



**HEIDELBERG**  
UNIVERSITY  
HOSPITAL



# NEUROSURGERY

**PERFORMANCE REPORT 2020**

Department of Neurosurgery  
University of Heidelberg  
Im Neuenheimer Feld 400  
69120 Heidelberg





Dear readers,  
Dear patients, relatives, and colleagues,

We have spent several months looking at all aspects of our Department of Neurosurgery. After a thorough review, we have collected the most important news for you.

You are currently holding the result in your hands, fresh off the press: I am very pleased to be able to present our totally revised performance report! If you want to know what we really do, how the procedures work, and what happens behind the scenes, you will find the answers here. I am truly proud to present this publication to you with an attractive design, many reports, and compact summaries of all facets of our daily work. I am fully convinced that regardless of whether you are a patient, a family member, an employee, or a colleague, you will find something new for you to discover.

You are cordially invited: to take this journey of discovery through our modern building, be astonished by the new aspects, and to get to know the staff, as well as obtain a clear overview of our performance!

Sincerely,

**Prof. Dr. med. Andreas Unterberg**

Chairman and Director, Department of Neurosurgery, University Heidelberg

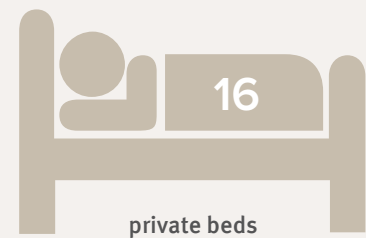
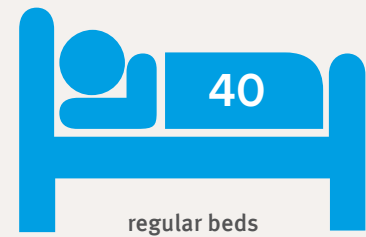
# CONTENTS

Overview of the Neurosurgical Department	p. 6
Our Guiding Principles – Our Values	p. 8
Interview with Prof. Unterberg	p. 11
Our Team	p. 16
Practical Information for Patients	p. 32
Treatments	p. 36
Surgical Interventions & Technical Equipment	p. 56
Our Performance	p. 66
Research & Teaching	p. 68
Science & More	p. 88
Awards	p. 90
Publications	p. 92
Imprint	p. 98

At a glance:

# DATA, FACTS AND FIGURES

From outpatient treatment through to accredited surgery: We have compiled the most important data in a compact form to give you a better idea of our department.



**Number of beds**  
A total of 68 beds are available for our patients, of which 40 are regular beds, 16 private beds and 12 intensive care beds.

# 3,754

inpatients in 2019

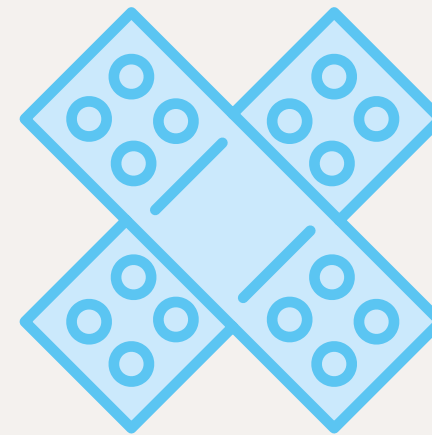


**CERTIFICATE**  
Certified Center for Skull Base Surgery (German Society of Skull Base Surgery) and spine surgery (AO Spine)

**1,103 patients**  
included in clinical studies in 2019

# 34

large medical devices

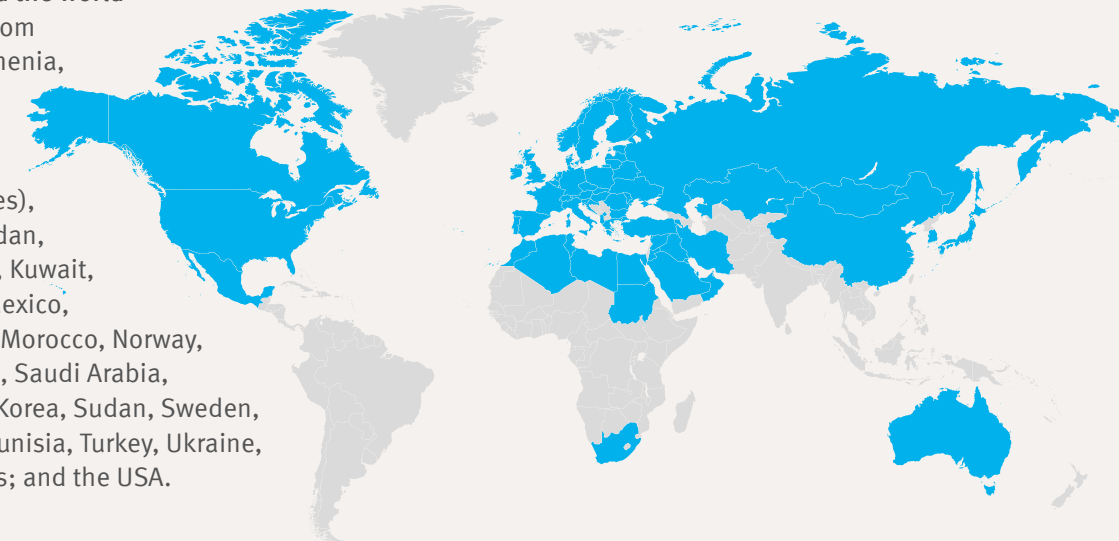


**Outpatient treatment in 2018**  
In the past year, we treated 11,218 outpatients:

General patients:	6,983
Emergency patients:	2,374
Private patients:	1,780

**Patients from around the world**

Our patients come from Albania, Algeria, Armenia, Australia, Bahrain, Belarus, Canada, China, Egypt, EU (all Member States), Iran, Iraq, Japan, Jordan, Kazakhstan, Kosovo, Kuwait, Libya, Luxemburg, Mexico, Moldova, Mongolia, Morocco, Norway, Oman, Qatar, Russia, Saudi Arabia, South Africa, South Korea, Sudan, Sweden, Switzerland, Syria, Tunisia, Turkey, Ukraine, United Arab Emirates; and the USA.



about  
**3,350**  
surgical interventions in 2019

**The interventions in which we specialize:**

Brain tumor surgery
Skull base surgery
Vascular neurosurgery
Pituitary gland surgery
Complex spine surgery
Spinal tumor surgery
Functional neurosurgery
Pediatric neurosurgery



At a glance:

# OUR GUIDING PRINCIPLES – OUR VALUES

“We live our values and we orient ourselves towards them every day”, says Professor Andreas Unterberg, Director of the Department of Neurosurgery. Education, diligence and precision are special attributes in Heidelberg. But also respect – for patients, relatives, staff and colleagues.



MANUAL PERFECTION; SCIENTIFIC PRINCIPLES, AND EMPATHIC ATTENTION ARE OUR KEY TRAITS.

# 1

## Respectful interaction

We pay special attention to respectful interaction within our team and towards our patients and their relatives.

## Scientifically tested

The Department of Neurosurgery has enhanced its profile as an university institution in the last 15 years. “It was my personal objective to develop academic neurosurgery in many sectors on the basis of scientific principles”, says Professor Andreas Unterberg. “We want to alleviate and cure our patients’ suffering – and adhere to strict academic principles.” This ensures that future treatments are performed on the basis of scientifically proven facts. “We therefore always critically question and reevaluate our results. Furthermore, we are eager to apply our latest research results to optimize our treatment, e.g. the results from our neuro-oncological laboratory.”

# 2

# 3

## Solidarity

Highly specialized medicine, is characterized in particular, by specialists coming together quickly and working on special problems. “At our university, we need this solidarity and the other disciplines that work with us. Only in this way, progression is possible”, says Unterberg. In addition, it is important that everyone remains self-critical and always questions their results.

## Always optimistic

People shape the success and progress of the Department. “We always enter into an operation with optimism”, says Professor Andreas Unterberg, and emphasizes: “The objectives of our work are successful treatment and the well-being of our patients.”

# 4



“I have a team that is really keen on always achieving the best results!”

All indicators point to growth: The number of brain tumors operated on has more than doubled in the last 15 years and complex spine surgery operations have tripled. The therapy services provided at the Department of Neurosurgery at Heidelberg University Department have also increased in general. Professor Andreas Unterberg has been chairman and director for exactly this period. In this interview, he looks back on an eventful time and paints a picture of the future of neurosurgery.



**Professor Unterberg, how have you been able to grow your department so strongly in the past 15 years?**

From the start, we have emphasized certain elements in order to continue to develop the core areas at our department every year. Heidelberg has always stood for the treatment of tumors. The surgical strategies have become substantially more intense and targeted using the latest technology. We have also made clear advances in spine surgery, pediatric neurosurgery, pain therapy, and stereotaxy.

**What was the facility like when you arrived just after the start of the new millennium?**

At that time – on April 1, 2003 to be exact – I was able to take over a very well structured and excellently organized neurosurgical department. This was the basis on which I was able to build up all further developments towards today's achievements.

**How would you explain what your department stands for to a patient and their relatives within three minutes?**

To summarize very succinctly: The Neurosurgical Department in Heidelberg deals with diseases of the brain and the nervous system that can be treated surgically.

**Does it always have to be an operation?**

Often there is no other choice, when dealing with such diseases. However, we critically ask ourselves the following question before each intervention: Is the operation necessary? Is it useful? Are there risks? Then, we weigh everything up with care. We struggle with these questions every time. We do not operate if we are not absolutely convinced of a positive benefit for our patients.

**Is that the key to the success of your department?**

Not just that. Our interdisciplinary cooperation is an important component for success, e.g. cooperations with experts within our hospital. We need partners in anesthesiology, neurology, neuroradiology, radiotherapy, pediatrics, maxillofacial surgery, and many other specialities. We also work closely with the German Cancer Research Center and the National Center for Tumor Diseases affiliated with the University of Heidelberg. This is true teamwork.



**How have your treatment methods changed during the last decade?**

The greatest change we have seen has been in technology. We use intraoperative MRI and CT scanner several times a day. The navigation opportunities have been multiplied over the years. Electrophysiological monitoring has become substantially more intense. Other treatment methods have also been added, such as endoscopy. We are at the highest level, technologically, and are equipped with everything that can be used in modern neurosurgery today.

**What objectives have you set for the coming years?**

I try to be realistic in that regard. My aim is to be able to operate on brain tumors even more safely. This can be achieved in small steps only.

**Looking back, what milestones were particularly important to you?**

In recent years, we have set new priorities in many areas of neurosurgery. We have made considerable advances in brain tumor surgery, complex spine surgery, pain therapy operations,



**I can understand my patients much better today – their worries and what their hopes are for their treatment. My patients get my entire and focused opinion.**



**How have you been able to integrate all these technologies?**

We have implemented a system with an industrial partner to centrally record all important information and to collect data, pre- and intra-operatively. Everything at a single glance, in every operating room. This is quite unique. I am very proud of that!

deep brain stimulation, and decompression surgery, and within pediatric neurosurgery through the introduction of rhizotomy and in the development of fetal surgery. The further development of our neuro-oncological laboratory under the leadership of Professor Christel Herold-Mende was of particular importance. In recent years, this specialization has created a

highly qualified team. We look for physicians and young scientific staff who are looking for something special and who have the ambition to develop neurosurgery academically.

**How would you assess your personal development since joining the department?**

I am always learning something new. Let's start with the patient: I can understand my patients

**With all of your experience, how are you going to ensure that your department will continue to play a leading role in the next 15 years?**

We can only make advances if we have the latest instruments and a motivated staff. In order to achieve this, I attend a lot of congresses, give numerous lectures and ensure that other professionals are aware of our department. I enjoy sharing my enthusiasm in public. This has allowed me to



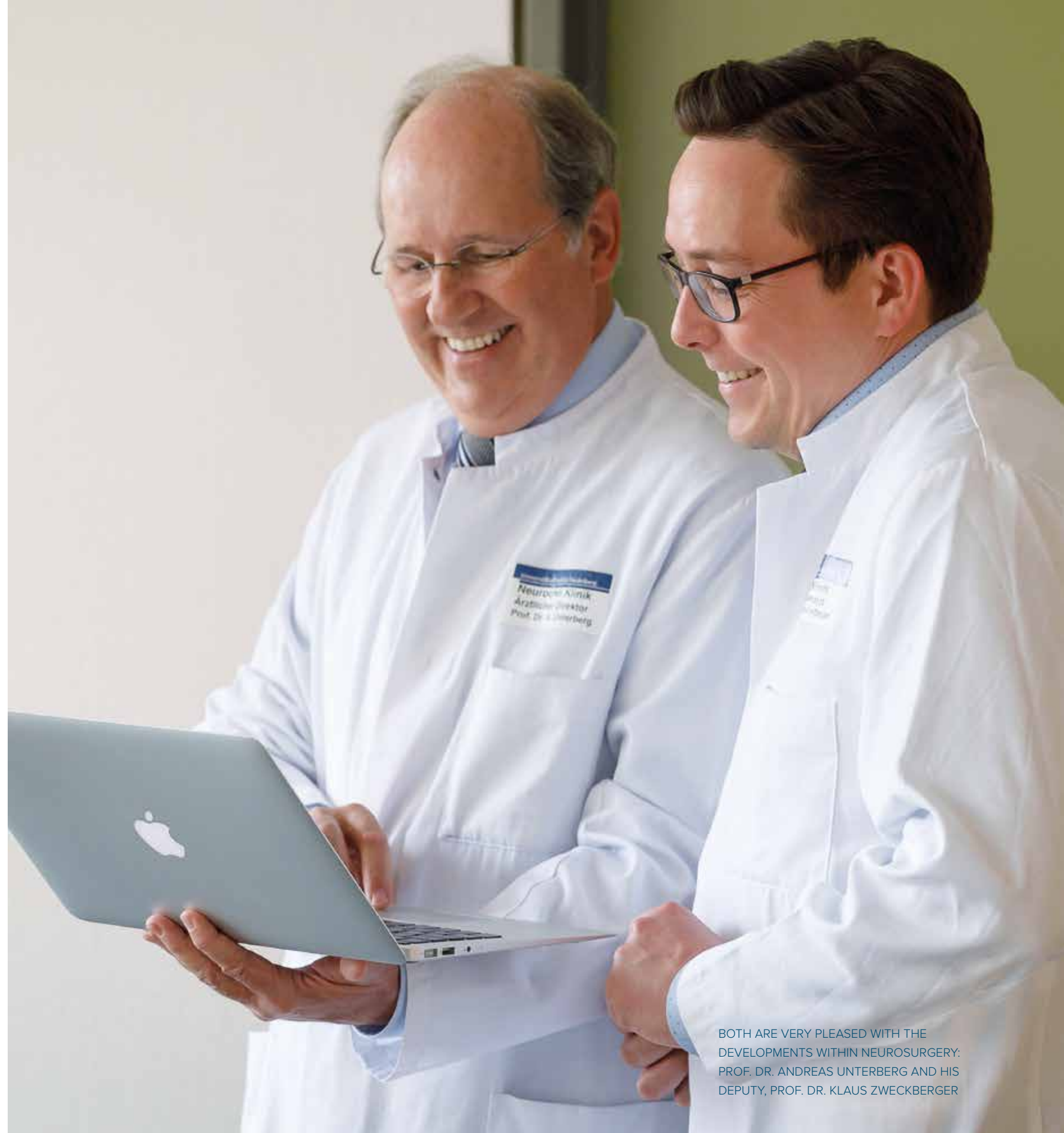
**My aim is to be able to operate on brain tumors even more safely. This can only be achieved by taking small steps.**



much better today – their worries and what their hopes are for their treatment. My patients get my entire and focused opinion. I have also learned to better understand the wishes of my staff. I personally consider this to be of the utmost importance.

bring a team together in recent years that is really keen on always achieving the best results.

All our experts have many years of experience. They know precisely what is possible and which problems can be treated. This can be planned much better now than it could 15 years ago – and our patients can rely on this in the future, too.



BOTH ARE VERY PLEASED WITH THE DEVELOPMENTS WITHIN NEUROSURGERY: PROF. DR. ANDREAS UNTERBERG AND HIS DEPUTY, PROF. DR. KLAUS ZWECKBERGER



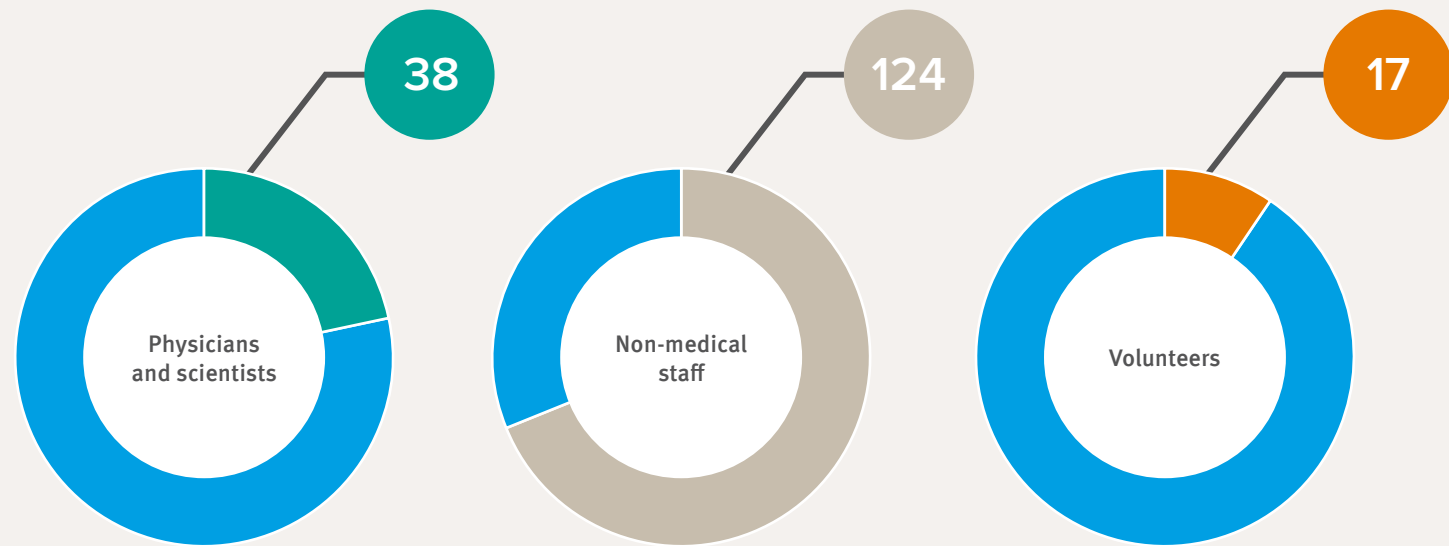


# 1 OUR TEAM

At a glance:

# OUR TEAM

From doctors to volunteers: We all care for you – around the clock! Our team is not only large and interdisciplinary; we also speak more than a dozen languages.



Besides our 38 doctors, there are also 124 employees and 17 volunteers who are there to care for our patients.



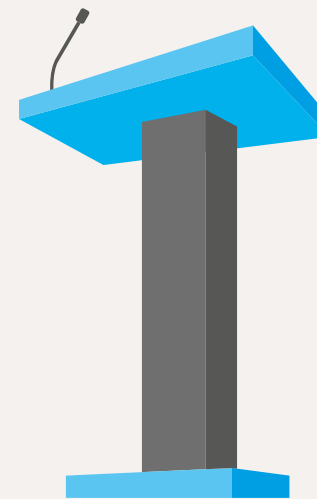
# 142

Our 20 specialists have spent a total of 142 years in the operating room.



# 40

Last year, we shared our knowledge with students in 40 lectures.



# 146

In 2018, we showcased our work and findings in 146 presentations around the world.



Our experts have received 14 prizes for their work since 2014.



# A STRONG TEAM FOR YOUR HEALTH

Our experienced doctors, who are specialists in their respective areas, work together on a daily basis in order to be able to provide optimal and efficient treatment.



Empathy, scientific analysis, surgical care, team orientation, and respect for life are the indispensable foundations of our work.



Prof. Dr. med. Andreas Unterberg

## Management



Prof. Dr. med. Andreas Unterberg, Chairmen and Director



Prof. Dr. med. Klaus Zweckberger, Vice Chairmen



Dr. med. Christine Jungk, Executive Senior Attending



Prof. Dr. med. Karl Kiening, Head of Stereotactic Neurosurgery



Prof. Dr. rer. nat. Christel Herold-Mende, Head of Neurosurgical Research, Biologist

## Acting Division Heads



Dr. med. Ahmed El Damaty, Pediatric Neurosurgery



Dr. med. Basem Ishak, Spinal Neurosurgery

## Division Head



Priv. Doz. Dr. med. Rezan Ahmadi, Head of Surgical Pain Therapy and Peripheral Nerves

## Senior Attending Physicians



Priv. Doz. Dr. med. Christopher Beynon



Dr. med. Daniel Haux



Dr. med. Jan-Oliver Neumann



Residents

Attending Physicians



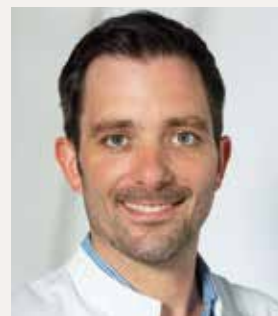
Dr. med. Stepan Fedorko



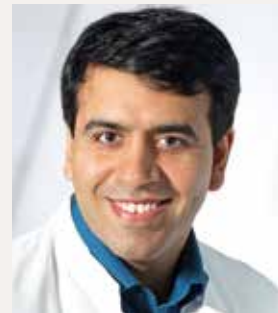
Dr. med. Henrik Giese



Dr. med. Modar Kentar



Dr. med. Moritz Scherer



Awais Akbar Bajwa



Martin Grutza



Arthur Gubian



M. Mehdi Hajiabadi



Mohammed K. M. Issa



Dr. med. univ. et scient. med.  
Gerhard Jungwirth, BSc.



Katharina Klumbies



Edina Kovacs



Mohammed Nofal



Agnieszka Parda

Fellows



Priv.-Doz. Dr. Benito Campos



Dr. med. Martin Jakobs



Dr. med. Huy Philip Dao Trong



Dr. med. Alexander Younsi



Arturo Olivares Rivera



Dr. Renan Sanchez-Porras



Dr. med. Edgar Santos



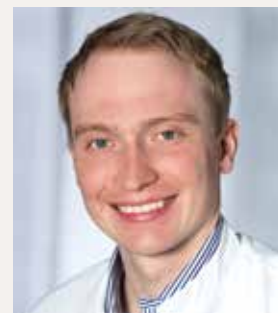
Stephanie Schmidt



Edgar Tessmann



Dr. med. Jan Teuber, M.A.



Dr. med. Johannes Walter



Carola Wieckhusen



Hyeon Joo Kelly Yoo



Bilal Younes



# OUR OUTPATIENT CLINIC

We provide outpatient care to more than one million people in the Rhine-Neckar metropolitan area in Baden-Württemberg and beyond.



THE TEAM (L. TO R.): KARIN WAGENBLASS, LUCIA HANFT, DR. MED. CHRISTINE JUNGK (EXECUTIVE SENIOR ATTENDING PHYSICIAN), ANAND PADMANABHAN, AND DORLE ISRANG

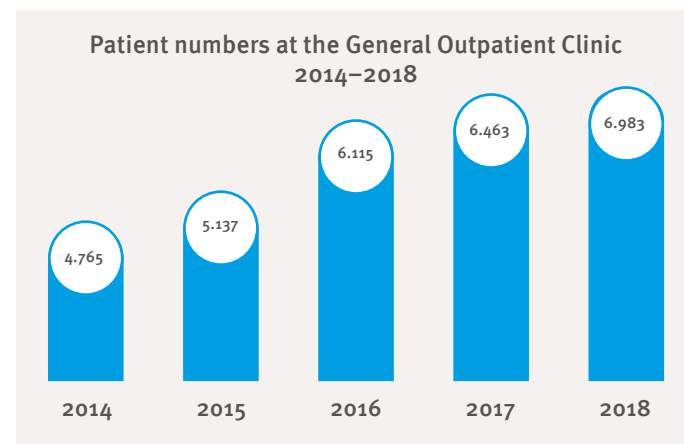
## General Neurosurgical Outpatient Clinic

Our services in the General Neurosurgical Outpatient Clinic and our Specialist Outpatient Department include the diagnosis of neurosurgical diseases, assessment of the indications for surgical interventions, and the realization of therapy concepts. Besides our general consultation hours, we also offer additional appointments every day for specific medical problems (see page 32/33). At these appointments, our patients are advised by specialized attending physicians.

The entire team works closely with all neighboring departments and centers at Heidelberg University Hospital, thus guaranteeing an optimal diagnosis and therapy. Our scientific cooperation with numerous research facilities also allows our outpatients to voluntarily participate in clinical trials in order to realize new treatment concepts.

## Emergency Outpatient Clinic

Open 24/7: Acute care of neurosurgical patients is one of our central duties.

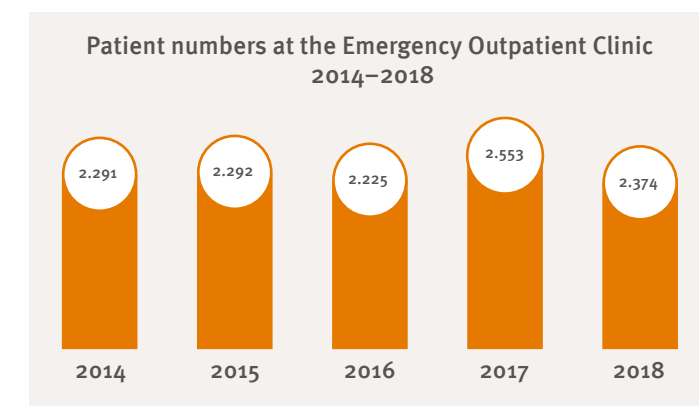


THE TEAM FOR SURGICAL PAIN THERAPY (L. TO R.): PRIV. DOZ. DR. MED. REZVAN AHMADI (DIVISION HEAD), ESTHER MARX, DOREEN FANOUS, HEIKE BRUNN, AND DR. MED. CHRISTIANE GEIST (ANESTHESIOLOGY)

Patients with acute diseases of the brain and the spine need to be examined and treated immediately by specialists. Our Emergency Department is responsible for this service, and is available 24/7.

In 2018, we treated a total of 2,374 patients in the Emergency Outpatient Clinic for Neurosurgery, including 1,200 patients with traumatic brain injury.

Emergency patients are treated immediately by the physicians on call, who arrange further diagnostic tests and therapy, if necessary. Vital signs of critical ill patients are continuously monitored.



## Outpatient Clinic for Surgical Pain Therapy

For patients with chronic pain, we provide a special service. Our specially-trained staff members ensure competent advice and care as well as surgical interventions, such as microvascular decompression, ablation or neuromodulation. The training and instruction of the patients using the stimulator system are particularly important to us in order to achieve an improved quality of life and relief of pain in everyday life.





PATIENTS IN THE INTENSIVE CARE UNIT ARE CLOSELY MONITORED AFTER SURGERY BY OUR TEAM OF DOCTORS AND NURSES.



COMPREHENSIVE INFORMATION: BEFORE CHANGING SHIFTS, THE NURSING TEAM ON THE STANDARD WARD DISCUSSES PATIENT CARE

## NURSING TEAMS

**Our competent teams of certified nurses care for our patients – professionally and around the clock!**

### General and Private Ward Nursing Team

One of the most important tasks is the professional care of our patients, their wounds and the provision of the prescribed medication. Beyond this, we place particular emphasis on our nurses still having sufficient time to have conversations with our patients. These exchanges not only promote well-being but also help patients to cope with their disease.

**Well-staffed:** Each ward has a team assistance for support in management e. g. to organize appointments for examinations.

### Intensive Care Unit Nursing Team

Approximately 1,300 patients are treated on our neurosurgical intensive care unit every year. Medical care is managed in a three-shift system by a team of six residents – headed by a senior attending physician.

The Intensive Care Unit (ICU) is part of our neuro-ICU, comprising neurology and neurosurgery. In our ICU, we primarily treat brain trauma, intracranial bleeding, subarachnoid hemorrhages and infections of the nervous system. We also monitor and control patients after extended surgery.

In addition to the ten ventilation beds in the ICU, we have also access to four intermediate care beds. Patients that no longer require artificial ventilation, but still require intensive care, are treated appropriately.

The nursing team currently comprises 38 full-time staff members, of which 32 are nurses. Of these,



A STRONG TEAM: THE INTENSIVE CARE UNIT NURSING TEAM

approximately half have completed specialist training in anesthesia and intensive care medicine. The internal clinic training curriculum ensures comprehensive operations in general and specialized neurosurgical intensive medicine. The entire nursing staff is trained in the latest treatment techniques in order to allow for the rapid recovery of our patients. There is a main focus on neuro-monitoring, during which the functional parameters of the endangered brain are continuously recorded.

### Scrub Nurses

The support of specialist nursing staff is particularly important during surgical interventions. Our scrub nurses assist during complex brain and spine surgeries. This is how we fulfill our high-quality care requirements.



**In 2018, we treated a total of 3,486 inpatients at our department.**



SPECIFIC TRAINING: OUR SCRUB NURSES IN THE OR



# GOOD ORGANIZATION IS TEAMWORK

**Working together for recovery: Many different teams in our department work to ensure you recover quickly.**



HERE FOR YOU (L. TO R.): MICHELINE HAKE AND BIRGIT ELSSEN (SOCIAL SERVICES), SVETLANA BOCK (PATIENT MANAGEMENT), AND ANJA ROTH (DISCHARGE MANAGEMENT)



IN CHARGE OF THE OFFICES (L. TO R.): EVA MATYSSEK, JUDITH SAM, KARIN VOGEL, SABINE SAELENS, MARIA HOLZ, AND ESTHER MARX

## Offices

In order to coordinate operations and the administration of our department: The seven members of our offices ensure that the organization runs smoothly. This includes written and telephone contact with patients, funding bodies, general practitioners and other departments. They work with our Central Patient Management (CPM) and the International Office (IO) to coordinate appointments for our domestic and international patients, for our patient consultations and surgical interventions.

## Central Patient Management (CPM)

The CPM coordinates all appointments relating to inpatient care and planned surgery in close cooperation with the physicians. The CPM also arranges necessary pre-surgical exams and is responsible for planning the admission to the neurosurgical wards. Patients who are admitted can talk to the staff at Central Patient Management with confidence at any time.

## Social Services

Some patients worry about different issues surrounding their illness and also about private and professional aspects. Our Social Services Department offers corresponding information and personal help in such cases. Our staff members provide comprehensive advice for subjects like healthcare proxies and patient decrees, and they support patients and their relatives in the organization of domestic care or the search for suitable inpatient facilities for further care. A particular focus is advice and the organization of rehabilitation following

major surgical interventions in order to enable the fastest and most comprehensive recovery possible.

## Physiotherapy

Our physiotherapists support the care teams of the general wards and the Intensive Care Unit in close cooperation with the surgeons. The surgical result is supported by early mobilization after surgery and targeted functional training.

→



OUR PHYSIOTHERAPISTS (L. TO R.) CLAUDIA KERESZTES, HOLGER MAYER, AND ANKE KÜHLWEIN





DIPL.-PSYCH. DR. LIDIA VOGT (NEURO-PSYCHOLOGIST)

### Neuro-Psychological Services

The diagnosis or physical impairments caused by disease are great burdens for our patients. Therefore, our department offers neurological supports. One special feature is the co-supervision of the so-called 'awake surgery', where the team communicates with the patient during surgery.

### Pastoral Work

The pastoral staff of our department is always available when there is a need for a sympathetic ear, support, or a partner to pray with. In addition to visits to the wards, religious services are also held regularly at the hospital chapel. A Muslim prayer room is also available.

### The Lilac Ladies

Their support is an important part of life at our department and a blessing for our patients: On weekdays, our staff receives support from the 'Lilac Ladies', an ecumenical hospital volunteer group. These volunteers in their lilac-coloured uniform

take the time to talk to waiting relatives, accompany outpatients to examinations, or run small errands.

### DRG Coordination

As part of the DRG systems, where DRG stands for Diagnosis Related Groups, patients are classified in groups in accordance with their diagnoses and treatments. This forms the basis for the fixed-rate remuneration of our services. Our DRG coordinators ensure the consistent and correct allocation of patients, which requires close cooperation with doctors, nurses, administrative staff, and medical financial controllers. The coordinators are also the contact persons for all questions.



THOMAS SCHMIDT  
(DRG COORDINATOR)



JUTTA BAUMANN  
(DRG COORDINATOR)

## OUR EXPERTS ON THE TUMOR BOARD

The neuro-oncological tumor board is the central conference where all experts discuss the treatment of brain tumor patients every week.

An interdisciplinary team of neurosurgeons, neurooncologists, radiooncologists, neuroradiologists, neuropathologists and oncologists meet for this purpose at the National Center for Tumor Diseases (NCT) Heidelberg and develop a therapy recommendation. The attendees of the tumor board receive regular updates every month regarding the latest clinical trial and research results.

The NCT is also home to an interdisciplinary neurosurgical consultation office, which provides advice mainly to patients with primary brain tumors and brain metastases. This supplements the weekly office hours for the treatment of tumors of the skull base and the cerebellopontine angle.





**At a glance:****PRACTICAL INFORMATION  
FOR PATIENTS**

DORLE ISRANG TAKES  
CARE OF ALL KINDS OF  
TELEPHONE ENQUIRIES.

**We are here for you**

The Department of Neurosurgery is located in the 'Kopflinik' building complex  
Im Neuenheimer Feld 400  
69120 Heidelberg

**Neurosurgical Outpatient Clinic**

phone: +49 (0) 6221 56-6307  
fax: +49 (0) 6221 56-6810  
email: nchambulanz@med.uni-heidelberg.de

**Inpatient Registration/Central Patient Management (CPM)**

phone: +49 (0) 6221 56-38099 or +49 (0) 6221 56-6311  
fax: +49 (0) 6221 56-7572  
email: V-NCH.ZPM@med.uni-heidelberg.de  
Svetlana Bock, Central Patient Management

**Ward Office**

phone +49 (0) 6221 56-5780  
fax: +49 (0) 6221 56-6811  
Eva Matyssek

**Wards**

**Neurosurgery 1**  
phone: +49 (0) 6221 56-6312  
**Neurosurgery 2**  
phone: +49 (0) 6221 56-6313  
**Neurosurgery 3 (private ward)**  
phone: +49 (0) 6221 56-7541  
**Intensive Care Unit**  
phone: +49 (0) 6221 56-35648

**CONSULTATION HOURS AND VISITING TIMES****Outpatient and consultation hours**

We offer specific consultation hours for the following areas:

Private consultation hours:

- for patients from abroad
- Neurosurgery (first visit)
- Neurosurgery (subsequent visits)

Specific consultation hours:

- Aneurysms and vascular malformations
- Brain tumors
- Neurosurgical pain therapy and diseases of the peripheral nerves
- Pediatric neurosurgery
- Skull base tumors
- Spinal malformations/syringomyelia
- Spinal tumors
- Spine surgery
- Stereotaxis/functional neurosurgery

Please contact the [Neurosurgical Outpatient Clinic](#) for information on the individual consultation hours and to arrange an appointment over the phone:

phone: +49 (0) 6221 56-6307  
Mon-Thurs: 8 a.m.–3:30 p.m. and Fri: 8 a.m.–3 p.m.

You can arrange an appointment for the private consultation hours of Prof. Dr. med. Andreas Unterberg over the [phone](#) +49 (0) 6221 56-6301.

**Visiting times**

**Wards 1 to 3**  
Daily 8 a.m.–8 p.m.

**Neurosurgical Intensive Care Unit**

**Mornings:** only following telephone enquiries on the phone: +49 (0) 6221 56-35648  
**Afternoons:** Daily 3:30–6:30 p.m.

**Phone for relatives**

Family members and close relatives of patients being treated in the Intensive Care Unit can call us:  
phone: +49 (0) 6221 56-35648

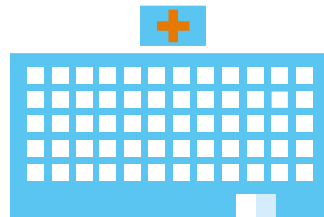


# SHORT DISTANCES: FROM ADMISSION TO DISCHARGE

We make your stay with us as pleasant as possible. Short distances and comprehensive information are essential. We are convinced: If you and your relatives understand the procedures of the Neurosurgical Department and can always find a competent contact person for your questions, then you will feel that you are in good hands.

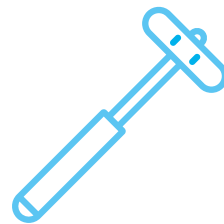
## Initial contact

As a patient, you will come to us for an appointment in our Neurosurgical Outpatient Clinic. It is also possible that you are being transferred from the emergency room or as an inpatient from another department.



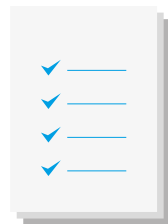
## Diagnosis

Following a comprehensive examination, our specialists will make a diagnosis and develop a therapy plan that they will explain to you in detail.



## Inpatient treatment

If the therapy plan includes surgery and admission to our department, our Central Patient Management (CPM) will confirm all dates.



## Registration and admission

On the day of admission, you will register at the patient administration office on the ground floor of the 'Kopflinik'. Then, you will go to your allocated ward, where our staff will welcome you and accompany you to your room.



## Surgery

Additional information may be collected as necessary prior to the operation. This helps to plan the intervention. Our specialists will carry out an operation in the most minimally invasive and most gentle way possible so you can recover as quickly as possible.



## Aftercare and visits

After surgery, our team will look after your daily needs. Your wounds will be treated in accordance with the instructions of the doctor. We will give you coordinated physiotherapy to provide optimal support for your recovery. Talk to the team at any time if you have questions, concerns, or requests. Your senior physician will also see you regularly.



## Discharge

You and your senior physician will mutually decide on the date of your discharge. The CPM staff will prepare all necessary documents for you, including a provisional letter with all the important medical findings. This is followed by a detailed treatment letter to your general practitioner. Our social services are pleased to help you finding suitable rehabilitation facilities or adequate home care.





WELL-CONNECTED EXPERTS:  
CURRENT ANALYSIS DATA IS CALLED  
UP IN REAL TIME.

# TREAT- MENTS

## OUR NEUROSURGICAL DEPARTMENT – OUTSTANDING EQUIPMENT AND CUTTING-EDGE TECHNOLOGY



THE TEAM OF OUR PHYSICIANS

The neurosurgical experts in our department are some of the best. They carry out more than 3,500 operations every year, more than 1,500 of cranial and more than 1,000 spinal surgeries. Five operating rooms with outstanding, cutting-edge medical equipment are available. Surgical approaches can already be planned prior to the operation using sets of imaging data, and the images can be projected in 3D onto special monitors in the operating room.

The combination of specialization, experience, research, and the latest technical equipment makes us one of the most internationally renowned neurosurgical departments.

### Our special features:

- The highest level of expertise for brain and spine surgery, particularly also on the spinal cord: surgery for vascular malformations, tumors of the skull base and pediatric interventions; deep brain stimulation, neuromodulation and stereotactic operations, as well as neuro-intensive medical therapy
- Outstanding equipment with cutting-edge diagnostic tests and surgical technology
- Low-risk and maximally comfortable interventions using the latest anesthesia procedures and optimized operation processes
- Clinical and experimental research
- Close interdisciplinary cooperation with all neighboring departments and specialist centers on campus
- The support and involvement of relatives in the treatment process through transparent explanations, a telephone for relatives to use (for patients in intensive care) and psychological support.



TREATMENT OF VASCULAR MALFORMATIONS: EVERYTHING AT A GLANCE AT ALL TIMES.

## VASCULAR MALFORMATIONS: ANEURYSMS, CAVERNOMAS OR ARTERIOVENOUS MALFORMATIONS

Your contact: Prof. Dr. med. Klaus Zweckberger

Vascular malformations in the brain hold the risk of brain hemorrhage – sometimes with serious consequences.

Following careful diagnostics, patients are thoroughly informed about possible treatment options. However, if treatment is indicated, then this will be carried out at our Neurovascular Center. We always work closely together with our neuroradiological partners, e.g. patients with arteriovenous malformation (AVM) are discussed in a specialized board on a regular basis.

### Different treatment techniques are available:

- Microsurgical resection of cavernomas or AVMs
- Microsurgical clipping of aneurysms

- Endovascular coiling of aneurysms or embolisation of AVMs
- Radiotherapy of AVMs

In emergencies, such as an aneurysm rupture with subarachnoid hemorrhage, the patients are taken to our neurosurgical intensive care unit. The treatment concept is determined by fast diagnostics followed by instantaneous treatment, e. g. the evacuation of the hemorrhage, clipping or coiling of the aneurysm.



Per year, we carry out more than one hundred neurosurgical vascular interventions – approximately two a week.



# BRAIN TUMOR SURGERY

Your contact: Dr. med. Christine Jungk



EXPERIENCED EXPERTS AND THE LATEST TECHNOLOGY ALLOW PRECISE SURGICAL RESECTION OF BRAIN TUMORS.

Many patients who come to our department already have a diagnosis and are looking for an independent second opinion. Therefore, we first take a detailed medical history – we make decisions on therapy in a weekly, interdisciplinary Tumor Board (see page 31). Thereby, we take naturally the latest research findings into account. We use a wide range of the different surgical techniques, which successfully supplement our operative experience and expertise in order to provide our patients with the best possible treatment.

## Outstanding equipment with the latest surgical technology

Even before surgery, we look at the functional areas of the brain's surface using a functional MRI and we also look at the fiber tracks deeper within the brain using the so-called tractography procedure. These findings are then used directly to plan the surgery. During the operation, computerized navigation systems are used, allowing our surgeons to reach even the smallest tumors in deep areas of the brain with great precision in order to remove them safely. For tumors adjacent to cranial nerves or fiber tracks our electrophysiological neuromonitoring allows

identification of functional areas down to one millimeter during surgery, thereby enabling a gentle removal of the tumor.

One special technical feature of our neurosurgical department is the high-field magnetic resonance tomography. This technology is only available in few places around the world. This MRI scanner allows our neurosurgeons to precisely control the extent of tumor resection. Accordingly, more tumor tissue can be safely removed. This technique is absolutely standard at our facility and at the same time, the subject of ongoing research – in cooperation with other neurosurgical departments across Germany (GesGIM: German Study Group of Intraoperative MRI).

Our highly specialized and established team can also operate on awake, pain-free patients with primary tumors in the brain, because of their experience for many years. An awake craniotomy procedure is used in order to monitor and spare the corresponding function of the brain during tumor removal.

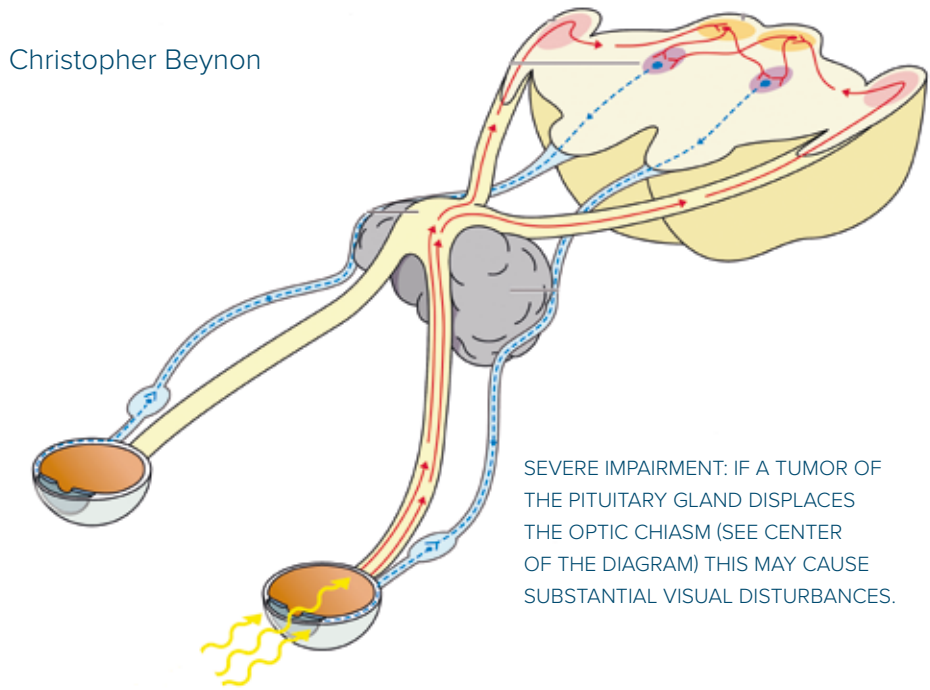
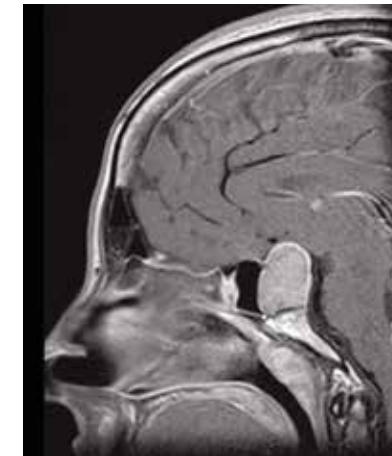


We specialize particularly in these types of tumors:

- Gliomas
- Meningiomas
- Brain metastases
- Pituitary adenomas
- Acoustic neuromas

# TUMORS OF THE PITUITARY GLAND

Your contact: Priv. Doz. Dr. med. Christopher Beynon



SEVERE IMPAIRMENT: IF A TUMOR OF THE PITUITARY GLAND DISPLACES THE OPTIC CHIASM (SEE CENTER OF THE DIAGRAM) THIS MAY CAUSE SUBSTANTIAL VISUAL DISTURBANCES.

The pituitary gland plays an important role in the hormonal system and controls numerous bodily functions. Tumors in this area can cause serious visual disorders because of their vicinity to the optic nerves and the optic chiasm (chiasma opticum). They can also affect the functioning of the pituitary gland itself and other organ systems as well, through a pathological distribution of hormones. The most common type of tumor is the pituitary gland adenoma, but many other tumors may occur, such as Rathke cysts, meningiomas, or craniopharyngiomas.

Hormones and other metabolic parameters are first determined in the blood to obtain a diagnosis. Further hormonal function tests are often necessary, and these are carried out by endocrinologists. The extent of the tumor is visualized using imaging procedures such as MRI. If there are visual disturbances or if the optic nerve or optic chiasm are displaced, further ophthalmological tests will be carried out.

## How we treat tumors of the pituitary gland

Tumors that displace the optic nerves or the optic chiasm are removed surgically. We also treat tumors that lead to hormonal abnormalities. One exception to this is a prolactinoma: these benign tumors are initially treated by medication. Tumors that are discovered by chance and that do not dis-

place any surrounding structures are monitored in regular checks. If a tumor is shown to have grown then we consider surgery before it results in clinical complaints.

Tumors of the pituitary gland can normally be removed surgically through the nose. A craniotomy (opening of the skull) is only necessary in rare cases. We use both microscopic and (fully) endoscopic surgical techniques. The decision which procedure is used is taken by our surgeons depending on the extent of the tumor and anatomical features, among other things.

## Resection monitoring using intraoperative imaging

We routinely carry out an intraoperative MRI scan in the course of the operation. This allows complete tumor removal, if some tissue might have been left during the initial resection. Additional navigation procedures increase the safety of the intervention in complex cases.

# SKULL BASE TUMORS

Your contact: Prof. Dr. med. Klaus Zweckberger and Dr. med. Daniel Haux

The localization and treatment of skull base tumors are a particular challenge. The tumors are located closely to adjacent blood vessels and cranial nerves. Therefore, treatment is only offered in selected, highly specialized centers, such as our Department of Neurosurgery.

## How we diagnose and treat skull base tumors

The diagnosis encompasses a detailed medical history, thorough clinical examinations and diagnostic imaging, such as magnetic resonance imaging (MRI) and computer tomography (CT). In some cases, further tests, such as electrophysiology or an angiography, are necessary. Therefore, we closely cooperate with other disciplines, such as ENT, maxillofacial surgery, ophthalmology, and neuroradiology.

Computer-assisted neuronavigation is an important technical feature: During surgery, it provides us with an exact comparison of the operatively recorded MRI or CT images with the current surgical situation. Using the latest microscope technique, a millimeter-precise tumor resection that spares the surrounding structures becomes possible. Constant electrophysiological monitoring of brain and nerve functions, is standard for these operations. Endoscopic visualization that we use for the resection of clivus chordomas, e.g. offers an optimal view even into areas that are difficult to reach.

## Certified center for skull base surgery

Because of their location, surgical treatment of skull base tumors is a challenge. Specialists from the Department of Neurosurgery, ENT, maxillofacial surgery, and radiotherapy established an interdisciplinary center for skull base surgery.

Special features of our certified skull base center are interdisciplinary tumor boards (see page 31), that determine interdisciplinary treatment strategies and operations. For example, our specialized neurosurgeons will operate together with our colleagues from ENT or maxillofacial surgeons when complex tumors extend from the nose into the brain. This combines the competence and experience of different specialists, thus making complex interventions safe.

We use the latest treatment techniques, such as a fully endoscopic, transnasal approach for tumors extending from the nose far into the skull. Beyond this, there is also close cooperation with the Departments of Ophthalmology, Neurology and Neuroradiology as well as Neuropathology. This allows for the optimal treatment of patients with extensive skull base tumors.

## Comprehensive aftercare and controls

Consistent aftercare is necessary for patients with skull base tumors. Depending on the histologic results, it might be necessary to undertake post-operative imaging or to provide radio- or chemotherapy. To this end, we closely cooperate with the Departments of Radiation Oncology and Neurooncology at the Heidelberg University Hospital and the National Center for Tumor Diseases (NCT).

We also offer numerous scientific studies, in which selected patients can choose to participate. Depending on the tumor entity, patients are enrolled into studies, focussing on the neuropsychological outcome. The group of Prof. Dr. Christel Herold-Mende



COMPLETELY CONCENTRATED AND WITH A TOTALLY STEADY HAND: SKULL BASE TUMORS ARE ONLY TREATED BY OUTSTANDING SPECIALISTS.



also focuses on molecular mechanisms that are responsible for tumor growth. We thus can ensure the optimal treatment and future care of our patients in accordance with the current research results.

**We operate on more than 800 brain tumor patients every year; therefore our team of physicians and nurses is one of the most experienced teams in the world.**





IT IS POSSIBLE TO REACT IMMEDIATELY TO THE SLIGHTEST CHANGES OR COMPLICATIONS.

## INTENSIVE THERAPY OF TRAUMATIC BRAIN INJURY, AND CEREBAL HEMORRHAGES

Your contact: Dr. med. Jan-Oliver Neumann and PD Dr. Christopher Beynon

Traumatic brain injuries (TBI) are some of the most common diseases with increasing incidents, especially in older patients. Every year, our neurosurgeons undertake more than 200 interventions that can be traced back directly to traumatic brain injury.

Our objective treating TBI: We treat cranio-cerebral trauma to stabilize the patient as quickly as possible and preventing consequential damage! Patients who are severely injured might be put into a deep coma during treatment for several days or weeks, during which they are artificially ventilated.

### Neurosurgical intensive therapy

After emergency surgery, e.g. the removal of space-occupying hemorrhages, treatment continues in our neurosurgical intensive care unit. Our patients are also closely monitored using so-called 'extensive neuromonitoring'. Hereby, probes are inserted into the brain by our neurosurgeons providing continuous information about the condition of the injured brain.

### Comprehensive care at our neurosurgical intensive care unit

The treatment of traumatic brain injury is not limited to the head. Artificial ventilation for several days or even weeks and the lack of movement caused by anesthesia affect the entire body. That is why our neurosurgeons are also experts for neurosurgical intensive medicine.

In complex cases, we closely cooperate with our partners from the Neurology, Neuroradiology and Anesthesiology Departments.

### Cooperation during neurorehabilitation – optimal care beyond our doors

Early and intensive, neurological rehabilitation should be carried out as soon as the patient is stable. We transfer our patients to specialized departments of neurorehabilitation. We are in close contact and exchange with the experts there.

ALL DATA COMES TOGETHER HERE:  
THE INTENSIVE CARE TEAM MONITORS SEVERAL  
HUNDRED PATIENTS EVERY YEAR.





HIGH PRECISION AND MILLIMETER-PRECISE WORK IN SPINE SURGERY.

## SPINE SURGERY

Your contact: Prof. Dr. med. Karl Kiening, Dr. med. Jan-Oliver Neumann, Dr. med. Stepan Fedorko, Dr. med. Basem Ishak, Dr. med. Modar Kentar, and Dr. med. Moritz Scherer

A well-established team of highly qualified and internationally renowned specialists performs operations using the latest intervention techniques and conducts clinical and experimental research.

**We perform approximately 1,200 spinal surgeries per year, representing around one-third of all the operations of our department.** We often operate on patients with complex diseases or injuries of the spine or the spinal cord.

### Spinal stenosis

Stenosis of the spinal canal can occur anywhere within the spine but are frequently located within the area of the cervical and lumbar spine. The aim of surgery is to release the narrowed spinal canal and the compressed spinal cord or nerve roots. At the same time, we are careful not to impair the

stability of the spine. The surgical concept is always individually adapted to the requirements of each patient.

### The following treatments are available:

- Interlaminar fenestration
- Hemilaminectomy
- Laminectomy
- Stabilization and fusion
- Ventral discectomy and cage fusion or prosthesis
- Corpectomy and vertebral body replacement procedures using lateral or frontal approaches at any level of the spine

Our principle: Any surgical intervention is always carried out in the most targeted manner possible and is only extended as far as necessary.



**By using point-to-point navigation, we only had a missplacement of 0.3 per cent of 6,059 screws – in 1,059 patients – a figure that is far below the international average.**



Ishak B. et al. Neurosurg Rev. 2018

Stabilization procedures are only used when it is clearly indicated, such as instabilities caused by listhesis, trauma or tumor.

### Slipped discs

The treatment of intervertebral disc disease is one of our specializations. This also includes complex cases such as recurrence cases, multiple slipped discs or intervertebral disc disease in old patients or those with pre-existing co-morbidities. All interventions are carried out using an operating microscope. Through skin incision on the back, the intervertebral disc tissue compressing the nerve is gently and safely removed. In some cases, endoscopic procedures are also used. We carried out a total of more than 300 intervertebral disc operations in 2019.

### Spondylolisthesis

In these cases, the listhesis is corrected in the most natural position possible. This normalizes the spinal balance and hence prevents from further degeneration. Any disc protrusions or spinal canal stenosis will be addressed during the same operation

because they are often the cause of our patients' complaints. During surgery, we particularly pay attention to a sufficient decompression of the trapped nerve roots, hence relieving symptoms in the long run.

### High stability with precise implant positioning

In order to correct and stabilize a listhesis, we use custom-fitted titanium screws. In general, this stabilization is carried out through the back, as a so-called spondylodesis. During the operation, high-resolution images of the spine are routinely produced using an intraoperative CT or 3D X-ray technology. These are used on a neuro-navigation system in order to individually plan the screw size and position. In this way, we can guarantee optimal screw positioning and a minimal risk of complications.

Furthermore, we also use vertebral body replacement for complex fractures, extended degenerative processes or tumor by a lateral or anterior approach.

# SPINAL MALFORMATIONS AND TUMORS

Your contact: Dr. med. Basem Ishak, Dr. med. Ahmed El Damaty, and Dr. med. Jan-Oliver Neumann



MAGNIFIED MANY TIMES: OPERATIONS ON THE SPINE ARE ALWAYS CARRIED OUT WITH THE HELP OF A MICROSCOPE.

Our specialists regularly treat patients with spinal malformations or tumors. We always advise our patients in great detail and discuss the personalized treatment concepts. Following the intervention, the surgeons and their team ensure a proper aftercare.

## Surgical treatment: as gentle and as safe as possible

Our doctors operate as gently and safely as possible with the help of the latest technology. Standard procedures include an operation microscope and intraoperative electrophysiological monitoring of the spinal cord function. This technology enables us to react to changes in the spinal cord function during surgery and prevent neurological damage.

## We specialize in the treatment of:

- Spina bifida aperta ('open spine')
- Spina bifida occulta
- Spinal dysraphia
- Dermal sinus
- Tethered spinal cord

## Implantation of medication pumps

If the cause of complaints – for example, severe muscle cramps – cannot be treated or only with a high risk, medication pumps are inserted into the spinal fluid. This minimizes the risk of systemic side effects. During a small operation, our physicians implant a special medication pump with a catheter into the spinal canal to administer the drug.

## How we treat spinal tumors

One specialization of our department lies in the surgical treatment of spinal tumors. Our objective for each operation is the complete removal of the tumor while preventing neurological damage. Our patients benefit from many years of experience and high-level of specialisation of our surgeons as well as from the latest technology, e.g. the use of intraoperative neuro-monitoring. In the case of invasive tumors, e.g. into the thoracic space, our surgeons operate together with colleagues from other surgical departments.

## We are specialized in the treatment of:

- Neurinomas
- Meningiomas
- Ependymomas
- Glioma/astrocytomas
- Spinal metastases

## The treatment of spinal metastases

In patients with carcinoma, spinal metastases often occur in course of their disease. Besides pain, these often cause neurological deficits due to the compression of the spinal cord. The objective of the operation is to relieve pressure on the spinal cord, remove the tumor and restore the stability of the spine.

If the tumor creates instability of the spine, additional stabilization is necessary. In this case, tumor removal and stabilization can be achieved in one intervention via neuronavigation and intraoperative CT. According to the histological diagnosis of the tumor, subsequent radiotherapy or oncological treatment following surgery are necessary.

## The treatment of neurinoma, meningioma and ependymoma

The removal of neurinoma, meningioma and ependymoma are common interventions in our department. Neurinoma and meningioma are located inside the dura (the skin of the spinal cord), but outside the spinal cord itself, whereas ependymoma grow inside the spinal cord. The operation is carried out by neurosurgeons with extensive experience in this field using neuromonitoring to completely remove the tumors and to avoid any permanent damage to the spinal cord.

## The treatment of glioma/astrocytoma

As a result of diffuse tumor extension within the spinal cord, surgical resection of gliomas is limited. Hence we often can only achieve tumor debulking or obtain a histological diagnosis. In such cases, we perform extension plasty of the dura in order to relieve pressure on the spinal cord.



HIGHLY DEVELOPED NEURO-NAVIGATION ALLOWS PRECISE LOCATION AND REMOVAL OF SPINAL TUMORS USING THE LATEST INSTRUMENTS.

## Interdisciplinary networking

Our staff members work closely together with other departments of the University of Heidelberg and with the National Center for Tumor Diseases (NCT) and the German Cancer Research Center (DKFZ). In this way, our experts always have access to the latest findings in international cancer research.



Every year, we operate on approximately 160 spinal tumors – equivalent to 3 every week.





THE INTERVENTION IS PLANNED PRIOR TO THE OPERATION USING THE LATEST TECHNOLOGY AND IMAGING.



OUR SPECIALISTS FOR STEREOTACTIC PROCEDURES OR DEEP BRAIN STIMULATION (L. TO R.): DR. MED. MARTIN JAKOBS, DR. MED. CHRISTINE JUNGK, AND PROF. DR. KARL KIENING

## FACTS

Our specialists have been working on DBS and other stereotactic operations since 1995.

## DEEP BRAIN STIMULATION

Your contact: Prof. Dr. med. Karl Kiening and Dr. med. Martin Jakobs

This is a minimally invasive intervention that is highly effective: Deep brain stimulation, abbreviated DBS, is a procedure that has been established since the end of the 1980s and is used for diseases such as dystonia, Parkinson's disease, and essential tremor. The objective is the alleviation of symptoms, thus improving the quality of life. In this treatment, electrodes are placed at exact points within deep brain structures. A small neurostimulator is used as the energy supply and is usually placed under the clavicle. Depending on the model, it may be necessary to change the battery after several years or to charge it inductively through the skin for around one hour every week.

### Interdisciplinary patient care

The treatment requires an experienced and established team in order to be successful: For DBS surgery, the patient's head is fixed in a stereotactic frame, guaranteeing the highest level of precision. For medical indication, intraoperative and post-operative care and longterm therapy, we collaborate with teams of neurologists, psychiatrists, and pediatricians.

### Screening over several days

Comprehensive examinations are carried out by our experts over several days in order to obtain precise information regarding the movement disorder. They clarify any possible pre-existing conditions in order to rule out surgical risks. An intensive diagnosis allows our surgeons to estimate whether and to what extent our patients might benefit from the interventions.

### Minimal invasive intervention at the highest level

We always use the latest technology for planning and surgery. This includes real-time imaging, intraoperative MRI and CT, high-precision surgical instruments and, of course, the latest computer software. This allows our neurosurgeons to quickly reach any point in the brain with sub-millimeter precision. The latest surgical and anesthesia techniques can only be provided by specialized centers at large university hospitals, such as Heidelberg.

### Careful surgical follow-up

Following surgery, our patients stay at our department for seven to ten days. In this time, their wounds can heal and the previously taken medication can be adjusted. At the same time, we can optimize the strength and the type of DBS. Subsequent examinations take place every three months initially and then annually, once the stimulation has been set to an optimum level. We use these appointments to check the battery status and the function of the implanted stimulator.

### Dystonia

Dystonia is a neurological movement disorder or muscle contraction that cannot be controlled. If medical treatment becomes less effective or if it is associated with detrimental side effects, DBS might be an option. Patients with Oppenheim's syndrome, a type of dystonia that begins in early childhood, considerably benefit from this treatment. It is usually the only effective method.

### Parkinson's disease

When used correctly, DBS leads to substantial alleviation of the typical symptoms such as shaking or immobile, stiff muscles in the arms and legs. The treatment improves our patients' mobility. The dosis of medication can usually be substantially reduced.

### Essential tremor

Essential tremor, which results in uncontrolled shaking, can be effectively treated using DBS. The success of the treatment is visible and noticeable immediately after the operation. It is usually possible to substantially reduce shaking – or eventually prevent it.



# SURGICAL PAIN THERAPY

Your contact: Priv. Doz. Dr. med. Rezvan Ahmadi and Dr. med. Martin Jakobs

We specialize in the diagnosis and treatment of chronic pain. In particular, we advise and treat patients with chronic pain syndromes, who are suffering despite conservative therapies. In many of these patients, pain surgery can alleviate symptoms. Such operations include, for instance, the decompression of nerve structures. This kind of surgery often results in long-term pain relief. Furthermore, there are ablative and neuro-modulative procedures, which are available in cases of recurring and

therapy-resistant pain. We have a wide range of surgical techniques and the technical equipment and implants for these surgical procedures.

## A multidisciplinary team

We know that optimal pain treatment depends on cooperations with other departments. We first evaluate the patients' medical history and examine the current disease status carrying together all results finally providing an individual treatment concept.

## Surgery as pain therapy:

- Microvascular decompression, e.g. in cases of trigeminal neuralgia
- Thermo-coagulation of the ganglion gasseri: in cases of therapy-resistant trigeminal neuralgia
- Occipital nerve stimulation (ONS): in cases of cluster headaches or migraine
- Subcutaneous peripheral nerve stimulation (sPNS): in cases of neuropathic trigeminal pain or post-craniotomy headache
- Sphenopalatine ganglion stimulation (SPG): in cases of cluster headaches
- Deep brain stimulation (DBS): in cases of cluster headaches or neuropathic trigeminal pain
- Motor cortex stimulation (MCS): in cases of neuropathic trigeminal pain
- Spinal cord stimulation (SCS), dorsal root ganglion stimulation (DRG) etc. as therapy for neuropathic pain and mixed pain, e.g. back/leg pain

## Careful follow-ups

We check the function of the inserted implants at regular intervals. This includes for instance, optimizing the settings for patients with neuro-stimulators and refilling of medication pumps. This follow-up is provided by the treating physician and specially trained nurses.

# FACTS

We can treat the following pathologies using neurosurgical therapies:

- Trigeminal neuralgia/neuropathy
- Cluster headaches
- Anesthesia dolorosa of the head and the face
- Neuropathic pain following nerve injury
- Neuropathic pain in the arms/legs: CRPS, FBSS etc.
- Back pain
- Pain from circulatory disorders (ischaemic pain), for example in cases of peripheral arterial occlusive disease (PAOD), angina pectoris
- Spasticity, for example as a result of multiple sclerosis (MS) and stiffman syndrome (SPS)

## Medical research for the treatment of chronic pain

As an University Center, we are engaged in innovation and the improvement of knowledge. We already offer a wide range of possible therapies, particularly in the area of neuro-modulation, some of which are not (yet) recommended as standard in medical guidelines but that have been successfully used in many cases. We promote the inclusion of our patients in clinical studies in order to obtain new findings for future treatments. You can find a list of current studies in the chapter 'Research and Teaching' on page 68 onwards.



WORKING TOGETHER ON A THERAPY CONCEPT: PRIV. DOZ. DR. REZVAN AHMADI IN CONVERSATION WITH ANESTHESIOLOGIST DR. MED. CHRISTIANE GEIST.

# PEDIATRIC NEUROSURGERY – CARE, ATTENTION, AND OPTIMAL MEDICAL SUPPORT

Your contact: Dr. med. Ahmed El Damaty

Our services are in demand around the world: Specialists from Heidelberg treat children with brain or spinal cord disease from all over Europe and the Middle East. Thanks to our comprehensive range of cutting-edge surgical techniques we can also operate on very rare and unfavourably located tumors in a targeted manner. We can treat your child using the latest findings and experience. Care, attention, and child-oriented nursing are just as much a part of our standard as optimum medical support.

## Integrated treatment for your child – thanks to interdisciplinary cooperation

Developmental disturbances in the central nervous system can affect the surrounding organs and physiological functions. That is why we always work closely with neighbouring departments, such as maxillofacial surgery or ENT medicine. There is a special dysraphia section where specialists from different departments examine patients with an ‘open back’ together to coordinate a personalized treatment strategy. Besides the surgical removal of a tumor, our small patients often require further treatment. They may require radiation, pharmacological tumor therapy or careful neurological and socio-medical support. Close interdisciplinary cooperation allows us to offer child-oriented and personalized therapy at each treatment stage.



**In 2016, we were the first department in Germany to operate the open back of an unborn child microscopically. Since then, we have successfully performed this intrauterine operation 15 times.**

We work together very closely with the National Center for Tumor Diseases in Heidelberg (NCT) and the globally renowned German Cancer Research Center (DKFZ) – two oncological research centers with a worldwide reputation. This allows us to offer new, personalized and risk-adapted therapies with the development and use of molecular markers and medications.

## Open fetal surgery for treatment of spina bifida aperta (open spinal cord)

Between the 19th and 25th week of pregnancy, we can treat this malformation in a fetus – so-called spina bifida aperta (MMC) – using open fetal surgery. In this procedure, we close the spinal cord through a small opening in the womb. Intrauterine treatment protects the spinal cord from damage at an early state and reduces the risk for the development of a hydrocephalus. Our multidisciplinary spina bifida team will support you and your child from diagnosis through treatment through multiple years of aftercare.

## Innovative treatment possibilities for spasticity/infantile cerebral palsy

We offer extensive medication therapy and so-called selective dorsal rhizotomy, a kind of microsurgical operation, for the treatment of this movement disorder, caused by brain damage in early childhood. Our doctors are specialized in this surgical procedure, which has only been offered in four other departments to date. In order to treat spasticity, nerve fibers are severed in a targeted manner. Neighbouring, healthy nerve fibers are spared with the help of neuromonitoring. The effect of the microsurgical intervention lies way above the results of the treatment possibilities that were available previously and also displays a lifetime effect. It is primarily suitable in cases where both legs are affected by



WORKING FOR THE SMALLEST PATIENTS: AFTER ESTABLISHING THE SECTION OF PEDIATRIC NEUROSURGERY FROM 2010 TO 2019, PD DR. HEIDI BÄCHLI IS HANDING IT OVER NOW TO DR. AHMED EL DAMATY (L. TO R. DR. MED. AHMED EL DAMATY AND PRIV. DOZ. DR. HEIDI BÄCHLI).

the spasticity. We thus achieve substantially improved standing and walking ability; improvements in the mobility of arms and hands are also possible.

If our specialists recommend pharmacological therapy, we offer tablets and botox injections to relax muscles and the implantation of special medication pumps for children. These pumps dispense muscle relaxants via a fine tube to the point where the spasticity originates.

## Hydrocephalus therapy: shunt or endoscopy

We treat excessive collections of cerebrospinal fluid in the brain (hydrocephalus) using various procedures. A so-called shunt allows for long-term drainage in cases of chronic hydrocephalus. For this, we generally use a combination of a programmable differential pressure valve and a gravitation valve. The individual adjustment of the fluid flow is carried out magnetically from the outside.

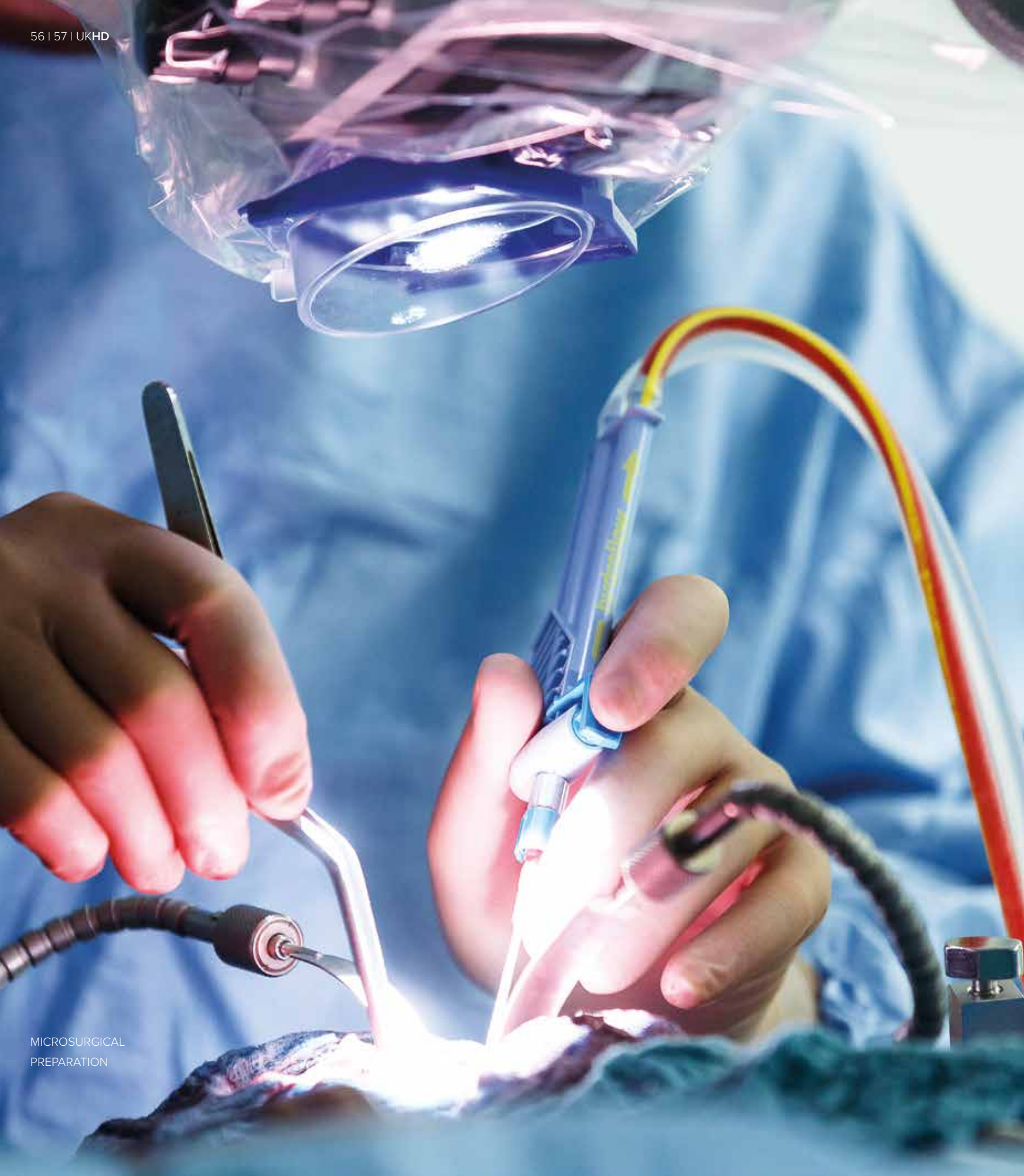
If hydrocephalus is caused by an obstruction of the fluid system, we can widen this narrow section with a small endoscopic intervention. This ensures natural drainage. Following a successful operation, no further interventions are generally required.

However, regular aftercare examinations are important in order to treat any recurrence of the narrowing in good time.

## We specialize in the diagnosis and treatment of:

- Pilocytic astrocytoma
- Medulloblastoma
- Ependymoma
- Craniopharyngioma
- Tumors in the first years of life
- Pituitary adenoma (tumor of the pituitary gland)
- Brain stem glioma
- Germ cell tumors (germinoma or teratoma)





# SURGICAL INTERVENTIONS





SPINAL INTERVENTION  
WITH INTRAOPERATIVE CT

## Surgical interventions:

# THIS SETS US APART

We perform more than 3,300 surgical interventions every year. Our main focus is the treatment of brain tumors. In addition, the number of interventions on the spine has risen by 11 percent since 2014 to 929 interventions in 2018.

CATEGORIES	2014	2015	2016	2017	2018
Total	3,387	3,362	3,394	3,377	3,209*
Brain tumor craniotomy	687	726	652	623	684
Pituitary tumor	47	61	79	85	76
Stereotactic brain biopsy	80	81	71	72	67
Aneurysmal clipping/AVM surgery	77	54	60	69	60
Intracerebral hematoma (ICB)	63	61	70	61	63
Neuromodulation surgery (SCS, PNS)	135	146	160	133	123
Hydrocephalus surgery	262	255	268	255	295
Functional neurosurgery	7	21	18	21	25
Excision of a cervical slipped disc	115	154	94	107	105
Excision of a lumbar slipped disc	194	226	256	222	241
Surgery for spinal stenosis	189	204	201	296	223
Spinal instrumentation	205	216	208	225	201
Excision of a spinal tumor	128	120	123	131	159
Traumatic brain injury	124	123	109	121	108
Surgery for chronic subdural haematoma (cSDH)	139	119	99	85	116
Cranio-facial malformations (together with MF surgery)	27	35	49	53	66
Decompressive craniectomy	18	23	40	44	58
Microvascular decompression	24	26	33	26	17
Surgery on peripheral nerves	35	31	25	34	30
Neural tube defect (Chiari, MMC, tethered cord)	32	25	24	32	36
Intracerebral, EVD, etc.	338	315	245	289	267
Cranioplastics	73	44	29	47	37
Other surgical interventions	378	296	481	346	152

\* Room 5 was out of use for seven weeks because of the installation of a new intraoperative CT



# TECHNICAL EQUIPMENT

**Always up to date: The technology at the Neurosurgical Department is among the best in the world. Individual pieces of equipment have been specifically adapted to the requirements of the surgeons in Heidelberg.**

The department has five modern operating rooms that are connected via a so-called PACS server – an information system for image archiving and improved communication. Our specialists can rely on the following technical equipment when making plans before interventions and operations:

## Imaging

### • Intraoperative MRI: 1.5 Tesla Siemens Espree Scanner

This special magnetic resonance imaging is only available in very few neurosurgical departments. It provides more control for the resection of intracranial and pituitary gland tumors. The MRI also provides planning data sets for stereotactic interventions and deep brain stimulation.

### • Intraoperative CT: SOMATOM Scope Sliding Gantry CT (Siemens®)

This is a new device since 2019: This computer tomography is used for direct imaging during surgery, to navigate complex spinal interventions, and for stabilization procedures. Furthermore, the CT is also available for resection control in tumors of the skull base, deep brain stimulation, and for providing planning data sets for stereotactic interventions.

### • Intraoperative ultrasound: BK-Medical 800

## Mobile X-ray equipment

- C-arm for fluoroscopy
- Two 3D C-arms for intraoperative tomography and the generation of navigation data sets for spinal neuronavigation

## Microscopes

- Four Zeiss Pentero microscopes for intraoperative tumor fluorescence and fluorescence angiography. They also offer integrated neuronavigation for intraoperative tumor visualization.
- Zeiss NC4

## Neuronavigation

- Three Stryker navigation devices
- Two Brainlab navigation devices with the ability of fibre tractography for tumor removal in especially critical areas of the brain

## Display

- Four Brainlab-Buzz monitors for interactive image display
- Zeiss Trenion 3D-HD monitor for the intraoperative 3D-display of the microscope image

## Neuromonitoring

- Three Inomed neuromonitoring systems, neurophysiological monitoring for individual discharges and local field potentials (Inomed)

## Endoscopy

- Two HD AIDA Karl Storz camera systems
- Two LOTTA Karl Storz systems for intraventricular endoscopy
- Two small LOTTA Karl Storz systems intraventricular endoscopy
- Two Neurovitom mounting systems
- One Karl Storz endoscopy set for surgery at the skull base
- One Karl Storz endoscopy set for craniosynostosis
- One Minop TEAM endoscope (Aesculap)



OUR SPECIALISTS FOR STEREOTACTIC INTERVENTIONS (R. TO L.): PROF. DR. KARL KIENING, DR. MED. CHRISTINE JUNGK, AND DR. MED. MARTIN JAKOBS

# STEREOTAXY

**Stereotaxy is an independent treatment highlight within neurosurgery.**

This minimally invasive procedure allows us to reach certain brain structures with millimeter precision. The stereotactic operation is a procedure that was established many decades ago and still constantly generates new areas of application.

## Safe surgery with a 3D image of the brain

In a stereotactic operation, a ring system is anchored on the patient's head. This is the basis for a three-dimensional space that is created virtually using an MRI. Within this space, each point in the brain is allocated to destination coordinates. These 3D images allow the surgeon to select the safest and most effective path to the target area during the operation.

The interventions are particularly gentle for our patients because of our experienced operating team and our extraordinary infrastructure. The fitting and removal of the stereotaxy ring takes place under a general anesthetic and is thus totally pain-free. The actual intervention only requires a cut into the skin

of a few centimeters and a small opening of the skull measuring about one centimeter. The operating time is kept as short as possible.

Stereotactic operations for diagnosis – for example the targeted removal of tissue samples – are carried out by us as a stereotactic intervention. We furthermore implant electrodes for the treatment of dystonia, Parkinson's disease, or essential tremor using deep brain stimulation (see page 51).



**We undertook 92 stereotactic interventions in 2018, of which 67 were brain biopsies and 25 functional interventions for deep brain stimulation.**

# ENDOSCOPY

Endoscopy has greatly extended the spectrum of neurosurgery through the possibility of minimally invasive approaches.



SURGICAL INTERVENTION WITH AN ENDOSCOPE: CYSTS OR TUMORS CAN BE REMOVED MORE SAFELY.

Besides a faster recovery time, endoscopic treatment is less traumatic for patients than open surgery. In this so-called keyhole technique, an endoscope – i.e. a tube with a light source, video camera, and working channel – is fed into the skin through a natural body orifice or a small cut in the skin. Fine operating instruments can be fed through the endoscope as needed.

Many interventions can now be carried out using the endoscope, for example the resectioning or fenestration of cysts or tumors in the cerebral ventricles. Depending on the diagnosis, it is also possible to remove tumors of the skull base following minimally invasive access via the paranasal sinus. The procedure is also particularly successful in the treatment of obstructive hydrocephalus (see pages 54/55 as well).



**Our endoscope equipment was used in 88 interventions last year.**

The endoscope is also used in open surgery with a microscope. This allows the surgeon to look into blind corners of the microscope and thus to get additional information. Using endoscopic-assisted microsurgical techniques thus helps to achieve gross total tumor removal, e.g. in intrameatal acoustic schwannomas or epidermoids of the CP angle.

# INTENSIVE CARE UNIT

Experienced doctors and nurses care for patients with acute neurosurgical diseases in 14 fully equipped beds.

Many years of professional experience and the tremendous expertise of our team cover the entire intensive care spectrum in neurosurgery. We place a special focus on the following treatment areas:

- Aneurysmal subarachnoid hemorrhage
- Traumatic brain injury
- Intracerebral hemorrhage
- Multimodal monitoring
- Patient support in the early post-operative stage

## Multimodal monitoring – a window into the brain

Patients with acute brain injury are often sedated and artificially ventilated. Comprehensive observation equipment allows for the optimal monitoring of the patients in order to be able to react as quickly as possible to changes. For example, intracranial pressure is measured continuously via special probes. The oxygen supply and the metabolism of the brain are also monitored in this way. A color-coded ultrasound also allows for close monitoring of the

blood flow within the brain, the extent of intracranial bleeding, and of the inner cerebrospinal fluid spaces. Special electrodes assess brain activity parallel to the above mentioned parameters.

## Post-operative monitoring – the important first 24 hours

Intensive monitoring and the active prevention of potential complications are particularly important in the first 24 hours following major surgery. In the neurosurgical intensive care unit, we monitor patients in the acute stage following complex brain or spine operations.

Relatives who want to receive information as quickly as possible after an operation can contact us using the telephone number for relatives by calling +49(0)6221-56 35648. Visits to the intensive care unit bed are also possible during visiting hours. For exact information on this, see page 32/33.



THE PATIENTS ARE CONTINUOUSLY OBSERVED VIA MONITORS IN ORDER TO BE ABLE TO REACT IMMEDIATELY TO ANY CHANGES.





THE INTRAOPERATIVE MRI PROVIDES HIGH-RESOLUTION IMAGES OF THE BRAIN DURING SURGERY.

## NEURONAVIGATION, NEUROMONITORING, AND INTRAOPERATIVE IMAGING

**Precise, safe and gentle: Our specialists work with the latest surgical technology in order to carry out complex interventions safely.**

### Neuronavigation

The patients' safety is the ultimate priority in neurosurgical operations. Neuronavigation is an important component for precise and safe surgeries and has been standard practice for brain and spine surgery in Heidelberg for many years. In the same

way that car navigation systems show us roads, neuronavigation provides neurosurgeons with millimeter-precise images of brain structures during the operation. The 'map' for the navigation is based on high-resolution MRI or CT images. This technique allows for the precise planning of skull base

operations and for safe access to pathologies that lie deep in the brain. Thus, access to deep tumors or other pathologies have become easier and safer.

### Intraoperative neuromonitoring

The function of the cranial nerves is monitored during the operation, particularly for tumors at the skull base.

### Intraoperative imaging

This is what makes the difference of our discipline from other surgical disciplines: When operating on brain tumors, it is particularly important to treat the healthy and functional brain around the tumor as gently as possible. Thus, the exact visualization of brain tumors is a central focus of our neurosurgical operating technique. In Heidelberg, we use intraoperative MRI for this purpose in order to create high-resolution images of the brain during the operation. This allows us to check the progress of safe tumor removal in real time.

Our department in Heidelberg was the first neurosurgical department in Europe having used this procedure more than 20 years ago. Since then, numerous scientific papers by our neurosurgeons have dealt with the further development of this technique. Today, our neurosurgical department is one of the leading centers for intraoperative MRT imaging in the world. For example, it has been shown that the use of the intraoperative MRT results in a greater rate of tumor resection and thus leading to a prolonged survival of patients with malignant gliomas.

We can also use intraoperative CT imaging in our hybrid OR in order to visualize bone or vessel structures and can integrate this into our surgical planning.



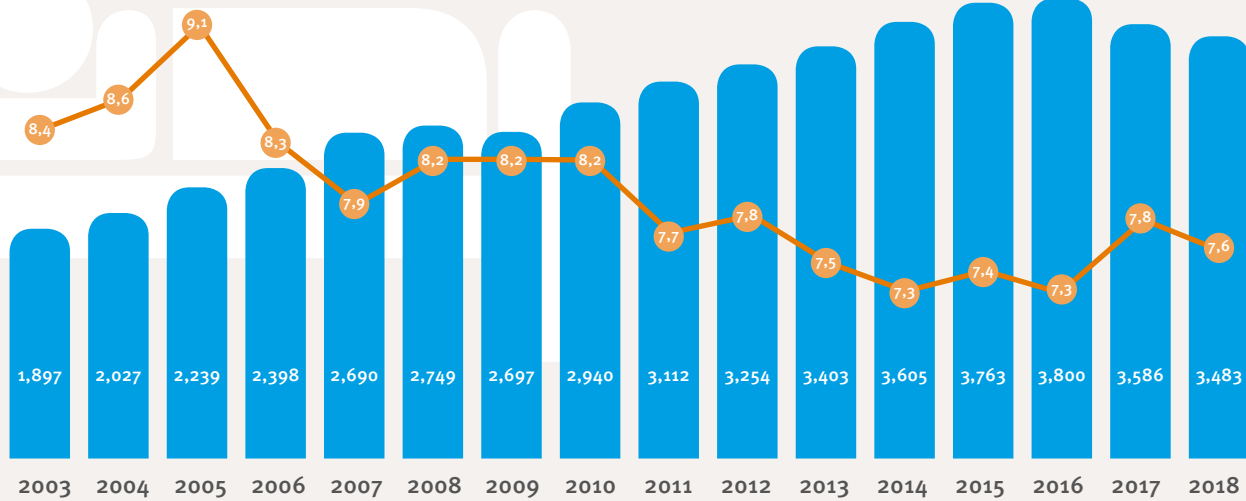
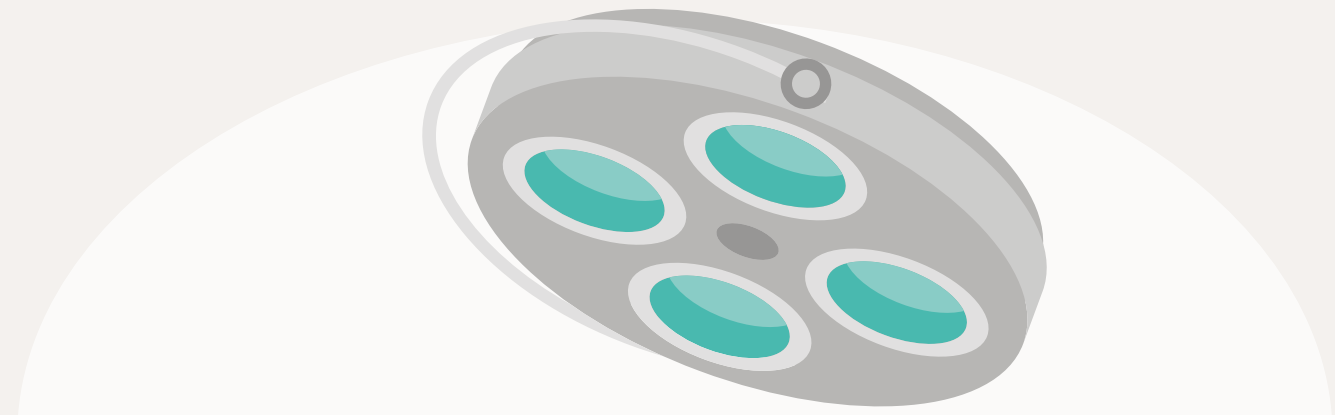
THIS PROVIDES OUR SPECIALISTS WITH VERY DETAILED REAL-TIME IMAGES OF THE TUMOR TO BE REMOVED.

**In 2019, we carried out 203 spinal and 544 cranial neuro-navigation procedures.**

At a glance:

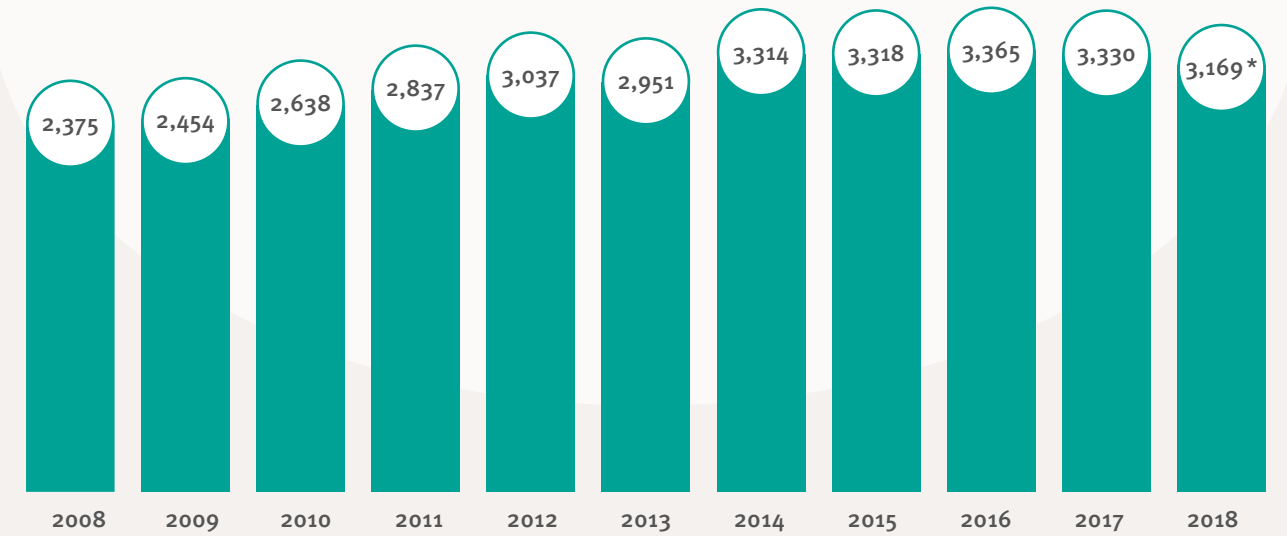
# OUR PERFORMANCE

The Neurosurgical Department is excellently positioned for the treatment of several thousand patients a year. We are constantly extending our range of services.



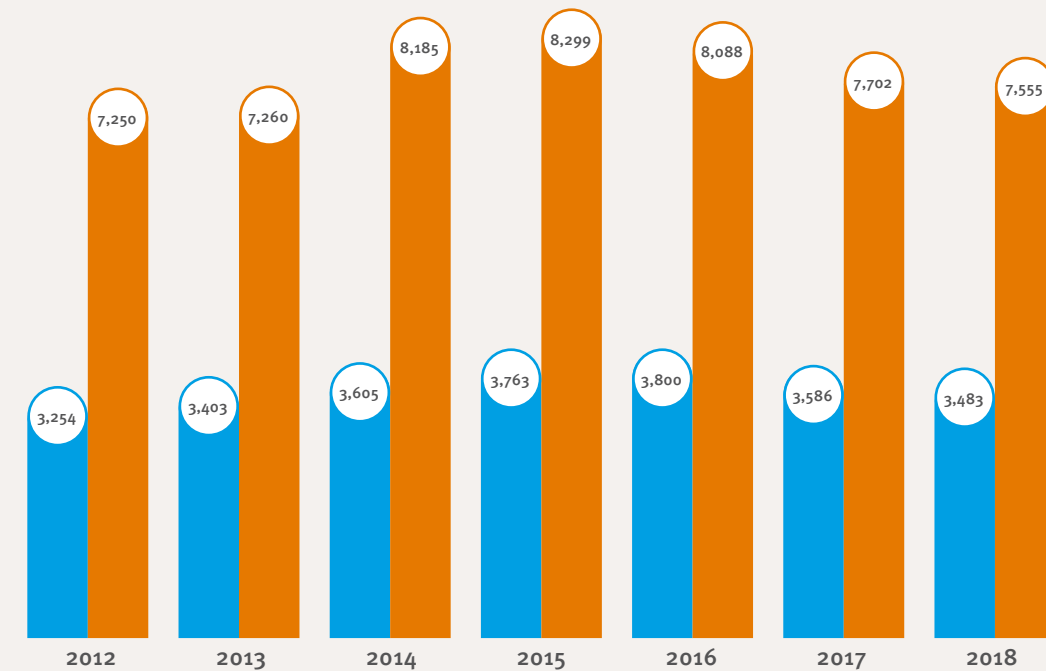
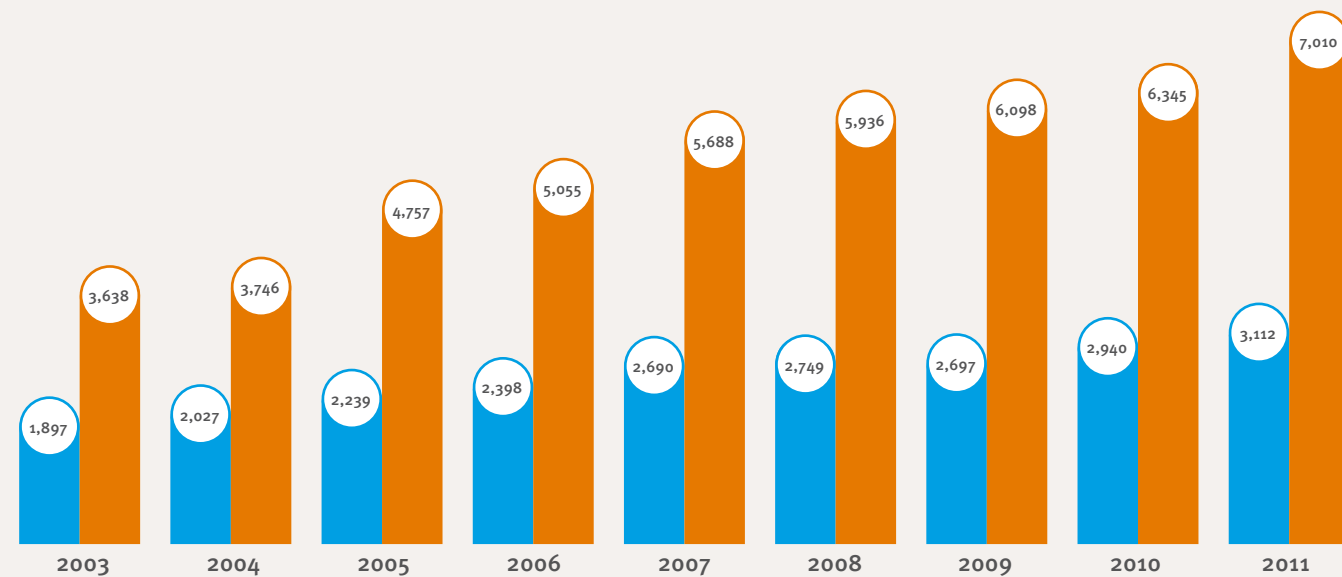
■ Number of inpatients  
■ Length of stay in days

Every year, we treat more than 3,300 patients. The average stay is currently just seven and a half days. This can vary throughout the year, but it demonstrates the high quality of the treatment services.



Total number of surgical interventions: We have been carrying out more than 3,300 neurosurgical interventions per year since 2014 – a higher number than almost every other department in Germany.

\*Room 5 was out of operation for seven weeks because of conversion and installation work on a new intraoperative CT device.

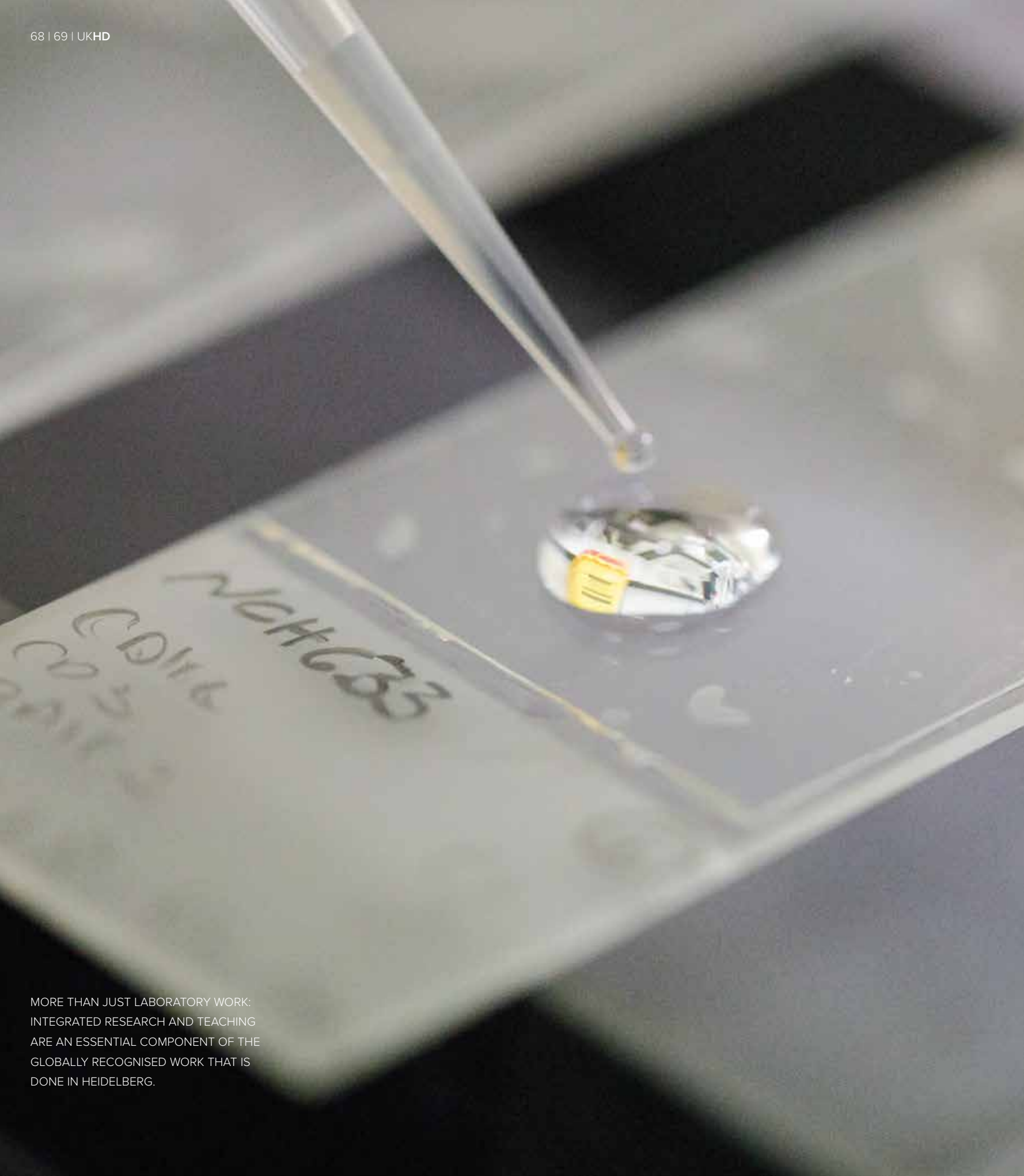


**Growth through the years:** The average severity of the cases which we have treated has increased along with the number of patients. Hospitals use the so-called case mix index to compare the ratio of case groups of differing severity to the number of patients treated. This uniform value allows us to observe the development in detail.

Number of cases and case mix points

■ Number of inpatients  
■ Case mix





# 4 RESEARCH & TEACHING

MORE THAN JUST LABORATORY WORK:  
INTEGRATED RESEARCH AND TEACHING  
ARE AN ESSENTIAL COMPONENT OF THE  
GLOBALLY RECOGNISED WORK THAT IS  
DONE IN HEIDELBERG.



## Teaching

# THE TRAINING OF OUR YOUNG TALENTS IS VERY IMPORTANT FOR US

**We place great emphasis on the practical teaching of academic education and training for our staff and young neurosurgical talents in order to also be able to satisfy our high-quality requirements in the future.**

We offer students from Heidelberg as well as exchange students from all over the world a wide range of opportunities to intensify their theoretical and practical neurosurgical knowledge and skills.

Within the medical faculty at Heidelberg University, we play an active role in the HeicuMed curriculum for the education of our medical students. The program is characterized by a high degree of practical application and an approach that is oriented towards problems and symptoms, and it is constantly under development. It was evaluated by the Science Council as being ‘exemplary’ for the Federal Republic of Germany.

### Practical year

Medical students can spend one-third of their practical year with us. On the basis of an internal training plan, students rotate through different areas of the department (e.g. OR, normal/intensive care unit, outpatient clinic). They are involved in the daily work on the wards or the outpatient clinic and are introduced to independent work with the patient. Depending on their personal abilities, they can partly take over patient care, under the super-

vision of the responsible physicians and can acquire manual skills in surgery while assisting there. Teaching for students, together with our colleagues from the Departments of Neurology and Neuro-radiology, takes place every week and covers the most important and interesting pathologies on the basis of current cases.

### Clinical traineeships

Interested students can obtain more detailed training by taking a clinical traineeship. This offer attracts great interest and thus we host approximately 6-12 students at our department during the break between terms. Visiting physicians from around the world are also welcome to work at our department for a limited period in order to learn from and with each other.

### Unterharnscheidt Society

The Unterharnscheidt Society was established within the framework of the mentoring and tutoring program at the medical faculty of Heidelberg University. It is a consolidation of the different specialized departments that care for traumatic brain and head injury on the basis of their anatomic vicinity

(neurosurgery, maxillofacial surgery, ENT, forensic medicine, ophthalmology, neuroradiology). The students are in direct contact with the lecturer as part of an interactive seminar. They learn interdisciplinary diagnostics and therapeutic concepts in casuistry and topic-oriented workshops.

### Board-qualified neurosurgeon

In order to become a board-qualified neurosurgeon, young physicians can do at least 6 years training in our department. A curriculum was created for this purpose, with clearly defined training steps in order to guarantee a structured and high-quality training. The stages of surgical training and the rotation into specialized teams (e.g. ICU) are defined. We are also authorized to provide specialist medical training for the additional designation of ‘intensive care medicine’. This further education takes a minimum of two years.

### Nursing school

Teaching events by lecturers of the Neurosurgical Department are fixed components in the training and further education of nurses, scrub nurses, and intensive care unit nurses at the nursing school at the Heidelberg University Hospital.

### Lecturer training at the medical faculty

Many of our lecturers regularly go back to become students themselves. They receive special training for didactic skills: Under the principle of ‘train the trainer’, several training courses are offered that provide practice in a wide range of didactic methods.

## Visiting doctors

### 2018

---

Mostafa Raafat M. Allam, Egypt,  
09/2018–09/2018

Taher Mohamed Ali, Egypt,  
09/2018–09/2018

Makoto Ohno, Japan,  
05/2018–06/2018

Saiko Watanabe, Japan,  
04/2018–03/2019

Hao Zhang, China,  
10/2016–06/2020

### 2016

---

Guoli Zheng, China,  
09/2015–09/2017

Renan Sanchez Porras, Mexico,  
01/2011–10/2015

### 2015

---

Karla Fiorella León Cabanillas, Portugal,  
11/2014–12/2015

Zheng Zelong, China,  
12/2010–02/2015

### 2014

---

Humberto Silos Rodriguez, Mexico,  
09/2013–11/2014

Yuan Gang, China,  
02/2013–01/2014



# IMPROVED THERAPY THANKS TO INTENSIVE NEUROSURGICAL RESEARCH

**Clinical research forms the basis of the excellent and modern clinical treatment of our patients.**

The success of established therapies is re-evaluated and new therapy approaches are examined in the course of clinical trials. Our neurosurgeons receive substantial help from a team of experienced study nurses when they execute prospective multi-center, randomized trials. Great innovative advances have been made in all areas of neurosurgery in recent years and these have been studied in clinical trials. One focus of our work in this regard lies in the examination of patients who are

extent of surgical resection– determined by intra-operative MRT imaging or fluorescence – and the role of vaccination in tumor control and patient survival. Studies also play an important role in neuro-cognitive and neuro-psychological outcomes in patients with benign tumors (meningiomas).

Several studies are also being carried out in the area of spinal surgery and the care of patients with hydrocephalus. Special focus is also placed



» **Clinical and experimental research forms the basis for the modern and excellent medical treatment of patients.**

**Head: Division of Neurosurgical Research  
Prof. Dr. rer. nat. Christel Herold-Mende**

treated in intensive care units following severe traumatic brain injury or aneurysmal subarachnoid bleeding. In such treatment, we either try to prevent the development of secondary brain damage or to counteract vasospasm – a typical complication of subarachnoid bleeding – using various treatment approaches.

Another point of emphasis lays on neuro-oncology. In this area, we examine both the influence of the

on studies with patients who have chronic pain. A neuro-physiological characterization of chronic pain patients and their treatment with spinal cord stimulation (SCS) is also being carried out as part of an association with the special research area SFB 1158.

## Clinical research CLINICAL TRIALS

The following clinical trials are currently on offer:

### Traumatic Brain Injury

<b>Study title:</b>	NOSTRAIII
<b>Brief description:</b>	Efficacy of VAS203 in patients with moderate and severe traumatic brain injury (NOSTRAIII). A confirmed, placebo-controlled, randomized, double-blind, multi-center study.
<b>Phase:</b>	III
<b>EudraCT-Number:</b>	2013-003368-29
<b>Status:</b>	recruiting
<b>Contact:</b>	Prof. Dr. Klaus Zweckberger, Dr. med. Alexander Younsi, Mohammed Nofal, Martin Grutza, Younes Bilal

<b>Study title:</b>	Center-TBI
<b>Brief description:</b>	A European research project with the aim of improving care for patients with traumatic brain injury.
<b>Status:</b>	Recruitment complete. At follow-up stage
<b>Contact:</b>	Dr. med. Alexander Younsi

### Subarachnoid hemorrhage (SAB)

<b>Study title:</b>	Protocol ID-054-304, REACT
<b>Brief description:</b>	A prospective, multi-center, double-blind, randomized, placebo-controlled, parallel-group, Phase 3 study to assess the efficacy and safety of clazosentan in preventing clinical, deterioration due to delayed cerebral ischemia (DCI), in adult subjects with aneurysmal subarachnoid hemorrhage (aSAH).
<b>Status:</b>	recruiting
<b>Contact:</b>	Prof. Dr. med. A. Unterberg, Prof. Dr. Klaus Zweckberger, Dr. med. Johannes Walter, Mr. Martin Grutza, Mr. Mohammed Nofal, Mr. Arturo Olivares Rivera, Dr. med. Jan-Oliver Neumann, Dr. Edgar Santos Marcial, Mr. Bilal Younes

## Clinical research

# CLINICAL TRIALS

<b>Study title:</b>	PlaFuSAH
<b>Brief description:</b>	A prospective study of in-vitro thrombocyte function in whole blood and the concentration of thrombocytes in the cerebrospinal fluid of patients with aneurismal subarachnoid hemorrhage
<b>Status:</b>	recruiting
<b>Contact:</b>	Prof. Dr. Klaus Zweckberger, Dr. med. Johannes Walter

<b>Study title:</b>	VANQUISH (Volatile Analgo-sedation quality in SAH)
<b>Brief description:</b>	The objective of this multi-center observation study is to collect data regarding the safety and feasibility of routine intravenous (i.v.) sedation compared to volatile sedation in patients with aneurismal subarachnoid hemorrhage – following successful treatment of the aneurism.
<b>Status:</b>	recruiting
<b>Contact:</b>	Prof. Dr. Klaus Zweckberger, Dr. med. Johannes Walter

## Neuro-oncology

<b>Study title:</b>	NOA19
<b>Brief description:</b>	Retest reliability and localisation-dependent sensitivity of neuro-cognitive testing in patients with primary glioblastoma
<b>Status:</b>	recruiting
<b>Contact:</b>	Dr. med. Christine Jungk, Dr. med. Huy Philip Dao Trong, Dr. med. univ. et scient. med. Gerhard Jungwirth, BSc.

<b>Study title:</b>	GeSGIM
<b>Brief description:</b>	The influence of intraoperative MRI imaging on the extent of resectioning in patients with newly diagnosed glioblastoma – a prospective, multi-center, parallel-group study
<b>Status:</b>	recruiting
<b>Contact:</b>	Prof. Dr. med. A. Unterberg, Dr. med. Moritz Scherer, Dr. med. Christine Jungk

## Clinical research

# CLINICAL TRIALS

## Neuro-oncological studies involving neurosurgery

<b>Study title:</b>	VXMo1-AVE-04-INT
<b>Brief description:</b>	An open-label, Phase I/II multi-center clinical trial of VXMo1 in combination with avelumab in patients with progressive glioblastoma following standard treatment, with or without second surgery
<b>Status:</b>	recruiting
<b>Contact:</b>	Dr. med. Christine Jungk, Prof. Dr. rer. nat. Christel Herold-Mende

<b>Study title:</b>	VXMo1-02-DE
<b>Brief description:</b>	VXMo1 phase I pilot study in patients with operable recurrence of a glioblastoma to examine safety, tolerability, immune and biomarker response to the investigational VEGFR-2 DNA vaccine VXMo1. (Exploratory, open-label, uncontrolled, mono-center, Phase I pilot study)
<b>Phase:</b>	I
<b>Status:</b>	Recruitment complete, in the follow-up stage
<b>Contact:</b>	Prof. Dr. med. A. Unterberg, Dr. med. Christine Jungk, Prof. Dr. rer. nat. Christel Herold-Mende

<b>Study title:</b>	N2M2
<b>Brief description:</b>	Multi-center, prospective, open, Phase I/II clinical umbrella study – Identification of a personalized therapy option for patients with glioblastoma with unmethylated MGMT promoter
<b>Status:</b>	recruiting
<b>Contact:</b>	Prof. Dr. rer. nat. Christel Herold-Mende



## Clinical research

## CLINICAL TRIALS

## Hydrocephalus

<b>Study title:</b>	Sygrava
<b>Brief description:</b>	Multi-center, randomized study to test the effectiveness and safety of programmable compared to fixed anti-siphon valves in idiopathic normal pressure hydrocephalus in adults (siphon-preventing versus gravitational valves for controlling drainage complications in NPH)
<b>Status:</b>	recruiting
<b>Contact:</b>	Prof. Dr. med. A. Unterberg, Dr. med. Stepan Fedorko, Carola Wieckhusen, Arturo Olivares Rivera

---

## Spine

<b>Study title:</b>	Snapping Cage Synchrony Study
<b>Brief description:</b>	Open, mono-center, purely descriptive application observation in degenerative disc disease in the area of the spine LWK2-SWK1 in patients requiring surgical treatment using an internal fixation system and intervertebral cages.
<b>Status:</b>	recruiting
<b>Contact:</b>	Prof. Dr. med. Karl Kiening, Dr. med. Basem Ishak, Edina Kovacs

---

## Pain

<b>Study title:</b>	SFB1158: Neuro-physiological characterization of the patient with chronic pain and SCS treatment
<b>Brief description:</b>	Open, mono-center, clinical study as part of the cooperation with the Institute for Neuro-physiology in Mannheim as associated project of the special research area (SFB-Pain 1158)
<b>Status:</b>	recruiting
<b>Contact:</b>	PD Dr. med. Rezvan Ahmadi

---

## Clinical research

## CLINICAL TRIALS

## Other

<b>Study title:</b>	Setpointz
<b>Brief description:</b>	Stroke-Related Early Tracheostomy versus Prolonged Orotracheal Intubation in Neurocritical care Trial 2
<b>Status:</b>	recruiting
<b>Contact:</b>	Dr. med. Jan-Oliver Neumann, Mohammed Nofal, M. Mehdi Hajiabadi, Dr. med. Sara Euteneuer

---

<b>Study title:</b>	GERMAN CRANIAL RECONSTRUCTION REGISTRY (GCRR)
<b>Brief description:</b>	Prospective, multi-center and controlled registration study on (decompressive) craniectomy and subsequent cranioplastic operation
<b>Status:</b>	recruiting
<b>Contact:</b>	Dr. med. Henrik Giese

---

<b>Study title:</b>	S-488/2017
<b>Brief description:</b>	Retrospective and prospective analysis of the health and cognition-related life quality of neurosurgical patients with intracranial meningeoma
<b>Status:</b>	recruiting
<b>Contact:</b>	Dr. med. Christine Jungk, Dr. med. Huy Philip Dao Trong, Dr. med. univ. et scient. med. Gerhard Jungwirth, BSc

---

<b>Study title:</b>	Multi Recharge S312/2017
<b>Brief description:</b>	Questionnaire on nutrition, use and handling of rechargeable neuro-stimulators for deep brain stimulation for movement disorders
<b>Status:</b>	completed
<b>Contact:</b>	Dr. med. Martin Jakobs

---

EXPERIENCED STUDY NURSES  
SUPPORT OUR NEUROSURGEONS.







Division of Neurosurgical Research/  
Experimental Research

## MOLECULAR NEURO- ONCOLOGY GROUP

Head: Prof. Dr. rer. nat. Christel Herold-Mende

### Immunological changes and therapeutic targets during tumor progression in gliomas

The Molecular Neuro-Oncology Group has been working on the effect of the immune system on disease progression in glioma patients and how these findings can be used for the development of immunotherapies. T cells might play a de-

cisive role here. After being activated, they are able to recognize certain structures on tumor cells and to destroy them. However, the entry of T cells into the tumor is inhibited by tumor cells and by the corresponding tumor environment. That is why we examine the entry of T cells into the tumor at different stages of the disease and the influence of and how the tumor environment interacts (figure 1). We were able to demonstrate a prognostic role of tumor-associated myeloid cells (Geisenberger et al. 2015). We were also able to identify immunogenic tumor structures in primary and recurrent tumors (figure 2) as part of a project supported by the Anni-Hofmann Foundation. These are specifically recognized by T cells from glioma patients, but not by T cells from healthy donors. They are of particular interest for the development of effective immunotherapies because they are also expressed by dormant glioma stem cells that are held responsible for the recurrence of gliomas (Rapp et al., 2017, Dettling et al., 2018).

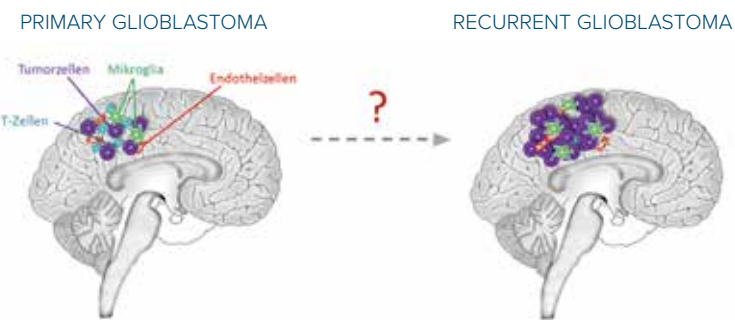
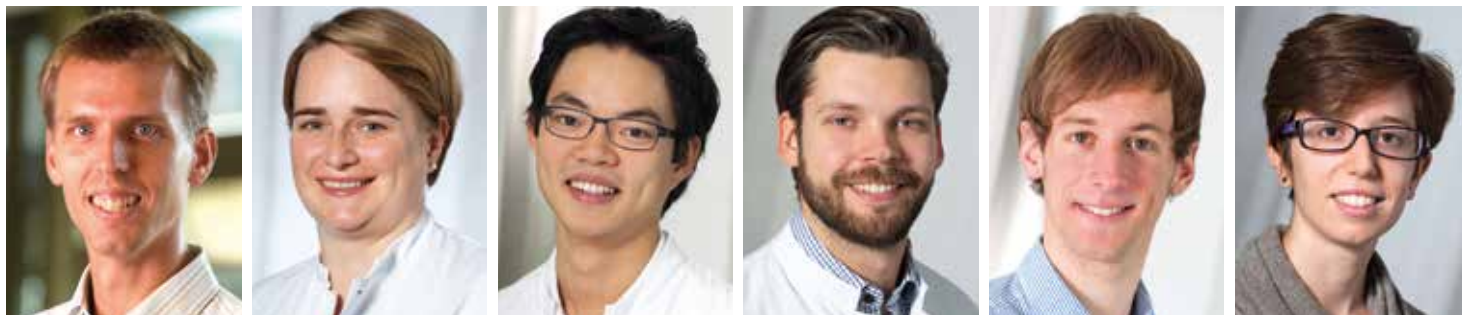


FIGURE 1: ADAPTATIONS OF TUMOR CELLS AND TUMOR ENVIRONMENT DURING THE COURSE OF THE DISEASE CHANGE THE RESPONSE TO THERAPY (RAPP ET AL. 2017).

#### Lab staff:



DR. SC. HUM. ROLF WARTA, DEPUTY HEAD  
DR. MED. CHRISTIN JUNGK, DEPUTY HEAD  
DR. MED. HUY PHILIP DAO TRONG, PHYSICIAN  
DR. MED. UNIV. ET SCIENT. MED. GERHARD JUNG-WIRTH, PHYSICIAN  
DR. MED. ANDREAS MOCK, PHYSICIAN  
VALENTINA FERMI, PHD CANDIDATE

### Identification of prognostic markers in glioblastoma

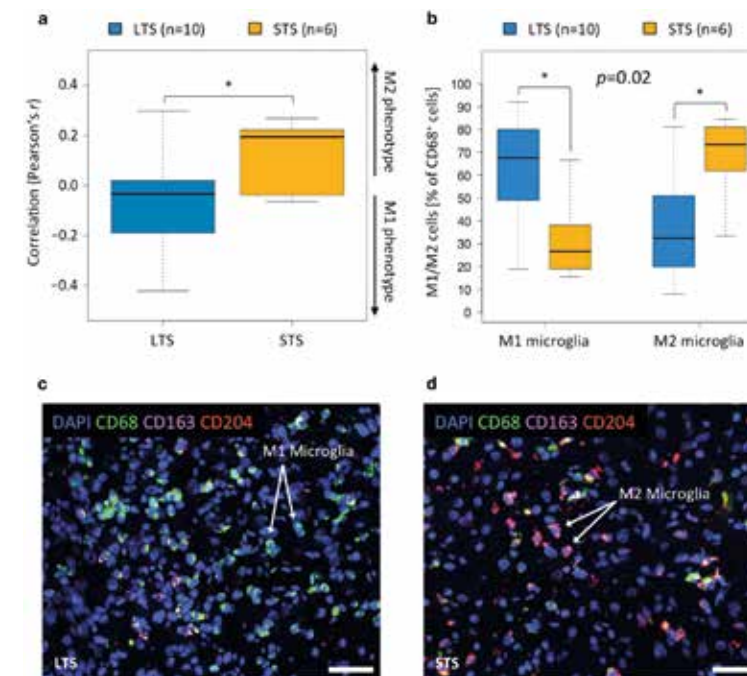
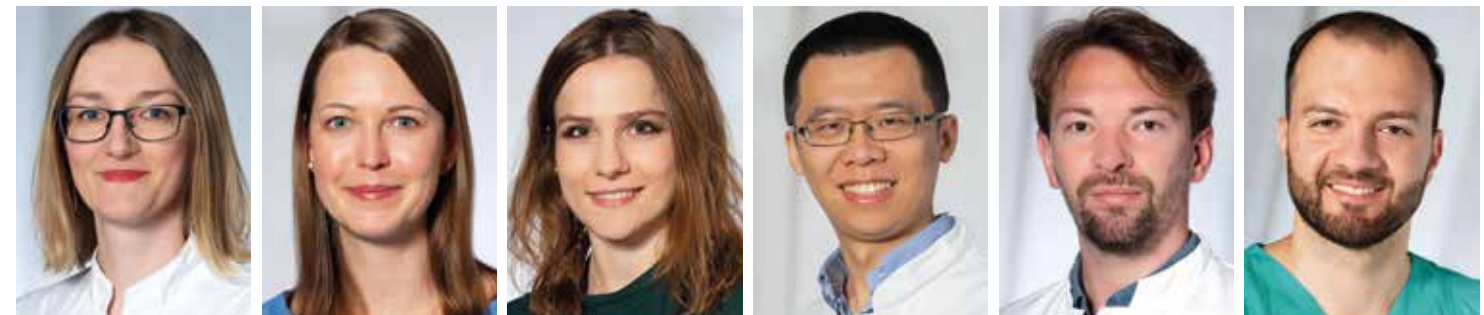


FIGURE 3 MICROGLIA INFILTRATION AND ACTIVATION STATUS IN SHORT-TERM (STS) AND LONG-TERM SURVIVAL (LTS) GLIOBLASTOMA PATIENTS. A) SIGNIFICANT ENRICHMENT OF GENES IN M2 POLARIZATION IN STS PATIENTS ON THE mRNA LEVEL, B-D) SIGNIFICANTLY INCREASED PROTEIN EXPRESSION OF M2 MARKERS IN TISSUES IN STS AND OF M1 IN LTS, C-D) EXAMPLE MICROGLIA STAINING IN THE TUMOR TISSUE OF AN LTS (C) AND STS PATIENT (D). (FROM GEISENBERGER ET AL., 2015)

The working group examines which factors are decisive for the survival of tumor patients using an internal biobank. This aims to predict the prognosis and also to expand our knowledge regarding the possible therapeutic targets. Using a collection of tumors from so-called long-term survivors and in cooperation with the translational radio-oncology unit of our university (Prof. Amir Abdollahi, Prof. Jürgen Debus), it was possible to identify chromosomal changes that frequently occur in long-term survivors. Conversely, substantial changes in the

tumor environment were also determined in those patients who survived for a particularly short time. This showed an increased occurrence of anti-inflammatory M2 polarized microglia cells and macrophages in gene expression signatures and on the protein level (Geisenberger et al., 2015, figure 3). Therefore, the current work focuses on the inhibition of these cells which might have an unfavourable effect on patients immune response.

#### Scientific staff:



DR. RER. NAT. TAMARA BENDER, POSTDOC  
LENA SCHULZE-EDINGHAUSEN, PHYSICIAN  
CATHARINA LOTSCH, PHD CANDIDATE  
TAO YU, MD CANDIDATE  
FLORIAN STAMMLER, MD CANDIDATE  
MONTADAR ALAA EDDINE, MD CANDIDATE



### Creation of the FORAMEN Consortium for the improved analysis and therapy of aggressive meningioma

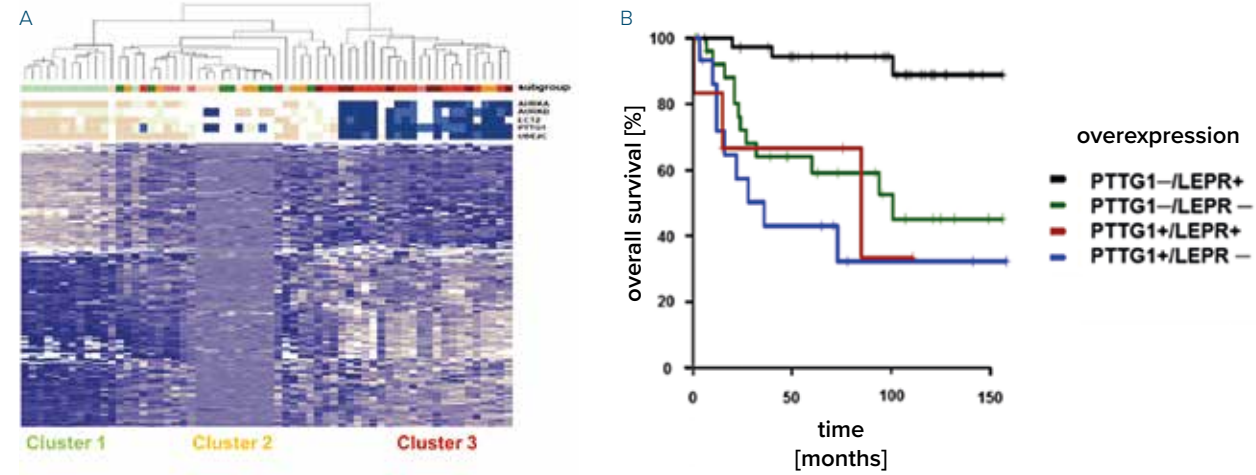


FIGURE 4 TRANSCRIPTOME ANALYSES ON A COLLECTION OF BENIGN AND AGGRESSIVE MENINGIOMAS LED TO THE IDENTIFICATION OF NEW PROGNOSTIC AND THERAPEUTIC MARKERS. A) CLUSTER ANALYSIS, B) SURVIVAL OF MENINGIOMA PATIENTS DEPENDING ON THE EXPRESSION OF PTTG1 AND LEPR. (FROM SCHMIDT ET AL., 2016)

Meningiomas are some of the most common brain tumors and are usually curable using surgical resection. However, a small number of benign tumors and most aggressive tumors recur. To focus on the rare aggressive tumors, we established a research group for aggressive meningioma (FORAMEN) with Prof. Simon (Bielefeld) and under the auspices of the German Society for Neurosurgery (DGNC). To date, six German neurosurgical departments are participating in this research group. The objective is to collect tissue from these aggressive meningiomas in order to look for biomarkers and therapeutic

approaches. As part of this initiative, it was possible to identify new prognostic biomarkers using transcriptome analyses. As the next step, we will search for therapeutic substances already available for these targets (figure 4, Schmidt et al., 2016).

#### Scientific staff:



MANDY BARTHEL, STUDY NURSE | MELANIE GREIBICH, HEAD TECHNICIAN | ILKA HEARN, TECHNICIAN | FARZANEH KASHFI, TECHNICIAN | LEONARD BÄCKER, TRAINEE | LISA PETERMANN, TRAINEE



## PAIN AND NEURO-MODULATION GROUP

Head: PD Dr. med. Rezvan Ahmadi

Precise, safe, and gentle: Our specialists work with the latest operating technology in order to carry out complex interventions safely.

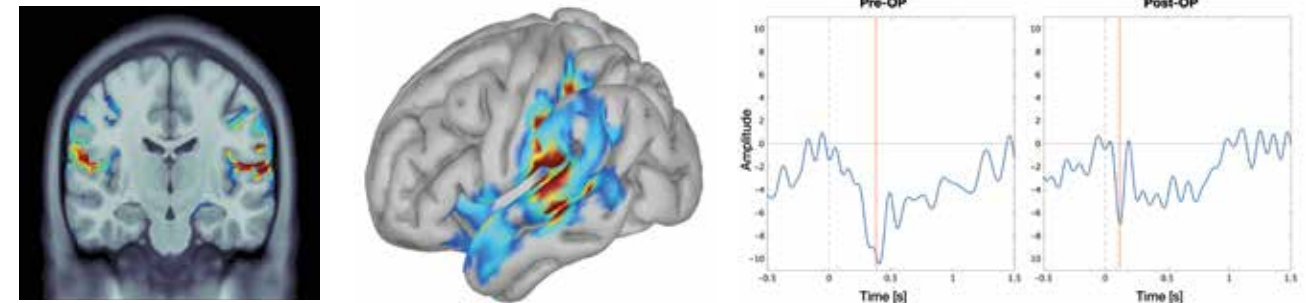


FIGURE 1: ANALYSIS OF EVOKED FIELDS AND OSCILLATORY BRAIN RESPONSES IN MEG FOR PATIENTS WITH TRIGEMINAL NEURALGIA.

The “pain and neuromodulation” working group, which was established within the Division of Surgical Pain Therapy, aims to examine and improve the efficacy of surgical therapies for chronic pain. It also studies the effect of microvascular decompression to treat trigeminal neuralgia and explores cortical biomarkers for treatment response (figure 1 in cooperation with the Division of Biomagnetism, the Department of Neurology, and within the framework of SFB1158). The group also

investigates the neuro-physiological effects of peripheral nerve stimulation for the therapy of phantom pain in cooperation with ZI Mannheim. A major research focus is investigating ways to optimize spinal cord stimulation for the treatment of neuropathic pain. In particular, the group studies clinical and neuro-physiological effects of different paresthesia-free stimulation paradigms for the treatment of back and leg pain in a prospective, multi-center study (PARS study).

#### Scientific staff:



PD DR. MED. BENITO CAMPOS, PHYSICIAN | DR. MED. DENT BRITTA KRETZSCHMAR, PHYSICIAN | DR. MED. MEHDI HAJIABADI, PHYSICIAN | DR. MED. AKBAR BAJWA, PHYSICIAN





## Experimental Research

# NEUROTRAUMA AND NEURO-REGENERATION GROUP

**Head:** Prof. Dr. Klaus Zweckberger

The research group on neurotrauma and neuroregeneration, headed by Prof. Zweckberger, focuses on vegetative and inflammatory changes and regeneration following traumatic spinal and traumatic brain injuries. The objective is to discover pathophysiological mechanisms following traumatic damage, both in clinical trials and in the experimental settings, and to develop possible therapeutic strategies.

Traumatic brain injury leads to a primary injury of the brain tissue. Over a period of several hours, secondary damage is added to the primary injury. Inflammatory metabolic processes, partially triggered by hypoperfusion and hypoxia, cause progressive tissue damage, edema formation, and finally an increase in intracranial pressure. It was shown that therapeutic intervention with glibenclamide, a SUR-1 inhibitor, reduced the formation of cytotoxic

edema and, therefore, was able to prevent the rise of intracranial pressure. Current studies focus on the role of interleukins and their therapeutic use in order to counteract post-traumatic inflammation. The current research focuses on the investigation of the acute stage of traumatic brain injury and work on neuroregeneration. Traumatic brain injury leads to progressive neurodegeneration, e.g. the destruction of neural networks in the hippocampus, and to cognitive impairment. In cooperation with the group of Prof. Kirsch (Neuroanatomy, Heidelberg) in a rat model, stem cells are transplanted into the traumatized brain and their neuro-regenerational potential is studied.

Spinal trauma does not only result in the fracture of bony structures, but more importantly in the damage of the spinal cord that often causes lifelong tetra-, or paraplegia. In the experimental model,



MICROSURGICAL PREPARATION IN THE EXECUTION OF AN EXPERIMENTAL SPINAL CORD INJURY IN AN ANIMAL STUDY



FROZEN STORAGE OF STEM CELLS CULTURED IN THE LABORATORY

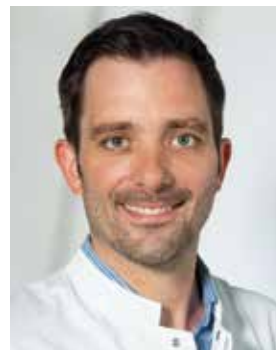
neuroregeneration is studied following cervical or thoracic trauma. In cooperation with the group of Prof. MG Fehlings (Toronto), Prof. Weidner (Heidelberg) and Prof. Skutella (Heidelberg), neural precursor cells are isolated and cultured, and then transplanted into traumatized rats using stereotactic methods. It was shown that this leads to reduced chronic inflammation. In order to foster neuroregenerative effects of stem cells, synergistic approaches were developed, e.g. prior to the treat-

ment with so-called 'self-assembling peptides' that optimize the post-traumatic milieu and serve as a scaffold structure. This optimizes the survival and differentiation of the stem cells and improves functional outcome. It was also possible to show that exogenous (e.g. treadmill training) or endogenous (e.g. manipulation of the sonic hedgehog pathway) trigger factors foster regeneration by neural precursor stem cells.

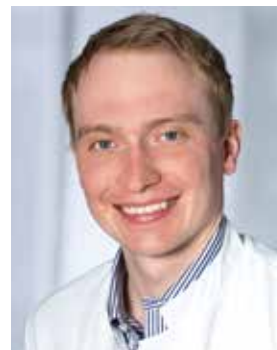
### Scientific staff:



DR. MED. ALEXANDER YOUNSI  
(DEPUTY HEAD OF THE  
PHYSICIAN GROUP)



DR. MED. MORITZ SCHERER,  
PHYSICIAN



DR. MED. JOHANNES WALTER,  
PHYSICIAN



MARTIN GRUTZA,  
PHYSICIAN



CAROLA WIECKHUSEN,  
PHYSICIAN

### Doctoral candidates:

Anna-Kathrin Harms  
Olga Kovalenko  
Lennart Riemann  
Mohamed Tail  
Hao Zhang  
Guoli Zheng

### Cooperating partners:

AG Prof. Dr. Joachim Kirsch (Anatomy Heidelberg)  
AG Prof. Dr. Thomas Skutella (Anatomy Heidelberg)  
AG Prof. Dr. Norbert Weidner (Paraplegiology Heidelberg)  
Dr. Claudia Pitzer (INBC Heidelberg)  
AG Prof. Dr. MG Fehlings (Dept. Neurosurgery, University of Toronto)  
AG Prof. Dr. Alan Nimmo (James Cook University, Townsville, Australia)





READING THE LATEST MEDICAL AND SCIENTIFIC PUBLICATIONS IS A MANDATORY REQUIREMENT.

# 5 SCIENCE & MORE





THE CONFERENCE HAS BEGUN: PROF. ANDREAS UNTERBERG WELCOMES THE PARTICIPANTS TO JOINT MEETING OF THE DGNC WITH THE AMERICAN ACADEMY OF NEUROLOGICAL SURGEONS.

## CONGRESSES & EVENTS

Every year, numerous experts and physicians from around the world come to the Department of Neurosurgery in order to participate in important events. Here is a selection:

### Treatment strategies for back pain in 2018

Bundled information for patients, doctors, and physiotherapists: In May 2018, our experts presented all possible treatment strategies and therapies for back pain. Short consultations were also possible at the same time. Our aim was to use this informative event to take away the fear of surgical intervention and point out alternative treatment methods.

### Annual skull base surgery conference in 2017

The topics were trauma, tumors of the skull base, and the treatment of the most severe chronic head and face pain: Approximately 200 doctors and scientists came together at the 25th annual conference of the German Society of Skull Base Surgery to discuss the latest results. In September 2017, experts in clinical and experimental research from neurosurgery, ENT, maxillofacial surgery and neighboring disciplines collaborated on new treatment approaches. A separate workshop was offered for

young surgeons with national and international experts in skull base surgery.

### Jubilee: 125 years of brain tumor surgery in 2015

Two reasons to celebrate: The Department of Neurosurgery in Heidelberg is turning 50! At the same time, it is also the 125th anniversary of the first successful brain tumor operation in Germany – carried out by Vincenz Czerny in Heidelberg. To celebrate the two dates, the department hosted an anniversary symposium in November 2015 entitled ‘Brain Tumor Surgery Over Time’, followed by an open house.

### ‘Neurointensive care: a three-day hands-on workshop’

This ‘Neurointensive’ workshop has been fully booked every year for 13 years: Renowned experts from neurosurgery and neurology share specialized knowledge in a specially developed compact course. Colleagues who are interested in neurointensive care are the addressed audience. Theo-

retical knowledge is first communicated in short, concise introductions, and then the practical implementation takes place in small groups. In this way, the approximately 40 participants learn the specific diagnostics and therapy of intracranial bleeding, brain trauma, or serious infections of the CNS.

### Joint Meeting of the DGNC and AAcNS in 2015

This meeting was a must for every academic neurosurgeon: The members of the German Society for Neurosurgery (DGNC), the German Academy for Neurosurgery (DANC), and the American Academy of Neurosurgical Surgery (AAcNS) exchanged views on the latest studies and research results. In October 2015, 200 of the world’s leading neurosurgeons came together at this joint meeting in Heidelberg.

### Interdisciplinary Medico-Ethics-Seminars in 2013, 2015, 2017, and 2019

Genome editing and the use of gene scissors, research regarding surgery on persons who are unable to give consent, fetal surgery or surgery on Siamese twins: Medicine involves many ethical questions. That is why these and other topics were discussed at medico-ethical seminars on the campus of Venice International University (VIU). Doctoral candidates, residents, and the chairpersons of the various units took part in these interdisciplinary conferences, supplemented by experts in various areas. These seminars were organized together with the Neurosurgical Departments in Bern, the Walter Brendel Institute for Surgical Research, and the Institute for Stroke and Dementia Research at LMU Munich.



HANDS-ON TRAINING: THE ACQUIRED KNOWLEDGE IS IMPLEMENTED IMMEDIATELY THROUGH PRACTICAL EXERCISES.

# AWARDS AND PRIZES

## Prizes

### Dr. Christoph Geisenberger

Andreas Zimprich Prize, German Cancer Research Center (DKFZ) Heidelberg (2017)

### Dr. med. Alexander Younsi

Young Talent Prize of the German Society of Spine Surgery (DWG) (2015)

### Dr. med. univ. et scient. med. Gerhard Jungwirth

Fundamental Research Price (NeuroWiss e. V.) (2019)

## Best lectures/contributions

### Prof. Dr. Klaus Zweckberger

Best Lecture, Annual conference of the spine section of the German Society of Neurosurgery (DGNC) (2016)

### Dr. med. Martin Jakobs

St. Jude Medical Science Prize: Best Contribution on Pain Therapy, Annual Conference of DGNC Frankfurt/Main (2016)

### Prof. Dr. rer. nat. Christel Herold-Mende

Proffered Paper 24th European Association for Cancer Research (EACR) Congress, Manchester, UK (2016)

### Dr. med. Basem Ishak

Best lecture, DGNC section conference on pain (2017)

### Dr. med. Alexander Younsi

First lecture prize at the DGNC section conference on intensive medicine and neurotraumatology in Heidelberg (2018)  
Lecture prize at the DWG annual conference, Stuttgart (2017)

## Grants/bursaries

### Prof. Dr. Klaus Zweckberger

Travel Award INTS Toronto (2018)  
Travel Award INTS Budapest (2014)

### PD Dr. Benito Campos

Travel Fellowship of EACR (2014)

### Dr. med. Basem Ishak

B. Braun Bursary (2018)  
DGNC travel bursary to Munich, (2017)  
DGNC Depuy Synthes spine hands-on bursary (2017)  
DWG travel bursary to Seattle, USA (2016)

### Dr. med. Alexander Younsi

DAAD congress bursary, participation in the annual conference of the American Association of Neurological Surgeons (AANS), New Orleans, USA (2018)  
DGNC congress bursary, participation in the annual conference of DGNC in Berlin, (2018)  
DAAD congress bursary, participation in the AANS annual conference, Los Angeles, USA (2017)

### Dr. med. univ. et scient. med. Gerhard Jungwirth

Funds from the Foundation for Cancer and Scarlet Fever for 'Expression and function of kinesins in meningioma' (2017)  
Physician Scientist Program of the Medical Faculty, Heidelberg

### Dr. med. Martin Jakobs

Grant from the Vera and Volker Doppelfeld Foundation for Science and Culture (2018)  
Selected for Clinical Fellowship in Stereotactic and Functional Neurosurgery, Toronto Western Hospital, Toronto, Canada (2018)

### Dr Daniela Becker

Research bursary: Olympia Morata Program, Medical Faculty, Heidelberg (since 02/2018)

## Poster prizes

### Dr. med. Martin Jakobs

First poster prize, DGNC annual conference, Münster (2018)

### Dr. med. Alexander Younsi

First poster prize for section AANS/CNS at INTS in Toronto, Canada (2018)

### Dr. med. Basem Ishak

DGNC Best poster for innovative neuromodulation (2016)

### Dr. med. Andreas Mock

First poster prize EACR Conference on Cancer Genomics, Cambridge, UK (2015)

### Dr. sc. hum. Rolf Warta

First poster prize, Joint Meeting of the German Society of Neurosurgery (DGNC) with the American Academy of Neurological Surgery (AAcNS), Heidelberg, (2015)

# FELLOWSHIPS

## Prof. Dr. Klaus Zweckberger

DFG – Research Fellowship at the Krembil Neuroscience Institute at the University of Toronto, Canada (2013/2014)

## Dr. med. Basem Ishak

Fellowship at the Swedish Neuroscience Institute/Seattle Science Foundation in Seattle, USA (2018/2019)

## Dr. med. Martin Jakobs

Clinical Fellowship in Stereotactic and Functional Neurosurgery, Toronto Western Hospital, Toronto, Canada (2018)

## Dr. Christine Jungk

Clinical Fellowship in Functional Brain Mapping and Oncological Neurosurgery, CHU, Montpellier, Frankreich (2015)

# APPOINTMENTS

## 2018

PD Dr. Klaus Zweckberger, appointed as adjunct Professor of Neurosurgery on 06/02/2018  
Dr. med. Benito Campos, appointed as private lecturer (Priv. Doz. / PD) on 13/07/2018

## 2017

Dr. med. Christopher Beynon, appointed as private lecturer (Priv. Doz. / PD) on 19/05/2017  
Dr. med. Rezvan Ahmadi, appointed as private lecturer (Priv. Doz. / PD) on 15/12/2017

## 2015

Dr. med. Carla Jung, appointed as private lecturer (Priv. Doz. / PD) on 23/01/2015  
Dr. med. Berk Orakcioglu, appointed as private lecturer (Priv. Doz. / PD) on 12/06/2015

# FAREWELLS

## 2018

PD Dr. med. Carla Jung, active as Executive Senior Physician from 01/05/2015, left on 30/04/2018 – Director, Department of Neurosurgery, Agaplesion Bethesda Hospital Wuppertal

## 2017

Dr. med. Patrick Schiebel, left on 30/06/2017 – Neurosurgical practice in Speyer  
Dr. med. Daniel Hertle, left on 14/11/2017 – Neurosurgical practice in Mannheim

## 2016

PD Dr. med. Berk Orakcioglu, from 01/05/2015 Head of the section 'Neurosurgical spine surgery', left on 20/02/2016 – Neurosurgical practice, Ethianum, Heidelberg

## 2015

PD Dr. Karsten Geletneky, left on 30/04/2015 – Director, Department of Neurosurgery, Klinikum Darmstadt  
Prof. Dr. med. Oliver Sakowitz, Vice Chairman from 01/09/2013, left on 30/06/2015 – Director, Department of Neurosurgery, Klinikum Ludwigsburg

**Thank you for your committed cooperation!**



# PUBLICATIONS

**A selection of the most important publications from 2014 to 2019 – a comprehensive list is available at [www.pubmed.de](http://www.pubmed.de).**

**Rapp C, Dettling S, Liu F, Ull AT, Warta R, Jungk C, Roesch S, Mock A, Sahm F, Schmidt M, Jungwirth G, Zweckberger K, Lamszus K, Gousias K, Kessler AF, Grabe N, Loehr M, Ketter R, Urbschat S, Senft C, Westphal M, Abdollahi A, Debus J, von Deimling A, Unterberg A, Simon M, Herold-Mende CC.**

Cytotoxic T Cells and their Activation Status are Independent Prognostic Markers in Meningiomas. *Clin Cancer Res.* 2019 Sep 1;25(17):5260-5270.

- **Identification of the relevance of tumor-infiltrating T cells for patient survival in a large cohort of aggressive meningiomas.**

**Beynon C, Brenner S, Younsi A, Rizos T, Neumann JO, Pfaff J, Unterberg AW**

Management of Patients with Acute Subdural Hemorrhage During Treatment with Direct Oral Anticoagulants. *Neurocrit Care.* 2019 Apr;30(2):322-333.

- **Prohaemostatic and surgical treatment of patients with intracranial hemorrhage during anti-thrombotic treatment.**

Capper D, Jones DTW, Sill M, Hovestadt V, Schrimpf D, Sturm D, Koelsche C, Sahm F, Chavez L, Reuss DE, Kratz A, Wefers AK, Huang K, Pajtler KW, Schweizer L, Stichel D, Olar A, Engel NW, Lindenberg K, Harter PN, Braczynski AK, Plate KH, Dohmen H, Garvalov BK, Coras R, Hölsken A, Hewer E, Bewerunge-Hudler M, Schick M, Fischer R, Beschoner R, Schittenhelm J, Staszewski O, Wani K, Varlet P, Pages M, Temming P, Lohmann D, Selt F, Witt H, Milde T, Witt O, Aronica E, Giangaspero F, Rushing E, Scheurlen W, **Geisenberger C**, Rodriguez FJ, Becker A, Preusser M, Haberler C, Bjerkvig R, Cryan J, Farrell M, Deckert M, Hench J, Frank S, Serrano J, Kannan K, Tsirigos A, Brück W, Hofer S, Brehmer S, Seiz-Rosenhagen M, Hänggi D, Hans V, Rozsnoki S, Hansford JR, Kohlhof P, Kristensen BW, Lechner M, Lopes B, Mawrin C, Ketter R, Kulozik A, Khatib Z, Heppner F, Koch A, Jouvet A, Keohane C, Mühleisen H, Mueller W, Pohl U, Prinz M, Benner A, Zapatka M, Gottardo NG, Driever PH, Kramm CM, Müller HL, Rutkowski S, von

Hoff K, Frühwald MC, Gnekow A, Fleischhack G, Tuppelt S, Calaminus G, Monoranu CM, Perry A, Jones C, Jacques TS, Radlwimmer B, Gessi M, Pietsch T, Schramm J, Schackert G, Westphal M, Reifenberger G, Wesseling P, Weller M, Collins VP, Blümcke I, Bendszus M, Debus J, Huang A, Jabado N, Northcott PA, Paulus W, Gajjar A, Robinson GW, Taylor MD, Jaunmuktane Z, Ryzhova M, Platten M, **Unterberg A**, Wick W, Karajannis MA, Mittelbronn M, Acker T, Hartmann C, Aldape K, Schüller U, Buslei R, Lichter P, Kool M, **Herold-Mende C**, Ellison DW, Hasselblatt M, Snuderl M, Brandner S, Korshunov A, von Deimling A, Pfister SM

DNA methylation-based classification of central nervous system tumours. *Nature* 2018; 555(7697):469-474.

- **New tool for the precise diagnosis of brain tumors**

**Dettling S, Stamova S, Warta R, Schnölzer M, Rapp C, Rathinasamy A, Reuss D, Pocha K, Roesch S, Jungk C, Warnken U, Eckstein V, Grabe N, Schramm C, Weigand MA, von Deimling A, Unterberg A, Beckhove P, Herold-Mende C**

Identification of CRKII, CFL1, CNTN1, NME2, and TKT as Novel and Frequent T-cell Targets in Human IDH-Mutant Glioma. *Clin. Cancer Res.* 2018; 24(12):2951-2962.

- **Identification of new target molecules for immunotherapy for IDH mutant glioma**

Schuh-Hofer S, **Fischer J, Unterberg A, Treede RD, Ahmadi R.**

Spinal cord stimulation modulates descending pain inhibition and temporal summation of pricking pain in patients with neuropathic pain. *Acta Neurochir (Wien).* 2018 Dec;160(12):2509-2519

- **Study of the modes of action of spinal cord stimulation in patients with neuropathic pain**

**Jakobs M, Krasniqi E, Kloß M, Neumann JO, Campos B, Unterberg AW, Kiening KL**

Intraoperative Stereotactic Magnetic Resonance Imaging for Deep Brain Stimulation Electrode Planning in Patients with Movement Disorders. *World Neurosurg.* 2018 Nov;119:e801-e808. doi: 10.1016/j.wneu.2018.07.270. Epub 2018 Aug 8.

- **Intraoperative MRI can be used safely for deep brain stimulation.**

**Fedorko S, Zweckberger K, Unterberg AW**

Quality of life following surgical treatment of lesions within the pineal region. *J Neurosurg.* 2018 Feb 1:1-10. doi: 10.3171/2017.7.JNS17260. [Epub ahead of print]

- **Assessment of the mortality, morbidity, quality of life and necessity for VP shunting obligation following removal of a tumor of the pineal region**

**Roesch S, Rapp C, Dettling S, Herold-Mende C**

When Immune Cells Turn Bad-Tumor-Associated Microglia/Macrophages in Glioma. *Int J Mol Sci* 2018; 19(2). pii: E436.

- **Overview of the influence of the tumor environment on the gliomas**

**Ishak B, Campos B, Brunn H, Unterberg AW, Ahmadi R.**

Feasibility, Safety, and Efficacy of Subcutaneous Peripheral Nerve Field Stimulation for the Treatment of Refractory Low Back Pain: A Two-year Single-center Study. *Neuroscience.* 2018 Sep 1;387:38-47.

- **Clinical study of peripheral nerve stimulation for back pain**

**Ishak B, Schneider T, Gimmy V, Unterberg AW, Kiening KL**

A Modified Posterior C1/C2 Fusion Technique for the Management of Traumatic Odontoid Type II Fractures by Using Intraoperative Spinal Navigation: Midterm Results. *J Orthop Trauma.* 2018 Sep;32(9):e366-e371. doi: 10.1097/BOT.0000000000001241.

- **Medium-term results following modified, navigation-supported stabilization of C1 and C2 following traumatic odontoid fractures**

**Ishak B, Schneider T, Gimmy V, Unterberg AW, Kiening KL**

Early Complications, Morbidity, and Mortality in Octogenarians and Nonagenarians Undergoing Posterior Intra-Operative Spinal Navigation-Based C1/2 Fusion for Type II Odontoid Process Fractures. *J Neurotrauma.* 2017 Dec 15;34(24):3326-3335. doi: 10.1089/neu.2017.4968. Epub 2017 Aug 4.

- **Complication and mortality rates following navigation-supported stabilization of C1 and C2 in patients over 80 and 90 years of age**

Sahm F, Schrimpf D, Stichel D, Jones DT, Hielscher T, Schefzyk S, Okonechnikov K, Koelsche C, Reuss DE, Capper D, Sturm D, Wirsching HG, Berghoff AS, Baumgarten P, Kratz A, Huang K, Wefers AK, Hovestadt V, Sill M, Ellis HP, Kurian KM, Okuducu AF, **Jungk C**, Drieschler K, Schick M, Bewerunge-Hudler M, Mawrin C, Seiz-Rosenhagen M, Ketter R, Simon M, Westphal M, Lamszus K, Becker A, Koch A, Schittenhelm J, Rushing EJ, Collins VP, Brehmer S, Chavez L, Platten M, Hänggi D, **Unterberg A**, Paulus W, Wick W, Pfister SM, Mittelbronn M, Preusser M, **Herold-Mende C**, Weller M, von Deimling A

DNA methylation-based classification and grading system for meningioma: a multicentre, retrospective analysis. *Lancet Oncol.* 2017; 18(5):682-694.

- **New tool for the improved assessment of disease progression in meningioma patients**

**Geletneky K, Hajda J, Angelova AL, Leuchs B, Capper D, Bartsch AJ, Neumann JO, Schöning T, Hüsing J, Beelte B, Kiprianova I, Roscher M, Bhat R, von Deimling A, Brück W, Just A, Frehtman V, Löbhard S, Terletskaia-Ladwig E, Fry J, Jochims K, Daniel V, Krebs O, Dahm M, Huber B, **Unterberg A\***, Rommelare J\***

Oncolytic H-1 Parvovirus Shows Safety and Signs of Immunogenic Activity in a First Phase I/IIa Glioblastoma Trial. *Mol Ther.* 2017 Dec 6;25(12):2620-2634. doi: 10.1016/j.ymthe.2017.08.016. Epub 2017 Aug 24. \*Equal contribution

- **First use of H-1PV in patients with recurrent glioblastoma**

# PUBLICATIONS

## Warta R, Herold-Mende C

Helping EGFR inhibition to block cancer. *Nat Neurosci*. 2017 Jul 26;20(8):1035-1037.

- **Description of therapy resistance mechanisms in cases of EGFR inhibition in glioblastoma**

## Rapp C, Warta R, Stamova S, Nowrouzi A, Geisenberger C, Gal Z, Roesch S, Dettling S, Juenger S, Bucur M, Jungk C, DaoTrong P, Ahmadi R, Sahm F, Reuss D, Fermi V, Herpel, Eckstein V, Grabe N., Schramm C, Weigand M.A. Debus J, von Deimling A, Unterberg A., Abdollahi A, Beckhove P, Herold-Mende C

Proteomics-based identification of T cell target antigens in quiescent stem-like glioblastoma cells. *Acta Neuropathol* 2017; 134(2):297-316.

- **Identification of new target molecules for immunotherapy of glioblastomas**

## Zweckberger K, Hallek E, Vogt L, Giese H, Schick U, Unterberg AW

Prospective analysis of neuropsychological deficits following resection of benign skull base meningiomas. *J Neurosurg*. 2017 Dec;127(6):1242-1248.

- **Prospective analysis of neuropsychological deficits following surgical resection of benign meningiomas of the skull base**

## Sánchez-Porras R, Santos E, Schöll M, Kunzmann K, Stock C, Silos H, Unterberg AW, Sakowitz OW

Ketamine modulation of the haemodynamic response to spreading depolarization in the gyrencephalic swine brain. *J Cereb Blood Flow Metab*. 2017 May;37(5):1720-1734.

- **Study of the influence of ketamine on the haemodynamic response following experimentally induced, spreading depolarization in the swine brain**

## Mock A, Geisenberger C, Orlik C, Warta R, Schwager C, Jungk C, Dutruel C, Geiselhart L, Weichenhan D, Zucknick M, Nied A, Friauf S, Exner J, Capper D, Hartmann C, Lahrmann B, Grabe N, Debus J, von Deimling A, Popanda O, Plass C, Unterberg A, Abdollahi A, Schmezer P, Herold-Mende C

Enriched LOC283731 promoter hypermethylation in long-term surviving IDH1 wild-type glioblastoma patients. *Int J Cancer* 2016; 139(2):424-32.

- **Identification of survival-associated methylation patterns in glioblastoma**

## Jungk C, Mock A, Exner J, Geisenberger C, Warta R, Capper D, Abdollahi A, Friauf S, Lahrmann B, Grabe N, Beckhove P, von Deimling A, Unterberg A, Herold-Mende C

Spatial transcriptome analysis reveals Notch pathway-associated prognostic markers in IDH1 wildtype glioblastoma involving the subventricular zone. *BMC Med*. 2016; 14(1):170.

- **Identification of location-dependent molecular markers from the notch pathway with prognostic relevance in glioblastoma**

Hutchinson PJ, Koliass AG, Timofeev IS, Corteen EA, Czosnyka M, Timothy J, Anderson I, Bulters DO, Belli A, Eynon CA, Wadley J, Mendelow AD, Mitchell PM, Wilson MH, Critchley G, Sahuquillo J, Unterberg A, Servadei F, Teasdale GM, Pickard JD, Menon DK, Murray GD, Kirkpatrick PJ; RESCUEicp Trial Collaborators. Trial of Decompressive Craniectomy for Traumatic Intracranial Hypertension. *N Engl J Med*. 2016 Sep 22;375(12):1119-30.

- **Results of decompression surgery for the reduction of intracranial pressure following severe cerebral trauma**

## Jungk C, Scherer M, Mock A, Capper D, Radbruch A, von Deimling A, Bendszus M, Herold-Mende C, Unterberg A

Prognostic value of the extent of resection in supratentorial WHO grade II astrocytomas stratified for IDH1 mutation status: a single-center volumetric analysis. *J Neurooncol*. 2016 Sep;129(2):319-28.

- **Extended tumor resection prolongs the time of progression in IDH mutated astrocytomas of WHO grade II**

## Mock A, Herold-Mende C

Non-invasive glioblastoma immunoprofiling by printed peptide arrays. *Oncoimmunol* 2015 Aug 12;5(2):e1069941. eCollection 2016 Feb.

- **Evidence of disease-associated immune profiles by peptide arrays**

## Schmidt S, Mock A, Jungk C, Sahm F, Ull A.T, Warta R, Lamszus K, Gousias K, Ketter R, Roesch S, Rapp C, Schefzyk S, Urbschat S, Lahrmann B, Kessler AF, Löhr M, Senft C, Grabe N, Reuss D, Beckhove P, Westphal M, von Deimling A, Unterberg A, Simon M, Herold-Mende C

Transcriptomic analysis of aggressive meningiomas identifies PTTG1 and LEPR as prognostic biomarkers independent of WHO grade. *Oncotarget* 2016; 7(12):14551-68.

- **Evidence of specific expression signatures in aggressive meningiomas**

## Jungk C, Chatziaslanidou D, Ahmadi R, Capper D, Lorenzo Bermejo J, Exner J, von Deimling A, Herold-Mende C, Unterberg A

Chemotherapy with BCNU in recurrent glioma: Analysis of clinical outcome and side effects in chemotherapy-naïve patients. *BMC Cancer* 2016; 16(1):81. doi: 10.1186/s12885-016-2131-6.

- **Analysis of the effectiveness and tolerability of chemotherapy with BCNU in patients with recurrent gliomas**

Sahm F, Schrimpf D, Olar A, Koelsche C, Reuss D, Bissel J, Kratz A, Capper D, Schefzyk S, Hielscher T, Wang Q, Sulman EP, Adeberg S, Koch A, Okuducu AF, Brehmer S, Schittenhelm J, Becker A, Brokinkel B, Schmidt M, Ull T, Gousias K, Kessler AF, Lamszus K, Debus J, Mawrin C, Kim Y-K, Simon M, Ketter R, Paulus W, Aldape KD, Herold-Mende C, von Deimling A TERT promoter mutations occur in malignant meningioma and identify patients at risk for early recurrence. *J Natl Cancer Inst* 2015 Dec 13;108(5). pii: djv377. Print 2016 May.

- **Significance of the TERT mutation for the survival of meningioma patients**

## Scherer M, Jungk C, Younsi A, Kickingeder P, Müller S, Unterberg A

Factors triggering an additional resection and determining residual tumor volume on intraoperative MRI: analysis from a prospective single-center registry of supratentorial gliomas. *Neurosurg Focus*. 2016 Mar;40(3):E4.

- **Assessment of findings during intraoperative MRI and its effect on the resection of gliomas**

Coburger J1, Merkel A, Scherer M, Schwartz F, Gessler F, Roder C, Pala A, König R, Bullinger L, Nagel G, Jungk C, Bisdas S, Nabavi A, Ganslandt O, Seifert V, Tatagiba M, Senft C, Mehdorn M, Unterberg AW, Rössler K, Wirtz CR

Low-grade Glioma Surgery in Intraoperative Magnetic Resonance Imaging: Results of a Multicenter Retrospective Assessment of the German Study Group for Intraoperative Magnetic Resonance Imaging. *Neurosurgery*. 2016 Jun;78(6):775-86.

- **Effect of the extent of resection on the survival of patients with low-grade glioma following resection using intraoperative MRI**

## Chiblak S, Tang Z, Campos B, Gal Z, Unterberg A, Debus J, Herold-Mende C\*, Abdollahi A\*

Radiosensitivity of Patient-Derived Glioma Stem Cell 3-Dimensional Cultures to Photon, Proton, and Carbon Irradiation. *Int J Radiat Oncol Biol Phys*. 2015 Jun 14. pii: S0360-3016(15)00636-7. \*Equal contribution]

- **The effect of various irradiation modalities on glioblastoma stem cells**

Mendelow AD, Gregson BA, Rowan EN, Francis R, McColl E, McNamee P, Chambers IR, Unterberg A, Boyers D, Mitchell PM; STITCH(Trauma) Investigators Early Surgery versus Initial Conservative Treatment in Patients with Traumatic Intracerebral Hemorrhage (STITCH[Trauma]): The First Randomized Trial. *J Neurotrauma*. 2015 Sep 1;32(17):1312-23.

- **Effect of early neurosurgical treatment of intracerebral hemorrhage following traumatic brain injury compared to initial conservative treatment**



# PUBLICATIONS

**Campos B, Weisang S, Osswald F, Ali R, Sedlmeier G, Bageritz J, Mallm J-P, Hartmann C, von Deimling A, Popanda O, Goidts V, Plass C, Unterberg A, Schmezer P, Burhenne J, Herold-Mende C** Retinoid Resistance and Multifaceted Impairment of Retinoic Acid Synthesis in Glioblastoma. *Glia* 2015; 63(10):1850-9.

- **Differentiation resistance in glioblastoma**

**Geisenberger C, Mock A, Warta R, Rapp C, Schwager C, Korshunov A, Nied A-K, Capper D, Brors B, Jungk C, Jones D, Collins VP, Ichimura K, Bäcklund LM, Schnabel E, Mittelbron M, Lahrmann B, Zheng S, Verhaak RGW, Grabe N, Pfister SM, Hartmann C, von Deimling A, Debus J, Unterberg A, Abdollahi A, Herold-Mende C**

Molecular profiling of long-term survivors identifies a subgroup of glioblastoma characterized by chromosome 19/20 co-gain. *Acta Neuropathol* 2015; 130(3):419-34.

- **Molecular determinants for improved survival of glioblastoma**

Brat DJ, Verhaak RGW, Aldape KD, Yung WKA, ... Calatozzolo C, **Campos B**, Carlotti CG, Chan TA, Cuppini L, Curley E, Cuzzubbo S, Devine K., DiMeco F, Duell R, Elder B, Fehrenbach A, Finocchiaro G, Friedman W, Fulop J, Gardner J, Hermes B, **Herold-Mende C, Jungk C**, Kendler A, Lehman NL, Lipp E, Liu Q, Mandt R, McGraw M, McLendon R, McPherson C, Neder L, Nguyen P, Noss A, Nunziata R, Ostrom QT, Palmer C, Perin A, Pollo B, Potapov A, Potapova O, Kimryn Rathmell W, Rotin D, Scarpace L, Schilero C, Senecal K, Shimmel K, Shurkhay V, Sifri S, Singh R, Sloan AE, Smolenski K, Staugaitis SM, Steele R, Thorne L, Tirapelli DPC, **Unterberg A**, Vallurupalli M, Wang Y, Warnick R, Williams F, Wolinsky Y, Bell S, Rosenberg M, Stewart C, Huang F, Grimsby JL, Radenbaugh AJ, Zhang J Comprehensive, Integrative Genomic Analysis of Diffuse Lower Grade Gliomas *New Engl Med* 2015; 372(26):2481-98.

- **Milestone publication on molecular changes in IDH mutated gliomas**

**Mock A, Warta R, Geisenberger C, Bischoff R, Schulte A, Lamszus K, Stadler V, Felgenhauer V, Schichor C, Schwartz C, Matschke J, Jungk C, Ahmadi R, Sahm F, Capper D, Glass R, Tonn J-C, Westphal M, von Deimling A, Unterberg A, Lorenzo Bermejo J, Herold-Mende C**

Printed peptide arrays identify prognostic TNC serumantibodies in glioblastoma patients. *Oncotarget* 2015; 6(15):13579-90.

- **Identification of survival-associated serum markers in glioblastoma**

Zweckberger K, Hackenberg K, Jung CS, Hertle DN, Kiening KL, Unterberg AW, Sakowitz OW. Glibenclamide reduces secondary brain damage after experimental traumatic brain injury. *Neuroscience*. 2014 Jul 11;272:199-206.

- **Glibenclamide reduces secondary brain damage after experimental traumatic brain injury.**

**Campos B, Gal Z, Baader A, Schneider T, Sliwinski C, Gassel K, Bageritz J, Grabe N, Beckhove B, Mogler C, Goidts V, Unterberg A, Eckstein V, Herold-Mende C**

Aberrant Self-Renewal and Quiescence Contribute to the Malignant Phenotype of Glioblastoma. *J Pathol* 2014; 234(1):23-33.

- **Dormant cells contribute to the aggressiveness of glioblastomas.**

Sotiropoulou PA\*, Christodoulou MS, Silvani A, **Herold-Mende C\***, Passarella D\*

Chemical Approaches to Targeting Cancer Stem Cells. *Drug Discov Today* 2014; pii: S1359-6446(14)00167-6.

\* equal contribution

- **Overview of substances that effectively attack tumor stem cells**

**Mock A, Chliback S, Herold-Mende C**

Lessons learned from high-throughput and top-down systems biology analyses about glioma stem cells. *Curr Pharml Design* 2014; 20:66-72.

- **The significance of high throughput analyses of glioma stem cells**

Jüttler E\*, **Unterberg A\***, Woitzik J, Bösel J, Amiri H, Sakowitz OW, Gondan M, Schiller P, Limprecht R, Luntz S, Schneider H, Pinzer T, Hobohm C, Meixensberger J, Hacke W; DESTINY II Investigators Hemicraniectomy in older patients with extensive middle-cerebral-artery stroke. *N Engl J Med*. 2014 Mar 20;370(12):1091-100. \*Equal contribution

- **Study on the surgical treatment of malignant middle cerebral artery stroke using decompressive hemicraniectomy in a population of older patients**

Jortzik E, **Farhadi M, Ahmadi R, Tóth K, Lohr J, Helmke B, Kehr S, Unterberg A, Ott I, Davioud-Charvet E, Réau R, Becker K, Herold-Mende C** Antiglioma activity of GoPI-sugar, a novel gold(I)-phosphole inhibitor: chemical synthesis, mechanistic studies, and effectiveness in vivo. *BBA - Proteins and Proteomics* 2014; pii: S1570-9639(14)00009-0.

- **Gold-bearing substances display effectiveness against glioblastoma cells**

Uozumi Y, **Sakowitz O, Orakcioglu B, Santos E, Kentar M, Haux D, Unterberg A**

Decompressive craniectomy in patients with aneurysmal subarachnoid hemorrhage: a single-center matched-pair analysis. *Cerebrovasc Dis*. 2014;37(2):109-15.

- **Decompressive craniectomy in patients with aneurysmal subarachnoid hemorrhage and malignant cerebral edema achieves a good outcome in 25 percent of the cases without a significant difference to the control group in this single-center study.**

**Herold-Mende C, Mock A**

Microenvironment and brain tumor stem cells: impact of the niche. *Anti-Cancer Agents Med Chem* 2014; 14:1065-74.

- **The importance of the tumor environment for the grown of tumor stem cells**

## Board Certifications in Neurosurgery

2018

Dr. med. Martin Jakobs, 21/03/2018

Dr. med. Stephanie Anetsberger, 05/09/2018

Dr. med. Alexander Younsi, 05/09/2018

Dr. med. Philip Dao Trong, 04/2018

2017

Dr. med. Basem Ishak, 29/03/2017

Dr. med. Stepan Fedorko, 16/08/2017

Dr. med. Henrik Giese, 20/09/2017

Dr. med. Moritz Scherer, 20/09/2017

PD Dr. med. Benito Campos, 11/10/2017

2016

Dr. med. Kentar Modar, 26/10/2016

2015

PD Dr. med. Christopher Beynon, 21/01/2015

2014

Dr. med. Patrick Schiebel, 26/03/2014

# IMPRINT

## **Publisher**

Department of Neurosurgery  
University of Heidelberg  
Im Neuenheimer Feld 400  
69120 Heidelberg

## **Concept, realization & project management**

medXmedia Consulting KG

## **Design and layout**

Grafik + Design Ute Berretz, Munich

## **Editorial staff**

Prof. Dr. Unterberg, Andreas  
Prof. Dr. Zweckberger, Klaus  
Prof. Dr. Herold-Mende, Christel

## **Contributors**

Holz, Maria  
Schmidt, Thomas

## **Photos**

Medienzentrum, Hendrik Schröder  
Neurochirurgische Klinik Heidelberg  
Philip Benjamin M. A. Photo journalist/Photo designer, Ladenburg  
Pictograms: istockphoto.com, Vecteezy, Flaticon

## **Printing**

abcdruck GmbH, Heidelberg

## **Status**

March 2020



# NEUROSURGERY

## PERFORMANCE REPORT 2020

Department of Neurosurgery  
University of Heidelberg  
Im Neuenheimer Feld 400  
69120 Heidelberg