSPECTIVE
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OBJECTIVES

- Describe approaches to intensive insulin therapy.
- Gain historical perspective of insulin pump therapy.
- Identify components of an insulin pump.
- Understand the insulin pump delivery of basal and bolus insulin.
- Describe the basics of carbohydrate counting.
- Identify appropriate candidates for insulin pump therapy.
- Recognize limitations of insulin pump therapy.
- Discuss the advantages and disadvantages of insulin pump therapy.
- Know the myths associated with insulin pump therapy.
- Understand the role of continuous blood glucose monitoring in intensive insulin therapy.

*In the adult patient.
TERMINOLOGY

- MDI-Multiple daily injections
- CSII-Continuous subcutaneous insulin infusion
- TDD-Total Daily Dose (of insulin)
- Basal
- Bolus
  - Prandial
    - ICR-Insulin to Carbohydrate Ratio
  - Correction
    - ISF-Insulin Sensitivity Factor
- SMBG-self-monitoring blood glucose
- CGM-continuous glucose monitoring

INTENSIVE INSULIN REPLACEMENT

INSULIN DELIVERY IN TYPE 1 DM AND INTENSIVE DM MANAGEMENT

- Multiple daily insulin injection therapy
- Continuous subcutaneous insulin infusion

INSULIN DELIVERY IN TYPE 1 DM AND INTENSIVE DM MANAGEMENT

- Continuous subcutaneous insulin infusion

HISTORICAL PROSPECTIVE

1963 First insulin pump prototype  
1977 First commercial “artificial pancreas” device  
1978 “Big Blue Brick” first commercially available insulin pump called the Autosyringe  
1983 MiniMed introduces their first insulin pump  
2017 World’s first hybrid closed loop system for Type 1 DM

INSULIN PUMPS

- ~400,000 patients with type 1 DM in US use an insulin pump for disease management
- 30-40% of patients with type 1 DM are using insulin pump and sensor technology


COMMON MYTHS ASSOCIATED WITH INSULIN PUMP THERAPY

- Wearing an insulin pump is uncomfortable.¹
- You can “forget” you have diabetes.¹
- Anyone can use an insulin pump.¹
- Only patients with Type 1 DM can use an insulin pump.
- I don’t know a lot about technology, so I could never use an insulin pump.²
- If I wear the pump, everyone will know that I have diabetes.²
- You still have to do shots with a pump, and it’s painful.²
- Wearing an insulin pump will interfere with daily activities.²
- Insulin pumps and/or insertion sites are surgically implanted.

¹Myths and Facts About Insulin Pump Therapy
By Joel Shpigel R.Ph. on July 9, 2013

²MYTH VS REALITY: INSULIN PUMPS AND CONTINUOUS GLUCOSE MONITORS
COMPONENTS OF THE TRADITIONAL INSULIN PUMP

- The pump
  - Battery powered programmable device with multiple settings (most are about the size of a pager)
    - Reservoir to hold insulin
    - Pumping mechanism
    - Battery
    - Computer chip
    - Screen

COMPONENTS OF THE TRADITIONAL INSULIN PUMP

- Infusion set
  - Allows insulin to flow to the subcutaneous tissue via a cannula that is self inserted by the patient via a needle insertion
  - Cannula is then secured to the skin
  - Changed every 3 days

TYPES OF INSULIN PUMPS

- Insulin pumps with tubing
- Tubeless insulin pumps
WHAT IS AN INSULIN PUMP SYSTEM WITH TUBING?

- Small device programmed to deliver insulin subcutaneously via a small cannula

WHAT IS A TUBING FREE INSULIN PUMP SYSTEM?

https://www.myomnipod.com/omnipod-system

https://www.myomnipod.com
TUBELESS INSULIN PUMP INSERTION

COMPONENTS OF THE TRADITIONAL INSULIN PUMP

- The insulin
  - Rapid acting insulin

Activity Profiles of Different Types of Insulin

https://dtc.ucsf.edu/images/charts/4.1.png


https://dtc.ucsf.edu/images/charts/4.1.jpg
INSULIN INSERTION SITES

DELIVERY OF INSULIN USING INSULIN PUMP

- Basal rate-continuous infusion of insulin that is delivered automatically based on settings. Purpose is cover hepatic glucose production and maintain euglycemia during fasting.
  - Programmable basal rate tailored to patient's 24 hour glucose profile and insulin needs
  - Single or multiple rates over 24 hour period
  - Can be modified for a different rate every hour
    - Dawn phenomenon
    - Daily activity
    - Exercise
    - Work schedule
    - Sleep
  - Temporary rate

  ![Image of suggested pod orientation]

https://www.medtronicdiabetes.com/customer-support/minimed-670g-system-support/add-basal-rate
https://www.medtronicdiabetes.com/customer-support/minimed-630g-system-support/basal-patterns
DAWN PHENOMENON

- Nocturnal spikes of growth hormone secretion result in increase blood sugar without ability of insulin to compensate
- Occurs between 2AM and 8AM (depending on patient’s sleep schedule)

![Sample Basal Rate Profile Showing Three Basal Rates](https://www.tandemdiabetes.com/docs/default-source/general-guides/005023_b-guide-to-successful-pumping.pdf?sfvrsn=a8553bd7_4)

DELIVERY OF INSULIN USING INSULIN PUMP

- **Bolus rate** - a dose of rapid acting insulin to cover food intake and/or lower an elevated blood sugar
  - Prandial-bolus dose of insulin with each meal or snack based on planned carbohydrate intake
    - Insulin to carbohydrate ratio
  - Correction-bolus of insulin to “correct” an elevated blood sugar
    - Insulin sensitivity factor
  - Calculators
    - Individualized prandial and correction insulin dosing algorithms, blood glucose targets and active insulin time
INSULIN TO CARBOHYDRATE RATIO

- The amount of carbohydrate in grams that one unit of insulin will cover
- ICR 1:10

Goals:
- Match insulin more closely with planned intake
- Increase flexibility and timing of food intake

COUNTING CARBOHYDRATES

- Steps:
  1. Develop a meal plan
  2. Learn which foods contain carbohydrates
  3. Use measuring tools
COUNTING CARBOHYDRATES

- Utilize resources for counting carbohydrates

CORRECTION BOLUS

- The amount of blood glucose lowered by one unit of insulin.
- ISF = 1:50
CURRENT INSULIN PUMP MARKET

- Medtronic
- Omnipod
- Tandem

WHAT DOES THE RESEARCH SAY ABOUT INSULIN PUMP THERAPY COMPARED TO MDI?

- Mildly reduced HbA1C
- Improved quality of life
- Reduced incidence of hypoglycemia

Recommendations for CSII over MDI (basal-bolus with analog insulin):
- Patients with type 1 DM who have not achieved their A1C goal, as long as the patient and caregivers are willing and able to use the device.
- Patients with type 1 DM who have achieved their A1C goal but continue to experience hypoglycemia or high glucose variability, as long as the patient and caregivers are willing and able to use the device.

Suggestions:
- Patients with type 1 DM who require increased insulin delivery flexibility or improved satisfaction and are capable of using the device.
- CSII with good adherence to monitoring and dosing in patients with type 2 DM who have poor glycemic control despite intensive insulin therapy, oral agents, other injectable therapy, and lifestyle modifications.

Common themes:
- “as long as the patient and caregivers are willing and able to use the device”
- “are capable of using the device”
- “CSII with good adherence to monitoring and dosing”

PATIENT REQUIREMENTS FOR INSULIN PUMP USE

- Motivated
- Responsible
- Knowledgeable about diabetes self care
- Desires better glycemic control
- Psychologically stable
- Willingness to monitor blood sugars a minimum of four times daily
- Willing to learn and utilize carbohydrate counting
- Willing to undergo insulin pump training to safely use technology
- Appropriate expectations of capabilities of insulin pump therapy
- Understands that success of insulin pump therapy is reliant on knowledgeable user
- Acknowledges that the insulin pump is not autonomous
- Adherence to blood glucose monitoring and interaction with insulin pump team is paramount to success
- Recognizes as a longer term therapy
- Willingness to comply with medical follow-up

LIMITATIONS OF INSULIN PUMP THERAPY

- Limitation of intensive blood glucose control
- **Hypoglycemia**
ADVANTAGES OF INSULIN PUMP THERAPY

- Increased flexibility in lifestyle.
- Predictable insulin delivery.
- Precise insulin delivery.
- Ability to accurately deliver 1/10th of a unit of insulin.
- Tighter blood glucose control, while reducing the risk of low blood glucose.
- Reducing episodes of severe hypoglycemia.
- Reducing wide fluctuations in blood glucose.
- Helping manage the "dawn phenomenon."

DISADVANTAGES OF INSULIN PUMP THERAPY

- Risk of skin infections at the catheter site.
- Risk of diabetic ketoacidosis (DKA) from pump malfunction or absorption problems.
- Cost: pumps are expensive, plus the continuing cost of supplies.
- Checking blood glucose at least 4 times per day.
- Letting others know that you have diabetes.
COMPLICATIONS OF INSULIN PUMP THERAPY

- Failure to deliver the required amount of insulin
- Disruption of insertion site (visible or invisible), kink in tubing, machinery malfunction
- User error (inadvertent or incorrect changes to pump settings or bolus delivery calculations)
- Hypoglycemia

DAY TO DAY

No matter the delivery system

- Blood glucose testing supplies
- Insulin
- Fast acting carbohydrate to treat hypoglycemia
- Extra snack
- Medical alert identification
- Injectable glucagon for emergency treatment
- Back up MDI plan if pump failure
  - With insulin, supplies, prescriptions
- Sick day plan
  - Ketone test strips

Insulin Pump users

- Pump supplies
- Infusion set supplies
HISTORY OF GLUCOSE MONITORING

- Commercialization of urine glucose testing
- First blood glucose test strip
- First glucose meter
- First “professional” CGM

1908 1965 1970s 1999


CONTINUOUS GLUCOSE MONITORING (CGM)

- Real time measurement of glucose levels 24 hours daily
- Provides comprehensive picture of glycemic variability
- Allows glucose fluctuations to be linked to daily events
- Data can be downloaded to observe glucose trends
CONTINUOUS GLUCOSE MONITORING (CGM)

- Two types
  - Real time
    - Continuously report glucose levels
    - Alarm for hypoglycemic and hyperglycemic excursions
  - Intermittently scanning
    - Does not communicate continuously
    - Communicates on demand
    - Does not have alerts
    - Approved for adults only

3 parts:

1. Sensor
   - Measures glucose concentration in interstitial fluid every five minutes
   - Delay between blood glucose value and interstitial value
   - Inserted under the skin by user with an applicator
   - Can be worn for 7-14 days depending on system

2. Transmitter
   - Sits on top of the sensor and transmits data wirelessly to receiver

3. Receiver (insulin pump, device, smart device)
   - Displays real-time glucose number, trend and history
CONTINUOUS GLUCOSE MONITORING (CGM)

- Generates downloadable data
  - Provides a measure of time blood glucose in within range
  - Duration and severity of hypoglycemia
  - Trends
  - Relationships to other activities
- Can alert to high and low blood sugars
- Newer devices require fewer or no calibration


CONTINUOUS GLUCEOSE MONITORING (CGM)

- Integration of CGM with insulin pumps includes both threshold and predictive hypoglycemia suspend feature.
- Some devices allow data to be shared with others (example-allow a parent to remotely monitor the child’s blood sugars)

CGM DEVICES CURRENTLY AVAILABLE IN THE US

<table>
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<th>Freestyle Libre 14-day</th>
<th>Dexcom G6</th>
<th>Medtronic Guardian Sensor 3</th>
<th>Senseonics Eversense</th>
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<td>Yes</td>
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</tbody>
</table>

https://diatribe.org/continuous-glucose-monitors

ARTIFICIAL PANCREAS-CLOSED LOOP SYSTEM

- Automated basal insulin delivery based on sensor data
  - Insulin pump, CGM device and algorithms
    - “Threshold suspend” feature
    - “Auto mode” feature

COMMON MYTHS ASSOCIATED WITH INSULIN PUMP THERAPY - REVISITED

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MYTH VS REALITY: INSULIN PUMPS AND CONTINUOUS GLUCOSE MONITORS

REALITIES OF INSULIN PUMP THERAPY

- “The one absolute requirement for using a pump is that you and/or your caregivers are ready and willing to do what it takes to use the pump safely.”
- The insulin pump does not eliminate the need to check blood glucose and give insulin before a meal.
- There is more technology involved with insulin pump use than using injections.
- It only contains short acting insulin.
- Must have a back up plan (and insulin and supplies) if pump malfunction.
- It is expensive but covered by insurance.
- It is an extra piece of hardware.
- It is a choice.
- It is not lifelong but does require commitment.

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“Important to note, success of these devices and technologies is directly linked to the level to which people are educated, capable, and willing to use them.”


“Only providers whose practice can assume full responsibility for a comprehensive pump management program should offer this technology.”


REFERENCES