

# Insulin pump

**Insulin pump** is an electronic device operating on the principle of **continuous subcutaneous insulin infusion** (continuous subcutaneous insulin infusion = **CSII**/The Insulin Pump). It is used to treat, or rather to compensate, disease diabetes mellitus.

## Pump components:

- control unit (checks the position of the piston, dispenses in the order of 0.01 IU);
- insulin reservoir (reservoir/cartridge) with a volume of 2-3 ml (ie 200-300 IU);
- infusion set (cannula + catheter).

The control unit is its own electronic device, which consists of a microprocessor, a printed circuit board (DPS), a motor, a piston, a battery, a display and buttons. The stepper motor moves the piston, which pushes the insulin from the reservoir into the catheter to the cannula inserted into the subcutaneous tissue.

## Basal-bolus

In treatment with an insulin pump, **insulin is dosed by infusion in the basal-bolus mode**. The pump uses one type of insulin for both basal and bolus. It is a fast-acting insulin analogue.

In treatment with an insulin pen, insulin is dosed by injection several times a day (multiple daily injections - **MDI**), where the injections use a fast-acting analog to correct blood glucose and a slow-acting analog to cover the basal need for insulin, so that it can work evenly over a 24-hour period.

The concept of an insulin pump as a continuous infusion thus better mimics the physiological secretion of insulin.

## Basal

- It covers the body's basal need for insulin.
- It is administered in the form of microdoses throughout the day (approx. 2 to 3 minutes between individual infusions).
- The size of the microdose is set according to the physiological need and daily activity, which changes during the day.
- The pump allows you to set **basal profiles**, e.g. for weekdays and weekends, as well as a **temporary basal dose** (DBD) - i.e. an increase in basal (due to an increased need for insulin in connection with illness or menstruation) or a decrease in basal (during sports, when the need decreases - physical activity reduces insulin resistance and thereby increases the effect of insulin).

## Bolus

- It is a one-time larger dose.
- We divide into individual types:
  1. **prandial** covers the rise in blood glucose and is given before/with/after a meal according to baseline blood glucose;
  2. **corrective** is intended for the correction of hyperglycemia, the so-called "supplement" is given between meals or after replacing a malfunctioning infusion set (due to, for example, a bent cannula);
  3. **a filing** bolus fills the cannula when introducing a new infusion set (the software does not count this bolus into the daily dose).
- Method of administration:
  1. normaln ("classic"),
  2. spread out,
  3. combined (normal, then spread),
  4. superbolus (higher bolus of normal bolus, then basal reduction).
- Insulin pumps usually have a bolus calculator that, using correctly set parameters, can very accurately recommend the bolus dose, the accuracy depends on the entered values of the ISF (insulin sensitivity factor) and CIR (carbohydrate to insulin ratio) factors according to the given formulas, another parameter is the CDDI (total daily dose of insulin monitored by the pump software), setting of basal doses, time of active insulin and target blood glucose range.

# Treatment with an insulin pump

Treatment of CSII is recommended by the attending diabetologist at the diabetes center. What is important is the patient's motivation and willingness to cooperate, the possibility of consultation with the medical facility or the distributor company's helpline. The insulin pump is covered by the insurance company based on the decision of the examining physician.

## Indications (podle AADE - American Association of Diabetes Educators)

**Suitable patients are those who have:**

- HbA1c higher than 7% DCCT (53 mmol/mol) + numerous severe hypoglycemia;
- hypoglycemic episodes that require another person and that affect the patient at work, school or family;
- sharp changes in blood sugar;
- difficulties in achieving personal and work goals.

**Division of suitable patients into groups:**

- **Group 1** - patients with DM1 treated with MDI, cooperate and measure their glycemia, but in whom the diabetes is labile, there is a risk of ketoacidosis in fluctuations, they often have hypoglycemia or do not recognize it, the dawn phenomenon is present (i.e. the phenomenon when counterregulatory hormones increase glycemia in the morning - by setting the basal profile, morning hyperglycemia is avoided), they are extremely sensitive to insulin or it is pregnancy or elite sports.
- **Group 2** - patients with DM1 treated with MDI who are interested in CSII therapy, regardless of compensation with current treatment.
- **Group 3** - patients with DM2 requiring insulin therapy and meeting one of the following conditions: compensation is suboptimal with MDI, dawn phenomenon is present, they have an irregular daily routine, they have significant insulin resistance; patients with another type of diabetes (e.g. after pancreatectomy).

## Contraindications

according to the Czech Diabetes Society and its standard

- After failure to meet expectations from the start of treatment, effectiveness is continuously evaluated (the achievement of the target HbA1c is monitored).
- Serious psychiatric illness or drug addiction that does not allow for reliable control of the pump and control of diabetes.
- Inability to cooperate and consult.
- Severe vision and/or fine motor impairments, unless another person can help.
- Bad hygiene habits.

## Education

- More time consuming than other insulin therapies.
- The patient must be able to determine the nutritional composition of food, perform self monitoring ([https://www.wikiskripta.eu/w/Selfmonitoring\\_glykemie](https://www.wikiskripta.eu/w/Selfmonitoring_glykemie)) - i.e. blood glucose measurement at least 4 times a day, optimally 6-8 times.

## Device selection

- The patient should have the possibility of consultation with the doctor and the possibility of free choice in the selection of the device.
- There are several manufacturers on the Czech market (pump model in brackets) such as:
  - Roche (Accu-check Insight),
  - Animas Corporation (Animas Vibe),
  - Ypsomed (YpsoPump),
  - SOOIL (Dana Diabecare R),
  - Medtronic (MiniMed 640G).
- When choosing, the size of the reservoir and the use of the function of continuous glucose measurement (**CGM** - Continuous Glucose Monitoring), which can be a part of the insulin pump, must be considered.



Photo of an insulin pump and its application

- The patient also chooses infusion sets– cannulas can be Teflon or metal, with different inclinations and lengths; Catheters can also be of different lengths.

## Traffic

- The infusion set with Teflon cannula should be changed every 3 days, with metal cannula every 2 days.
- Check for air bubbles in the catheter and cannula application site.
- Compliance with hygiene rules during application.
- Placing the pump at an appropriate height to the cannula so that the dosing rate is not affected.
- The pump enables simple and quick disconnection of the catheter from the cannula (e.g. when bathing), the cap is placed on the free cannula.
- Contact of the fixation patch with water leads to premature peeling.

**Alarms** notify if:

- running out of insulin,
- low battery,
- clogging of the system,
- empty tray.

**The pump** is connected to the **CGM** in case of hypoglycemia or hyperglycemia. The whole set also includes cases, clips, tapes, colored stickers.

## Application Locations

The patient should regularly rotate the application sites and take care of them (with cream, and massages). The doctor must look at these places during the check-up. Inserting the cannula into the same places leads to damage to the subcutaneous tissue, which makes it harder for insulin to be absorbed.

**Subcutaneous application:** abdomen, hips, buttocks, outer side of the arm, outer side of the thigh.

**Intraperitoneal:** the administration of insulin is physiological, but not extended due to the difficulty in terms of the application itself and possible peritonitis.

## Side effects and complications

- Some limitations in sports or love life (discomfort score low in the study).
- In patients with a significantly higher BMI , the initiation of therapy to compensate for diabetes did not help (according to an English study).
- Damaged subcutaneous tissue and related impaired absorption of insulin in the given area and cosmetic defects.
- Lipohypertrophy at the site of frequent cannula application.
- Local infection.
- Inducing fear in the surroundings, explaining during security checks, e.g. at the airport.

## Conclusion

Treatment with an insulin pump is clearly beneficial, although most patients do not use the full potential that the insulin pump offers (bolus calculator, temporary basal dose). 93% of the interviewed patients are satisfied with the treatment, 88% would not like to end the therapy. One of the reasons why diabetes compensation does not improve may be the patient's lack of awareness or laziness. It would make sense to help such patients with an individual approach and education.

## News in development

Currently, a new method of treatment based on the principles of the insulin pump is being developed under the name Bionic pancreas . This new method uses the basic principles of an insulin pump, but uses glucagon in addition to insulin for more precise regulation.

## Links

- ws:Inzulínová pumpa

## Related articles

- Diabetes mellitus 1. type (endocrinology)
- Diabetes mellitus 1. type (biochemistry)
- Diabetes mellitus 2. type (endocrinology)
- Diabetes mellitus 2. type (biochemistry)
- Continuous blood glucose measurement

- Bionic pancreas

## Resources

- ŠTECHOVÁ, Kateřina, et al. *Technologie v diabetologii*. první? edition. Praha : Maxdorf s. r. o, 2016. 168 pp. ISBN 978-80-7345-479-1.
- HOLUBOVÁ, Anna. *Technologie pro inzulínoterapii* [lecture for subject Pokročilé technologie v diabetologii, specialization všeobecné lékařství, 1. lékařská fakulta Univerzita Karlova]. Praha. 9.11.2016. Avaliable from <<http://www.albertov.cz/wp-content/uploads/2018/03/Technologie-pro-léčbu-inzulínem.pdf>>.