

# SCRIPTA MEDICA

FACULTATIS MEDICAE UNIVERSITATIS BRUNENSIS MASARYKIANAE  
SPISY LÉKAŘSKÉ FAKULTY MASARYKOVY UNIVERZITY V BRNĚ

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Tomus 80 (2007)

Fasciculus 3

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## DETECTION OF PATHOGENS IN CHILDREN WITH SEPSIS: COMPARISON OF MOLECULAR AND TRADITIONAL MICROBIOLOGICAL METHODS

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*Received after revision February 2007*

### Abstract

We performed this study to compare the polymerase chain reaction (PCR) results with the results of traditional microbiological methods when searching for pathogens in children with sepsis.

A group of patients contained 38 children, 22 boys and 16 girls, at the age range from 1 month up to 20 years admitted to the Paediatric Intensive Care Unit. Samples taken from these patients were simultaneously examined via the PCR method and via the classical microbiological method of pathogen detection including cultivation, microscopy, and/or serology. The PCR method was set to be able to detect universal bacterial or fungal pathogens with further species specification.

Detection of bacterial pathogens in the examined samples was 30 to 40% more successful with PCR than with standard microbiological techniques. Bronchoalveolar lavage (BAL) samples proved to be the most reliable sample type in terms of detection of bacterial pathogens. PCR successfully detected bacterial pathogens in 100% of BAL samples from patients with lower respiratory tract infections. Pathogen detection was more successful when two or more samples were taken. The results of both pathogen detection methods were identical in 81% of the cases. From the total number of 90 samples, PCR produced 36 positive detections and standard culture techniques produced 27 positive detections. In 13 samples pathogens were detectable only by PCR. Both PCR and culture were negative in 56% of the samples.

In conclusion, detection of infectious pathogens was more successful with the PCR method than with traditional microbiological techniques. Detection was also more successful when more than one sample was examined from each patient. Therefore, using the PCR method can improve pathogen detection and should be considered as a useful tool complementary to standard microbiological techniques when searching for pathogens in children with sepsis.

### Key words

PCR, Sepsis, Children, Intensive care unit

## Abbreviations used:

PCR, polymerase chain reaction; PICU, paediatric intensive care unit; SIRS, Systemic Inflammatory Response Syndrome; MODS, Multiple Organ Distress Syndrome

## INTRODUCTION

Sepsis and its associated complications still remain a major cause of mortality in intensive care units. Septic shock is the most common cause of death in these patients (1). The sepsis-associated mortality rate varies from 20% in patients with sepsis to 30 to 50% in those with severe sepsis, and can reach more than 50% in patients with septic shock. In contrast, the stroke-associated mortality rate has been reported at a range of 12–20%, and for patients with heart attack at 5–10% in the first 30 days of hospitalisation (2).

Microbiological techniques used for the detection of causative pathogens in sepsis are only partially successful, leading only to 30–50% pathogen detection from clinical samples of blood cultures (1). To improve pathogen detection in children with sepsis we performed a prospective study examining the same clinical sample by classical microbiological techniques based on cultivation, microscopy, and/or serology with a highly sensitive PCR pathogen detection system. The PCR system is based on detection of bacteria-specific genomes in any clinical sample taken.

## MATERIALS AND METHODS

Thirty-eight patients (group of patients), 22 boys and 16 girls at the age of 1 month up to 20 years, were admitted from April 2005 to February 2006 at the Paediatric Intensive Care Unit (PICU), Department of Paediatric Anaesthesiology and Resuscitation, Faculty of Medicine, Masaryk University, Brno. All patients or their parents/legal guardians signed an informed consent form created in accordance with the Declaration of Helsinki and approved by the local ethical commission.

The patients were divided into 4 groups according to their clinical stage. There were 5 patients with SIRS (Systemic Inflammatory Response Syndrome), 11 children with sepsis, 17 patients with severe sepsis, and 5 patients with septic shock and/or MODS (Multiple Organ Distress Syndrome) defined according to the recommendations of the international conference guidelines (3) (Fig. 1).

The following clinical samples were taken: blood, bronchoalveolar lavage (BAL), urine, cerebrospinal fluid, and fluid taken from effusions. Blood was taken as a part of routine blood tests. All consecutive samples were taken from the same patient at least 6 hours apart. These samples were simultaneously examined via the PCR method and via classical microbiological methods (i.e., they were cultured and microscopically examined). In some cases, when other than bacterial infection was suspected, appropriate serological tests were performed.

PCR was used to determine if universal bacterial or fungal DNA was present in clinical samples. If the PCR detection of universal bacterial or fungal DNA was positive, further species characterisation was performed with a species-specific PCR detection system for the Enterobacteriaceae species, *Pseudomonas* species, *Staphylococcus* species, *Strepto-Enterococcus* species, *Candida albicans*, *Candida nonalbicans*, *Cryptococcus* species, and *Aspergillus*, as previously described (5). In cases where viral infection was suspected, the samples were examined via viral DNA-specific PCR to detect herpes-simplex virus 1 and 2, Epstein-Barr virus, cytomegalovirus, and tick-borne encephalitis, as previously published (4).

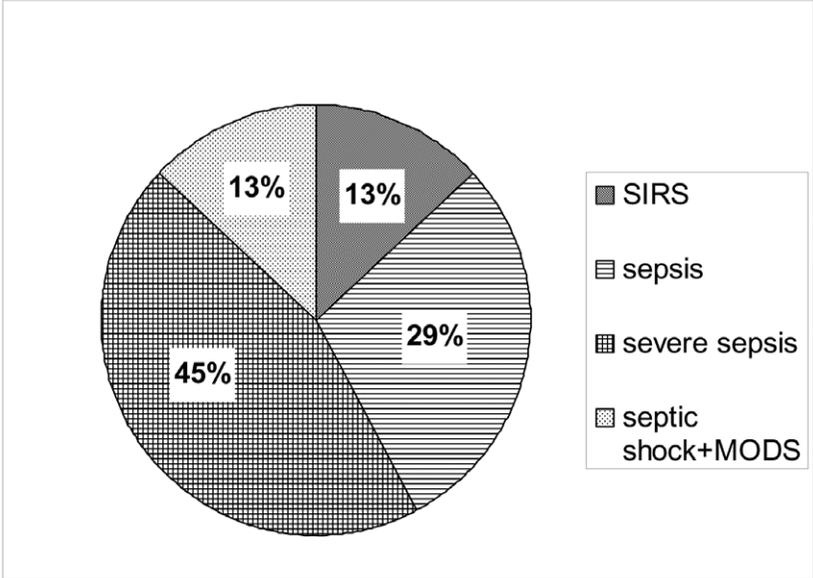


Fig. 1  
Clinical stage groups

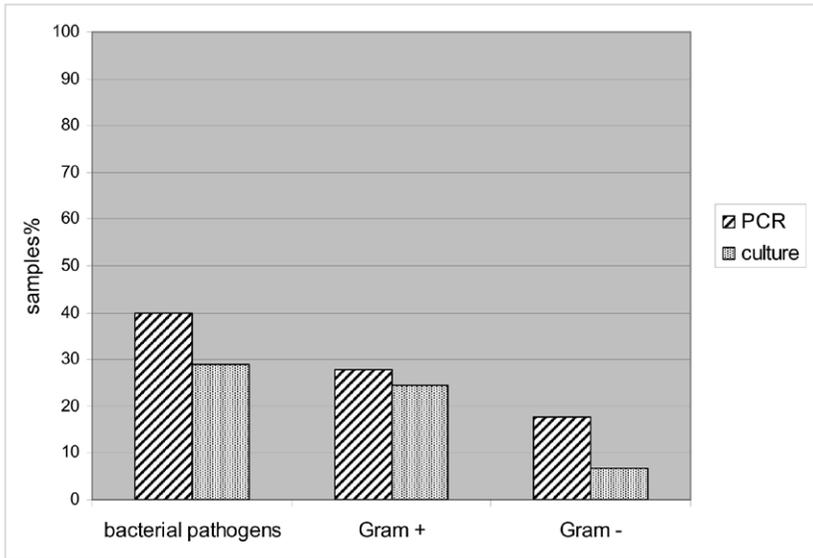


Fig. 2  
Detection of bacterial pathogens

## RESULTS

Detection of bacterial pathogens in the examined samples was 30 to 40 % more successful with PCR than with standard microbiological cultures. Altogether, 90 samples were taken from 38 patients. Gram-positive bacteria were detected more often than their Gram-negative counterparts both with the PCR and standard culture techniques (*Fig. 2*).

BAL samples proved to be the most reliable sample type in terms of detection of bacterial pathogens. Again, PCR was the more sensitive detection method (*Fig. 3*).

PCR successfully detected bacterial pathogens in 100 % of BAL samples from patients with lower respiratory tract infections, i.e. pneumonia, bronchopneumonia and bronchitis, whereas standard culture techniques were positive in only 75 % of the cases (*Fig. 4*).

Pathogen detection was always more successful when two or more samples were taken. PCR detection was successful in 78 % of these patients, whereas standard culture techniques were successful in only 61 %. In patients from whom only one sample had been retrieved, PCR detection produced positive results in 40 %, whereas standard culture techniques produced positive results in only 10 % of the cases (*Fig. 5*).

The results of both pathogen detection methods were identical in 81 % of the cases. In 40 samples, which equals 44 % of the total number of samples taken, a pathogen was found with at least one method. From the total number of 90 samples, PCR produced 36 positive detections and standard culture techniques produced 27 positive detections. Twenty-three samples were positive for both PCR and standard culture techniques, i.e. 26 % of the total number of samples. In 13 samples pathogens were detectable only by PCR. In these 13 cases, PCR results always corresponded with the presence of a clinical condition in the patient being tested. In another 4 samples, culture was the only successful method for pathogen detection, but these samples were probably contaminated since there was no correlation with clinical conditions of those patients. After one week of prolonged in vitro culture of these 4 samples, coagulase-negative Staphylococci were found without a corresponding positive PCR match. Both PCR and culture was negative in 56 % of the samples tested (*Fig. 6*).

## DISCUSSION

In general, detection of pathogens in patients with sepsis is successful in only 30–50 % of all cases. PCR is generally considered to be a more sensitive method of pathogen detection than the standard culture. Another major benefit of PCR is its fast speed. PCR results are available within 4 to 8 hours, whereas culture techniques take considerably longer time. Detecting pathogens with PCR is also possible in samples from patients currently on antibiotic therapy. Such samples are often false-negative with culture tests (2, 5).

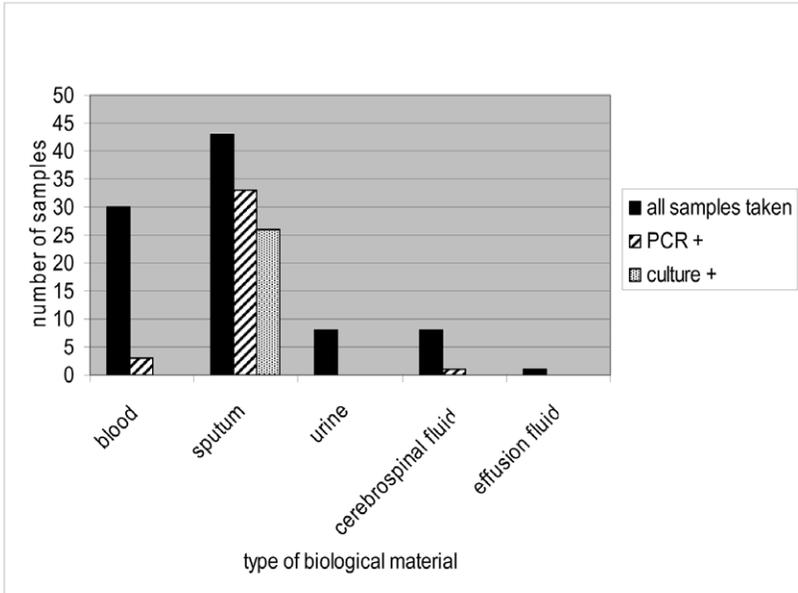


Fig. 3  
Pathogen detection from different clinical samples

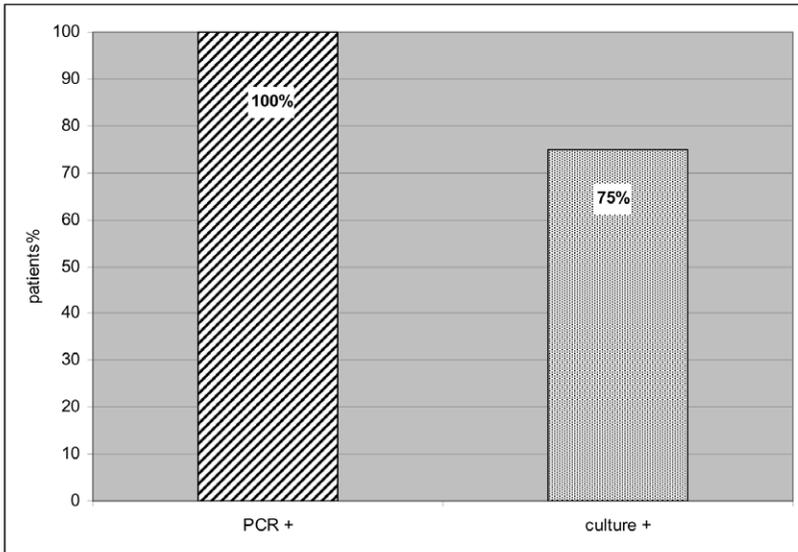
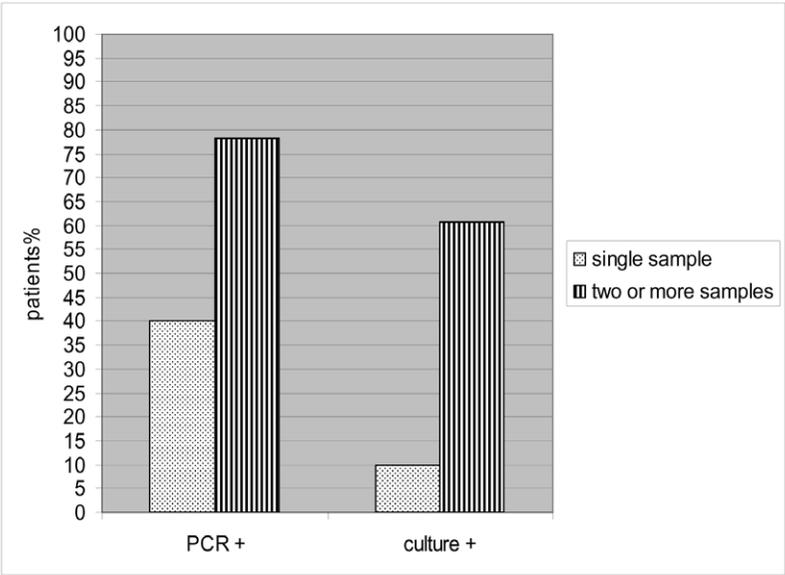
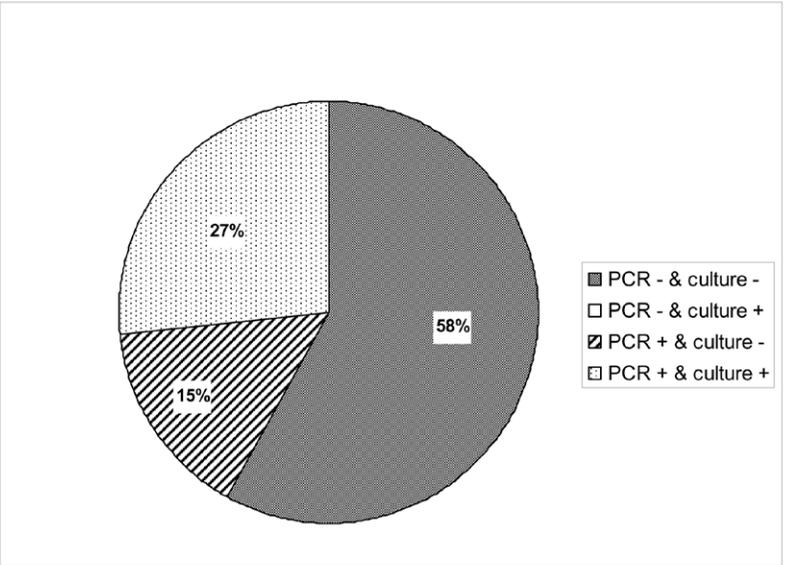


Fig. 4  
Pathogen detection from BAL in patients with lower respiratory tract infection



*Fig. 5*  
Comparison of single versus multiple sample testing



*Fig. 6*  
Comparison of pathogen detection by PCR and culture

It has been reported that with the PCR technique it is also possible to quantify the number of pathogens present in a clinical sample, and thus to follow the course of the infection (2). PCR can also detect pathogens that are generally more difficult to culture or detect via traditional methods.

The results of traditional microbiological techniques can thus be conveniently combined with the PCR results and can provide useful information and improve therapeutic intervention in children at an early development of sepsis. Nevertheless, it is always important to consider proper sample collection and handling to reach the optimal pathogen detection and to avoid contamination.

#### A c k n o w l e d g e m e n t s

This work was supported in part by the research project of the Internal Grant Agency of the Ministry of Health of the Czech Republic, IGA MZCR, No. NR/8046-3.

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## LONG-TERM RESULTS AFTER FEMORAL HEAD FRACTURES - CONSERVATIVE VERSUS OPERATIVE TREATMENT

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*Received after revision January 2007*

### Abstract

Fractures of the femoral head have become an increasingly common injury. The cause is usually a severe trauma most frequently sustained in motor vehicle accidents and falls from height. There is considerable controversy regarding the optimum treatment for this fracture in adults.

Thirty-nine patients with Pipkin fracture diagnosis treated between 1996 and 2000 were selected as the study sample with the mean follow-up time of 8 years and 2 months. According to Pipkin, there were 14 cases of the first, 5 of the second, 2 of the third, and 18 of the fourth type. Twelve patients were treated by closed reduction and 27 operatively.

Conservative treatment in Pipkin type I fractures gave better results than the operative one. In type II internal fixation provided more successful results than non-operative reduction. In type III the treatment was primary operative. In type IV there was found no difference between outcomes for hips reduced conservatively and those treated operatively.

The reposition of the fracture dislocation has to be performed as soon as possible and should be carefully controlled not only by routine X-ray examination but also by CT. If the head fragment in types I or II is displaced after reposition, a surgery is necessary. Arthroplasty should be often indicated in types III and IV. A high rate of the cases has radiographic criteria of osteonecrosis or post-traumatic arthritis.

### Key words

Femoral head fractures, Pipkin types, Treatment

### INTRODUCTION

Fractures of the femoral head have become an increasingly common injury in adults compared with such fractures in children (1). Torres *et al.* (2) already described a case with bilateral Pipkin type II fractures after bilateral posterior dislocations of the hips treated with open reduction and internal fixation via bilateral Smith-Peterson approaches.

The cause is usually a severe trauma most frequently sustained in motor vehicle accidents and falls from height. Only a few of these fractures result from trivial trauma, especially in elderly patients who have osteoporotic bones. Femoral head fractures associated with posterior dislocation account for less than 15% of all posterior dislocations (3, 4, 5).

The classification of Pipkin (6) has been the most frequently scheme used to date:

Type 1: femoral head fracture caudad to the fovea capitis femoris (*Fig. 1*).

Type 2: femoral head fracture cephalad to the fovea capitis femoris.

Type 3: one of the first two types associated with femoral neck fracture.

Type 4: one of the first two types associated with acetabular rim fracture.

It is clear that the outcomes from this injury are not uniformly good. There is considerable controversy regarding the optimum treatment for this fracture in adults and opinion remains divided on whether it should be treated in traction, excised, or fixed internally. Most orthopaedic surgeons treat only a few such cases in their professional career. Fractures of the femoral head remain of interest not because of their frequency, but because of the frequency of their complications, which include especially avascular necrosis and post-traumatic osteoarthritis.

Our experience with 39 cases is presented in this article.

#### MATERIALS AND METHODS

Between the years 1996 and 2000 we studied 41 Pipkin fracture cases and conducted a prospective controlled trial with 39 patients with Pipkin fracture diagnosis selected as our study sample (2 patients died). Complete clinical and radiographic documentations of these patients were available for the whole follow-up period. The mean follow-up time was 8 years and 2 months (range: 10 years and 1 month to 6 years and 2 months). Among the patients there were 31 men and 8 women. In 21 patients the right side and in 18 patients the left side were involved. The mean age was 36 years (range: 21 to 64 years).

A direct blow to the hip functioned as the mechanism of injury in 8, the axial load transmission from a fall from a height in 6, and a motor-vehicle accident in 25 cases. Associated injuries were present in 27 patients. The ipsilateral leg fracture was found in 8, contralateral leg fracture in 5, upper extremity fracture in 17, multiple rib fracture in 6, and pelvic fracture in 20 cases. The sciatic nerve palsy was associated in 7, the posterior acetabular wall fracture alone in 16 and together with column fracture in 2 cases. The femoral head was dislocated in all cases.

The femoral head fractures were classified according to Pipkin. There were 14 cases of the first, 5 of the second, 2 of the third, and 18 of the fourth type. Radiographs and CT scans of the injury were used to classify the fracture type. All radiographs were assessed by the first and second authors independently. Different opinions were resolved by consensus.

Twelve patients were treated by closed reduction. Then the balanced suspension with or without skeletal traction was used for 3 weeks. After this time, the non-weight bearing followed for 6 weeks. The patients were then gradually encouraged from partial to full-weight bearing. In this group, there were 6 fractures of the first, 1 of the second, and 5 of the fourth type.

The operative treatment was necessary in 27 cases. Eight cases were of the first, 4 of the second, 2 of the third, and 13 of the fourth type. The Smith-Peterson approach was used in 5 cases and the Kocher-Langenbeck approach in 22 cases of Pipkin fracture. The fixation of the head fragment with a malleolar or absorbable screw was done in 3 cases with the injury of type I, 4 of type II, and 9 of type IV. The fragment was excised in 5 cases of type I and 4 of type IV. The postoperative regimen varied according to individual stability of the hip. One femoral head in type III was excised as in Girdlestone procedure because of infection two weeks after internal fixation and in the second case of this type the hip joint was replaced as primary procedure due to the impossibility of restoring the head and neck.

The roentgenographic and clinical results were evaluated. The number of cases was not sufficient for statistical analysis.



*Fig. 1*

- a) A case of craniodorsal femoral head dislocation. Closed reduction was impossible because of interposition of multiple femoral head fragments located in the acetabulum.
- b) X-ray after an open reduction revealed the type I femoral head fracture with a large bone defect caudad to the fovea capitis femoris.

## RESULTS

From of 6 patients with the Pipkin type I fracture treated non-operatively 5 had satisfactory functional results without degenerative changes on X-ray evaluation. One patient suffered of pain after long walk and radiological control revealed degenerative changes. Of 5 patients after head fragment excision, osteonecrosis of the femoral head was found in 2 cases and in both the hip joint was replaced. Another 3 patients were satisfied with the result and on X-ray there were no degenerative changes or osteonecrosis. One patient after internal fixation of the fragment suffered pain due to arthritic changes and another 2 patients were without pain.

One patient after conservative treatment of the Pipkin type II fracture had painful osteonecrosis of the femoral head as well as 2 patients after internal fixation of the fragment. All three patients underwent total hip replacement. In another 2 cases after internal fixation of the fragment the radiological control found out no osteonecrosis or degenerative changes and the patients were free of pain.

In both cases of Pipkin type III fracture the primary operative treatment was used. The patient after Girdlestone procedure had pain during walking and a limp. The other after primary total hip replacement was satisfied.

Two out of 5 patients with the Pipkin type IV fracture treated conservatively suffered pain because of osteoarthritis, in 1 the hip was already replaced, and 2 were free of pain. In 6 out of 9 cases treated with fragment internal fixation a total hip arthroplasty was implanted. Another 3 patients were satisfied with the result. In 2 of 4 patients after fragment excision the joint instability developed with recurrent dislocations and because of osteonecrosis of the femoral head the hip joint was already replaced. One of them suffered pain because of osteoarthritis and one was free of pain without radiological degenerative changes. In 4 cases the iatrogenous sciatic nerve palsy was observed after Kocher-Langenbeck approach. In 3 of them the palsy was transient.

## DISCUSSION

Thompson and Epstein classified the posterior dislocations of the hip joint into five types (7). The fifth type involved fracture of the femoral head. *Pipkin* (6) subdivided the Thompson and Epstein fifth type of posterior dislocation of the hip into four types mentioned above.

*Thompson and Epstein* (7) found out all facts related to the traumatic dislocation of the hip. They evidenced that a case graded within the first five years according to roentgenographic and physical findings and symptoms would not be assigned to a higher or lower grade at a later date. They also proved that all dislocations with two or more attempts at reduction had fair or poor results and that one reduction was better than adding trauma upon trauma. They found increasing difficulty in securing reduction at the first attempt in their types III, IV, and V and postulated that general principles of reduction are traction in the line of deformity, restoration

of alignment, and apposition in the absence of muscle spasm. They stated that cases of dislocation not reduced within the first twenty-four hours after the injury had less successful results than cases of early reduced dislocations. If the open reduction is necessary to perform, it should be carried out promptly (until six hours after the injury).

Our experience, in accordance with *Nast-Kolb et al. (8)*, *Stockenhuber et al. (9)*, and *Weigand et al. (10)*, also shows that the reposition of the fracture dislocation has to be performed as soon as possible and should be carefully controlled not only by a routine X-ray examination but also by a CT of the pelvis. If the head fragment in Pipkin type I and II fractures is displaced after reposition, a surgery is necessary. The direct examination of the femoral head during the operation also reveals cartilage damage. Both cemented (11) and cementless (12) total hip replacements give good results and that's why in unreconstructable femoral head fractures primary replacement should be considered (9).

*Marchetti et al. (13)* reviewed the experience with 33 cases of posterior fracture dislocations of the hip followed for an average of 4 years. The overall results after the operative treatment according to Thompson and Epstein were 67% good, 18% fair, and 15% poor, with no excellent results. They found no statistically significant difference between the outcomes for hips reduced less or more than 6 h after injury and undergoing definitive surgery less or more than 24 hours after injury. There was no statistically significant effect of patient age on the outcome. They observed an avascular necrosis in an overall incidence of 10% in equal results comparing anterior versus posterior approach. All of these cases were reduced within 6 hours after injury. Seventy-five per cent of the patients were determined to have radiographic criteria of post-traumatic arthritis.

*Schönweiss et al. (14)* reported results after fracture of 14 femoral heads. The mean follow-up period was 6 years. All but one case of Pipkin fracture types I and II was treated by primary open reposition and screw fixation with good results. At our institution, greater cartilage fragments are also refixed by means of resorbable material. The clinical results according to Merle d' Aubigne were equal in fracture types I and II. Like in our hospital, in younger patients with Pipkin type III fractures Schönweiss prefers a screw fixation of the femoral neck, but total hip replacement in older patients. An exact reconstruction of the dorsal wall of the acetabulum has to be performed in Pipkin type IV fractures to prevent redislocation. The clinical results in cases of Pipkin fracture types III and IV after the primary operative treatment were nearly as good as in types I and II.

*Yoon et al. (15)* evaluated the outcomes of 30 femoral head fractures after the operative treatment followed for a mean of 5.5 years. They classified the femoral head fractures into four types, depending on the location, size, and degree of fragmentation. According to Thompson and Epstein criteria, the overall clinical outcomes were excellent in 7, good in 15, fair in 4, and poor in 1 case. They concluded that excision of the small fragment is a good choice of treatment in type 1. Early accurate

reduction with stable internal fixation in types II or III permits bone union. Arthroplasty is indicated in type IV.

The large number of car accidents among the found causes of fracture dislocations of the hip and the preponderance of men over women in our groups were also proved by *Harris (16)* and *Schönweiss et al (14)*. *Harris (16)* found out that post-traumatic osteoarthritis of the hip after these injuries arises in an average time of seven years. The solution of this late consequence is not so easy as e.g. in a knee joint (17) and aims usually to a total hip replacement. It should be delayed until pain and limited motion make the operation mandatory. The navigated and less invasive implantations of hip endoprostheses are used ever more frequently (18, 19), but there have been no references of these methods in the literature in cases after Pipkin fractures up to now.

## RESULTS

Fractures of the femoral head are severe injuries frequently associated with post-traumatic avascular osteonecrosis and/or osteoarthritis. According to our experience, the reduction of the femur has to be performed as soon as possible. If a closed reduction in Pipkin type I and II fractures is impossible or the head fragment remains displaced after reduction, a surgery is necessary. Bone fragments in type I lesions can only be removed. In type II fractures the head reconstruction should be always considered. In Pipkin type III injuries operative treatment is strongly recommended, either reconstruction or primary replacement. Type IV fractures are indicated for conservative treatment only if the hip remains stable and the head fragment is not displaced.

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## MICROSURGICAL ARTERIAL END-TO-SIDE ANASTOMOSIS- AN EXPERIMENTAL MODEL

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*Received after revision March 2007*

### Abstract

The aim of our study was to establish an experimental model of microvascular arterial end-to-side anastomosis in the rat. The standard anastomosis in experimental microvascular surgery is an arteriovenous fistula between the femoral artery and the vein. This model helps in laboratory training of surgeons. However, this is not acceptable as a model for extra-intracranial bypass because of different nature of venous and arterial walls. Experimental end-to-side anastomosis between both common carotid arteries corresponds with real clinical conditions. This model enables a better comparison of the influence of operative technique on short-term and long-term bypass patency and its thrombogenicity.

### Key words

Microsurgery, Arterial end-to-side anastomosis, Experimental model

### INTRODUCTION

Arteriovenous end-to-side anastomosis between the femoral artery and the ipsilateral femoral vein in the rat is a standard experimental microsurgical bypass model. The model is well defined and is optimal for microsurgical training. An alternative bypass model between the common carotid artery and the internal jugular vein has no additional benefits. It is again an arteriovenous fistula. The methodical problem is obvious. The difference in elasticity of the arterial and venous vascular walls and the different thrombogenicity do not correspond with clinical situation, where typical low-flow bypass is performed between the superficial temporal artery and a cortical branch of the middle cerebral artery. Both arteriovenous end-to-side experimental models are convenient for training in microsurgery. When we try to define a model which would fit the clinical situation, we must exclude both arteriovenous models. Bypass patency, thrombogenicity, and long-term maturation are parameters, which we can adequately evaluate only on an arterio-arterial experimental model. A decision to establish an arterial end-to-side carotid bypass model was made with the aim to determine the above-mentioned parameters in the future.

## MATERIALS AND METHODS

### *A new model of the arterial end-to-side*

The experiment was performed in the Department of Parasitology, Academy of Sciences of the Czech Republic. The Expert Committee for Experimental Animals Preservation of the Department of Parasitology, Academy of Sciences of the Czech Republic, confirmed that the methods of the use of experimental animals as proposed in our project are not in discrepancy with provision of Act No.167/1993 Coll. "On Preservation of Animals". The Department of Parasitology is the right-holder of the Central Committee for Preservation of Animals (Section 15, par. 2 of the Act) for manipulation with experimental animals. According to Section 21 par. 3, letter (e) of Act No. 246/1992 Coll., the acknowledgement for preservation of animals against excruciation was granted to the Department of Parasitology from 25th October, 2000, by a letter of credit on the user's facilities No. 1020/293/A/00.

Male Wistar rats weighing 250 to 350 g were used. They were anaesthetised using a combination of Rometar and Calypsol, administered intramuscularly.

Rometar 2% contains 20 mg of Xylazine in 1 ml of solution.

Depending on the dose, the mode of administration, and the type of experimental animal, it has different degrees of sedative, analgesic, anaesthetic and myorelaxant properties. The initial dose is 2 mg/kg, administered intramuscularly. The onset of effect after intramuscular administration is 5 to 10 minutes. The drug effect subsides within one hour. The effect can be extended by reapplication of 1/3–1/2 of the initial dose.

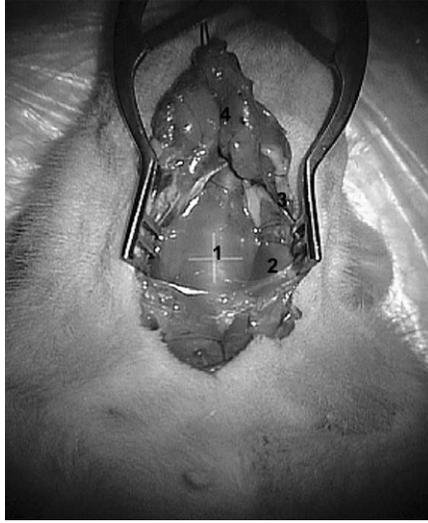
Calypsol contains 50 mg of ketamine in 1 ml of solution. The dose is 6 to 13 mg/kg in intramuscular administration. The onset of effect comes within 3–6 minutes, the biological half-time is 2.5 to 4 hours. The maintenance dose is 1/3 to 1/2 of the initial dose. During surgeries, we have used a Zeiss OPMI 1 microscope with halogen light source and binocular stereoscopy imaging. The lens has a focus of 200 mm and 12.5-fold magnification of the binoculars enables 4-to-25-fold magnification. The suture material Prolen 10/0 was used with a needle length of 3.75 mm, a round cross-section, a diameter of 75 micrometers, and a thread length of 13 cm.

Skin incision was made in a vertical direction in the midline from the jugular notch to the mandible level. Sharp dissection with scissors opens the subcutaneous tissues. The subcutaneous soft tissues including the glands and lymph nodes are dissected in the cranial direction. The flap of the subcutaneous layer is affixed with one stitch. The pull of the stitch exposes the muscular layer (*Fig. 1*).

Dissection is limited by the external jugular vein and the maxillary vein. It is essential to avoid their injury, which may result in major blood loss and the need of bipolar electrocautery. Correct mobilisation of the veins enables deeper dissection without other limitations.

The omohyoid muscle is dissected longitudinally and its lateral part is pulled aside using a retractor. This manoeuvre exposes the common carotid artery (*Fig. 2*). Frequently, a necessary requirement for a successful end-to-side anastomosis is the dissection of the infrahyoid muscles from the sternum and their retraction in the cranial direction using a fixative stitch. Occasionally, the donor artery is too short to perform an end-to-side suture even after it is cut in the maximum distal location at the bifurcation. Such a manoeuvre gives us sufficient space for an easy suture performance (*Fig. 3*). Excessive length of the donor artery occurs less frequently. It may be the case in older animals with advanced arteriosclerosis. Elongation of an atherosclerotic vessel is similar to that seen in humans. In such case there is no need for retraction of the infrahyoid muscles. The positioning of the Biemer clamps discontinues the blood flow at the site of performed suture.

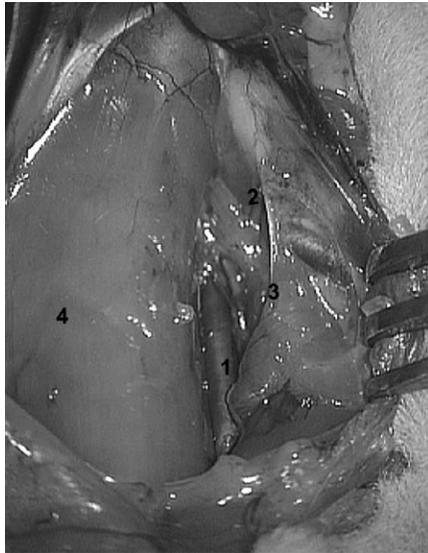
Ligature of the contralateral carotid artery at the bifurcation is made using Ethilon or Prolen 8/0. Prior to this step, a Biemer clamp must be positioned in the proximal jugular notch over the vessel and afterwards the artery is cut with scissors just proximally from the ligature. The vascular lumen is flushed with heparinised normal saline. After removing blood clots, a "dilatation" forceps is inserted and the mouth of the artery repeatedly distended. The goal is to reach 150% of the original artery width. Using straight microscissors, the adventitial layer is resected. There are two objectives for preventing the interposition of the adventitia into the anastomosis lumen. First, it prevents the lumen narrowing, and second, it reduces the risk of thrombosis. After the adventitia is resected, a longitudinal excision



*Fig. 1*

A schematic view of the surgical field after retraction of the subcutaneous layer

1. infrahyoid muscles, 2. sternomastoid muscle, 3. mandibular muscle, 4. retracted subcutaneous layer



*Fig. 2*

Preparation of the common carotid artery

1. common carotid artery, 2. linguofacial vein, 3. discission of the omohyoid muscle, 4. sternohyoid muscle

is performed in the medial side of the vessel. The length of the incision corresponds with the vascular lumen diameter. Resection of the sharp, rectangular margins closes the preparation of the donor.

Incision of the recipient carotid artery is made after placing clamps and removing the adventitia layer at the site of incision. The objectives for the adventitia removal are identical to those at the donor artery – to prevent thrombosis and narrowing of the anastomosis.

The key for a successful anastomosis formation is the fixation stitch. Ethilon 10/0 or Prolen 10/0 are to be used with needle size 3.75 mm (*Fig. 4*).

The technique of the fixation stitches depends on whether individual stitches will follow or whether the anastomosis is made by a continuing suture. In the case of individual stitches, we place 2 fixation stitches to the opposite ends of the incision (Numbers 3 and 9). We use the thread in its full length. Afterwards, central stitches are placed on the front side (Number 6) and the back side (Number 12). This makes up four quadrants. Two stitches are to be placed into each quadrant with equal distance between the stitches (*Figs. 5 and 6*).

If we use the continuing suture, it is essential to shorten the suture thread to less than 30 mm, otherwise there is a risk of knotting or misplacement in a longer thread. A thread of 30 mm is sufficiently long to make up the whole anastomosis, so that there is no waste. Our model is conveniently sutured by placing one fixation stitch – the one-way-up technique. In case of two fixation stitches we usually encountered problems with suturing the back wall. The problems with limited accessibility to the back wall are due to insufficient length of the donor artery. The length of the artery usually prevented us from extensive manipulation around its long axis, e.g. flipping over to expose its back wall. Therefore, the one-way-up technique is very beneficial for this suture (*Figs. 7 and 8*).

The prerequisite of a sound continuous suture is to perform the same length of incision in both arteries. An accurate tension of the thread in individual stitches is also a prerequisite of success. An excessive tension narrows the lumen, resulting in suboptimal blood flow. The most severe complication caused by slow flow is thrombosis and occlusion of the bypass. On the contrary, low tension of the thread results in anastomosis bleeding (*Fig. 9*).

## DISCUSSION

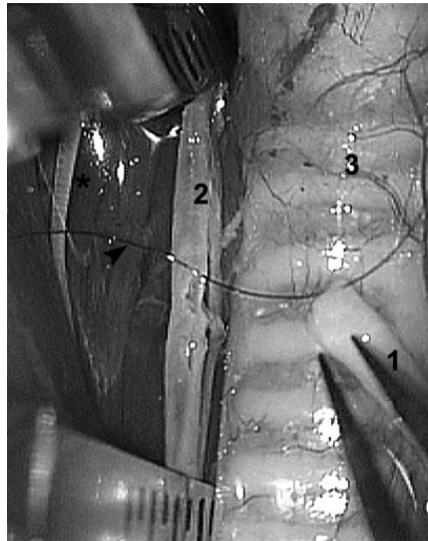
The use of microsurgical techniques in the surgery, namely neurosurgery, plastic surgery and others brought along a significant reduction of perioperative morbidity. Certain procedures, such as replantation in plastic surgery and extra-intracranial anastomosis, cannot be performed without microsurgery. Hence, a sound training of microsurgical techniques in a laboratory environment is required. Yasargil suggested that young physicians should operate for 3 months in a laboratory before they may enter the operating room (1). Microvascular experimental surgery was being developed in the 1960's (2). The first clinical application in neurosurgery was the performance of extra-intra-cranial anastomosis by Yasargil on October 30, 1967 (3). Animal models of experimental end-to-side bypass have been used to connect the femoral artery and vein (4) and the carotid artery and vein (5). Both models are arteriovenous fistulas. They are very convenient models to learn microsurgery. If one desires to evaluate the effect of different surgical techniques (e.g. to compare individual stitches vs. continuous suture) on the blood flow through the anastomosis, only arteries should be used. This corresponds with the real-life situation. This was our objective while developing the presented arterial end-to-side bypass model. Our future research goals include the study of the effect of different surgical techniques on blood flow through the anastomosis in a standardised laboratory model.



*Fig. 3*

Discission and cranial retraction of the infrahyoid muscles

1. left common carotid artery, 2. right common carotid artery, 3. sternohyoid and sternothyroid muscles



*Fig. 4*

Placement of the fixation suture

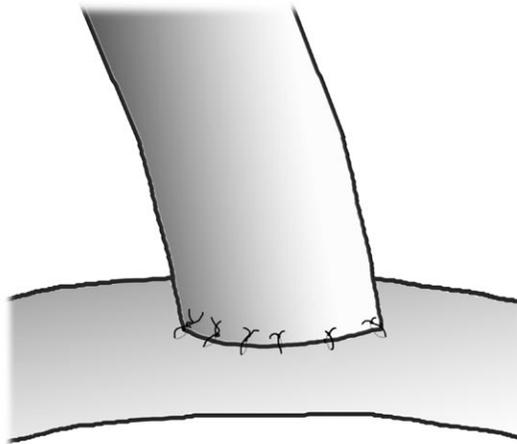
1. left carotid, 2. right carotid, 3. trachea, \* truncus vagosympathicus, ∇. thread of the fixation suture

## Acknowledgements

The author would like to acknowledge Mrs. H. Pešková for her valuable advice when working in the laboratory, and MUDr. M. Bombic for preparing the figures.

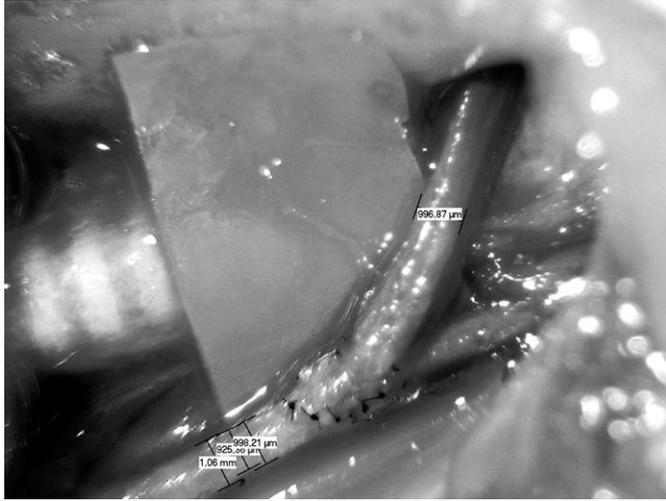
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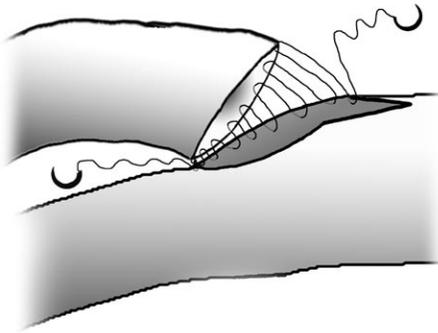


*Fig. 5*

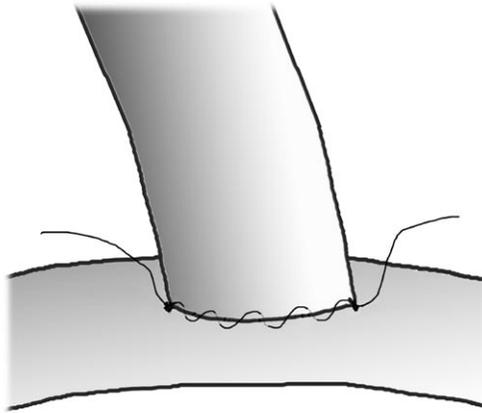
Microsuture end-to-side with individual stitches -scheme



*Fig. 6*  
Microsuture end-to-side with individual stitches - photograph



*Fig. 7*  
Microsuture end-to-side with continuous suture- the back wall “one-way-up technique”



*Fig. 8*  
Finishing the suture of the front wall with a continuous stitch - scheme



*Fig. 9*  
End-to-side anastomosis with a continuous stitch - photograph

## THE RELATION BETWEEN IMPLANTED MATERIAL AND INFECTION OF THE TOTAL JOINT REPLACEMENT

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*Received after revision May 2007*

### Abstract

Infection of the total joint replacement is the most severe complication seen in prosthetics. Besides a number of other factors, the rise of infection is also influenced by the material applied, not only by its chemical composition but even by the surface texture. This, together with the properties of the contaminating bacteria, has effects on the development of biofilm formation on the implant surface. A set of 91 infective complications of the total hip replacement was used to evaluate clinically the influence of implanted materials on the infection development. The relation between cemented, hybrid, and non-cemented substitutions, particularly the relation of various metals used for implantation and especially the effects of polyethylene were assessed. The time factor of the infection development was also evaluated. Statistical significance was found between the sets in all surveyed parameters. The implants with polymer materials were revealed to become contaminated more easily. Non-cemented implants with porous surfaces are infected less often; here infection appears earlier than in cemented implants with polished metal surfaces. This report aims at better understanding the problems of biomaterial surfaces and, thus, at decreasing the incidence of infections in total joint replacements.

### Key words

Endoprosthesis, Infection, Biomaterial

### INTRODUCTION

The present era of total joint replacements has been lasting for more than 40 years. Throughout this period, the effects of total replacement on improving the affected joint function have been proved unequivocally. This also improves the patient's social integration and general health condition (8, 10). However, joint prosthetics is not connected only with positive outcomes, it also brings some negative results.

Infection is the most severe complication after total joint replacement. Due to its surgical, psychological, and also economic aspects, it is highly difficult to treat the replacement infection. Repeated surgical interventions, long-term administration of antibiotics, and strenuous rehabilitation cause great psychic burden to patients. In many cases, even a revision replacement after treating an infectious complication fails, and the functional result of the repaired joint is unsatisfactory. Therefore, orthopaedists aim at minimising the occurrence of infectious complications. Those

that do appear must be diagnosed as quickly as possible and treated with the maximal effectiveness at the lowest costs resulting in the functioning adequate joint. Early diagnosis makes the therapy easier and morbidity lower (8, 9, 12). The treatment of periprosthetic infection can sometimes lead to multiple surgical debridement, arthrodeses, amputations, persistent chronic infections, or even the patient's death. The infection of total joint replacements means a great economic load, it increases morbidity and decreases the extent of subjective satisfaction of patients (6, 8).

Even the choice of total joint replacement is important for the infection development. Increased incidence of suspensory replacements is well documented if compared with unconstrained replacements. Here, the rotation force is transmitted on the cement-bone boundary, which results in the early loosening of prosthesis and the development of a macrophage membrane in the region of the boundary line. This environment is conducive for the growth of bacteria that are, due to poor blood supply, perfectly insulated from the host's defensive barriers. Generally, rapidly failing implants are at higher risks of infection (15, 16).

The effects of location and material dimensions on the infection development were analysed extensively, but only little attention was paid to the influence of the implant shape and its chemical composition (1, 4, 5, 6, 13, 14).

## MATERIAL AND METHODS

Our clinical study aimed at evaluating the effects of implanted material on the development of infection in total joint replacements. A set of patients with total hip joint replacements was assessed; all of them had undergone surgery at the First Department of Orthopaedic Surgery in Brno within 1986–2004 and suffered from infectious complications. The patients with replanted hip endoprostheses as well as those whose contaminated joint replacements implanted in some other centre were treated at our Department were excluded from the trial. The set was compared with a set of total hip joint replacements implanted at the 1st Department of Orthopaedic Surgery in the period mentioned in which no infection had occurred until then. Within 1986–2004, 7725 total hip joint replacements were performed in our Department, out of which 3982 were cemented, 2892 hybrid, and 892 non-cemented. Combinations of acetabular and femoral components of the hip joint replacements used most frequently in our department were involved in the statistical study. Combinations applied seldom were excluded due to the low validity of the set, except for those with an infectious complication. In this way a set was obtained consisting of 3806 cemented, 2775 hybrid, and 851 non-cemented replacements of the hip joint. A summary of implants and infections is shown in *Table 1*.

*Table 1*  
Implanted and infected materials within 1986–2004

	implanted	infection
<b>Poldi-Poldi</b>	3252	53
<b>Ultima-Poldi</b>	425	5
<b>Ultima-PFC</b>	121	2
<b>Howmedica-Exeter</b>	8	1
<b>Spotorno-Poldi</b>	1683	10
<b>Spotorno-PFC</b>	261	6
<b>Spotorno-CF 30</b>	332	6
<b>Spotorno-Exeter</b>	114	2
<b>Duraloc-C stem</b>	96	0
<b>Spotorno-MS 30</b>	143	0
<b>Morscher-Poldi</b>	146	1
<b>Spotorno-CLS</b>	453	4
<b>Walter-Motrolet</b>	128	1
<b>Plasmacup-Bicontact</b>	270	0

The set of 91 patients having an infectious complication of the total hip replacement where the primoimplantation was carried out within 1986–2004 was compared with the set of 7432 total hip arthroplasties carried out in the same period without infectious complications. For the set of evaluated patients - see *Table 1* and *Figs. 1-3*. Our attention was focused to the materials used at the surgery and the period elapsed between performing the replacement and appearance of an infectious complication. Stratification of the set is shown in *Figs. 1-3*.

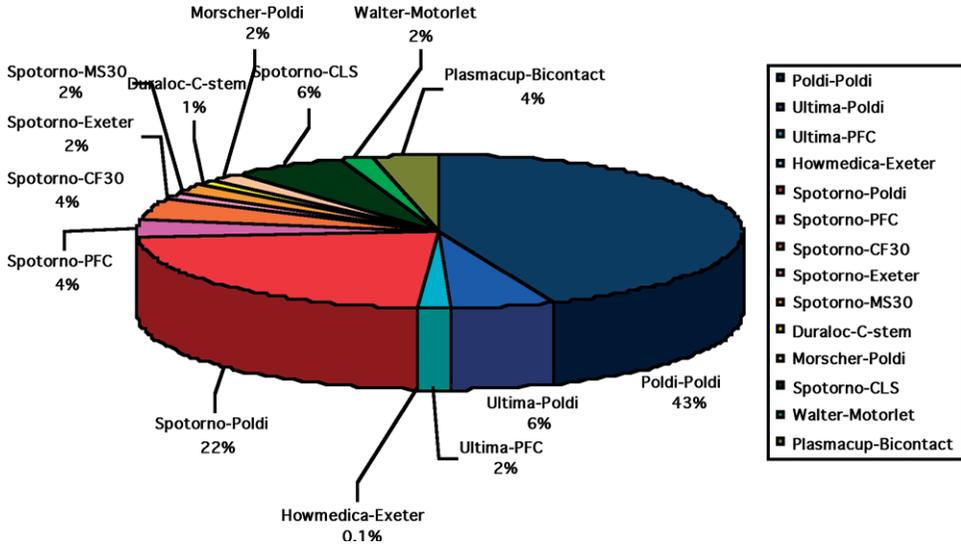


Fig. 1  
Implanted materials

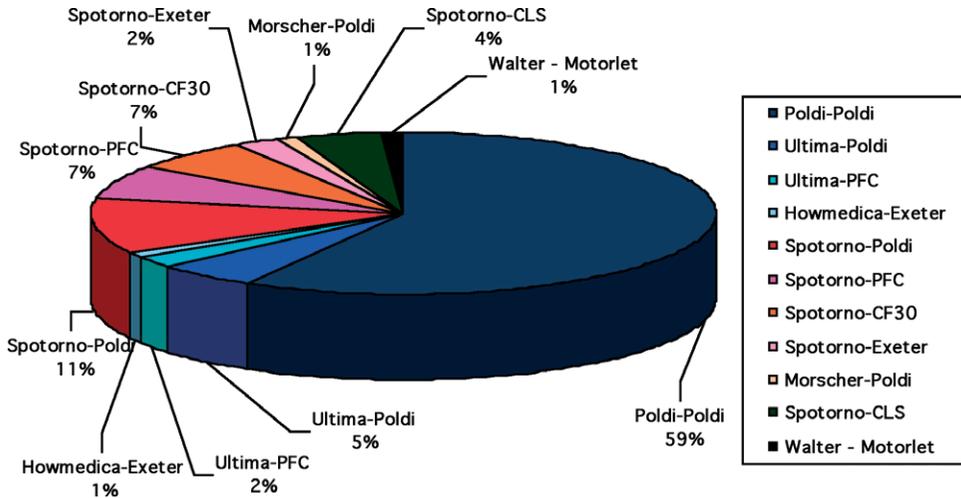


Fig. 2  
Infected materials

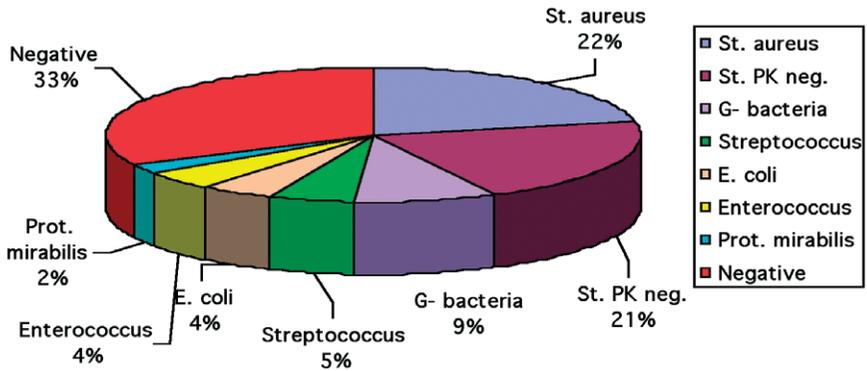


Fig. 3  
Infecting agents

On the basis of the data detected by our study, three hypotheses were explored and evaluated statistically.

Hypothesis 1: Cemented implants become infected more frequently than hybrid and non-cemented ones (Table 2, Figs. 4, 5).

Hypothesis 2: Material composition of the implants has effects on the occurrence of infection in total hip joint replacement (Tables 3, 4, Figs. 6-9).

Hypothesis 3: Non-cemented implants are more susceptible to early infections, while the cemented ones are more susceptible to late infections (Table 2, Fig. 10).

Table 2

The ratio of implanted: infected replacement; relation to polymethyl methacrylate

Type of implant	implanted	infection	av. T	material	implanted	infection	av. T	med. T
Poldi-Poldi	3252	53	50	cemented	3806	61	47.05	38
Ultima-Poldi	425	5	7.2					
Ultima-PFC	121	2	40					
Howmedica-Exeter	8	1	106					
Spotorno-Poldi	1683	10	30.4	hybrid	2775	24	20.45	9
Spotorno-PFC	261	6	21.5					
Spotorno-CF 30	332	6	15.8					
Spotorno-Exeter	114	2	2.5					
Duraloc-C stem	96	0						
Spotorno-MS 30	143	0						
Morscher Poldi	146	1	6					
Spotorno-CLS	453	4	6.1	uncemented	851	5	5.08	3.5
Walter-Motorlet	128	1	3					
Plasmacup-Bicont.	270	0						

Note: av. T - average time from implantation to infection; med. T - median of time from implantation to infection

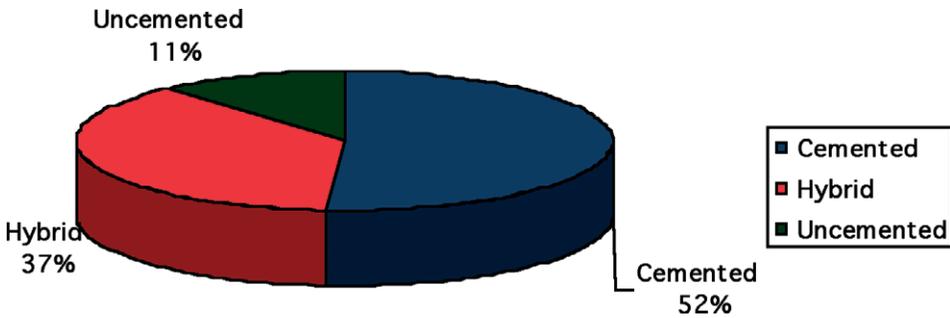


Fig. 4

Implanted hip replacements; relation to polymethyl methacrylate

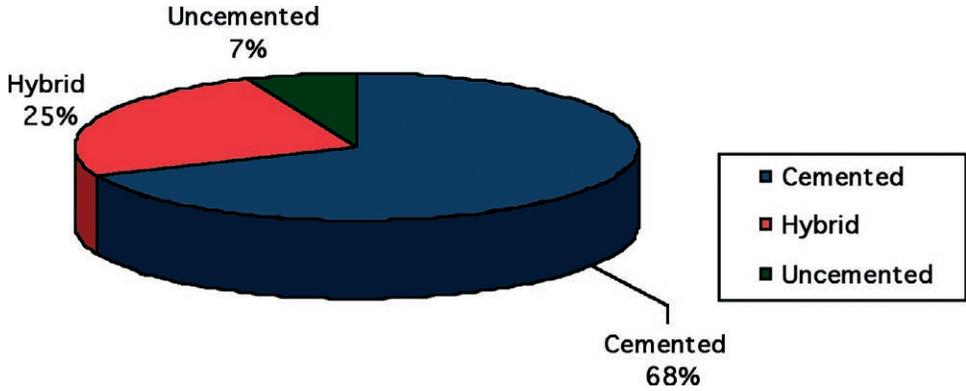


Fig. 5  
Infected hip replacements; relation to polymethyl methacrylate

Table 3  
The ratio of implanted: infected replacements; relation to metals used

Type of implant	implanted	infection	av. T	material	implanted	infection	av. T	med. T
Poldi-Poldi	3252	53	50	steel	3685	59	30.12	38
Ultima-Poldi	425	5	7.2					
Howmedica-Exeter	8	1	106					
Spotorno-Poldi	1683	10	30.4	steel + titanium	2182	13	24.24	21
Spotorno-Exeter	114	2	2.5					
Duraloc-C stem	96	0						
Spotorno-MS 30	143	0						
Morscher Poldi	146	1	6	porous titanium	723	4	6.13	6.5
Spotorno-CLS	453	4	6.1					
Plasmacup-Bicont.	270	0		corunded titanium	842	15	18.6	9
Walter-Motorlet	128	1	3					
Spotorno-PFC	261	6	21.5					
Spotorno-CF 30	332	6	15.8					
Ultima-PFC	121	2	40					

Note: av. T - average time from implantation to infection; med. T - median of time from implantation to infection

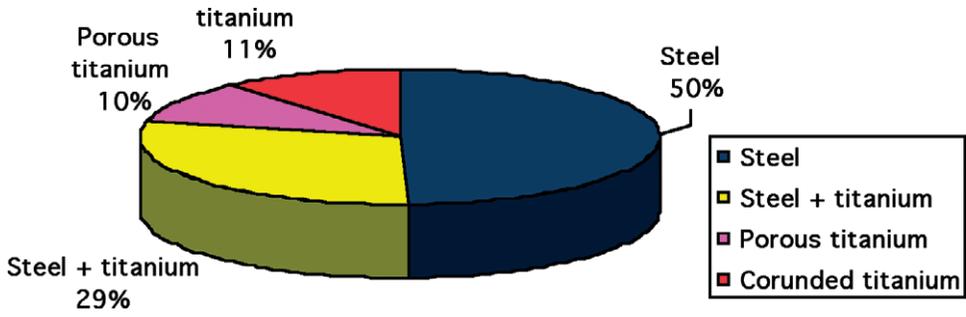


Fig. 6  
Implanted hip replacements; relation to metals used

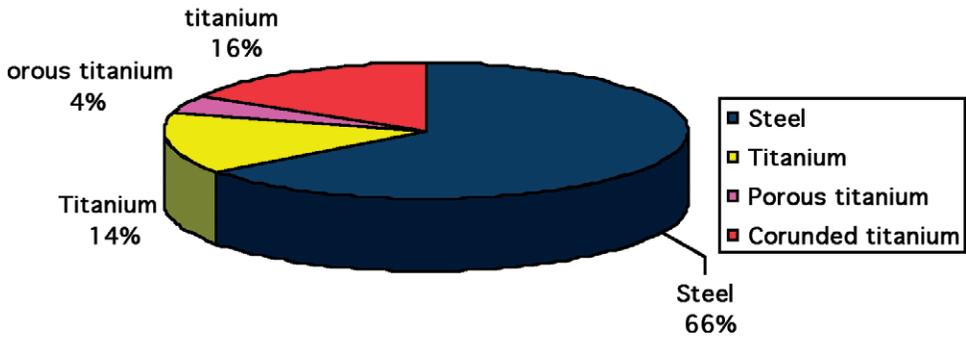


Fig. 7  
Infected hip replacement; relation to metals used

Table 4

The ratio of implanted: infected replacements; relation to polyethylene and ceramics

Type of implant	implanted	infection	av.T	material	implanted	infection	av. T	med.T
Poldi-Poldi	3252	53	50	polyethylene	7162	91	37.37	25
Ultima-Poldi	425	5	7.2					
Howmedica-Exeter	8	1	106					
Spotorno-Poldi	1683	10	30.4					
Spotorno-Exeter	114	2	2.5					
Duraloc-C stem	96	0						
Spotorno-MS 30	143	0						
Morscher Poldi	146	1	6					
Spotorno-CLS	453	4	6.1					
Walter-Motorlet	128	1	3					
Spotorno-PFC	261	6	21.5					
Spotorno-CF 30	332	6	15.8					
Ultima-PFC	121	2	40					
Plasmacup-Bicont.	270	0		ceramics	270	0		

Note: av. T - average time from implantation to infection; med. T - median of time from implantation to infection

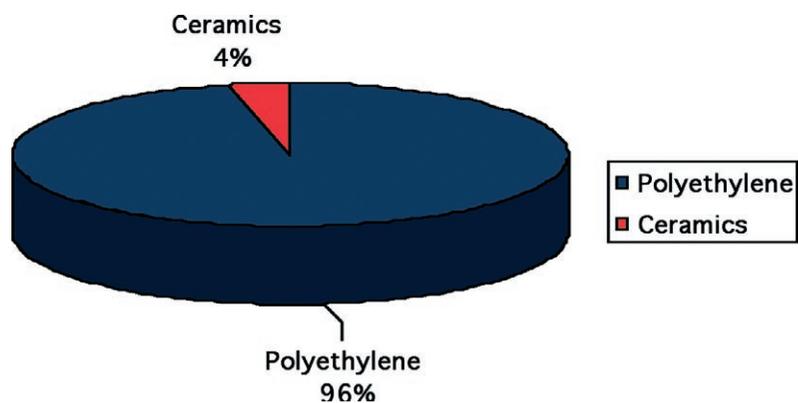
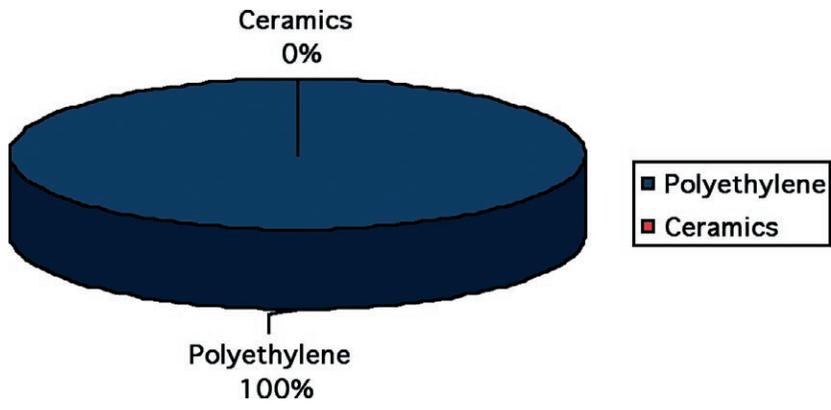
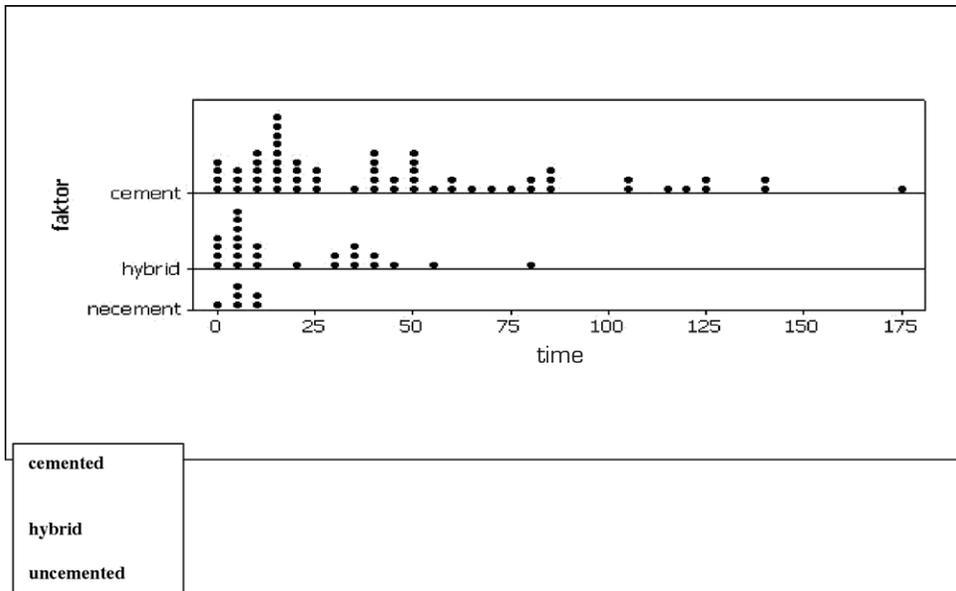


Fig. 8

Implanted hip replacements; relation to polyethylene and ceramics



*Fig. 9*  
Infected hip replacements; relation to polyethylene and ceramics



*Fig. 10*  
The period of implant infection

## RESULTS

The data obtained were submitted to statistical analysis on the basis of the hypothesis settled previously.

### Hypothesis 1:

Cemented implants become infected more frequently than the hybrid and non-cemented ones. Alternative hypothesis tested: the attack of infection is not dependent on the type of implant. As the ratios of defects are compared in more than two classes, the usage of a chi-square test of independence should be applied.

Chi-square test: cemented - hybrid - non-cemented: Chi-Sq = 10.426. DF = 2. P-value = 0.005.

The hypothesis that the infection attack does not depend on the type of implant is rejected on a significance level of 0.05. Based on standardised frequency differences, cemented replacements have proved to be more susceptible to infections than the hybrid and non-cemented ones.

### Hypothesis 2:

The material composition of the implants has effects on the occurrence of infection in the total hip joint replacement. Alternative hypothesis tested: the infection attack is independent of the type of material.

Chi-square test: steel 1 - steel + titanium - porous titanium - corunded titanium: Chi-Sq = 16.306. DF = 3. P-value = 0.001.

We reject the hypothesis that the infection attack is independent of the implant type at a significance level of 0.05.

The standardised differences of frequency have shown that steel and corunded titanium are more susceptible to infection than implants with steel + titanium and implants with plasmatic titanium coat.

Chi-square test: polyethylene - ceramics: Chi-Sq = 3.473. DF = 1. P-value = 0.062.

The hypothesis stating that the infection attack is independent of the presence of polyethylene or ceramics is not rejected on a significance level of 0.05. One theoretical frequency is lower than 5; i.e., there exists a greater risk of errors of the second type.

### Hypothesis 3:

Non-cemented implants are more often susceptible to early infections, while the cemented ones are more prone to late infections. The analysis of diffusion and T-tests (tests of mean values) cannot be applied as the data do not have normal classification. A test for median equality was used. Alternative hypothesis tested: groups of total replacements have the same median. Kruskal-Wallis test: time versus factor: H = 17.31. DF = 2. P = 0.000. H = 17.32. DF = 2. P = 0.000.

We have rejected the hypothesis that groups of total replacements have the same median on a significance level of 0.05. Thus, the time for infection development in non-cemented implants is shorter than that in hybrid and cemented ones.

#### DISCUSSION

The effects of implant surface on infection development depend on different algorithms of colonisation of these materials with tissue cells and bacteria. The results based on these reports have shown that porous materials are contaminated more easily than polished surfaces; i.e., bacteria colonise porous surfaces more quickly than do tissue cells if compared with polished surfaces. In a liquid environment, bacteria are found near the implant and reach quickly its porous surface, while tissue cells (fibroblasts and osteoblasts) are located in the bone tissue wall. Moreover, prokaryotic bacteria have a simpler and faster metabolism as well as reproductive functions in comparison with eukaryotic tissue cells. Thus, bacteria reach and colonise the biomaterial surface more rapidly than do tissue cells. Finally, the surface pores are filled with bacterial colonies and covered with a glycocalyx-forming biofilm. In his report, Gristina has called this phenomenon "race for the surface" (4, 5). The bacteria hidden in the biofilm formation live inside the pores with small zones of contact with the host environment, and thus are better protected against the influence of outer surroundings both in the sense of the host immune reaction and effects of the antibiotics administered. The results of these reports concerning different relations of cobalt-chromium and titanium to infection may be generalised for porous and polished surfaces. Logically, a strikingly larger surface of a porous material provides a higher chance for colonising with a bacterial pathogen (3). On the other hand, if the initial stage of microbial adherence is prevented, the material surface is better protected with a host tissue against contaminating microorganisms.

The data concerning total replacements mentioned in the literature were confirmed in our set of patients with high statistical significance.

Cemented implants were contaminated statistically significantly more often than hybrid and non-cemented ones. This phenomenon was confirmed in *Petty's* (14) experiments; they revealed that polymethyl methacrylate polymerised in vivo was infected with bacterial strains significantly more often than the others. *Barth* (1) has shown in "in vitro" and "in vivo" studies that *S. epidermidis* producing an exopolysaccharide substance colonises preferentially pure polymers (polymethyl methacrylate), while *S. aureus* colonises preferentially titanium alloy (Ti6Al4Vn), which is crystalline. This fact could not be confirmed by our study. In another clinical study, *Engesaeter* (7) proved that uncemented hip arthroplasties had the same risk of revision due to infection as had cemented arthroplasties with antibiotic-loaded cement, but a reduced risk compared to cemented arthroplasties without antibiotic cement. As a risk factor of infection can be always considered difference in the

operating time between cemented and uncemented implants (the operating time for the uncemented prosthesis is approximately 15 minutes shorter). Accordingly these operations were probably less exposed to perioperative contamination (2, 11). Another explanation can be necrotic bone around the cement, caused by cement toxicity or heat generation during curing of cement, which could be the potential growth medium (7).

However, in this part of clinical study there can occur misrepresentations of the studied set by the fact that cemented implants prevailed in the 1980ies, and at the beginning of the 1990ies, as late as this decade the ratio of cemented – hybrid – non-cemented total hip replacements gets near the median. It shows that cemented implants being in situ for a longer period have greater opportunity to become infected (the infection risk increases with the period for which a patient has an implant in his body).

It is very complicated to analyse the share of metal components of materials in infection because of its heterogeneity. Statistical analyses have shown that significantly more frequent infection is seen in materials containing polished steel or corunded titanium if compared with a combination of steel + titanium with plasmatic coat or in using only titanium with plasmatic surface. This fact has also confirmed in clinical practice Gristin 's postulate (4). As well *Chang* and *Merrit* (6) prove in experiment lesser bacterial adherence in vitro with pure titanium in comparison with steel and polymethyl methacrylate.

With perfect pre-, per- and post-operative elimination of risk factors, implants with osteoconductive surfaces give the best long-term results from the view of studying infectious complications. The implants the surface of which is not perfectly occupied with host's tissue elements (corunded titanium, polished steel) are more likely attacked with haematogenous infection. The evaluation of the infection rise in connection with the presence of polyethylene or ceramics is statistically insignificant (even though only on the boundary). The reason is still low number of implanted hip replacements with the contact surface ceramics – ceramics although the zero occurrence of infection in this set seem to be promising.

The analysis of the last hypothesis has clearly shown, with high statistical significance, relations between the type of implant and the period of infection development. In our set, late infections appear statistically significantly more often in cemented implants if compared with hybrid ones, and non-cemented implants are prone to statistically significantly more frequent early infections. Thus, even this part of clinical trial has confirmed biomaterial theory with Gristin 's postulate on „race for the surface“ in the replacement (4). The explanation of this phenomenon may depend on a better osteointegration of titanium if compared with cobalt-chromium. At present, due to its biocompatibility, titanium has been considered one of the best materials to be implanted into a human organism, especially into bones (4, 13).

On the other hand *Engeaster et al.* (7) shows that the 89% of the revision due to infection were performed during the first five years postoperatively. They claimed,

that it could be expected that the increased risk of infection should be decrease with the time i.e. after the necrotic tissue close to the cement had been resorbed and substituted by normal vascular tissue.

#### CONCLUSION

The tactics and strategy in treating the total replacement infection is not uniform. The opinions on the type of therapy as well as results differ significantly according to various authors. Although the basic principles in the treatment of infected replacements are already postulated, new methods are being developed to make diagnosis more accurate, local and general treating an infected total replacement more effective, and re-implantation easier with the effort to reduce the number of re-infections. Our aim is particularly to decrease the occurrence of the total replacement infection. This can be reached by careful selection of patients, elimination of subjects with accumulated risk factors and rigorous per-operative examinations focused on the elimination of associated infections and immunocompromising states. Physicians of subsequent care should be informed about the fact that a patient had undergone the total joint replacement. His associated infections must be treated and covered with antibiotics during a surgical intervention in the regions of predilection for haematogenous dissemination of infection.

If an infection appears, urgent diagnostics and adequate therapy are needed. In this sphere, there is required knowledge about biomaterial properties of the used total replacements with respect to the properties of infectious microorganisms especially from the view of abilities of some bacterial strains to create biofilm formations. These facts must be then taken into account both in diagnosing and choosing the therapy. The time factor in detecting infection has decisive influence on the further outcome of the total joint replacement.

Within the sphere of implants, the trend is directed to biomaterial surfaces with antimicrobial properties. The development is focused mainly on the texture of surface, modification of wettability, covering the implant surface with proteins or antibiotics, that all aiming at preferring the tissue adhesion to microbial one.

Clinical trials have shown the fact that the quality of biomaterial surface is one of the decisive factors for the total joint replacement outcome. This must be taken into account even in our clinical practice. Total joint replacements with a first-quality surface have to be given priority even at the price of higher costs as the return of investment after reaching the decrease of infectious complications of these replacements is evident.

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## PERSONALIA

### THE EIGHTIETH BIRTHDAY OF PROFESSOR MUDr. VLADIMÍR KOŘÍSTEK, DrSc.



Prof. Kořístek, the emeritus head of the Second Department of Surgery, St. Anne's Faculty Hospital, Masaryk University, Brno, Czech Republic, is 80 on 14 May 2007.

He was born in Zábudov, the district of Boskovice, in 1927. After finishing his studies at the Faculty of Medicine in Brno in 1951, he started to work as a house surgeon at the Department of Surgery of the hospital in Svitavy as well as a military physician at the Department of Surgery in Hradec Králové, led by Prof. J. Bedrna. There he could meet outstanding surgeons such as Prof. Lichtenberg, Prof. Procházka,

and Academician Petr. He was also employed at the Military Hospital in Brno headed by Miroslav Nešpůrek. Having left the army in 1960, he started to work at the First Department of Surgery led by Professor Josef Podlaha. There he dealt with abdominal surgery and urology, and started to be interested in vascular surgery. His experience was gathered from experimental work and further developed in association with clinical practice.

In 1962 Professor Kořístek defended successfully his candidate's thesis on vascular surgery - the application of venous grafts in vascular surgery. In 1963 he defended his habilitation work from the area of vascular surgery, and in 1964 he started to work at the Second Department of Surgery at the Faculty Hospital of St. Anne in Brno, led by Prof. J. Navrátil.

During the years 1965-1966 he was on a research fellowship concerning vascular surgery and cardiology in Houston. There he met Dr. De Bakey and Dr. Cooley, idols of these medical sciences.

After his return from the study stay, he started to devote himself to cardiology besides vascular surgery. When Prof. Navrátil left for Vienna in 1967, Prof. Kořístek went on developing vascular surgery, particularly in the fields of peripheral blood vessels, abdominal aorta, the pelvic vascular system, and extracranial vessels. Cardiosurgery became more and more interesting for him. Since 1968, besides clinical practice, he has been working hard on the problems of experimental surgery focused on liver transplantation and mechanical heart support in cardiosurgery.

On March 1, 1970, he became Head of the Second Clinic of Surgery and of the Second Surgical Department of UJEP University. At the age of 43 he was appointed Associate Professor. He was working steadfast on the conception of his clinic and its development. In 1972 he put through an extension of the Second Clinic of Surgery – the future centre of cardiology. In the course of time it was transformed into the Centre of Cardiovascular and Transplant Surgery. Prof. Jan Černý, a disciple of Prof. Kořístek, became its head.

In 1975, after intensive experimental work, Prof. Kořístek published his monograph entitled “Experimental Liver Transplantation”, which was the basis for his doctoral dissertation. In 1977 he was appointed Professor.

Prof. Kořístek has been inscribed unforgettably into the history of Czech surgery by the first successful liver transplantation carried out in the former Czechoslovakia. That was realised by his team at the Second Clinic of Surgery in Brno on 2 February 1983. At present, the patient with the transplanted liver is in good shape and feels well 24 years after the intervention.

Prof. Kořístek has been awarded a lot of professional and social prizes. In 1991 he left the Second Clinic of Surgery and worked at various surgical departments in the hospitals of Hustopeče, Boskovice, and Polička. Now he carries on his outpatient surgical practice. He belongs to the pioneers of vascular, cardiac, and transplantation surgery. Besides the liver transplantation he played an important role in the development of valvular surgery, the therapy for ischaemic heart disease, and myocardial revascularisation. In the Czech Republic he was the first doctor to introduce supporting heart mechanisms into clinical practice. As a teacher, he educated a great number of specialists; young physicians were always given possibilities of attending specialised meetings and congresses, and of meeting outstanding personalities of the Czech surgery school. He evaluated his fellow-workers according to their abilities and their work done. Therefore, our thanks justly belong to him for his lifelong work and generous attitudes toward his staff.

His current and lasting vitality presented by his work really deserves admiration.

We feel happy to wish him good health and well-being.

*Z. Gregor*

## ABSTRACTS

### **A FESTIVE SOIRÉE OF THE ASSOCIATION OF DOCTORS HELD BY THE TEAM OF THE SECOND DEPARTMENT OF SURGERY OF THE FACULTY OF MEDICINE OF MASARYK UNIVERSITY AND ST. ANNE'S FACULTY HOSPITAL IN BRNO ON THE OCCASION OF THE EIGHTIETH BIRTHDAY OF Professor MUDr. Vladimír Kořístek, DrSc.**

*R. Staffa, Z. Kříž, Z. Gregor, J. Leypold, Z. Konečný, R. Vlachovský* (Second Department of Surgery, Masaryk University Brno): **Pedal Bypass Grafting in the Treatment of Chronic Critical Limb Ischaemia**

**Aim.** Pedal runoff vessels are not always visible on preoperative arteriograms. In this study the long-term patency of pedal grafts was evaluated in relation to whether, preoperatively, the pedal arteries were visualised by angiography or not and were only detected by duplex ultrasound.

**Methods.** In 2000-2005, 81 pedal bypass grafts were performed in patients with chronic critical lower-limb ischaemia, of which 54 (66.7 %) had diabetes. Tissue loss was recorded in 68 (84.0 %) limbs and rest pain in 13 (16.0 %) limbs. In 24 limbs (29.6 %) bypass grafts were implanted on the pedal arteries that had not been visualised by preoperative angiography, but had only been detected by duplex ultrasound. The patients were followed up according to a standard graft surveillance program including clinical and colour Doppler-ultrasound examination at 1 and 2 months postoperatively, and then once every 6 months.

**Results.** During the follow-up (median 17 months; range, 3-69 months), 18 grafts (22.2 %) failed. Seven limbs had to be treated by early thrombectomy, which resulted in long-term graft patency and limb salvage. The early postoperative mortality rate was 2.5 %. Cumulative primary and secondary graft patency rates and limb salvage rates were 70.2 %, 80.2 %, and 82.4 %, respectively. No significant difference in the risk of graft occlusion was found between the patients with visible and those with invisible pedal arteries on preoperative arteriograms (Fisher's exact test).

**Conclusion.** Pedal bypass grafting is a safe method with good long-term outcomes. Duplex ultrasonography is a reliable modality for detection of pedal arteries invisible on arteriograms, and it helps reduce the number of patients with non-operable arterial occlusion disease by about 25 %.

*J. Podlaha, Z. Gregor.* (Second Department of Surgery, St. Anne's University Hospital Brno, Faculty of Medicine, Masaryk University Brno): **Abdominal Aortic Aneurysms.**

Aneurysms in the aortic area occur in dependence on arteriosclerosis and are for the most part under the level of renal arteries. This is often found during routine investigations of the digestive tract. Some aneurysms grow very slowly for years. Effective postoperative solution shows relatively low mortality, 2-5 %, unlike ruptured aneurysms whose mortality is between 50 to 70 %. Also, small aneurysms may rupture and become the cause of embolisation into the periphery and, in some cases, they may cause creation of aortocaval fistulae. The algorithm of our procedure, if there exists a suspicion of AAA rupture, is as follows: if the patient has a stable blood pressure over 90 mm Hg, the diagnosis may be confirmed by computer tomography. Echo examination is unique for making an aneurysm diagnosis; however, CT is better from the viewpoint of diagnostics of aneurysm rupture

height. As the rupture is not palpable, CT is a big contribution but it should not block the patient on his/her prompt way to the operating theatre because this acute patient belongs there. The patient's survival during these difficult surgical operations affecting immunity, homeostasis, coagulation, and haemodynamics depends on a properly made and vigorous operation, as well as on preoperative, operative, and particularly postoperative intensive therapy. Immediately after admission of the patient it is necessary to start the team co-operation without any delay for invasive intervention.

The presentation evaluates the surgical solution of aneurysms in the aortoiliac area performed from 1989 through 2006 at the Second Department of Surgery at the Faculty Hospital in Brno. The elective solution is preferred. The ruptured abdominal aortic aneurysm (AAA) continues to represent a common and highly lethal problem. We reviewed the records of 199 patients (160 men and 39 women) operated on for ruptured infrarenal AAA within the past 18 years (January 1989 through December 2006) at the Second Department of Surgery in Brno, Czech Republic. The mean age was 71 years (range 57 to 92 years). Only 20 patients were known to have an AAA before the rupture. Preoperative systolic blood pressure below 90 mmHg was present in 142 patients (71.36 %) and 31 patients (15.58 %) experienced cardiac arrest before surgery. The in-hospital mortality rate was 42.21 % (84 patients). Among the total of 199 patients, retroperitoneum was discovered only in 75 patients (37.69 %) with a mortality rate of 29.33 % (22 patients). In 124 patients (62.31 %) haemoperitoneum was also present, the mortality rate being 50.00 % (62 patients) in these patients. Multiorganic failure due to an irreversible haemorrhagic shock was the main cause of death in 56 patients (52.83 %). Further causes were: heart failure - 21 patients (19.81 %), pulmonary complications - 12 patients (11.32 %), renal failure - 11 patients (10.38 %), bleeding - 5 patients (4.72 %), and sepsis - 1 patient (0.94 %). The patient's prognosis depends on early diagnostics and on the duality of preoperative and postoperative care.

*M. Dvořák, R. Vlachovský, Z. Kříž, T. Novotný* (Second Department of Surgery, St. Anne's University Hospital Brno, Faculty of Medicine, Masaryk University Brno; Centre for Vascular Diseases Treatment, St. Anne's Faculty Hospital, Brno; Centre of Robotic Surgery, St. Anne's Faculty Hospital, Brno): **Robotic Mini-invasive Interventions in Vascular Surgery.**

The Centre of Robotic Surgery - one of three centres in the Czech Republic - was founded in the Faculty Hospital of St. Anne in Brno in 2006. Nowadays, robotic surgery has been more and more frequently an alternative for traditional vascular surgical interventions in the aorto-iliac-femoral region.

Indications for a robot-assisted vascular reconstruction are identical with those for an open surgery in an atherosclerotic obliterating disease in the aortoiliac region. Another indication is an abdominal aorta aneurysm without signs of rupture.

Contraindications are given only by internal limitations (for the instillation of capnoperitoneum), by a "surgically unfavourable abdomen" /previous abdominal surgical interventions (relative), conspicuous atherosclerotic affection of the subrenal aorta segment (porcelain aorta), inflammatory aneurysm, suprarenal cross clamping, ruptured aneurysm of the abdominal aorta/.

For the laparoscopic aorta preparation, a transperitoneal direct approach to the aorta is applied. A barrier for the small intestine loops is formed by the patient's position and by means of the retroperitoneum fixed to the abdominal wall. The next step is the installation of a da Vinci robotic system (Intuitive Surgical Inc., Sunnyvale, CA, USA). After performing longitudinal aortotomy, the central anastomosis is sewn up with a robotic system, and then the retroperitoneum is closed in a robotic way. Peripheral anastomoses are sewn using a classical technique.

Totally 14 patients underwent the surgery within May 2006 - February 2007. All of them were males, mean age 61.8 years. The following interventions were applied: iliac-femoral bypass in 1 case, aorto-femoral unilateral bypass in 5 cases, aorto-bifemoral bypass in 5 subjects, the abdominal aorta aneurysm in 3 cases. Other parameters studied are presented in *Table 1*.

Table 1

clamping time (min)	<b>61</b>	(50-120)
anastomosis length (min)	<b>29</b>	(25-50)
operation length (min)	<b>294</b>	(275-370)
IUC (days)	<b>2.2</b>	(2-4)
hospitalisation (days)	<b>8.2</b>	(6-16)
blood loss (ml)	<b>380</b>	(150-1400)
patency (%)	<b>100</b>	
mortality (%)	<b>0</b>	

The application of a robotic system increases the accuracy of sewing a vascular anastomosis - it eliminates shivering of the hands and enables nearly perfect movements of the instruments in all directions; moreover, all this in a perfect 3D picture. A lesser extent of preparation within the aortoiliac vascular system also decreases the risks of prosthesis infection. The interventions are accompanied by a lower blood loss, lesser postoperative pain, shorter stay in an ICU, shortened period of hospitalisation. The decreased risks of postoperative adhesions, shorter onset of intestinal peristalsis, reduced incidence of incisional hernias, and generally lesser peri- and postoperative morbidity are also of great importance. The patients are given higher comfort and return earlier to normal life. A disadvantage is the lack of sensitivity when tightening or knotting a stitch, the price is a relative disadvantage.

In vascular surgery the robotic system can also be used, besides the vascular anastomosis itself, even in arteriotomy and its enlargement in both directions, thrombendarterectomy of the aortoiliac vascular system, in possible fixation of the intimal arterial layer, in stitching on a patch from a prosthetic material, and in possible pericentesis of lumbar arteries during operations on abdominal aorta aneurysms.

The suitability of robot-assisted laparoscopic vascular interventions has already been unequivocally and sufficiently confirmed.

The Centre of Robotic Surgery and the Centre for Vascular Diseases Treatment of the Faculty Hospital of St. Anne in Brno have been classified as world centres performing robot-assisted vascular reconstructions.

*Z. Konečný, Z. Kríž, M. Dvořák, R. Vlachovský, T. Novotný, J. Buček* (Second Department of Surgery, St. Anne's University Hospital Brno, Faculty of Medicine, Masaryk University Brno): **Ten Years' Experience with Establishing A-V Shunts.**

The role of a surgeon co-operating with a haemodialysing centre is to provide access to the vascular system of a patient with renal failure for his/her permanent, repeated, safe, and painless connection to the artificial kidney. It means the establishment of an A-V shunt that provides both sufficient supply of blood for the extracorporeal circulation through an artificial kidney and its adequate return from the apparatus into the patient's circulatory system. If possible, a subcutaneous A-V shunt ought to be direct, established by a simple method, and in the most peripheral site.

The history of establishing access in patients involved in the haemodialysing programme started at our department in 1971. Within the years 1996 - 2006, totally 1453 accesses for haemodialysis were established. Out of them, Brescia-Cimino's variation was applied in 62 %, various types of A-V shunt in the cubital fossa in 20 %, other vascular possibilities in 9.5 %, Diastat implantation in 0.5 %, an access for peritoneal dialysis in 8 %. Most frequently the surgeries were carried out under local anaesthesia - 83.0 %, block anaesthesia was applied in 16 %, and general anaesthesia in 1.0 %.

Complications due to access for haemodialysis comprise thromboses, stenoses, aneurysmatic degradation of an output vein, hyperfunction (steal phenomena) of A-V shunts, and infections of implanted Diastats.

The establishment of an A-V shunt is indicated by a nephrologist, which is one of the principles for establishing accesses for haemodialysis observed at our department. An angiosurgeon decides on

the A-V shunt variation. If possible, interventions are performed under local anaesthesia. The aim is to utilise maximally the patient's autologous material. Diastat is implanted after exhausting all the possibilities of establishing A-V shunts from the use of the superficial venous system. When dealing with complications, early interdisciplinary co-operation of a nephrologist, an intervention radiologist, and an angiosurgeon is important. The patient's collaboration is necessary for peritoneal dialysis, the abdominal cavity must be free of larger adhesions or inflammation for inserting a catheter. Detailed instruction of the patient about the principles of maintaining an A-V shunt is of great importance.

In conclusion, the length of functioning of the access for haemodialysis depends on correct indication for its establishment, precise performance, careful use and, last but not least, increased care of the access by the patient himself.

*P. Piskač, L. Hnízdil, M. Dvořák, P. Vyplé* (Second Department of Surgery, St. Anne's University Hospital Brno, Faculty of Medicine, Masaryk University Brno): **Twenty Years of Flexible Endoscopy at Second department of surgery, St. Anne's University Hospital Brno, Masaryk University Brno, Czech Republic.**

The activities of the endoscopy section at the Second Department of Surgery started in 1988. They were focused particularly on urgent interventions; however, due to necessary erudition, even elective performances had to be carried out. Permanent 24-hour emergency service for urgent endoscopic haemostases is provided in the whole hospital. Injection therapy, bipolar electrocoagulation, and haemoclips are used for haemostasis. About 1000 - 1200 GFSs per year are performed in our centre; out of them more than 10 % are acute and done out of office hours. These investigations must be done within one hour after request at the latest, if there are no other contraindications. Our centre reaches 88 % of successful endoscopic haemostases at about 10 % of haemorrhage relapses. These results are fully in accordance with those obtained by foreign centres.

Simultaneously with GFS, we have also carried out ERCP. First it was only diagnostic, later connected with an endoscopic extraction of gallstones. Although the number of these interventions decreased due to the leaving of some licensed physicians, the total annual amount of these predominantly therapeutical interventions is about 70. The spectrum of treatment was also extended by the biliary tract drainage. Our workplace is a co-founder and an active participant in weekend duties for urgent ERCP covering the whole region of Southern Moravia.

For a certain period our department also helped with colonoscopies but nowadays these are performed only exceptionally.

Since 2002, angioscopies have been carried out as well.

Our results have been continuously presented at both Czech and foreign congresses (Rome, Nice) and published both in Czech and foreign journals (totally 28 publications).

Our workplace was given the accreditation from the ČLK (Czech Medical Chamber) for the education and granted licences for gastrofibrosopies.

*E. Jandoušová, P. Gladiš, L. Hnízdil, Z. Kříž, J. Buček* (Second Department of Surgery, St. Anne's University Hospital Brno, Faculty of Medicine, Masaryk University Brno): **Thyroid Gland Surgery Carried out at the Second Department of Surgery 20 Years Ago and Today.**

In recent years, surgery of the thyroid gland has become one of the main programmes at the 2nd Department of Surgery.

Since 1995 we have had larger sets of patients. By that time, goitres were operated on only occasionally and according to the so-called "old school" at our department. During the surgery, the patient was in a half-sitting position with his head bent backwards. Only subtotal interventions were carried out without visualising the n. laryngeus recurrens.

As usual, the beginning was the most difficult: not managing the operation technique of radical interventions but especially convincing the endocrinologists, who are used to refer their patients to various surgical departments, of the best results achieved by our department.

In the following years, the number of operations on the thyroid gland continued to increase rapidly. We became members of the University Oncological Centre and co-ordinators for problems of the thyroid gland. Our department is a teaching centre for operations on the thyroid gland. In recent years about 230 interventions per year have been performed. In about 85 % these are total thyroidectomies, 15 % unilateral lobectomies. Malignant tumours appear in about 8 % of patients.

The interventions are carried out or assisted by a stable team of physicians. We perform operations on tumours, thyroiditis, intrathoracic goitres, and those of extraordinarily large size. Most intrathoracic goitres are treated from the cervical incision, sternotomy is carried out only exceptionally. A precise preparation technique in a bloodless operating field, i.e. consistent haemostasis, is the basic precondition for the operation success. The n. laryngeus recurrens is not prepared routinely, but, in most cases, it is visualised in the course of the intervention within the operating field. Visualisation and fine preparation of parathyroids without damaging their vascular pedicle are stressed. The intervention radicality is needed to reach really total proclaimed thyroidectomy.

The operating technique as well as instruments have changed in the course of time. We have passed from the classical preparation by fine dissectors with careful ligation of blood-vessels to the application of a harmonic scalpel both in classical and video-assisted interventions. If needed, the 2nd assistance is substituted with a mechanical wound retractor. Recently, suitable cases have undergone mini-invasive video-assisted thyroidectomy. The struma is removed from a short, about 2 cm long incision using an endoscopic technique but without gas insufflation. The so-called MIVAT technique can be applied only in benign strumae with a volume of 20 ml and the maximal size of a nodule of 30 mm without signs of thyroiditis, without previous surgical intervention or neck irradiation. This technique has been used in 5 patients so far. A neuromonitor for the safe identification of the n. laryngeus recurrens must be obtained. If the nerve has an atypical course, not even telescopic lenses can differentiate clearly the nerve from the vascular structure.

The n. recurrens function is checked up regularly by postoperative routine ENT examinations on the 1st postoperative day, and the serum calcium level is observed as well. In our department, permanent pareses of the n. laryngeus recurrens occur in 3–4 %, permanent hypocalcaemia with necessary substitution appears in about 10 %. This number is relatively high but comparable with that reported by other first-class centres. The number of complications given by various workplaces often differs quite considerably. Early complications, postoperative haemorrhage or recurrences have almost not been observed.

Our department co-operates closely with endocrinological centres. Surgeries have been performed in patients examined and prepared carefully from the point of view of endocrinology with a given range of interventions. The outcome of the operations is markedly influenced by the first-quality preoperative preparation. The team also involves anaesthesiologists and otorhinolaryngologists. Very good co-operation of all participants must be highly appreciated.

*J. Buček, T. Novotný, L. Hnízdil* (Second Department of Surgery, St. Anne's University Hospital Brno, Faculty of Medicine, Masaryk University Brno): **The Possibilities of Mesh Hernia Repair.**

The formation of postoperative hernias has been a worldwide problem, mainly in classical open surgery. Incisional hernias usually appear in 11–19 % of all the patients exposed to laparotomy. As many as 60 % of them are symptomatic, but 6–15 % show incarceration that in 2 % requires intestinal resection due to strangulation. A large number of patients feel permanent abdominal discomfort, and sometimes they become disabled because of the hernia extent.

The open suture repair with simple suturing of fascial edges is dubious due to recurrence seen in 31–60 % of cases. Kingsnorth and Schumpelick have given the necessity to use a mesh in all defects above 4 cm in diameter.

The repairs are divided into onlay, inlay, sublay, and IPOM according to the mesh position in the abdominal wall layers.

In onlay repair, the mesh is placed in front of the fasciae in the hypoderm. This repair is technically the simplest method, its advantage being usability in any location with the minimal overlap (the overlap of the mesh or its contact with the firm tissues of the abdominal wall) of 3–4 cm. Its disadvantage is

the necessary extensive preparation of the hypoderm with frequent formation of seromas and the risk of infectious complications.

Inlay repair has been the least recommended repair worldwide. Due to small contacts between the mesh and firm tissues, the number of recurrences nearly agrees with the simple suturing of the fascial edges.

The lowest number of recurrences is given for the sublay technique; it is usually around 10 %. The mesh is positioned in the middle line within the retromuscular space (the technique according to Rives) or preperitoneally in the lateral location (Stoppa). These repairs belong to the most difficult ones, both in view of technique and time. An overlap for a sufficient repair of minimally 5 cm in all directions is recommended in sublay techniques.

The intraperitoneal positioning of the mesh (IPOM position) has nowadays been a domain of laparoscopic surgery. The mesh is in direct contact with the abdominal organs, therefore tissue-separating meshes must be applied (high price). The mesh is fixed with transperitoneal stitches knotted in the hypoderm or, in smaller defects, only by Protacks.

The indication scheme at the Second Department of Surgery is as follows: incisional hernias of 2 cm in size are repaired by a suture, defects between 2–5 cm by the technique using PHS or UHS mesh (sublay technique) – suitable particularly in the port-side hernias and recurring umbilical hernias. The defects above 5 cm are repaired in the middle line using the repair according to Rives, defects located laterally mainly after transversal incisions are indicated for onlay. IPOM is indicated in patients with BMI > 30 or in those with parastomal hernias.

Within the period of 2/2004 to 2/2007 (i.e. 3 years), in our Hernia Centre at the Second Department of Surgery, St. Anne's Faculty Hospital, there were 82 operations of incisional hernias using the technique according to Rives (retromuscular position of the mesh) with 2 successive recurrences (2.44 %) – always under the mesh. The reason was probably an incomplete repair of the original scar. Furthermore, 14 repairs were performed with the onlay technique (so far without recurrence) and 53 repairs using the IPOM method (out of them 2 open operations, the others were laparoscopies). In the IPOM technique 2 recurrences (3.77 %) were seen during the postoperative follow-up. The optimistic results in our, so far not large, set of patients operated on due to incisional hernias are also caused partially by the short period of postoperative follow-up (a median of 16 months).

*Compiled and revised Z. Gregor*