

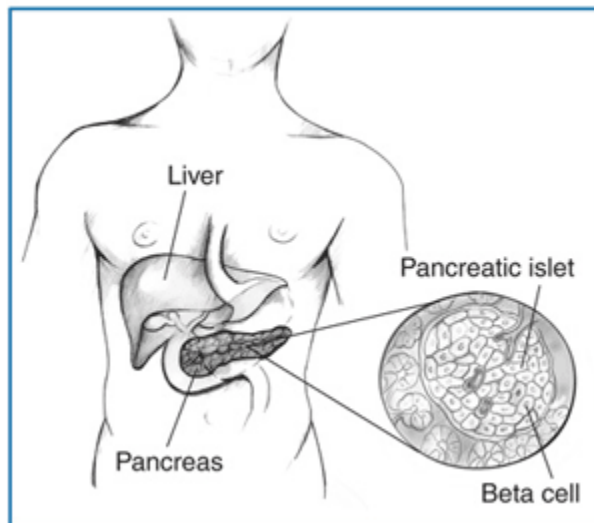
Pancreatic Islet Transplantation

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What are pancreatic islets?

Pancreatic islets, also called islets of Langerhans, are tiny clusters of cells scattered throughout the pancreas. The pancreas is an organ about the size of a hand located behind the lower part of the stomach.

Pancreatic islets contain several types of cells, including beta cells, that produce the hormone insulin. The pancreas also makes enzymes that help the body digest and use food.



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When the level of blood glucose, also called blood sugar, rises after a meal, the pancreas responds by releasing insulin into the bloodstream. Insulin helps cells throughout the body absorb glucose from the bloodstream and use it for energy.

Diabetes develops when the pancreas does not make enough insulin, the body's cells do not use insulin effectively, or both. As a result, glucose builds up in the blood instead of being absorbed by cells in the body.

In type 1 diabetes, the beta cells of the pancreas no longer make insulin because the body's immune system has attacked and destroyed them. The immune system protects people from infection by identifying and destroying bacteria, viruses, and other potentially harmful foreign substances. A person who has type 1 diabetes must take insulin daily to live. Type 2 diabetes usually begins with a condition called insulin resistance, in which the body has trouble using insulin effectively. Over time, insulin production declines as well, so many people with type 2 diabetes eventually need to take insulin.

What is pancreatic islet transplantation?

The two types of pancreatic islet transplantation are

- allo-transplantation
- auto-transplantation

Pancreatic islet allo-transplantation is a procedure in which islets from the pancreas of a deceased organ donor are purified, processed, and transferred into another person. Pancreatic islet allo-transplantation is currently labeled an experimental procedure until the transplantation technology is considered successful enough to be labeled therapeutic. For more information, see the section "[What are the obstacles to pancreatic islet allo-transplantation?](#)"

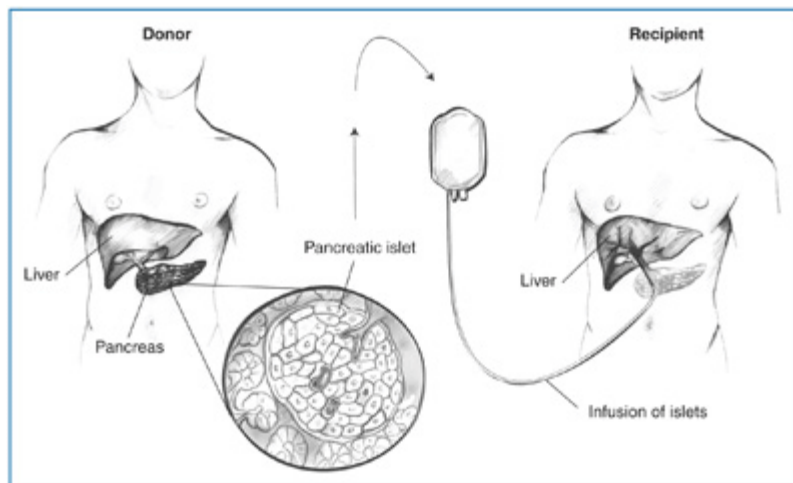
For each pancreatic islet allo-transplant infusion, researchers use specialized enzymes to remove islets from the pancreas of a single, deceased donor. The islets are purified and counted in a lab. Transplant patients typically receive two infusions with an average of 400,000 to 500,000 islets per infusion. Once implanted, the beta cells in these islets begin to make and release insulin.

Pancreatic islet allo-transplantation is performed in certain patients with type 1 diabetes whose blood glucose levels are difficult to control. The goals of the transplant are to help these patients achieve normal blood glucose levels with or without daily injections of insulin and to reduce or eliminate hypoglycemia unawareness—a dangerous condition in which a person with diabetes cannot feel the symptoms of hypoglycemia, or low blood glucose. When a person feels the symptoms of hypoglycemia, steps can be taken to bring blood glucose levels back to normal.

Pancreatic islet allo-transplants are only performed at hospitals that have received permission from the U.S. Food and Drug Administration (FDA) for clinical research on islet transplantation. The transplants are

often performed by a radiologist—a doctor who specializes in medical imaging. The radiologist uses x rays and ultrasound to guide the placement of a thin, flexible tube called a catheter through a small incision in the upper abdomen—the area between the chest and hips—and into the portal vein of the liver. The portal vein is the major vein that supplies blood to the liver. The islets are then infused, or pushed, slowly into the liver through the catheter. Usually, the patient receives a local anesthetic and a sedative. In some cases, a surgeon performs the transplant using general anesthesia.

Patients often need two or more transplants to get enough functioning islets to stop or reduce their need for insulin injections.



Pancreatic islet allo-transplantation (above). In islet auto-transplantation, the islets are extracted from the patient's own pancreas.

Pancreatic islet auto-transplantation is performed following total pancreatectomy—the surgical removal of the whole pancreas—in patients with severe and chronic, or long lasting, pancreatitis that cannot be managed by other treatments. This procedure is not considered experimental. Patients with type 1 diabetes cannot receive pancreatic islet auto-transplantation. The procedure is performed in a hospital, and the patient receives general anesthesia. The surgeon first removes the pancreas and then extracts and purifies islets from the pancreas. Within hours, the islets are infused through a catheter into the patient's liver. The goal is to give the body enough healthy islets to make insulin.

What happens after pancreatic islet transplantation?

Pancreatic islets begin to release insulin soon after transplantation. However, full islet function and new blood vessel growth from the new islets take time. Transplant recipients usually take insulin injections until the islets are fully functional. They may also receive various medications before and after transplantation to promote successful implantation and long-term functioning of the islets. However, the

autoimmune response that destroyed transplant recipients' own islets in the first place can happen again and attack the transplanted islets. Although the liver has been the traditional site for infusing the donor islets, researchers are investigating alternative sites, such as muscle tissue or another organ.

What are the benefits and risks of pancreatic islet allo-transplantation?

The benefits of pancreatic islet allo-transplantation include improved blood glucose control, reducing or eliminating the need for insulin injections to control diabetes, and preventing hypoglycemia. An alternative to islet transplantation is whole organ pancreas transplantation that is performed most often with kidney transplantation. The advantages of whole organ pancreas transplantation are less dependence on insulin and longer duration of organ function. The main disadvantage is that a whole organ transplant is a major surgery that involves a greater risk of complications and even death.

Pancreatic islet allo-transplantation can also help reverse hypoglycemia unawareness. Research has shown that even partial islet function after a transplant can eliminate hypoglycemia unawareness.

Improved blood glucose control from a successful allo-transplant may also slow or prevent the progression of diabetes problems, such as heart disease, kidney disease, and nerve or eye damage. Research to evaluate this possibility is ongoing.

The risks of pancreatic islet allo-transplantation include the risks associated with the transplant procedure—particularly bleeding and blood clots. The transplanted islets may not function well or may stop functioning entirely. Other risks are the side effects from the immunosuppressive medications that transplant recipients must take to stop the immune system from rejecting the transplanted islets. When a patient has received a kidney transplant and is already taking immunosuppressive medications, the only additional risks are the islet infusion and the side effects from the immunosuppressive medications given at the time of allo-transplantation. Immunosuppressive medications are not needed in the case of an auto-transplant because the infused cells come from the patient's own body. Read more in the section ["What is the role of immunosuppressive medications?"](#)

Collaborative Islet Transplant Registry Data

In its 2010 annual report,¹ the Collaborative Islet Transplant Registry presented data on 571 patients who received pancreatic islet allo-transplants between 1999 and 2009. Although most procedures were pancreatic islet allo-transplants alone, 90 procedures were done in conjunction with a kidney transplant. The majority of the islet transplant patients received one or two infusions of islets; at the end of the decade, the average number of islets received per infusion was 463,000.


According to the report, about 60 percent of transplant recipients achieved insulin independence—defined as being able to stop insulin injections for at least 14 days—during the year following transplantation.

By the end of the second year, 50 percent of recipients were able to stop taking insulin for at least 14 days. However, long-term insulin independence is difficult to maintain, and eventually most recipients needed to start taking insulin again.

The report identified factors linked to better outcomes for recipients, including

- age—35 years or older
- lower pre-transplant triglyceride, or blood fat, levels
- lower pre-transplant insulin use

The report noted that even partial function of the transplanted islets can improve blood glucose control and reduce the amount of insulin needed after loss of insulin independence.

¹Collaborative Islet Transplant Registry seventh annual report. Collaborative Islet Transplant Registry website.  https://web.emmes.com/study/isl//reports/01062012_7thAnnualReport.pdf External Link Disclaimer (PDF, 8,387 KB). Updated December 30, 2011. Accessed July 23, 2013.

What is the role of immunosuppressive medications?

Immunosuppressive medications are needed to prevent rejection—a common problem with any transplant.

Scientists have made many advances in islet transplantation in recent years. In 2000, islet transplantation researchers at the University of Alberta in Edmonton, Canada, reported their findings in the *New England Journal of Medicine*. Their transplant protocol, known as the Edmonton protocol, has since been adapted by transplant centers around the world and continues to be refined.

The Edmonton protocol introduced the use of a new combination of immunosuppressive medications, also called anti-rejection medications, including daclizumab (Zenapax), sirolimus (Rapamune), and tacrolimus (Prograf). Researchers continue to develop and study modifications to the Edmonton protocol, including improved medication regimens that promote successful transplants. Medication regimens vary from one transplant center to another. Examples of other immunosuppressive medications used in islet transplantation include antithymocyte globulin (Thymoglobulin), alemtuzumab (Campath), basiliximab (Simulect), belatacept (Nulojix), etanercept (Enbrel), everolimus (Zortress), and mycophenolate mofetil (CellCept, Myfortic). Researchers are also evaluating nonimmunosuppressive medications, such as exenatide (Byetta) and sitagliptin (Januvia).

Immunosuppressive medications have significant side effects, and their long-term effects are still not fully known. Immediate side effects may include mouth sores and gastrointestinal problems, such as upset stomach and diarrhea. Patients may also have

- increased blood cholesterol, or blood fat, levels
- high blood pressure
- anemia, a condition in which red blood cells are fewer or smaller than normal, which prevents the body's cells from getting enough oxygen
- fatigue
- decreased white blood cell counts
- decreased kidney function
- increased susceptibility to bacterial and viral infections

Taking immunosuppressive medications also increases the risk of developing certain tumors and cancers.

Scientists are seeking ways to achieve immune tolerance of the transplanted islets, in which the patient's immune system no longer recognizes the islets as foreign. Immune tolerance would allow patients to maintain transplanted islets without long-term use of immunosuppressive medications. For example, one approach is to transplant islets encapsulated with a special coating, which may help to prevent rejection.

What are the obstacles to pancreatic islet allo-transplantation?

The shortage of islets from donors is a significant obstacle to widespread use of pancreatic islet allo-transplantation. According to the Organ Procurement and Transplantation Network, in 2011 there were about 8,000 deceased organ donors available in the United States.² However, only 1,562 pancreases were recovered from donors in 2011.² Also, many donated pancreases are not suitable for extracting islets for transplants because they do not meet the selection criteria, and islets are often damaged or destroyed during processing. Therefore, only a small number of islet transplants can be performed each year.

Researchers are pursuing various approaches to solve this shortage of islets, such as transplanting islets from a single, donated pancreas, using only a portion of the pancreas from a living donor, or using islets from pigs. Researchers have transplanted pig islets into other animals, including monkeys, by encapsulating the islets with a special coating or by using medications to prevent rejection. Another approach is creating islets from other types of cells, such as stem cells. New technologies could then be employed to grow islets in the lab.

Financial barriers also prevent the widespread use of islet allo-transplantation. Until the transplantation technology is considered successful enough to be labeled therapeutic rather than experimental, the costs of islet allo-transplants must be covered by research funds. Health insurance companies and Medicare generally do not cover experimental procedures. Federal law also does not allow health care providers or hospitals to charge patients or health insurance companies for research procedures. Some patient advocates and islet researchers feel that islet allo-transplantation is close to having a therapeutic label. The National Institutes of Health (NIH) currently supports studies that are working toward obtaining FDA licensure to reclassify islet allo-transplantation as therapeutic. In other countries, such as Canada and Scandinavia, islet allo-transplantation is no longer considered experimental and is an accepted therapy in certain patients.

²National data. Organ Procurement and Transplantation Network website.

<http://optn.transplant.hrsa.gov/latestData/step2.asp>[External Link Disclaimer](#). Accessed July 23, 2013.

Eating, Diet, and Nutrition

A person who receives a pancreatic islet transplant should follow a meal plan worked out with a health care provider and dietitian. Immunosuppressive medications taken after the transplant can cause changes in a person's body, such as weight gain. A healthy diet after the transplant is important to control weight gain, blood pressure, blood cholesterol, and blood glucose levels.

Points to Remember

- Pancreatic islets, also called islets of Langerhans, are tiny clusters of cells scattered throughout the pancreas. Pancreatic islets contain several types of cells, including beta cells, that produce the hormone insulin. Insulin helps cells throughout the body absorb glucose from the bloodstream and use it for energy.
- Pancreatic islet allo-transplantation is a procedure in which islets from the pancreas of a deceased organ donor are purified, processed, and transferred into another person.
- Pancreatic islet allo-transplantation is performed in certain patients with type 1 diabetes whose blood glucose levels are difficult to control. The goals of the transplant are to help these patients achieve normal blood glucose levels with or without daily injections of insulin and to reduce or eliminate hypoglycemia unawareness.
- Pancreatic islet auto-transplantation is performed following total pancreatectomy in patients with severe and chronic pancreatitis that cannot be managed by other treatments. This procedure is not considered experimental. Patients with type 1 diabetes cannot receive pancreatic islet auto-transplantation.

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The NIDDK would like to thank:

Marlon Levy, M.D., medical director of the Pancreas and Islet Cell Laboratory, Baylor University Medical Center and Baylor All Saints Medical Center

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September 2013