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The German Heart Centre, Munich (DHM) at the Technical University of Munich is one of the most modern specialised centres in Germany for the treatment of cardiovascular disease in adults and children. The free State of Bavaria is the responsible body for this hospital. Three highly specialised clinics (the Clinic for Cardiovascular Surgery, the Clinic for Cardiovascular Disease and the Clinic for Paediatric Cardiology and Congenital Cardiac Defects) as well as three institutes (the Institute of Anaesthesiology, Radiology and Nuclear Medicine and the Institute of Laboratory Medicine) are all located at a single facility.
Outstanding achievements of the Clinic for Cardiovascular Surgery

- First successful heart transplant in Germany on May 7th, 1981
- First totally endoscopic mitral valve repair with the aid of the “Da Vinci” telemanipulator in 2000
- Introduction of mammary artery anastomosis in Germany
- Setup of a homograft bank for processing human valves
- Advancement of extracorporeal circulation
- Surgery by means of a telemanipulator ("robotic surgery")
- Development of new procedures to preserve heart transplants
- Development of a new centrifugal pump for the heart-lung machine
- Pilot clinic for the development of quality assurance in cardiac surgery
As well as being the largest centre for the treatment of congenital cardiac defects in Germany, the Clinic of Cardiovascular Surgery of the German Heart Centre Munich is a global leader in the treatment of acquired heart defects (bypass and heart valve surgery etc.). Prof. Dr. Rüdiger Lange has been the director of the clinic since 1999.
The entire spectrum of cardiac surgery is performed here, ranging from infant surgery, valve repair procedures, coronary artery revascularisation and surgical repair of the large intrathoracic aorta to heart transplants and artificial heart.

Approx. 47,000 cardiovascular operations, 12,000 of which were in children, have been performed in the Clinic for Cardiovascular Surgery since its establishment over 30 years ago.
All areas of expertise of the Clinic for Cardiovascular Surgery

- Bypass surgery
- Heart valve operations
- Combined bypass and valve surgery
- Multiple valve replacement
- Minimally invasive surgical procedures
- Off-pump surgical procedures, i.e. without heart-lung machine (OPCAB)
- Heart transplants and artificial heart
- Surgical procedures with the aid of the telemanipulator (“robotic surgery”)
- Repair of congenital heart defects in every age group
- Heart surgery in premature infants, neonates and children
- Surgery of cardiac tumours
- Vascular surgery (e.g. aneurysm surgery)
- Endovascular stent implantation of descending aorta
- Pacemaker surgery
- Arrhythmia surgery
Heart valve outpatients:
Priv.-Doz. Dr. Walter Eichinger speaking to a patient

Ventricular aneurysm

Heart tumour removal

Intensive care bed at the Clinic for Cardiac Surgery
13,782 operations  
German Heart Centre Munich, 1999 - 2004

The entire spectrum of cardiac surgery is performed here, ranging from infant surgery, valve repair procedures, coronary artery revascularisation, surgical repair of the large intrathoracic aorta to heart transplants and artificial heart.

The graph shows the enormous increase in the number of patients attending the Clinic for Cardiovascular Surgery during the past 31 years. In 2004, there were, for the first time, 2,000 patients who underwent surgery with a heart-lung machine.
Approx. 2,600 surgical procedures are performed in our clinic annually. They are made up as follows:
- 2,000 on-pump surgical procedures, 450 of which are on-pump in children
- 200 patients are less than one year old
- 550 off-pump surgical procedures

Optimal medical care

The cardiac surgical department can accommodate a total of **55 patients round the clock**, providing state of the art medical care.

Scientific efficiency

In addition, the Clinic for Cardiovascular Surgery has a large experimental laboratory at its disposal (head of which is Priv.-Doz. Dr. R. Bauernschmitt) in which numerous projects are carried out, such as:
- the development of an automatic heart-lung machine
- tissue engineering
- experimental and clinical examination of heart valves
- development of new technologies for surgical robots and
- development of a heart replacement pump

Our scientists work closely with our clinicians, thus ensuring an exceptionally high level of scientific efficiency.
Surgical treatment of acquired cardiac defects

Mortality associated with isolated on- and off-pump bypass surgery in 2004

<table>
<thead>
<tr>
<th></th>
<th>in Germany</th>
<th>in the USA</th>
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<tr>
<td>with heart-lung machine</td>
<td>2.8 %</td>
<td>2.4 %</td>
</tr>
<tr>
<td>without heart-lung machine</td>
<td>1.9 %</td>
<td>(source: STS)</td>
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(source: DGTHG)

Coronary bypass surgery

Arteriosclerotic cardiovascular disease continues to be the most common cause of death in Germany and other industrial nations.

At the German Heart Centre Munich, coronary bypass surgery makes up about 40% of all surgical procedures.

Complete arterial revascularisation with in-situ use of both thoracic arteries (LIMA, RIMA) as well as of the radial artery is the procedure of choice in state of the art bypass surgery. The long-term patency rates of the arterial grafts are far superior to those of the great saphenous vein. The radial grafts and saphenous vein transplants are removed in a minimally invasive or endoscopic procedure.
Beating heart surgery (off-pump)

Beating heart surgery represents a further development in the surgical treatment of coronary arteries.

A heart-lung machine is not required for this procedure. A stabilising device is used in the area of anastomosis to restrict movement of the heart, and the heart can be positioned by means of a suction cup.

Dr. Bernhard Voss
Heart transplants

Since the mid eighties, the orthotopic heart transplant has been accepted as the procedure of choice in the treatment of refractory terminal heart failure.

This procedure was successfully performed for the first time in Germany at the German Heart Centre Munich on May 7th, 1981. Today, heart transplantation is performed regularly at our clinic. The international one year survival rate is higher than 80% while the five year survival rate is higher than 60%.
Heart transplants
Actuarial survival rate worldwide

Artificial heart systems

Artificial heart systems, such as the left ventricular Assist Device (Novacor) or the biventricular Assist Device (Berlin Heart) are also being used as a bridge-to-transplant.
Isolated aortic valve replacement
German Heart Centre Munich, 1995 - 2004

Mortality (2004)
German Heart Centre Munich 3.0 %
Federal Republic of Germany 3.4 % (Source: DGTHG)
USA 3.4 % (Source: STS)

Bypass surgery with aortic valve replacement
German Heart Centre Munich, 1994 - 2004

Mortality (2004)
German Heart Centre Munich 4.7 %
Federal Republic of Germany 6.2 % (Source: DGTHG)
USA 6.1 % (Source: STS)
Aortic valve surgery

Prof. Rüdiger Lange: “Aortic valve surgery is the most common procedure performed in the area of aortic surgery. The aortic valve is usually too tight or is leaking and needs to be replaced by a biological or mechanical artificial valve. Aortic valve defects may be congenital or brought about, for example, by a protracted infection where bacteria stick to the valve and destroy it. However, the cardiac surgeon also operates on dilatations (aneurysms) and tears (dissections) of the main thoracic arteries.”
Heart valve reconstruction („repair“)

Thanks to the development of new techniques, diseased valves can be “repaired” more and more, rather than being replaced (heart valve repair).

The procedure of heart valve repair requires highly experienced, specially trained surgeons and is therefore only performed in large cardiac surgical centres, such as the German Heart Centre Munich.

Director of the clinic
Prof. Dr. Rüdiger Lange
All techniques for valve-sparing mitral valve repair are performed at the German Heart Centre Munich.

Mitral valve repair. Here: Quadrangular resection P2 of the posterior leaflet with placement of an half open annuloplasty ring.

Mitral valve repair and mitral valve replacement

German Heart Centre Munich, 1991 - 2004
Surgical treatment of **acquired** cardiac defects

The German Heart Centre Munich is also one of the leading centres in Germany in the field of thoracic aortic surgery.

If the aortic valve ring is significantly dilated, combined with the presence of a pathological aortic valve, a valved conduit (tube prosthesis with integrated heart valve prosthesis) is frequently implanted. The coronary ostia are anastomosed end-to-side with the prosthesis, thereby being re-implanted (**Bentall's procedure**). Today, a valve-sparing procedure is the method of choice where possible, especially if the aortic valve exhibits no macroscopic structural changes. However, this surgical technique is more demanding from a technical point of view and requires a high level of surgical experience.

Valve-sparing surgery saves the patient from the need of anticoagulants or later valve prosthesis replacement. Apart from that, the haemodynamics of the patient's own valve are always more favourable than those of a valve prosthesis.

Pronounced aneurysm of the descending aorta.
3D demonstration in CT picture (left) and equivalent intraoperative findings (right)
Yacoub procedure: Aortic valve-sparing surgical technique used in the treatment of aneurysms of the ascending aorta

Surgery of the aorta
German Heart Centre Munich, 1999 - 2004
Keyhole surgery is being applied more and more in the field of cardiac surgery in specialised centres, such as the German Heart Centre Munich.

A technique that is not only advantageous for the patient from a cosmetic point of view, but is also a contributing factor to the success of surgery. Only few centres in Germany have offered this innovative type of cardiac surgery to date.
The Clinic for Cardiovascular Surgery of the German Heart Centre Munich is specialised in the technique of minimally invasive heart valve surgery, particularly in mitral valve repair with minimal incisions of five to six centimetres in length extending from the right rib cage.
Aortic valve replacement is also performed using keyhole surgery where possible. Only the upper half of the sternum is split for this procedure.

The incision is now a vertical incision in the middle of the chest measuring only about 6-8 centimetres instead of 20-30 centimetres in the traditional approach. When performed by experienced cardiac surgeons, the outcome is comparable with surgery involving a full sternotomy and complete opening of the rib cage. The advantages of keyhole surgery in aortic valve operations are considerable, particularly with regard to the healing process.
The sternum is much quicker to heal following only a partial sternotomy. Since only the top half of the sternum is now severed, the lower part stabilises the upper part in the postoperative healing phase. In this way wound healing disturbances can be avoided almost completely. Furthermore, postoperative pain, for example during breathing is significantly reduced. A partial sternotomy rather than a full sternotomy is now also performed for surgery on the ascending aorta.

Since the introduction of these new techniques in 2000, nearly every fifth operation in the German Heart Centre is now performed using keyhole surgery.
Minimally invasive surgical procedures

The radial artery and the saphenous vein are commonly used as bypass vessels. It is possible to use keyhole surgery for these procedures.

Endoscopic harvesting of the radial artery and the saphenous vein in bypass surgery

A skin incision of approx. three centimetres (instead of the usual 25-30 centimetres) is required. Harvesting is performed by means of an endoscope.

This method offers considerably better cosmetic results with a smaller wound area than the conventional method, while ensuring graft quality for its use in bypass surgery.
Surgeons at the German Heart Centre Munich have developed a further innovative minimally invasive technique for the repair of atrial septal defects.

The surgical occlusion has already been performed in children via an incision through the ribs on the right chest in order to spare patients a large vertical scar on the sternum. However, this technique has been advanced considerably.

Prof. Lange: “It was not uncommon for such girls to later have differently sized breasts. This came about because in prepubescent children it is impossible to predict where exactly the breast will later develop. A larger surgical incision in this area may interfere with the development of breast tissue in puberty. We now avoid this problem by opening the rib cage from the side, practically just below the armpit. The breast tissue remains undamaged in this way and the breast can develop normally. A scientific study performed in our clinic has proven this without doubt. The cosmetic result is sensational.”

This midaxillary muscle-sparing, right-sided thoracotomy has been available at the German Heart Centre Munich for over one year now for all prepubescent patients suffering from atrial septal defects.
Minimally invasive surgical procedures

Furthermore, the German Heart Centre Munich has a telemanipulator (robot) at its disposal for special surgical procedures. The German Heart Centre Munich was one of the first hospitals worldwide to use a telemanipulator system for endoscopic cardiac surgery.

The first totally endoscopic mitral valve repair, i.e. without opening the rib cage, to be performed worldwide was carried out in 2000 at the German Heart Centre Munich. Furthermore, a number of purely endoscopic bypass operations have been performed successfully by means of the telemanipulator.

In addition, the clinic is currently conducting clinical trials and experimental studies to establish new surgical techniques using a telemanipulator. The goal of such techniques is to perform valve-sparing surgery and valve replacement on a closed thorax via four to five small ports. To date, we have already operated on a large group of patients with the aid of a robot. Partial steps of newly planned techniques have been applied and optimised during this time.

Priv.-Doz. Dr. Stephen M. Wildhirt
Interventional treatment of aortic aneurysms: inner vessel support of aorta (aortic stent). It is placed by means of a catheter via the femoral artery.

Non-invasive treatment of aortic aneurysms

Various surgical procedures are applied in the Clinic for Cardiovascular Surgery for the treatment of disorders related to the large intrathoracic artery (aorta). Among other procedures, so-called stents (inner vessel supports) have been implanted for several years now. The rib cage does not need to be opened for their positioning nor does the patient need to be attached to a heart-lung machine.

Priv.-Doz. Dr. Robert Bauernschmitt
Surgical treatment of **congenital** cardiac defects

German Heart Centres arranged according to number of on-pump operations in ascending order

Source: E. Bruckenberger, Herzbericht, 2003
The Clinic for Cardiovascular Surgery specialises in particular in the treatment of congenital cardiac defects.

Performing 550 surgical procedures annually in children, adolescents and adults with congenital heart defects, the clinic ranks among the leading international institutions in this field.

As a rule, complex congenital cardiac defects are repaired in the German Heart Centre Munich even in subjects weighing less than 2,000 grams.

The German Heart Centre Munich has a valve bank at its disposal in which human valves are freshly processed for implantation in children undergoing the commonly required pulmonary artery valve replacement in paediatric cardiac surgery.
Ebstein’s disease

Ebstein’s disease is a congenital heart defect in which the origin of the septal and/or posterior leaflet of the tricuspid valve is displaced in the right ventricle. Tricuspid valve insufficiency is the primary haemodynamic complaint.

The surgical technique developed at the German Heart Centre Munich (Monocusp patch with anterolateral displacement of the anterior leaflet) has made valve-sparing repair possible in 90% of patients suffering from Ebstein’s disease. The perioperative risk associated with this method is only slight, especially when compared on an international level. This reflects the safeness of the surgical technique. The majority of patients were in NYHA stage III prior to surgery. Long-term studies over a period of 30 years have revealed a significant improvement in nearly all patients in terms of their capacity for exertion (88 out of 90 patients in NYHA stage I or II). Further analysis has shown that early surgery is an essential factor in further reducing the morbidity and mortality rate as well as achieving a lasting improvement in the quality of life of such patients.
The Shelhigh Injectable Pulmonic Valve represents a new possibility for patients after repeated surgery of the right ventricular outflow tract (RVOT).

The porcine valve, mounted in a self-expanding metal frame, was first implanted at the German Heart Centre Munich in April 2005. A young patient with the most severe form of pulmonary valve insufficiency, who had undergone Fallot’s repair in the past, underwent implantation of a stented valve with median sternotomy via the dilated RVOT.
Quality has always been of the utmost importance for the German Heart Centre Munich. As early as in the mid-eighties, the director at the time, Prof. F. Sebening, took up the concept of quality assurance at a time when only few dealt with this subject.

Together with seven other hospitals, the Clinic for Cardiac Surgery took part in a model project that was sponsored by the Ministry of Health. The aim of the project was to establish a quality assurance system for the entire area of cardiac surgery. One of the most comprehensive and successful schemes of external quality assurance in Germany emerged from this project.

All 87 hospitals and departments specialised in cardiac surgery participate in the scheme today and forward their records, featuring after all more than 300 characteristics, in anonymous format to a centralised location. This centre in turn analyses and compares all hospital data, after which each hospital is forwarded its own data in relation to the mean values of all other hospitals. A so-called hospital profile is thus produced, which shows us how we compare on a national level to other hospitals.
Approx. 47,000 cardiovascular operations have been performed at the Clinic for Cardiovascular Surgery since its establishment 30 years ago. New techniques and scientific progress have made it possible to keep lowering the age at which congenital cardiac defects can be operated upon. Just as the age at which elderly patients can be successfully operated upon is constantly on the rise.
**Euroscore, ICU stay and early mortality**
German Heart Centre Munich, 2004

![Graph showing the relationship between Euroscore, ICU stay, and early mortality.](image)

**Number of patients**

<table>
<thead>
<tr>
<th>Euroscore:</th>
<th>lowest risk 0-2</th>
<th>medium risk 3-5</th>
<th>high risk 6-9</th>
<th>highest risk ≥10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients</td>
<td>0.8</td>
<td>1.6</td>
<td>2.2</td>
<td>6.5</td>
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<tr>
<td>Mean ICU stay in days</td>
<td>1.6</td>
<td>1.6</td>
<td>2.2</td>
<td>4.0</td>
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<td>Early mortality in %</td>
<td>0.8</td>
<td>1.6</td>
<td>2.2</td>
<td>6.5</td>
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</table>

**Age, Euroscore and mortality**
German Heart Centre Munich, 2004

<table>
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<tr>
<th>On-pump surgery</th>
<th>n</th>
<th>Mean age</th>
<th>Euroscore</th>
<th>30-day-mortality [%]</th>
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<tr>
<td>Isolated coronary bypass</td>
<td>676</td>
<td>65.9</td>
<td>3.4</td>
<td>1.8</td>
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<td>Isolated aortic valve</td>
<td>236</td>
<td>67.9</td>
<td>5.6</td>
<td>3.0</td>
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<tr>
<td>Coronary bypass with aortic valve</td>
<td>172</td>
<td>73.3</td>
<td>6.4</td>
<td>4.7</td>
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<td>101</td>
<td>60.8</td>
<td>4.4</td>
<td>0</td>
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<tr>
<td>Ascending aorta (with and without coronary bypass)</td>
<td>95</td>
<td>59.0</td>
<td>7.0</td>
<td>1.1</td>
</tr>
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</table>
We pay particular attention to the development of quality assurance in the field of paediatric cardiac surgery. We participate in the European paediatric cardiac data bank in Warsaw. As the leading hospital for paediatric cardiac surgery we also take part on a national level, together with our Clinic for Paediatric Cardiology and Congenital Cardiac Defects, in the setting up of the German “quality assurance for paediatric cardiology” within the scope of the Federal Office for Quality Assurance.

During our C&D conferences, illnesses are discussed that have not taken the expected course. Following a short description of the case, physicians discuss whether something could have been done to affect the clinical course more favourably.
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A large children’s party was organised on September 13th, 2003 to celebrate the 11,111th paediatric cardiac operation.

Patients from all over the world: Prof. Lange at the bedside of a small patient from Tanzania.