



## **A** ventricular assist device is a ray of hope for patients with chronic congestive heart failure

Heart disease is a major cause of death in developed countries, and in Japan, it is one of the top three causes of death along with cancer and stroke. The most common and difficult heart disease to treat is congestive heart failure, where the pumping ability of the heart decreases, and blood does not reach the entire body.

The most effective treatment is a heart transplant, but there is always a shortage of organ donors. The ray of hope for patients suffering from this condition is **circulatory assistance with a ventricular assist device**.

## **I**n 1991, NTN developed a revolutionary blood pump that uses a magnetic force to levitate an impeller

Previously, blood pumps for artificial hearts were pulsatile pump that simulated the motion of a heart, but this type of heart was expensive and it was difficult to reduce its size. In recent years, continuous-flow blood pumps, which have fewer parts and can be miniaturized, has been receiving

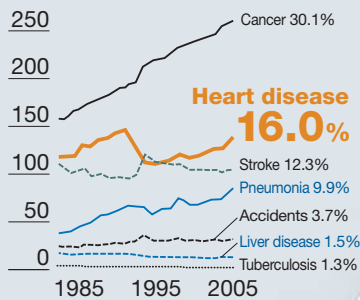
attention as an option that increases the QOL (Quality of Life) of patients.

However, these continuous-flow pumps also have drawbacks. When the bearings supporting the impeller that is used to pump blood all over the body and seals are in the pump chamber, these parts interfere with the flow of blood, increasing the chances of blood clots. In addition, the friction of the bearing crushes the cell membrane of the red blood cells, which generates hemolysis.

NTN focused on this problem and applied the magnetically levitated bearing technology for the use in the clean rooms used in a semiconductor manufacturing process where not even fine particles of dust are permitted. In 1991, NTN teamed up with Professor Teruaki Akamatsu (currently a Professor Emeritus at Kyoto University), a world authority on assistive artificial hearts, to develop a **“centrifugal blood pump with magnetic levitation technology for ventricular assist devices.”** In this revolutionary system, the position of the impeller is detected with sensors and the impeller is levitated with electromagnets, allowing the bearing and seal to be completely removed from the pump chamber.

**Causes of death (2005)**

(per 100,000 people)



Ministry of Health, Labor, and Welfare  
2005 Vital statistics overview

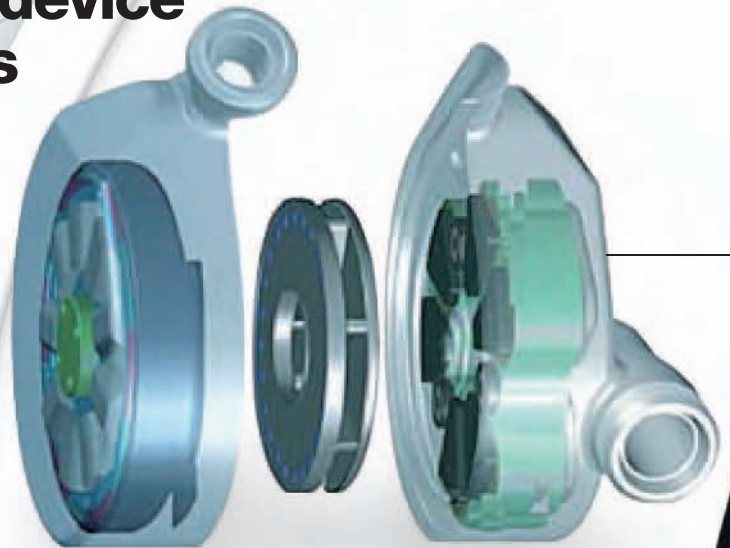
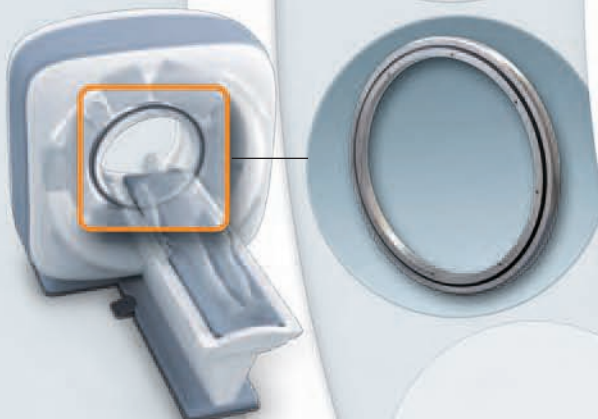
# Using our unique magnetic bearing technology in a ventricular assist device for transplant patients

NTN's non-contact bearing technology is used in the blood pump of an artificial heart.

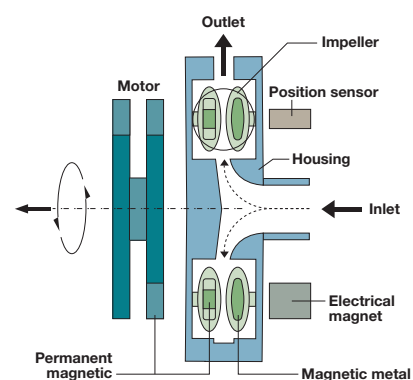
## Bearings play a part in the medical field in CT scanner technology

NTN not only supplies specialized parts for artificial hearts, but also for CT scanners, which are important medical diagnostic tools.

There are high expectations for NTN bearings as an important part underpinning smooth motion in CT scanners with increased speed and diversification.



**Structure of a centrifugal blood pump with magnetic levitation technology for ventricular assist devices**



This innovation solved the problems with conventional blood pumps.

## Sales of our implanted artificial hearts start in Europe; Clinical trials start in the US and Japan

After that, we started a partnership with **Kyoto University and TERUMO CORPORATION, a major manufacturer of medical equipment** to research and develop a implantable artificial heart that lasts for long-term patient support. The three partners created various types of prototypes and carried out animal tests in order to demonstrate that this non-contact bearing technology can provide high durability and resist blood clots. We also confirmed through durability testing that the levitation of the impeller remained stable even when subjected to intense vibration during exercise.

After that, we carried out two types of animal testing – one using an external device and one with an implanted device – and we achieved the world record for the longest continuous operation of a continuous-flow pump. TERUMO CORPORATION, moved their R&D facilities to the US in 2000, and

clinical trials started in Germany in January 2004. Thirty-three patients used our products and we are monitoring their effectiveness and reliability. Then in August 2007, the devices became available in Europe as the **Dura Heart**, and clinical trials are also planned in the US and Japan.

We will continue to improve our magnetic bearing technology to improve the quality of life for patients.



## Saving patients with severe heart failure – the dream that we shared with NTN became the key to success



**Chisato Nojiri, M.D., PhD,**  
Senior Executive Officer,  
Terumo Corporation  
Chairman & CEO, Terumo Heart, Inc.

Awarded "2008 Woman of the Year" by the women's magazine Nikkei Woman. (Japanese technology goes out into the world: The development of a durable and commercially viable ventricular assist device)

The development of artificial hearts requires various fundamental technologies (including material, electrical, mechanical, and software technologies). The **Dura Heart** is a device that was made possible by bringing together NTN's strengths with those of Terumo, but neither company has ever had a product that took over 10 years to develop and bring to market.

A variety of technologies (material, electricity, machine, and software, etc.) are necessary for the development of the artificial heart.

In 2007, we were able to commercialize this product in Europe. We believe that it is our mission to provide patients suffering from heart failure all over the world with even better artificial hearts. We plan to add more improvements to make this heart easier to use for patients and to work on the 2nd generation **Dura Heart** with NTN.

## We joined forces with NTN engineers, who brought superb technical skills to the table to develop this product

When I first saw the magnetic levitation pump on a sheep, I had my doubts about whether we could really make it compact enough to implant. After that, however, I saw firsthand the technical prowess of NTN and my doubts disappeared.

Even though we have different specialties, we were all able to learn from one another, and it was great to be able to develop this product with a sense of unity.

**Takehisa Mori**  
Research Manager, R&D Center  
Terumo Corporation

