DIABETES TECHNOLOGY & THERAPEUTICS
Volume 12, Number 10, 2010

DOI: 10.1089/dia.2010.0027

Perspective

Use of Insulin Pumps in India: Suggested Guidelines Based on Experience and Cultural Differences

Jothydev Kesavadev, M.D.,[1] Ashok Kumar Das, M.D.,[2] Ranjit Unnikrishnan I[st], M.D.,[3] Shashank R. Joshi, D.M.,[4] Ambady Ramachandran, M.D.,[5] Jisha Shamsudeen, B.Pharm.,[1] Gopika Krishnan, B.Pharm.,[1] Sunitha Jothydev, M.A.,[1] and Viswanathan Mohan, M.D.[3]

Abstract

All type 1 diabetes mellitus (T1DM) subjects and the majority of type 2 diabetes mellitus (T2DM) subjects at one time or another require insulin to sustain life. Syringes and pens are presently the most popular insulin delivery devices. Though in use for more than 3 decades, insulin pumps are now being more commonly used because of their unique ability to continuously infuse insulin, closely mimicking that of physiological secretion from a normal pancreas. Unlike insulin shots with syringes, pump infusion sites need to be changed less frequently. Scientific evidence from published studies have proven added benefit of insulin pumps in improving quality of life, normalizing sugars in recalcitrant diabetes, improving sexual function, and relieving the intractable pain of neuropathy. In the western world, pumps are commonly used with T1DM subjects, whereas in India 80% of pumpers are T2DM subjects. The success of insulin pump therapy depends on selection of the right candidate, extensive education, motivation, and implementing the sophisticated programs with skill. However, all affordable patients are not ideal candidates for pump therapy because for successful continuation of pump therapy other inclusion criteria should also be fulfilled. Among the other indications discussed are a high level of insulin resistance, brittle diabetes, chronic kidney disease on renal replacement therapy, and continuous glucose monitoring pattern strongly suggesting need for a variable basal insulin infusion rate. In International Diabetes Foundation data released in 2009, estimated diabetes prevalence for 2010 is 285 million, representing 6.4% of the world's adult population, with a prediction that by 2030 the number of people with diabetes will have increased to 438 million. Considering this massive growth in T2DM and its propensity after 10–15 years to lead to an insulin-deficient state, available evidence from studies is a compelling indication not to deny the benefits of continuous subcutaneous insulin infusion in selected T2DM subjects. This article aims at suggesting guidelines based on clinical experience and cultural diversity for India and developing countries.

What Is an Insulin Pump?

The continuous subcutaneous insulin infusion (CSII) pump (insulin pump for short) is a pager-sized device that can be connected to the body through an infusion set so as to deliver insulin continuously. It consists of a disposable reservoir for insulin and a disposable infusion set, including a cannula for subcutaneous insertion and a tubing system that connects the insulin reservoir to the cannula.

Insulin pump therapy by itself is not a new therapy for diabetes mellitus. It is an alternative delivery mechanism for administration of insulin and is found to be superior to ordinary syringes and insulin pens. When insulin is administered subcutaneously via a properly programmed insulin pump, delivery of insulin is expected to mimic the insulin release pattern of a normal healthy pancreas better than other modalities of insulin delivery.

Willingness on the part of the patient is absolutely essential before going on the pump. However, mere willingness to initiate pump therapy does not make a patient a candidate for the same. Other indications mentioned below need to be present if a patient is to be considered for pump therapy. Conversely, if a patient who fulfils one or more of the indications is not comfortable wearing the pump even after due

[1]Jothydev's Diabetes and Research Center, Trivandrum, Kerala, India.
[2]Jawaharlal Institute of Post-Graduate Medical Education and Research, Puducherry, Tamil Nadu, India.
[3]Dr. Mohan's Diabetes Specialities Centre and Madras Diabetes Research Foundation, Chennai, Tamil Nadu, India.
[4]Joshi Clinic and Lilavati & Bhatia Hospital, Mumbai, Maharashtra, India.
[5]India Diabetes Research Foundation and Dr. A. Ramachandran's Diabetes Hospitals, Chennai, Tamil Nadu, India.

explanation and counseling, he or she should not be put on the pump.

In India at present, insulin pumps are usually not reimbursable or covered by insurance, and the patient needs to buy the pump and also the consumables, both of which are currently expensive. Cost of the pump is a one-time expense, but the cost of the consumables is a recurring expenditure. Hence, the family should be aware of the continuing expenditure when they decide to start with insulin pump therapy. If they cannot afford it in the long term, it is better not to initiate pump therapy at all because there is likelihood for discontinuation due to lack of affordability, and this will mean a huge loss to the patient. This article proposes some guidelines for use of insulin pumps in India and other developing countries and is significant because most physicians in India are unaware about the pump or the indications for its use.

Evolution of Pump Therapy

The first insulin pump was introduced in the early 1960s by a Los Angeles doctor by the name of Arnold Kadish. The first model was so big that it had to be worn like a backpack. In the beginning of the 1990s more user-friendly models appeared with features like bolus calculators and compatibility with personal computers so that users could have greater control of their insulin intake and monitor their blood sugars more efficiently.

In 2006, Medtronic MiniMed (Northridge, CA), historically recognized as pioneers in insulin pump therapy, introduced real-time insulin pumps where the glucose sensor and the pump were combined. The introduction of real-time insulin pumps was a major breakthrough toward "closing the loop" of insulin delivery, very near to the dream of inventing fully automatic devices. At present in India, apart from Medtronic (Northridge, CA) devices, Roche (Basel, Switzerland) pumps are also available.

Guidelines on Insulin Pumps

CSII should be initiated only in a center with sufficient infrastructure and a trained team of diabetes specialist, nurse, and dietitian (National Institute for Health and Clinical Excellence guidelines).[1] The pump can be continued in an outpatient setting provided patients have the mental and physical capacity to do so (following the 2010 American Diabetes Association guidelines).[2] According to the International Diabetes Federation guidelines, pump therapy should be considered only at the comprehensive care level, and in type 2 diabetes mellitus (T2DM) it should remain as a potential option in highly selected subjects.[3]

Where Can Insulin Pumps Be Used?

Type 1 diabetes mellitus

Insulin pump therapy is a fully established insulin delivery option in type 1 diabetes mellitus (T1DM). In the scenario where virtually no insulin is being produced from the pancreas, pumps are a proven, time-tested therapeutic option in T1DM at all ages, offering near-physiological delivery of insulin. There are even pump models with remote controls enabling parents of young children either to suspend or to bolus insulin from a distance when the child is playing or eating. Any subject with an established diagnosis of T1DM is a potential candidate for the pump provided other inclusion criteria are fulfilled (listed below).

Type 2 diabetes mellitus

T2DM is characterized by progressive beta-cell dysfunction in the presence of insulin resistance. Eventually the insulin secretory defect predominates, resulting in an insulin-requiring state. As opposed to insulin resistance, which tends to plateau, beta-cell dysfunction progresses over time. Thus people with T2DM eventually require insulin therapy to maintain glycemic control, in addition to their oral antidiabetes agents.[4] The initiation of insulin therapy by itself may not lead to sustained improvement in glycemic control because of the necessity for escalating the dosages and frequency of shots to meet glycemic goals. According to American Diabetes Association, the ideal form of insulin therapy consists of a multiple dose regimen, based on long-acting insulins once daily—the basal component—and multiple doses of rapid-acting insulin with meals—the bolus component.[5] However, a major limitation of the basal bolus regimen is the progressive increase in insulin dosages and injection frequency, leading to a higher total daily insulin dose, weight gain, and missed doses. Moreover, the use of multiple shots of insulin is often associated with increased fluctuations in blood sugar levels, frequent hypoglycemic episodes, and poor quality of life (QOL). It has been shown that the development of diabetes complications depends not only on glycemic control per se, but also on the magnitude of glycemic excursions in a patient, which is usually measured as the mean amplitude of glycemic excursions.[6] None of the currently available multiple-injection insulin regimens can decrease the mean amplitude of glycemic excursions to physiological levels.

In insulin-requiring T2DM, a judicious use of insulin pumps in selected candidates is not only beneficial in reducing glycated hemoglobin (HbA1c) levels, but also in minimizing glycemic excursions. More recent studies with insulin pumps have shown excellent improvement in quality of life, sexual function, and symptoms of peripheral neuropathy.[7]

Advantages of Intensive Therapy in T2DM

The benefits of tight control of blood sugars in preventing chronic diabetes complications has been unequivocally brought out by the Diabetes Control and Complications Trial in T1DM[8] and by the United Kingdom Prospective Diabetes Study in T2DM.[9] An HbA1c reduction of just 1% can result in 37% reduction in microvascular complications like retinopathy, nephropathy, and neuropathy. Unfortunately, as the duration of diabetes increases in T2DM, it becomes more and more difficult to achieve sufficient reductions in HbA1c even with the use of high doses of insulin in combination with oral antidiabetes agents. In addition, intensification of treatment is often hampered by factors like weight gain and frequent hypoglycemia, which are an inevitable accompaniment of the nonphysiological insulin regimens commonly used.

Insulin pump therapy was developed to provide a more physiological mode of insulin delivery to the insulin-requiring patient. First, the insulin pump uses only regular insulin or rapid-acting insulin analogs, which provide a more consistent, reproducible absorption pattern than intermediate-acting insulin suspensions. In contrast to subcutaneous insulin

injections, where the patient may inject him- or herself on the abdomen, thigh, or arm by rotation, the insulin pump commonly administers insulin at a single site, most commonly the anterior abdominal wall. The primary use of a single anatomic site for infusion of insulin contributes to a more consistent insulin effect. Depending on the body fat distribution, age, and convenience, hips, thighs, or buttocks may be selected. In young children buttocks are the preferred infusion site. The more predictable delivery and bioavailability of insulin may explain one of the prime advantages of pump therapy over the multiple dose injection (MDI) regimen.

Earlier studies have shown that most poorly controlled subjects on MDI achieved a significant improvement in control after changing over to insulin pump therapy.[10] CSII with an insulin pump is a feasible alternative for such people provided they are adequately educated and motivated and can afford a pump. CSII more closely mimics the way the body delivers insulin and is both safe and effective when used to treat T2DM. Because insulin pumps only use short-acting insulin, the rate and timing of the insulin infusion can be adjusted to the user's glucose profile meal timings and exercise patterns. This could lead to better control as shown by lower HbA1c levels even in the most difficult-to-treat diabetes.[11]

In 2007, Bode BW[12] reported the use of CSII with rapid-acting insulin aspart as a viable choice in both T1DM and T2DM for close-to-physiologic insulin treatment. However, in T2DM, CSII and the MDI regimen offer similar efficacy and tolerability, although CSII was suggested to be less burdensome. Pickup and Renard[13] stated in a review article that CSII is the best current therapeutic option for some T1DM subjects and it is possible that CSII will be beneficial in selected patient groups with T2DM as well.

The Indian Experience with Insulin Pumps

When compared to the West, the majority of pumpers in India are type 2 subjects. Pumps have been introduced as an alternative insulin delivery device with far more advantages than the popular syringes and insulin pens. Much more than affordability, other factors such as level of motivation, self-learning skills, and family support are taken into consideration in selecting the right candidate.

The proportion of T1DM and T2DM patients who are put on the pump would vary from center to center. T2DM comprises over 95% of all diabetes cases in India and a majority of all pump users as well ($\sim$80%). T2DM patients have some special features, e.g., the insulin requirement would depend on whether the oral hypoglycemic agents are continued or not (in majority of the patients oral hypoglycemic agents are continued in order to reduce the insulin doses). Furthermore, they have features of insulin resistance and are older than T1DM patients.

As early as the 1980s, the benefits of using an insulin pump in patients in a hospital setting were published from India.[14] However, at that time there were no sales or service of insulin pumps in India, which precluded their use at home by patients. Insulin pumps were first introduced around 1996. Today, over 1,000 patients use an insulin pump on a continuous basis in India, and some reports on the effectiveness of pumps have been published from India and these are briefly reviewed below.

A case report was presented at the American Diabetes Association meeting in 2007 of a 58-year-old subject with T2DM of 20 years' duration with bilateral peripheral painful neuropathy. Insulin pump therapy resulted in dramatic improvement in neuropathic symptoms. By day 6 of pump usage definite signs of improvement were revealed without any concomitant medications for neuropathy, and by day 10 the pain, which had not responded to multiple daily insulin shots, almost disappeared. The relief of pain remained consistent, resulting in incredible improvement in QOL.[7]

Scientific evidence supporting the use of insulin pumps in T2DM points to not only significant reduction in Hb1Ac levels but also to improvement in QOL. In a real life study, a total of 46 subjects with T2DM using MDI were switched over to CSII for 6 months. HbA1c, body weight, and total daily dose of insulin were measured before initiation of CSII and compared with the values 6 months later. After 6 months of CSII, study subjects were asked about their satisfaction with the therapy; they were also asked to assess treatment flexibility, frequency of side effects, and interference with regard to side effects. The mean HbA1c value 6 months after initiation of CSII was $7.6 \pm 1.2\%$, compared to $8.1 \pm 1.4\%$ at baseline while using MDI. The difference in mean HbA1c at 6 months from baseline (-0.54%) was statistically significant and subjects also expressed high overall satisfaction level with CSII after 6 months.[15]

Subjects were also asked to assess how CSII affected the sexual function and peripheral neuropathic pain. After 6 months of CSII 83% of subjects noted an improvement in sexual function as opposed to when they were using MDI. With respect to peripheral neuropathic pain, 87% of subjects reported that they experienced significant reduction in pain after initiation of CSII.[15]

In a retrospective analysis of the medical records of 43 patients who were initiated on insulin pump therapy between 2002 and 2007, 33 patients (17 with type 1 diabetes and 16 with type 2 diabetes) who were on CSII were followed for a mean duration of 3.4 years. The study, aimed at evaluating the safety and effectiveness of CSII among recalcitrant diabetes, showed a statistically significant reduction in HbA1c after initiating CSII (prepump 10.7% vs. postpump 8.3%, $P < 0.001$), and a reduction in frequency of severe hypoglycemia after starting the CSII also occurred with no instances of diabetic ketoacidosis. The greatest reduction in HbA1c levels occurred in the first 6 months with a slight deterioration thereafter, possibly because some patients "relaxed" the control after the initial success with pumps was achieved.[11]

Indications for Insulin Pump in T2DM

High HbA1c despite MDI

Although MDI in a basal-bolus regimen is currently the most popular regimen used in the treatment of insulin-requiring T2DM, many patients fail to attain target levels of HbA1c even when prescribed this regimen. Possible causes could be failure to match insulin doses to the patient's needs, unsuspected hypoglycemic episodes leading to rebound hyperglycemia, and lack of adherence to the regimen leading to missed doses. In such patients, insulin pump therapy will help to deliver the prescribed dose in a more physiological manner, minimizing hypoglycemic episodes and ensuring patient compliance. The total daily dose of insulin can also be brought down when switched over to insulin pump.

Studies have shown improvement in QOL with use of insulin pumps in such individuals probably because of multiple factors like reduction in HbA1c, maintenance of ideal body weight, minimizing glycemic excursions and hypoglycemic episodes, and significant improvement in neuropathic pain.[15]

Insulin resistance

CSII may be an effective therapy to reduce insulin resistance in obese T2DM patients without the deleterious side effects associated with increasing insulin dosage.

Insulin resistance remains the predominant factor that may lead to higher HbA1c despite the MDI regimen. Obese T2DM patients with severe insulin resistance tend to develop chronic hyperglycemia, despite maximal intervention with diet, physical exercise, and oral hypoglycemic agents. Insulin therapy in these patients usually does not lead to satisfactory glucose control, even when the insulin dosage is very high. High doses of insulin also cause weight gain, which aggravates insulin resistance and exacerbates other cardiovascular risk factors.

In a study conducted among obese T2DM subjects, CSII was found to reduce total dose of insulin, HbA1c, body weight and the incidence of both postprandial hyperglycemia and severe hypoglycemia.[16] A total of 10 severely obese (body mass index, $>30\,kg/m^2$) T2DM patients with severe insulin resistance (insulin dose of $>1\,U/kg/day$) were recruited from a hospital-based practice. Subjects who qualified for the study had an HbA1c >8.5%, despite strict diet and compliance with the insulin regimen. All subjects in the study had a reduction in insulin requirements, from 1.46 ± 0.43 units/kg/day (mean $\pm$ SD) at week 0 to 1.19 ± 0.42 units/kg/day at week 40. Concomitantly, there was a slight decrease in weight, from 95.9 ± 13.2 kg at week 0 to 93.4 ± 12.7 kg at week 40. Most significantly, glycemic control improved, with a decrease in the HbA1c levels from $12.34 \pm 1.74\%$ at week 0 to $9.56 \pm 0.76\%$ at week 40.

In the presence of insulin resistance with high doses of insulin requirements, insulin pump therapy will not only help in normalizing the glycemia but will also help reduce the total daily dose of insulin.

Brittle diabetes

Brittle diabetes is characterized by constant, unpredictable fluctuations in blood sugar levels in spite of consistent diet, exercise patterns, and medication use. It is a challenge to the physician, patient, treatment team, and caretakers and caregivers at home and in office. Brittle diabetes is often encountered in T2DM subjects with a long history of uncontrolled diabetes and advancing age.[17] The insulin pump, because of its unique mechanism of preprogramming different basal profiles, enables use of up to 48 profiles per day (for example, with the Medtronic MiniMed Paradigm 715 or 722 pump), which is impossible with any other existing insulin regimen. Moreover, the patient can measure his or her blood glucose values before each meal and can decide on the exact dose of insulin to be administered using the Bolus Wizard (Medtronic MiniMed) function of the pump. This will avoid insulin stacking (active insulin that is left from a previously administered bolus) and the consequent hypoglycemia. Over time the subject can maintain near normal glycemia with lower insulin doses and fewer insulin injections.

Patients with frequent, serious symptomatic hypoglycemic episodes

The insulin pump delivers its basal infusion at miniscule rates, typically ranging from 0.1 to 2 U/h. Such small amounts of insulin are very unlikely to produce hypoglycemia. Moreover, the insulin used in the pump is regular insulin or rapid-acting insulin analogs, both of which have a short half-life and are rapidly degraded, thereby minimizing the risk of accumulation of insulin and subsequent hypoglycemia.

As far as the bolus administration is concerned, new "smart" insulin pumps come with varied features where patients or caregivers can program the functions like the insulin sensitivity factor during different times of the day and also make use of the Bolus Wizard function to calculate and administer insulin according to the varying carbohydrate content of the diet and blood glucose values. Such advanced functions when judiciously used result in physiological insulin secretion mimicking a normal human pancreas. So when insulin is administered properly using an insulin pump, there is no reason for which extra insulin is delivered. When insulin is administered with the help of the Bolus Wizard function, it will also take into consideration the phenomenon of bolus on board or insulin stacking, which is the bolus available in the blood stream from a previously administered bolus. This will also prevent further episodes of low sugars. All the studies have shown either minimal or absolutely no episodes of hypoglycemia occurring when patients are switched over to CSII.[16]

Patients seeking improved QOL while on insulin shots

Studies comparing those on insulin pumps to those on injections taken with a syringe or pen have shown a remarkable improvement in physical QOL when they were switched over to insulin pumps. Studies have also shown improvement in the pain of neuropathy or disappearance of symptoms of neuropathy in patients when using insulin pumps in T2DM. This disappearance of neuropathic pain has shown to occur within a period of 10–20 days of initiating insulin pump therapy.[7,15,18]

A patient who is on injections with a syringe or insulin pen needs to take injections on a scheduled basis. The insulin pump offers patients more flexibility with respect to meal timings and meal contents. An insulin pump also allows the patient switch over to a temporary basal at times of exercise or delayed food, thus reducing the dose of insulin that is delivered, thereby preventing hypoglycemic episodes and simultaneously retaining the advantages of continuous insulin infusion. On the other hand, when the patient consumes a meal rich in protein or fat, functions like square wave bolus or dual wave bolus that are available in modern insulin pumps offer better flexibility in lifestyle that can never be replicated with use of other injection devices or insulin regimens. Whether it is an unexpectedly delayed meal, unexpected exercise, or the presence of illnesses that require higher doses of insulin with higher frequency of shots, in all circumstances use of an insulin pump scores over conventional shots. Considering all these factors, it is not surprising that patients who switch over from MDI to CSII invariably report significant improvement in QOL.

Chronic kidney disease on dialysis or post-renal transplant patients

Chronic kidney disease is a condition where there is change in physiology of insulin metabolism and action. In such a situation even small doses of insulin can produce severe hypoglycemia. After renal replacement therapy, when the patient is usually put on steroids and immunosuppressants, there is often a profound rise in blood sugar values requiring high doses of insulin. In those patients who are on dialysis, insulin requirement changes day by day, typically being high immediately after dialysis and low on other days. With the help of "smart" insulin pumps, chronic kidney disease patients can manage blood glucose day to day and day after day with different basal profiles, use the functions like extended bolus, tiny doses of rapid-acting insulin to control high blood sugars without the risk of hypoglycemia.

Frequent travelers and those with untimely food habits

In those who are frequently traveling, especially businessmen, who may be actively involved in job discussions and meetings with untimely food habits, insulin pump therapy offers complete flexibility in their lifestyles. In those who are traveling within the country or from one country to another, where time zones change, smart pump offers the advantage of switching from one profile to another with the hit of a button. Depending on the type and timing of food and change in timing of exercise, travelers with diabetes will find it quite easy to manage their sugars intelligently with the help of a pump.

Micro- or macrovascular complications where intensive glycemic control may be beneficial in the long term

The Diabetes Control and Complications Trial (DCCT),[8] the United Kingdom Prospective Diabetes Study (UKPDS),[9] Action in Diabetes and Vascular Disease: Preterax and Diamicron Modified Release Controlled Evaluation (ADVANCE),[19] and similar international trials have proved the benefits of intensive glycemic control in preventing complications of diabetes. The only demerit of an intensive management regimen is the occurrence of hypoglycemia, which can be minimized or totally avoided when proper use is made of insulin pumps. Whenever management of T2DM is attempted with a goal of preventing micro- and macrovascular complications in the long term with intensive control of glycemia, insulin pumps can be used. Patients with early diabetes complications (microalbuminuria, early retinopathy, etc.) stand to gain particularly from tight control as it will help in preventing the progression of these complications.

Continuous glucose monitoring patterns strongly suggesting the need for a variable basal insulin infusion rate

Continuous glucose monitoring (CGM) is advocated for monitoring blood glucose continuously over a period of 3–6 days or more. CGM presents data on blood sugar pattern that can never be obtained with the help of blood sugar meters. CGM is similar to a video, providing blood glucose pattern over several days, whereas self-monitoring of blood glucose can only provide values similar to that of a picture that is less descriptive. Whenever a CGM pattern strongly indicates utilization of insulin pump therapy, patients can be advised to go in for the same. The Somogyi or dawn phenomenon, clearly interpreted by CGM, can be easily resolved with changes in the basal infusion profiles of the pump. However, with the use of currently available insulins and insulin regimens, such programming of basal profiles is next to impossible.

Modern insulin pumps give us the opportunity to go for up to 48 different basal profiles; however, an average T2DM patient will usually require only three or four basal profiles for minimizing or normalizing glycemic excursions and combating the dawn or Somogyi phenomenon.

Women with poor diabetes control in the childbearing age group contemplating starting a family or who are currently pregnant

With T2DM increasingly affecting younger individuals, there has been an increase in the number of women in the childbearing age with T2DM. Tight control of blood sugars is essential for a successful pregnancy outcome in these women, and the tight control should begin before conception. The need for good control is even greater if the woman has a bad obstetric history or is undergoing assisted reproductive procedures like in vitro fertilization. Often, control of blood sugars during pregnancy is difficult because the wide fluctuations in insulin requirement due to hormonal changes. Also, both hyper- and hypoglycemia episodes are deleterious to the fetus and must be avoided. Use of an insulin pump during pregnancy can help in maintaining near-normoglycemia throughout the pregnancy.[20]

Contraindications

Psychiatric illness

The major contraindication for pump therapy in T2DM is the presence of a major psychiatric illness. Here the patient may not be comfortable wearing the device and managing the functions of the pump or with somebody else assisting him or her. Among reasons for discontinuation of insulin pump therapy in T2DM, the presence of undiagnosed psychiatric illness has been reported.[18]

If in case there is history of psychiatric illness or if the patient is already on drugs for psychosis, pumps are better avoided. Pumps offer continuous infusion of insulin even during the sleep and also offer an advantage of hitting a button to administer the bolus, which in the presence of mental illness can result in unexpectedly high dosage delivery and even death of the individual.

Absence of at least one responsible educated caregiver

The use of insulin pump in an educated intelligent patient does not require the presence of a caregiver in most cases. However, at least during the first 2–3 months after initiation of insulin pump, the presence of an educated caregiver at home or office is always advisable for assistance with procedures like changing the accessories, filling the reservoir, introducing the cannula, and learning more about the advanced uses of the pump.

Lack of time to attend pump training sessions

Before and after the initiation of pump therapy, attending structured insulin pump education classes is mandatory. For those subjects who do not have the time to attend pump classes, insulin pumps are better avoided. It has been observed that majority of affluent subjects with T2DM desire to use insulin pumps but may lack the time and motivation to attend classes. It is mandatory that they dedicate themselves to classes and learn the new technology to ensure success in therapy.

Blindness

Broadly speaking, being blind is a relative contraindication to insulin pump therapy. But, a blind patient badly in need of an insulin pump can also be put on it, provided the patient is able to identify the suspend button and the bolus button. The important functions in a pump do not require looking at the pump; it requires only that the patient learns to use the buttons properly in the right combination.

Affordability

Although India is only a developing country, the upper economic class is fast growing in numbers. India is the 11th largest economy in the world by nominal GDP and the fourth largest by purchasing power parity.[21] According to government statistics, the wealthiest citizens comprising 2% of the population command 20% of consumption, and the average income for a rich Indian is around $22,000 per annum.

However, there is wide disparity in income levels in India. An estimated 30% of the population lives on less than $2 a day. There is a high degree of cost sensitivity in the middle class and low-income families. On the other hand, more and more people are moving out of poverty. McKinsey and Co. has projected threefold growth in the size of the Indian pharmaceutical market from 2005 to 2015, driven by factors such as rising disposable incomes and an upward shift in income demographics.[22] Currently, expensive long-acting analog insulins like glargine and detemir and the rapid-acting ones like lispro, aspart, and glulisine are freely available in the Indian market.

The cost of an insulin pump ranges from $2,500 to $6,500, and the monthly cost of accessories is around $100. This relatively high cost is a basic factor that determines the adoption and long-term use of an insulin pump.

Apart from the cost of pump usage, the patient should be able to meet the cost of insulin pump accessories. The accessories need to be changed once every 3 days. Moreover, insulin pumps are not covered under any insurance policy in India. Hence there is no point at present in suggesting insulin pumps to people who cannot afford therapy.

Follow-Up Schedule

Insulin pump deployment is only a minor procedure, and the treatment actually starts with it. The patients often have a wrong notion that this expensive equipment when adopted will ultimately be a cure for their illness, whereas the fact is that insulin pump usage will incur more responsibilities, more learning, more teaching, and more frequent blood glucose estimations until the blood sugars get stabilized. The main difference between a patient with T1DM and one with T2DM is that the latter can get his or her blood glucose stabilized more rapidly and requires less basal programming. At least for the initial 1–3 months after pump insertion, close follow-up with the diabetes treatment team in the hospital is essential. The reporting should be carried out on a daily basis for at least 1 week and then on a weekly basis following the initial days of pump adoption.

The programming in the pump and changing the basal and bolus doses are done slowly and steadily so as to normalize blood sugar levels over a period of time rather than rapidly. The diabetes treatment team taking care of the patient should educate the patient and caregiver on the importance of follow-up on a regular basis, and it should be customized for each individual patient. The reportings can be later changed over to fortnightly reportings based on the patient improvement with the initiation of CSII. The follow-up can be gradually relaxed to once in a month depending upon the patient's improvement. The follow-up can be evaluated in a scientific manner by providing QOL questionnaires at the baseline followed by 3 months. Periodic CGM will also help fine-tune the sugars and decide on multiple basal profiles.

Those subjects with a previous track record of successful utilization of self-monitoring of blood glucose and regularly following up with diabetes treatment team may easily switch over to insulin pump therapy. They will also exhibit ease in learning the techniques and calculations required for pump therapy. At the end of 2–3 months the subjects should be capable of managing their glucose values and their doses of insulin, and at the end of 6 months patients should be capable of utilizing the advanced functions of the pump like carbohydrate counting, bolus wizard, etc., perfectly well. In T2DM extra intake of calories and frequent bolusing should be discouraged for fear of weight gain, dyslipidemia, and other associated abnormalities. Incorporation of a trained dietitian in the treatment team familiar with use of pump therapy is mandatory.

Institutions offering pump therapy should have adequate numbers of trained pump educators to help the patient and caregivers get comfortable with the diabetes team and also to provide advanced learning sessions that are creative and may generate awareness.

Advantages of Insulin Pump Therapy

The following improvements can be reasonably expected following initiation of insulin pump therapy:

- Improvement in HbA1c
- Reduction in blood sugar fluctuations
- Reduction in major and minor hypoglycemic episodes
- Improvement in neuropathic pain and sexual function
- Reduction in total daily dose of insulin
- Improvement in QOL

Disadvantages of Insulin Pump Therapy

- Cost of pumps and consumables is beyond the reach of the common individual.
- There is a risk of infection if the cannula is not changed once in every 3 days.
- Overeating and frequent bolusing could result in weight gain and misuse of an insulin pump.
- Improper use of insulin pump boluses can lead to insulin stacking and low sugars.

Mechanical failure of the pump does not carry the same implications in T2DM as in T1DM because the former usually have sufficient endogenous insulin to prevent the development of ketoacidosis. Nevertheless, patients should be trained to check the pump for malfunction (and the canula for kinking) if blood sugars are found unexpectedly high at any time. They should also keep a stock of regular insulin in conventional delivery devices handy at home at all times, for temporary use in case of pump failure.

The Ideal Candidates for Insulin Pumps

Educated, motivated, affordable

Patients using an insulin pump should have a minimum educational status. The patient should be capable of learning the techniques, functions of the pump, and calculating his or her bolus doses in accordance with their diet, and this requires a scientific aptitude to know the excursions of their blood sugars and the management of the same with the pump. Motivation is another essential factor that should go hand in hand with the learning skills of the patient as it determines the compliance and enhances QOL of the patient. An educated person cannot be considered as an ideal candidate if his or her level of motivation is so low that he or she considers the pump only as an expensive alternative to treat diabetes without the willingness to learn in-depth. Affordability to an insulin pump should not be used as a yardstick for the selection of an ideal candidate because motivation and self learning skills are more important factors for future success in therapy.

Comfortable with gadgets and devices

A certain level of comfort with modern gadgets and devices is necessary for the patient to get the most out of his pump. An educated pumper may be tech-savvy to adhere to the pump software interface so that he or she can program doses in accordance with his or her own insulin requirements. Such a patient can even download his or her CGM data using a PC.

Responsible caregiver

The success of insulin pump therapy and follow-up largely depends on the contribution of a responsible caregiver. A responsible caregiver should be more trained, educated, and motivated than the patient him- or herself. After the pump adoption, during the initial days the pumper may require the assistance of a dedicated caregiver to manage the various options in an insulin pump like changing the insulin reservoir, infusion set, and the sensor needle and dealing with the different basal and bolus profiles. A caregiver can always motivate the patient to adhere to strict lifestyle modifications including diet and exercise and can also act as a leading hand for recurrent, periodic patient follow-ups.

Impressive track record (regular self-monitoring of blood glucose and follow-up)

Patients who are regular in their follow-up and who monitor their blood sugars on a regular basis while on MDI can be expected to show the same enthusiasm when switched over to an insulin pump.

Willing to learn and follow instructions

A prime quality that a patient on an insulin pump should possess is the willingness to learn and cooperate with the diabetes treatment team to ensure that the patient is capable of using the pump and its features properly. The patient should be motivated to contact the healthcare team at any moment in case of emergencies like pump malfunction, cannula problems, miscalculated insulin dosages, etc., and to handle the situation effectively.

Self-management

Self-management is an art that includes the subject managing the pump efficiently without intervening with his or her routine activities. The patient him- or herself should be comfortable with the pump like concealing the pump if he or she wishes so and protecting the pump from adverse conditions like excessive heat and humidity.

Cultural Adaptations to Insulin Pumps in India

Costumes and dressing styles in India differ from those in the West. Within India itself the language and traditional dressing styles differ from state to state. Most of the population wear traditional Asian outfits, like *dhoti* (a long, rectangular piece of unstitched cloth, wrapped around the waist and the legs) for men and apparel like *sari* and *churidar* for women.

FIG. 1. Pump being hooked on to a string around the neck by an Indian Saint.

FIG. 2. A waist belt cum pump pouch made of cloth designed by a patient wearing a *dhothi*.

For men and women who choose to use an insulin pump, the underlying debate is, primarily, the placement and appearance of the insulin pump and how it will be best camouflaged by clothing. However, a large number of pumpers (mostly those with T1DM) wear it externally on the waist belt with no concerns or embarrassment of others knowing about it. People in India are getting used to modern gadgets, with the widespread use of mobile phones among all economic strata being a notable example.

It may be of interest to readers that pumpers in India have discovered their own ways (Fig. 1) and means of concealing the pump by designing a belt cum pump pouch (Fig. 2), discreetly positioning it within a pocket behind the original pocket or at the anterior pocket of the underwear. Because the pump is a relatively small device, female patients with diabetes are at ease camouflaging the device, making insulin pump therapy very appealing. The *sari* is a flexible ethnic wear among Indian ladies, and each woman may design her own mode of pump-concealing techniques. The pump can be conveniently tucked within the inner garments or in the pocket of an undergarment (Fig. 3). The Indian ethnic wear like the *salwar* or *churidhar* are also so designed as to accommodate the pump by stitching side pockets to the apparel.

FIG. 3. Discreet positioning of the pump within a pouch worn above the undergarment.

Conclusions

Recent studies have shown benefits of CSII in both T1DM and T2DM. In India and developing countries, insulin pump therapy is fast catching up. The absence of reimbursement and insurance coverage has restricted the use of pumps to those who can afford to pay out of pocket. On the other hand, all signs point towards increasing affordability among patients in many emerging economies. However, it is not just affordability, but a multitude of factors that decide success in long-term therapy. Hence we have suggested guidelines to identify right candidates and exclude inappropriate indications.

Author Disclosure Statement

No competing financial interests exist.

References

1. National Institute for Health and Clinical Excellence: Technology Appraisal Guidance Number 151: Continuous Subcutaneous Insulin Infusion for the Treatment of Diabetes Mellitus. London: National Institute for Health and Clinical Excellence, 2008.
2. American Diabetes Association: Executive summary: standards of medical care in diabetes—2010. Diabetes Care 2010;33(Suppl 1):S4–S10.
3. International Diabetes Federation 2005 Clinical Guidelines Task Force. Global Guideline for T2 Diabetes. www.idf.org/webdata/docs/GGT2D%2010%20Insulin%20therapy.pdf (accessed April 27, 2010).
4. Lorenzo C, Wagenknecht LE, D'Agostino RB JR, Rewers MJ, Karter AJ, Haffner SM: Insulin resistance, beta-cell dysfunction, and conversion to type 2 diabetes in a multiethnic population: the Insulin Resistance Atherosclerosis Study. Diabetes Care 2010;33:67–72.
5. American Diabetes Association: Standards of medical care in diabetes—2009. Diabetes Care 2009;32(Suppl 1):S13–S61.
6. Monnier L, Colette C: Glycemic variability: should we and can we prevent it? Diabetes Care 2008;31(Suppl 2):S150–S154.
7. Kesavadev J, Rasheed SA: Dramatic response of painful peripheral neuropathy with insulin pump in type 2 diabetes [abstract 2097-PO]. professional.diabetes.org/Abstracts_Display.aspx?TYP=1&CID=55571 (accessed January 30, 2010).
8. The effect of intensive treatment of diabetes on the development and progression of long-term complications in insulin-dependent diabetes mellitus. The Diabetes Control and Complications Trial Research Group. N Engl J Med 1993;329:977–986.

9. Intensive blood-glucose control with sulphonylureas or insulin compared with conventional treatment and risk of complications in patients with type 2 diabetes (UKPDS 33). UK Prospective Diabetes Study (UKPDS) Group. Lancet 1998;352:837–853.
10. Hammond P: NICE guidance on insulin pump therapy: time for a re-appraisal? Pract Diabetes Int 2005;22:115–116.
11. Sudhakaran C, Anjana RM, Rao K, Unnikrishnan R 1st, Suresh T, Mohan V: Role of continuous subcutaneous insulin infusion in patients with recalcitrant diabetes in South India. Diabetes Technol Ther 2009;11:733–737.
12. Bode BW: Use of rapid-acting insulin analogues in the treatment of patients with type 1 and type 2 diabetes mellitus: Insulin pump therapy versus multiple daily injections. Clin Ther 2007;29(Suppl 4):S135–S144.
13. Pickup JC, Renard E: Long-acting insulin analogs versus insulin pump therapy for the treatment of type 1 and type 2 diabetes. Diabetes Care 2008;31(Suppl 2):S140–S145.
14. Mohan V, Shyamsunder R, Ramchandran A, Snehalatha C, Viswanathan M: Experience with insulin pump treatment in Indian diabetics. A preliminary report. J Assoc Physicians India 1983;31:715–717.
15. Kesavadev J, Balakrishnan S, Ahammed S, Jothydev S: Reduction of glycosylated hemoglobin following 6 months of continuous subcutaneous insulin infusion in an Indian population with type 2 diabetes. Diabetes Technol Ther 2009;11:517–521.
16. Wainstein J, Metzger M, Wexler ID, Cohen J, Raz I: The use of continuous insulin delivery systems in severely insulin-resistant patients. Diabetes Care 2001;24:1299.
17. Benbow SJ, Walsh A, Gill GV: Brittle diabetes in the elderly. J R Soc Med 2001;94:578–580.
18. Kesavadev J, Kumar A, Ahammed S, Jothydev S: Experiences with insulin pump in 52 patients with type 2 diabetes in India [abstract 2021-PO]. professional.diabetes.org/Abstracts_Display.aspx?TYP=1&CID=70361 (accessed January 30, 2010).
19. The ADVANCE Collaborative Group. Intensive blood glucose control and vascular outcomes in patients with type 2 diabetes. N Engl J Med 2008;358:2560–2572.
20. IDF Clinical Guidelines Task Force. Global Guideline on Pregnancy and Diabetes. Brussels: International Diabetes Federation, 2009. www.idf.org/webdata/docs/Pregnancy_EN_RTP.pdf (accessed April 28, 2010).
21. www.cia.gov/library/publications/the-world-factbook/rankorder/2001rank.html (accessed April 2, 2010).
22. India Pharma 2015: Unlocking the Potential of the Indian Pharmaceuticals Market. New York: Pharmaceuticals & Medical Products Practice, McKinsey & Co., 2007.

Address correspondence to:
Jothydev Kesavadev, M.D.
Jothydev's Diabetes & Research Center
JDC Junction
Trivandrum, Kerala, India 695032

E-mail: jothydev@vsnl.com
jothydev@gmail.com