DIABETES MELLITUS AND THE INSULIN PUMP: WHAT TEACHERS NEED TO KNOW

S. JOHN OBRINGER

KENNETH COFFEY
Mississippi State University

ABSTRACT

Diabetes is a condition where high amounts of glucose are found in the bloodstream due to impaired secretion of insulin. The hormone insulin was discovered by two physicians, Fredrick Banting and James Mcleod in 1921. Individuals with severe diabetes typically controlled their glucose level with multiple daily injections of insulin. Recently the insulin pump has gained popularity with individuals with Type I diabetes. A comprehensive review of the research literature is presented with advantages and disadvantages of pump therapy. Implications and recommendations for educators and other school personnel concerning students using pump therapy are included.

Diabetes Mellitus, commonly called diabetes, is a condition where high amounts of glucose are found in the blood stream due to impaired secretion of insulin. Typically the condition has been divided into two main subtypes: Insulin dependent (formerly termed juvenile) or Type I diabetes, and non-insulin dependent (formerly termed adult-onset) or Type II diabetes (Hitman & Metcalfe, 1993). It has been estimated that approximately l in 500 high school seniors are diabetic (Bowe, 2000). This is a concern for special educators and related service personnel since children and adolescents with diabetes are covered under the IDEA 2004 category of Other Health Impairments (Kirk, Gallagher, Anastasiow, & Coleman, 2006).

The cause for this condition is the malfunction of the islets of Langerhans located in clusters throughout the pancreas. While the exact etiology of this malfunction is not completely understood, it is hypothesized that an interaction of both heredity and environmental factors are involved (Heller, Alberto, Forney, & Schwartzman, 1996).

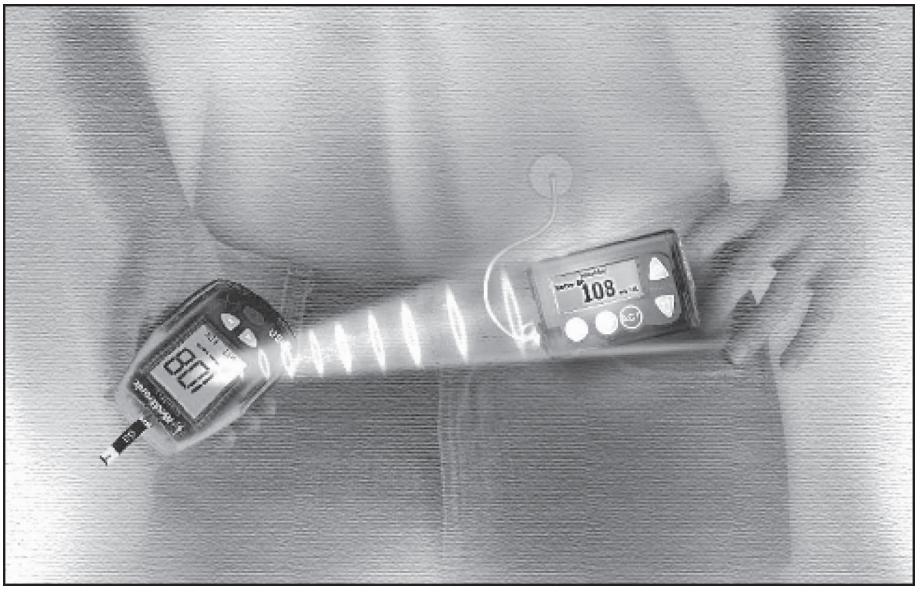
During digestion, under normal circumstances, some food is broken down into the glucose which serves as the central source of energy for all cells (Heller et al., 1996). As this process occurs, the pancreas simultaneously secretes insulin, a hormone needed to transport glucose to the various cells of the body. An individual with Type 1 diabetes does not secrete insulin and, therefore, cannot transport the energizing glucose to the cells.

Frederick Banting and John Macleod isolated the hormone insulin in 1923 for which they were awarded the Nobel prize for medicine. The discovery of insulin revolutionized the treatment of diabetes, as this isolated hormone could be obtained from various animal sources (King & Rubin, 2003). Before this time, the condition of diabetes was, many times, fatal. Insulin is typically delivered through multiple daily injections; however, an alternative to this delivery system is the insulin pump (Heine, 1993). This alternative has been growing in popularity each year (Hanas, 2002, "Health Topics," n.d.). In fact, Tamborlane, Bonfig, and Boland (2001) report a 10-fold increase in a recent two year period.

An early insulin pump was developed at both Guys and Yale hospitals in the late 1970's (Tamborlane et al., 2001). The current insulin pump weighs 3 ounces, is about the size of a pager, and can be worn on the belt. The insulin pump is comprised of four components: a pump reservoir, a small battery, a computer chip, and an infusion set (a thin plastic tube which delivers the insulin to the insertion site and a soft, flexible cannula that is inserted under the skin). The insertion site is changed every 2 to 3 days to avoid skin irritation or infection.

Although the insulin pump is not an artificial pancreas, it is intended to better manage blood sugar than multiple daily injections by delivering a small amount of insulin, called the basal rate, over a 24 hour period. Also, an additional dosage, called a bolus, is given just before meals. Newer models of the pump have bolus calculators which simplify the process of determining the proper bolus dose of insulin (Weinzimer et al., 2004).

The purpose of this study is to review the professional literature on insulin pump therapy and to ascertain the knowledge and skills needed for today's educators in managing diabetes through insulin pump therapy. Pump therapy offers a viable alternative for individuals with Type 1 diabetes. However, this form of insulin treatment is not suited for all individuals. The



A typical insulin pump

decision to use pump therapy can only be made with careful consultation with the supervising physician and diabetic medical team.

RESEARCH FINDINGS

USE OF THE PUMP WITH YOUNG CHILDREN

- Franklin, Torrance, Peebles, Wilkie, and Greene (2003) in a single subject design switched a seriously ill two year old child with Evans syndrome, alopecia, autoimmune bowel disease, candidiasis, and ectodermal dystrophy from traditional multiple daily injections to an insulin pump. Because the patient had significantly fewer episodes of ketoacidosis and hypoglycemia, in the words of his physician, pump therapy "revolutionized his care" (p. 151).
- Sadovsky (2003) in a six month study followed 9 children, all younger than age 4 with severe hyperglycemia. The investigator found a significant drop in their HbA_{1c} levels (a simple lab test that indicates the average amount of glucose in your blood stream over the last three months) from a mean of 9.5% with multiple daily injections to 7.9% with pump therapy. It is of interest that all 9 children showed a decrease. The tighter

glucose control offers a significant advantage since it better matches daily changes in calorie intake and energy expenditures. In addition, this tighter glucose control can reduce complications from common debilitating conditions associated with long-term diabetes. Finally, the researcher noted that with very young children one essential criteria for pump therapy wasthe child's ability to avoid "playing" with the mechanism and the understanding that it is a necessary piece of medical hardware.

- Weinzimer et al. (2004) in a longitudinal study followed 65 children utilizing pump therapy with a mean age of 4.5 years for a total 162 patient years of research. HbA_{1c} levels improved after 12 months and continued to improve even after four years. One emotional side effect of multiple daily injections, is that many mothers of infants and toddlers with Type 1 diabetes reported that management of diabetes was a full-time job that required constant vigilance. In contrast many mothers of pump treated infants and toddlers report "getting their life back after starting their children on pump therapy and returning to work outside the home" (p. 1604). The study further showed that paid caregivers such as paraprofessionals can be educated to carry out the basics of pump use. However, the researchers reported four episodes of diabetic ketoacidosis requiring emergency treatment versus no reported episodes in the 12 months preceding pump therapy.

Value of Pump Use versus Multiple Daily Injections

- Maniatis, Klingensmith, Slover, Mowry and Chase (2001) examined 56 patients, age 7 to 23 years divided into three groups based on their HbA_{1c} levels and found a decrease in seizure frequency and hypoglycemia leading to an overall improvement in diabetic control.
- Tamborlane et al. (2001), in a research summary, reported a number of significant findings. These include: the rate of severe hypoglycemia was 50% lower for pump therapy versus multiple daily injections; pump patients treated with pump therapy reported that it was easier to cope with diabetes; 98% of children who started pump therapy have remained on the pump; and although the initial cost of pump therapy is significantly more than traditional multiple daily injections, the prevention of later debilitating complications offsets this expense.
- Hanas (2002) found that pump therapy typically lowered the amount of insulin needed per day by 15–20%, a significant reduction. Pump therapy has also been successful in preventing recurrent hospital admissions for ketoacidosis.

- Weintrob et al. (2003) studied 23 children aged 9.4 to 13.9 in an open randomized crossover design for seven months. Each child received 3.5 months of pump therapy and 3.5 months with multiple daily injections therapy. The investigators found that pump therapy resulted in a lower daily insulin requirement, a higher patient satisfaction, and no significant change in weight. One concern of patients with Type 1 diabetes is that improved blood glucose control will be associated with a weight gain. In this study, weight was slightly increased with multiple daily injections therapy, but not during pump therapy. An associated benefit was that during pump therapy the students had a decreased need for snacks.
- McMahon et al. (2004) studied 100 patients with a mean age of 12.5 years and found that HbA_{1c} levels decreased from 8.3% with multiple daily injections to 7.8% after pump therapy was initiated. Also, the investigators found an improvement in quality of life measures including outlook on diabetes and self efficacy for managing diabetes, all of which may be attributed to the newfound flexibility available with pump therapy. In this study many female adolescents were motivated to begin pump therapy because it facilitated weight control.
- Heptulla, Allen, Gross, and Reiter (2004) studied 8 patients, ages 7–17 years for 3 months and found overall insulin requirements decreased, and improvements in glycemic control were noted, and concluded that there was convincing evidence for pump therapy in children.
- Deiss, Hartman, Hoeff, and Kordonouri (2004) investigated 50 children with a mean age of 12.6 years with Type 1 diabetes. After six weeks on pump therapy their HbA_{1c} improved from 8.1% to 7.7%. Interestingly, the effect was more distinct in boys, those with poor blood sugar control, and those over age 12.

Potential Problems with Pump Use

- Weintrob et al. (2003), in his study of 23 children, noted that pump therapy is not without medical risks or adverse events. The investigators found the following: 12 minor infusion site infections, 16 blockages, 42 dislodgments, and 2 hospital admissions for infection during pump therapy.
- Robert (2004) investigated 48 children and adolescents with a mean age of 15 years who had a history of diabetes for 8 years and found that up to 2/3 of teens periodically failed to administer their bolus dose due to forgetfulness.

ADVANTAGES OF THE INSULIN PUMP

- The pump can lessen later complications of diabetes such as diabetic neuropathy and amputation (Sandosky, 2003; Tamborlane et al., 2001).
- Adolescents are much more free to eat at variable times ("Insulin Pump," 2004).
- The pump offers increased flexibility in establishing or modifying the basal rate (Becker, 1998).
- The rate of severe hypoglycemia may be reduced as much as 50% for persons on pump therapy (Tamborlane et al., 2001).
- Adolescents have the option of sleeping later on the weekends, much like their unaffected peers ("Insulin Pump," 2004).
- Daily average insulin dosage is significantly lowered by 15%–20% (Hanas, 2002).
- Teens who are competent with computers or video games typically transition to the mechanism well ("Practical Living," 2001).
- Children and adolescents can play sports and be active without risking low blood sugar ("Insulin Pump," 2004).

DISADVANTAGES OF THE INSULIN PUMP

- The initial cost of the pump, $5,000 to $6,000, a $480 monthly cost, and an expected operational life of 4–8 years can make the pump cost prohibitive for many students ("Health Topics," n.d.; Samarsinghe, Treml, & Shotliff, 2003).
- Pump users have to learn how to count carbohydrates in a precise manner ("Insulin Pump," 2004).
- Many medical plans do not cover the high cost of pump therapy (Hanas, 2002).
- Many adolescents are not prepared for the extra effort and time required for effective pump usage (Becker, 1998).
- Like any mechanical device, the pump can malfunction or tubing can become kinked ("Insulin Pump," 2004).
- The HbA_{1c} may not change significantly with pump usage (Becker, 1998).
- The pump is stressful at first, but becomes more manageable over time ("Practical Living," 2001).
- Infections or irritations can occur at the insertion site ("Insulin Pump," 2004).

DISCUSSION

As the insulin pump increases in use, educators, related service personnel, and students need to become more aware of the benefits, drawbacks, and implications of this technology. Research indicates that caregivers, such as paraprofessionals and school based personnel, are able to manage pump therapy, but need a working knowledge of the mechanism provided through inservice training. Appropriate training includes issues and procedures related to insuring proper operation of the pump, attending to alarms, and assisting in determining the right bolus amount of insulin per meal.

Because counting carbohydrates is essential for pump therapy, the adolescent beginning pump therapy may well benefit from a nutrition course in the area of life sciences or regular contact with a diabetes counselor provided through health services in the community. Since it is quite normal for school aged students to be curious about new and unusual personal devices, a frank discussion with classmates on diabetes and the insulin pump may go a long way in reducing unwanted stares or teasing comments. While pump therapy leads to more freedom in physical education, the physical education teacher still needs to be aware of the signs and treatment of hyperglycemia (too much) or hypoglycemia (too little) blood sugar. In addition, many students disconnect the pump before sports involving contact. The physical educator would want to be sensitive to the student's need for privacy to disconnect and reconnect the pump. Especially in the elementary years, celebrations of holidays and birthdays often include candy, cakes, and drinks high in sugar. The teacher, student, and parents need to have appropriate alternative foods available. Students with diabetes may also require additional flexibility for water and restroom breaks, blood glucose monitoring followed by snacks as needed, and scheduling the lunch period at the optimal time. The student may need to have a snack during long bus rides or on field trips.

A written plan for emergency treatment should be available to all teachers including substitute teachers, paraprofessionals, and administrators; this plan should be reviewed prior to any off campus trip. The written plan should include warning signs that signal the possibility of adverse events. One of the more common adverse events is an infection at the infusion site which would be indicated by redness, warmness, drainage, and tenderness. If the inflamed site is larger than a dime, the student's physician should be consulted. A second adverse event is possible scarring at the infusion site. This condition is typically minimized if the site is changed every few days. As with any child with diabetes, the teacher should notify the school nurse if the following warning signs are seen: fatigue, irritability, dizziness, temporary blurred

vision, clammy skin, and lightheadedness. The written plan should be developed annually with the parents, physician, school nurse, and educational team.

As a component of the written plan, a daily behavioral regimen may also minimize complications with pump use. This behavioral regimen should be structured like a checklist to insure that students perform the following routines: calculate blood sugar with at least two finger sticks during the school day, administer the bolus before lunch, replace the pump if removed for physical education, and verify that the school lunch contains the appropriate amount of carbohydrates.

Challenges to increased pump usage include the high initial cost of the pump. One can only speculate, but, historically, the cost of technology has tended to decrease over time (e.g. desk top computer, DVD player). As pump therapy becomes more wide spread, insurance providers may be inclined to include this device in standard coverage. In addition, pump usage is well established in the "research community", but among family physicians and other health care providers it has met with slower acceptance.

Tighter glycemic control, available through pump therapy, has a number of benefits for children and adolescents. The most powerful and convincing argument for pump use, however, is that it has the potential to limit or reduce the effects of serious health conditions such as diabetic neuropathy, loss of motor control, abnormal gait, amputations, and foot ulcers. In addition to these effects on ambulation, other major complications in persons without tight glycemic control include: early retinopathy, dermopathy, later impaired intellectual functioning, and a significantly increased risk of kidney and heart disease. As medical centers continue the research in diabetic control, the next technological advancement in pump therapy may be a device that better mimics the function of the pancreas or, indeed, acts as an "artificial pancreas."

REFERENCES

Becker, D. (1998). Individualized insulin therapy in children and adolescents with Type 1 diabetes. *Acta Paediatr Supplement 425*, 20–24.

Bowe, F. (2000). *Physical, sensory, and health disabilities: An introduction*. Upper Saddle River, NJ: Prentice Hall.

Deiss, D. Hartman, R., Hoeff, J., & Kordonouri, O. (2004). Assessment of glycemic control by continuous glucose monitoring system in 50 children with Type 1 diabetes starting on insulin pump therapy. *Pediatric Diabetes*, *5*(3), 117–121.

Franklin, V.L., Torrance, T., Peebles, M., Wilkie, R., & Greene, S. (2003). Life-threatening autoimmunity with diabetes: Management with an insulin pump. *Pediatric Diabetes, 4*, 151–154.

Hanas, R. (2002). Selection for and initiation of continuous subcutaneous insulin infusion. *Hormone Research, 57* (suppl 1), 101–104.

Health topics A-Z (n.d.). *Insulin pumps*. Retrieved March 9, 2005 from http://www.hmc.psu.edu/healthinfo/insulinpumps.htm

Heine, R.J. (1993). Insulin therapy. *The Diabetes Annual,* 7, 284–302.

Heller, K.W., Alberto, P.A., Forney, P.E., & Schwartzman, M.N. (1996). *Understanding physical, sensory, and health impairments: Characteristics and educational implications*. Pacific Grove, CA: Brooks/Cole.

Heptulla, R.A., Allen, H.F., Gross, T.M., & Reiter, E.O. (2004). Continuous glucose monitoring in children with Type 1 diabetes: Before and after insulin pump therapy. *Pediatric Diabetes, 5*, 10–15.

Hitman, G.A., & Metcalfe, K.A. (1993). The genetics of diabetes: An update. *The Diabetes Annual, 7,* 1–17.

The insulin pump: Is it right for you? (2004) *Countdown, 25*(1), 4.

King, K., & Rubin, G. (2003). A history of diabetes from antiquity to discovering insulin. *British Journal of Nursing, 12*(18), 1091–1095.

Kirk, S.A., Gallagher, J.J., Anastasiow, N.J., & Coleman, M.R. (2006). *Educating exceptional children* (11th ed.). Boston: Houghton Mifflin.

Maniatis, A.K., Klingensmith, G.J., Slover, R.H., Mowry, C.J., & Chase, H.P. (2001). Continuous subcutaneous insulin infusion therapy for children and adolescents: An opinion for routine diabetes care. *Pediatrics* 107(2), 351–356.

McMahon, S.K., Airey, F.L., Marangou, D.A., McElwee, K.J., Carne, C.L., Clarey, A.J., Davis, E.A., & Jones, T.W. (2004). Insulin pump therapy in children and adolescents: Improvements in key parameters of diabetes management including quality of life. *Diabetic Medicine, 22,* 92–96.

Practical living: Teens on pump therapy. (2001) *Diabetes Forecast,* 54(1), 20–21.

Robert, S.S. (2004). Why some kids on pumps have poor control. *Diabetes Forecast, 57*(10), 27–28.

Sadovsky, R. (2003). Insulin pumps in young children with Type 1 diabetes. *American Family Physician, 67*(5), 1082, 1084.

Samarasinghe, Y.P., Treml, H., & Shotliff, K. (2003). Insulin pumps who, when, and why? *Update, 67*(9), 519–522.

Tamborlane, W.V., Bonfig, W., & Boland, E. (2001). Recent advances in treatment of youth with Type 1 diabetes: Better care through technology. *Diabetic Medicine, 18,* 864–870.

Weintrob, N., Benzaquen, H., Galatzer, A., Shalitin, S., Lazar, L., Fayman, G., Lilos, P., Dickerman, Z., & Phillip, M. (2003). Comparison of continuous subcutaneous insulin infusion, and multiple daily injection regimens in children with Type 1 diabetes: A randomized open crossover trial. *Pediatrics, 112*(3), 559–564.

Weinzimer, S.A., Ahern, J.H., Doyle, E.A., Vincent, M.R., Dziura, J., Steffen, A.T., & Tamborlane, W.V. (2004). Persistence of benefits of continuous subcutaneous insulin infusion in very young children with Type 1 diabetes: A follow-up report. *Pediatrics, 114*(6), 1601–1605.

Address correspondence to Dr. S. John Obringer, Department of Counseling, Educational Psychology, and Special Education, Box 9727, Mississippi State University, Mississippi State, MS 39762. sjol@ra.msstate.edu.