Acta Neurochir (Wien) (1988) 91: 153–165

Acta Neurochirurgica

Proceedings of the 39th Annual Meeting of the Nordisk Neurokirurgisk Forening (Scandinavian Neurosurgical Society), June 10–13, 1987, Oslo, Norway

Compiled by

J. Haase*

1. Stålhammar, D.[1], Starmark J.-E.[1, 2] ([1] Department of Neurosurgery, Sahlgren's Hospital and [2] Department of Psychiatry III, Lillhagens Hospital, Göteborg, Sweden): *Assessment of Responsiveness in Acute Cerebral Disorders. A Critical Review of Current Practice.*

In 1978 Langfitt pleaded for consistent use of the Glasgow Coma Scale for a five year period and as well for thoroughly testing of that scale. In order to find out the result of this plea we have performed a systemic review of four major neurosurgical journals, during 1983–1985, regarding methods for assessment of overall responsiveness in acute cerebral disorders. 52 of 74 studies some version of the Glasgow Coma Scale sum score was used. In 29/52 papers the GCS sum score was collapsed to "sum score scale" in three to five steps. 31 different aggregations were found and information on methodological issues is very scarce.

We concluded that current "coma-scaling" still is very inconsistent and since we consider the main reason being the constructional weaknesses with multi-scale methods and the lack of directions for their application we will present proposals on these matters.

2. Nordström, C.-H., Stålhammar, D., Starmark, J.-E., Holmgren, E., Eriksson, N., Fedders, O., Rosander, B. (Departments of Neurosurgery, Universities of Lund, Gothenburgh, Uppsala, and Copenhagen; Department of Psychiatry, University of Gothenburgh; The Swedish Foundation for Occupational Health and Safety for State Employees; and The Centre for Applied Mathematics, Chalmers University of Technology, Gothenburgh): *Assessment of Neurological Responsiveness in Acute Cerebral Disorders. A Multicentre Study of the Reaction Level Scale (RLS 85).*

The Reaction Level Scale (RLS 85) developed by two of the authors (D. S. and J.-E. S.) was tested in four scandinavian neurosurgical departments regarding inter-observer agreement and coverage. In a balanced study 49 observers peformed 164 paired tests in 88 patients. The data were analyzed by means of Kappa statistics. A Kappa value of $\geqslant 0.6$ is generally considered to reflect a good correspondence. The present study showed an overall Kappa value of 0.69 ± 0.04. There were no significant differences between the participating clinics. The assistant nurses performed more consistent assessments ($K = 0.77$) than the doctors ($K = 0.60$) and the registered nurses ($k = 0.70$). The Kappa values for trauma ($K = 0.76$) and vascular diseases ($k = 0.71$) were better than those for tumour cases ($K = 0.50$). The Kappa values for the separate levels in RLS 85 were all above 0.65 except for withdrawing ($K = 0.51$) and flexor response ($K = 0.55$). There was an excellent observer agreement in delineation of coma ($K = 0.71$).

In conclusion the RLS 85 proved to be easily learnt, it showed full coverage without pseudoscoring, and it was consistently utilized by all kinds of personnel in four different neurosurgical departments in two countries.

3. Starmark, J.-E.[1, 2], Stålhammar, D.[1] ([1] Department of Neurosurgery, Sahlgren's Hospital and [2] Department of Psychiatry III, Lillhagens Hospital, Göteborg, Sweden): *Assessment of Responsiveness in Acute Cerebral Disorders. A Comparison Between the Glasgow Coma Scale and the Reaction Level Scale (RLS 85).*

Reaction Level Scale (RLS-85) is based on the same information as the Glasgow Coma Scale (GCS), but the separate responses are directly weighted together to a scale in 8 steps. In a study, balanced over order of scales, order of raters, professional categories and reaction levels, 72 pairwise observations on 48 neurosurgical patients were made by 12 observers.

By the sign test the RLS-85 had a significantly better reliability than the GCS sum score and the EMV profile. A significant effect of order was noted in GCS Eye Scale and sum score. The Kappa values for GCS sum score was 0.43 ± 0.06 and for RLS-85 0.60 ± 0.06. GCS segments 6–10 and 9–12 had no reliability better than chance. The coverage in RLS-85 was 100%, but 43/72 observations in GCS needed pseudoscoring.

Thus, the study shows that the information in the GCS eye, motor and verbal scales can be combined directly with the RLS-85. This scale has better interobserver agreement and better coverage than the GCS sum score because pseudoscoring or exclusions due to untestable features are avoided.

4. Sundbärg, G. (Department of Neurosurgery, University Hospital, Lund, Sweden): *Which is the Best Way to Organize Intensive Care in Neurosurgery?*

The neurosurgical department in Lund has 63 beds (42 beds during 15 weeks per year) divided into three identical wards and serving around 1.5 mill inhabitants. The number of annual admissions exceeds 1,800, whereof 56% are as emergency cases. The mean rate of occupation of the beds is 88%. Average bed days per patient are 9.6. Each ward executes its own intensive care on an average of 6 patients (range 0–12) each day.

Different proposals to concentrate the intensive care within the department to one (or two) sectors instead of the present three have recently been actively discussed. In order to further elucidate this problem all registered and all state enrolled nurses were confronted with a confidential questionnaire. 83 day working (D) and 34 night working (N) persons replied, making an answer incidence of about 95%. Only 18% of all thought that the present system was definitely superior to all other possibilities. 59% of D and 50% of N decidedly looked forward to a future concentration of the intensive care, another 25 and 15%, respectively, were vaguely positive. Only 13% of D and 0% of N wanted to work within a calmer sector of the department, while another 25 and 9%, respectively, thought that it was, perhaps, interesting. 49+27% of D and 25+16% of N were definitely or vaguely positive to a system of periodic rotation between intensive and calm sectors. 32% of D and 18% of N meant that the work, as a rule, was mentally distressing. The corresponding figures for the physical part of the work were 37 and 26%, respectively.

In conclusion the study showed that a change of system might be hazardous, although many of our co-workers were dissatisfied with the present conditions.

5. Smith-Erichsen, N. (Department of Anaesthesiology, Akershus Central Hospital, Nordbyhagen, Norway): *Head Trauma in the Intensive Care Unit—an Analysis of Costs and Results.*

During a 7 year period 156 head trauma patients were admitted to the general intensive care unit (ICU) of Akershus Central Hospital. 63% were associated with multiple trauma. 62% of the patients were below the age of 30 years, and 78% were men. 35 patients (22%) died during intensive care, 34 while on mechanical ventilation; the mortality thus being 45% among the respirator treated patients. Mechanical ventilation was applied in 54% of the multiple trauma patients, and in 40% of the patients with only head traumas. The duration of mechanical ventilation as well as the mortality were, however, similar in the two groups of respiratory patients. The survivors of multiple trauma stayed for a longer period of time in the ICU than survivors of only head trauma.

The head trauma patients' demand on ICU-resources were modest, being less than 10% of the total costs of intensive care. 80% of these expenditures were, however, claimed by the patients in need of mechanical ventilation. The ICU-costs per patient were for the whole head trauma group of patients calculated to NOK 27800 which is at the level of the average ICU patient in our hospital. For the mechanically ventilated patients the ICU-costs amounted to NOK 46300 per patient. The estimated costs per predicted year of remaining life-span were also very favourable, being NOK 1400 for all patients, and NOK 3100 for mechanically ventilated patients. These figures are far below values calculated for other groups of patients commonly treated in the ICU.

The head trauma patients should thus be given high priority for ICU resources. The high frequency of associated multitrauma, furthermore, points in favour of treating these patients in a multidisciplinary ICU.

6. Wester, K.[1], Aas-Aune, G.[2], Syvertsen A.[2] ([1] Department of Neurosurgery, Rikshospitalet, Oslo, Norway, [2] Departments of Surgery and Radiology, Vestfold County Hospital, Tønsberg, Norway): *Severe Head Injuries in a Norwegian County Hospital 1982–1985. Effects of Introducing Computer Tomography.*

Introducing computer tomography in a county hospital resulted in a marked re-distribution of the handling of severe head injuries.

Before having a CAT scanner, the hospital referred a substantial number of these patients to the regional neurosurgical department. After having acquired its own scanner, the county hospital took over most of the diagnostic and therapeutic tasks concerning these patients.

This resulted in a reduced mortality from severe head injuries and, as was to be expected, reduced delays for surgery. Rather unexpectedly, the number of surgically treated patients increased considerably, from 25% to 68%.

These and other findings indicate a need for additional training of the county hospital staff. This is a task for the neurosurgical society.

7. Nordström, C.-H., Messeter, K., Sundbärg, G. (Departments of Neurosurgery and Anaesthesiology, University Hospital, Lund, Sweden): *Aggressive Neurosurgical Intensive Care Improves Outcome in Patients with Severe Head Injuries.*

It is well established that early surgical evacuation of extradural and subdural haematomas significantly improves outcome. The impact of aggressive neurosurgical intensive care (*i.e.* ICP monitoring and pharmacological treatment of increase in ICP) is however still controversial. The present investigation was initiated to study of a more active management of patients with severe traumatic brain lesions would significantly change overall outcome and in what patients improvements were possible to achieve.

Material: During a six year period (1977–82) 425 patients treated in the Department of Neurosurgery in Lund for severe traumatic brain injuries (coma > 6 hrs) were studied regarding epidemiology, management, and outcome. From 1983 a more aggressive management protocoll was introduced. This included education of all personnel in the local hospitals and the introduction of a more uniform treament protocoll in the Southern Region. Simultaneously, in the neurosurgical department ICP recording was started early in most patients and barbiturate coma therapy was used in patients with a dangerous increase in ICP. During 1983/84 162 patients were included in the study.

Results: Overall mortality was 48% in the first part and 35% in the second part of the study. Good recover/moderate disability was achieved in 39% of the patients in the first and 54% of the patients in the second part of the study. Both changes were statistically highly significant. No differences in age or the types of lesions occurred explaining the improvements. Improved outcome was observed in all kinds of lesions. This was partly explained by a better management

in the local hospitals illustrated in a decrease in the number of explorative craniotomies performed later than 3 hours after coma. However, the most pronounced improvement was observed in patients with no-mass lesions. It is concluded that aggressive neurosurgical intensive care significantly improves outcome in patients with severe traumatic brain lesions.

8. Sundbärg, G.[1], Norlund, A.[2], Nordström, C.-H.[1], Messeter, K.[3] (Departments of [1] Neurosurgery, [2] Business Administration, and [3] Anaesthesiology, University Hospital and University of Lund, Sweden): *Severe head injuries caused by traffic accidents. Previous and current outcome and costs.*

As a result of more aggressive neurosurgical intensive care and more uniform treatment of patients will severe traumatic brain injuries the outcome has improved markedly in the Southern Region of Sweden. In the light of this encouraging development all traffic accidents causing severe head injuries and treated in Lund 1977/78 (n = 67) and 1983/84 (n = 87) were analyzed with regard to type of accident, age, outcome and duration of treatment and costs in the neurosurgical department. The overall costs, corrected for inflation and expressed in swedish crowns = SEK, increased between the two periods by about 45% to an average of 103,000 SEK per patient. The average neurosurgical bed days increased from 16 to 21. For those who died this increase was from 7.5 to 9 days and for those who made a good recovery (Glasgow Outcome Score = GOS I-II) from 16 to 20 days).

The frequency of patients with GOS IV-V (vegetative or dead) diminished from 51 to 28% and increased for GOS I-II from 43 to 65%. The improved outcome 1983/84 compared to 1977/78 might in part be explained by a noted change in age distribution and number of single accidents by car. However, since better outcome occurred in all age groups and all types of accidents the improvement was mainly an effect of better treatment. Thus, although the overall costs rose by 45% per treated patient the total cost divided by the number of survivors did not increase but remained around 132,000 SEK.

9. Sundbärg, G., Nordström, C.-H., Messeter, K., Söderström, S. (Departments of Neurosurgery and Anaesthesiology, University Hospital, Lund, Sweden): *Complications Due to Prolonged Intraventricular Pressure Recording.*

The indications for intracranial pressure (ICP) monitoring have expanded during the last decade. During later years 120–180 patients have each year been subjected to prolonged ICP monitoring in the Department of Neurosurgery in Lund. In more than 50% of these patients drainage of CSF was desirable or necessary and a ventricular catheter consequently compulsory. The fear of violating the brain through the insertion of an intraventricular catheter and the potential risks of complications following this procedure have promoted the development of a number of different devices for extradural and subdural monitoring. In Contrast to this fear, a very limited number of investigations have been devoted to the study of the actual complications due to intraventricular pressure (IVP) recording.

We here present a prospective investigation of all complications in a consecutive series of 478 patients subjected to prolonged recording of IVP during 1982–1985. No permanent symptoms or deficits due to the IVP recording were noted and no haemorrhagic complications occurred. Definite infections caused by the IVP recording occurred in 3.4% of all patients surviving their disease or lesion. These infections were almost exclusively observed in patients treated with prolonged drainage of haemorrhagic ventricular fluid. In nine cases (1.9%) a reliable IVP recording was not obtained, invariably in trauma cases with compressed and/or dislocated ventricles.

It is concluded that complications caused by IVP recording can be kept at an acceptably low level and that an alternative technique for ICP monitoring is desirable in a few patients with compressed or displaced ventricles.

10. Carlsson, H., Ersson, U., Hedstrand, U., Mellström, A., Pontén, U. (Departments of Neurosurgery and Anesthesiology, University Hospital, Uppsala, Sweden): *Observations on Intracranial Dynamics at Endotracheal Suction (ES) and Bag Squeezing (BS) in Patients with Severe Brain Trauma.*

During ES coughing reflexes may induce rapid increases in ICP in patients with expanding intracranial lesions. If these reflexes are controlled by sedation ES will easily become inefficient. The BS, described by Clement and Hübsch 1968, gives an efficient airway care even without coughing. A large balloon (3–4 l) is used to inflate the lungs of intubated patients. The airway pressure is slowly increased and kept at a plateau of 80 cm H_2O for 2–3 sec to open up collapsed alveoli. Compression of the chest by the physiotherapist starts just before the balloon release. A very high flow rate in the airways occurs as in coughing. In previous work in our hospital BS was shown to be an efficient method to improve oxygenation of surgical intensive care patients. In the neurosurgical ICU we studied 13 unconscious, artificially ventilated patients with severe traumatic brain injuries. In well sedated and paralyzed patients consecutive efficient BS maneouvres could be performed with very small ICP responses. We studied 23 ES and 12 BS procedures and calculated the cerebral perfusion pressure (CPP) at fixed time intervals. The CPP did not differ between the groups before treatment. After BS no low CPP values were seen. One third of the ES treatments resulted in CPP values which were lower than the lowest BS values, some critically low.

Conclusions: Bag squeezing is an efficient method for airway care in intubated patients. It can be performed in well sedated patients and without dangerous ICP increase. For prophylactic purposes 2–3 times a day. More often for therapeutic reasons. Contraindications are pneumonia, emphysema and circulatory insufficiency.

11. Hevrøy, O., Nygaard, Ø., Kløw, N. E., Trumpy, J. H. (Department of Physiology and Department of Neurosurgery, University of Tromsø, Norway): *Effects of PEEP on Intracranial Pressure and Cerebral Blood Flow.*

Use of PEEP in patients with head injuries and coexisting acute respiratory failure is controversial. It has been shown that PEEP increases intracranial pressure (ICP) due to impeded venous return. This might have serious concequences. We have studied the effect of PEEP on ICP and cerebral blood flow (CBF) measured by H_2-desaturation technique in dogs with normal lungs anaesthetized with sodium pentobarbital. Effects of two different PEEP levels (10 cm

H_2O and 20 cm H_2O) were studied both during normal and elevated ICP, induced by inflating a balloon placed in the epidural space over right hemisphere. At $PEEP_{10}$ ICP increased by 1.6 ± 0.5 mmHg compared to pre-PEEP level and at $PEEP_{20}$ by 3.1 ± 0.8 mmHg during normal ICP. In dogs with elevated ICP, ICP increased by 2.3 ± 1.2 mmHg and 3.7 ± 1.7 mmHg at $PEEP_{10}$ and $PEEP_{20}$ respectively. Cerebral perfusion pressure (CPP) was not significantly reduced by PEEP, however, CBF decreased in both groups when PEEP was applied. No correlation was observed between changes in CO and CBF in either groups. Concequently, reductions in CBF during PEEP ventilation seem to be independant of changes in CPP and CO. We believe that the increased venous pressure due to PEEP increases interstitial fluid pressure in the brain and thereby impedes blood flow.

12. Sundbärg, G., Nordström, C.-H., Messeter, K., Söderström, S. (Departments of Neurosurgery and Anaesthesiology, University Hospital, Lund, Sweden): *A Comparison of Intraparenchymatous and Intraventricular Pressure Recording in Clinical Practice.*

During later years intracranial pressure (ICP) monitoring has been performed with increasing frequency in patients with severe traumatic brain lesions. In these patients the information from the ICP recording is often used as guidance for the treatment with hyperventilation, osmotherapy, or prolonged deep barbiturate coma. The potential adverse effects of such aggressive treatments necessitate and absolutely quantitative and reliable ICP recording.

Simultaneous measurements of intraventricular pressure (IVP) and intraparenchymatous pressure (IPP) were performed in eleven patients with severe traumatic brain lesions (duration 1–12 days). IPP was measured with a Honeywell Microtransducer (9815 155 00201) placed intracerebrally. Before the microtransducer was used in clinical practice its basic data on drift and temperature sensitivity were tested in *in vitro* experiments. The transducer had a maximal drift of $\pm$ 2 mmHg in 14 days. During clinical conditions the difference between the recorded IPP and IVP pressures was less than 4 mmHg within the pressure range 0–80 mmHg. This appears to be better than previous reports on different devices for epidural or subdural monitoring.

It is concluded that IPP monitoring is reliable in clincal practice and that such measurements are valuable in patients with compressed and/or dislocated ventricles.

13. Aaslid, R., Lundar, T., Lindegaard, K.-F., Nornes H. (Department of Neurosurgery, Rikshospitalet, Oslo, Norway): *Monitoring of intracranial pressure by Transcranial Doppler.*

A decrease in cerebral perfusion pressure (CPP) influences both mean flow and the pulsatile waveform of the flow in cerebral arteries. Normally, with a low ICP, the flow waveform is almost identical to that of the arterial blood pressure (ABP). In the extreme situation, with nearly zero CPP, there is practically no mean inflow, but a strong pulsatile signal can remain with "reverberating" characteristics. Many cases in intensive care fall somewhere between these two examples, and the pulsatile flow would have an intermediate type of waveform.

The present study was undertaken to explore if it is possible to obtain a reasonably accurate estimate of CPP or ICP from a pulsatility analysis of the signals. The waveforms of ABP, and the velocity in the middle cerebral artry (V) were recorded and analyzed by the Fourier transform. Only the amplitude of the first harmonic, *i.e.* the oscillation with the heart frequency, was used. The estimated CPP was calculated by the formula:

CPPe = (V0/V1)* ABP1. (V0 and V1 are mean and first harmonic of velocity, ABP1 is first harmonic of ABP). Six patients were studied during ventricular infusion tests. We found a good correlation between estimated and measured values of CPP: R = 0.89 with CPPe = 0.78 CPP + 11 mmHg. Further testing in the ICU also indicated that the method performed with clinincally useful accuracy.

14. Schalén, W., Nordström, C.-H., Sonesson, B., Messeter, K., Sundbärg, G. (Departments of Neurosurgery, Psychiatry, and Anaesthesiology, University Hospital, Lund, Sweden): *Complications and Outcome in Severely Head Injured Patients Treated with Thiopentone.*

During the period 1982–1986 38 patients with severe traumatic brain lesions were treated with prolonged i.v. infusion of thiopentone (4–8 mg/kg/hr). In all patients the treatment was started to reduce a dangerous increase in intracranial pressure.

Complications: 1) Arterial hypotension. In most patients continuous infusion of Dopamine (5 µg/kg/min) was necessary to keep cerebral perfusion pressure above 60 mmHg. 2) Hypo-potassemia. A severe fall in K^+/s was noted in 20 patients. 3) Septicemia occurred in 2 patients. 4) Acute respiratory distress syndrome was observed in 3 cases. 5) Increases in transferases indicating a liver dysfunction was observed in half of the patients. All complications were treated successfully and were completely reversible.

Outcome: 18 patients died as a direct consequence of their head injuries. One patient died in a traffic accident one year after the first trauma. Two patients died three years after the trauma: one in a vegetative state and one in a state of severe disability. At follow up examination 12 patients were in a state of good recovery, 3 were moderately disabled, 1 was severely disabled, and 1 remained in a chronic vegetative state.

Psychometric tests: Presently 12 patients have been subjected to psychometric tests. In 7 cases there were no or only mild signs of cognitive dysfunction. Verbal memory dysfunction was seen in 4 cases in CM I (immediate recall of verbal material) and in 6 cases in CM II (retention of verbal material after 3 hrs). Spatial memory function was definitely decreased in 3 patients and slightly decreased in 2 patients.

In summary, the majority of the surviving patients treated with barbiturate coma recovered to a useful social life. The complications of the treatment were completely reversible.

15. Nordström, C.-H., Messeter, K., Sundbärg, G. Schalén, W., Werner, M. (Departments of Neurosurgery and Anaesthesiology, University Hospital, Lund, Sweden): *Cerebral Blood Flow, Vasoreactivity, and Oxygen Consumption During Barbiturate Therapy in Severe Traumatic Brain Lesions.*

Brain ischaemia is probably the single most important mechanism in the production of secondary dysfunction and damage after severe head injury. In ischaemia the perturbation of cellular energy

state, the degree of intracellular acidosis, and the ensuing derangement of ionic homeostasis govern the extent of neuronal damage. Thus, in patients with severe traumatic brain lesions a logical approach to the intensive care would be to reduce intracranial pressure (ICP), to reduce cerebral metabolic rate ($CMRO_2$), and to increase intracellular pH. During pysiological conditions barbiturate anaesthesia brings about all three effects. The present investigation was designed to study whether these physiological, and potentially beneficial, effects are also obtained in patients with severe traumatic brain lesions.

The investigation includes 19 patients treated with continuous i.v. infusion of thiopentone (4–8 mg/kg/hr). In all patients barbiturate coma was induced to decrease a dangerous increase in ICP. The effect of extreme hyperventilation on ICP and CBF was tested in all patients prior to the barbiturate treatment. In 11 of the patients simultaneous calculations of $CMRO_2$ were performed.

In nine patients a physiological decrease in CBF and increase in cerebrovascular resistance (CVR) was obtained during the hyperventilation test. All these patients exhibited physiological decreases in CBF and $CMRO_2$ and an increase in CVR after induction of barbiturate coma. Seven of these patients ultimately recovered. Ten patients showed impaired vasoreactivity during the hyperventilation test. In these patients the physiological decreases in CBF and $CMRO_2$ and the increase in CVR during barbiturate treatment was not obtained. All except one of these patients died or remained in a chronic vegetative state.

16. Carlsson, Carin[1], Löfgren, J.[1], Svendsen, P.[2], Winsö, I.[3] (Departments of [1] Neurosurgery, [2] Diagnostic Radiology, [3] Anaesthesiology and Intensive care University of Göteborg, Sahlgren's Hospital, Göteborg, Sweden): *Is There an Justification for Barbiturates in the Intensive Care of Severely Head-Injured Patients?*

For the purpose of assessing the results with prophylactic barbiturate treatment in severe head injury, we have performed a follow-up study from 1978–1984 at the Sahlgren's Hospital. Barbiturate treatment was tried in deeply unconscious patients who presented extension movements on pain stimulation, despite conventional means of treatment. Pentobarbital was given in a continous infusion with individual dosage, to reach a level of anaesthesia with no reactions of the extremities but still some reaction at suction of the endotracheal tube. The basic principle has been the aim to decrease cerebral metabolism without endangering the cerebral perfusion, *i.e.* to avoid arterial hypotension.

In 1978–1984 52 patients received barbiturate therapy. Due to divergent opinions about barbiturates among the colleagues, there were another 46 patients that fulfilled the criteria for barbiturates, but who received only conventional treatment. Patients were excluded if we found events in the course of treatment that might have adversely affected outcome. It was then possible to find 20 pairs of patients from these two groups, with comparable lesions according to their CT scans and similar age within each pair. The 20 pairs were further analyzed concerning *e.g.* the status of the basal cisterns, pupillary reactions, surgical mass lesions, complicating diseases, causes of injury and multiple injuries—the results leading us to consider the groups comparable. A follow-up according to the Glasgow Outcome Scale, at least two years after the accident, has shown a significantly better outcome in the barbiturate group.

17. Lundar, T., Lindegaard, K.-F., Aaslid, R., Nornes, H. (Department of Neurosurgery, Rikshospitalet, Oslo, Norway): *Combined Monitoring of Middle Cerebral Artery Flow Velocity and Cerebral Perfusion Pressure.*

Simultaneous monitoring of the cerebral perfusion pressure (CPP) and middle cerebral artery (MCA) flow velocity was performed in 10 patients for periods from 1 to 10 days. CPP was continuously available by subtraction of intracranial pressure (ventricular or epidural) from arterial blood pressure. MCA flow velocity was recorded by transcranial Doppler technique using a self retaining probe designed for this purpose. Variations in the diameter of the proximal MCA segment precludes comparison of flow velocity between individuals. Excluding patients with vasospasm after subarachnoid haemorrhage, individual changes in MCA flow velocity will, however, reflect changes in the cerebral perfusion. Comparison between changes in MCA flow velocity and CPP indicated that such combined monitoring may give clinically useful information on the cerebral perfusion state the autoregulatory capacity as well as the CO_2 reactivity. The MCA flow velocity record itself appears to be a clinically useful index of cerebral perfusion and to contain valuable data on the individual intracranial pressure/perfusion relationship. MCA flow velocity monitoring may therefore in some patients replace intracranial pressure monitoring in the future.

18. Nordström, C.-H., Cronquist, S., Messeter, K., Schalén, W., Werner, M., Sundbärg, G. (Departments of Neurosurgery, Neuroradiology, and Anaesthesiology, University Hospital, Lund, Sweden): *Cerebral Vasoreactivity Predicts Outcome in Severe Traumatic Brain Lesions.*

In severe traumatic brain lesions outcome is correlated to the patient's age, neurological state, intracranial lesion, and the information obtained from CT-scan examination. This investigation was initiated to study whether measurements of cerebral blood flow (CBF), cerebral vasoreactivity, and cerebral metabolic rate ($CMRO_2$) give more exact prognostic information.

Material and methods: In 22 patients, below the age of 60, intracranial pressure (ICP) and CBF were measured during moderate and pronounced hyperventilation. In accordance with our previous studies in healthy adults a value of $\Delta CBF/\Delta PaCO_2 \geqslant 1$ was considered to be normal. In 19 of the patients $CMRO_2$ was measured simultaneously. All patients were examined by repeated CT-scans. To compare patients with different intracranial lesions, a scoring scale for evaluation of overall pathology from the CT-scan examination was constructed.

Results: No significant differences in age, neurological state or the type of intracranial lesion were seen between the two groups of patients who recovered well and those who died or remained in a chronic vegetative state. As expected, patients with very high scores on the CT-scan examination usually had a bad outcome but the overlap was so pronouced that no significant difference between the two groups of patients was obtained. Ten patients had a $\Delta CBF/\Delta PaCO_2 > 1$. Eight of these patients made a good recovery, 1 patient remained severely disabled, and 1 patient died. Twelve patients had a $\Delta CBF/\Delta PaCO_2 < 1$. Five of these patients died, 4 remained in a chronic vegetative state, 1 remained severely disabled, and 2 patients

recovered well. The two latter patients had a low intracranial pressure (5 and 7 mmHg respectively).

Conclusion: These preliminary observations indicate that measurements of CBF and cerebral vasoreactivity give prognostic information that is not obtained from ordinary clinical or CT-scan examinations. Thus, impaired vasoreactivity to hyperventilation correlates with a bad clinical outcome in patients with increased intracranial pressure.

19. Ganes, T., Lundar, I. (Rikshospitalet, Oslo, Norway): *Neurophysiological Monitoring in Comatose Patients with Severe Brain Damage Using EEG and Evoked Responses.*

EEG and evoked responses were recorded in 76 deeply comatose and unresponsive patients with traumatic or nontraumatic cerebral damage. Spontaneous EEG activity was absent in 37 patients on the initial examination. The cortical somatosensory evoked responses (SER) were invariably absent as were the visual evoked responses (VER). Brain stem evoked responses were abnormal either lacking all waves or with only wave I or II present. Cerebral angiography performed in 33 of the patients within minutes to a few hours of verified intracranial circulatory arrest.

Initial spontaneous EEG activity was present in 32 patients. Twenty of these demonstrated concomitantly bilateral abolished cortical SER. Ten of these 20 patients died a few hours after the initial examination. The other 10 were followed for 2–3 days, and subsequently developed electrocortical silence (ECS). Twelve of the patients with initial spontaneous EEG activity had preserved cortical SER either uni or bilaterally. The only two survivors were found in this group. In the patients followed with multiple recordings over a few days, the first parameter to indicate a grave prognosis was always disappearance of the cortical SER bilaterally, which generally occurred hours and sometimes a day or two before cessation of the spontaneous EEG activity. EEG records from 7 patients did not meet the technical criteria of ECS, all had however abolished cortical SER bilaterally, and none in this group survived. Combined monitoring with EEG and evoked responses is of considerable help in the handling of patients with severe brain damage.

20. Rabow, L., Cook, D., Lipper, M. H., DeSalles, A. A., Gruemer, H. D., Marmarou, A., Becker, D. P. (The Division of Neurological Surgery, Department of Surgery, and the Department of Radiology, Medical College of Virginia, Virginia Commonwealth University, Richmond, Virginia): *Relationship Between CT-attenuation Changes and Posttraumatic CSF-CK_{BB}-activity After Severe Head Injury in Man.*

A comparison has been carried out between the size of the cerebral contusion(s)—as estimated from the number of images on the CT-scan showing typical attenuation changes—and the CSF-CK_{BB}-activity, supposedly reflecting the volume of parenchymal brain injury, in a series of 29 patients with severe head injury.

A clearance curve for the elimination of CK_{BB} from the CSF was constructed in order to estimate the activity at 6 hours after trauma, when this activity is supposed to peak.

While the relationship between contusion volume and prognosis, and between CSF-CK_{BB} and prognosis were statistically significant at the 95% and 99% level respectively, no significant correlation could be shown between CSF-CK_{BB} and contusion size. The explanation for this lack of correlation is discussed.

References: Rabow L, DeSalles A, Becker DP *et al* (1986) CSF brain creatine kinase levels and lactic acidosis in severe head injury. J Neurosurg 65: 625–629

Nordby HK, Urdal P (1982) The diagnostic value of measuring creatine kinase BB activity in cerebrospinal fluid following acute head injury. Acta Neurochir (Wien) 64: 93–101

21. Gjerris, F., Sørensen, P. S., Thomsen, C., Henriksen, O. (University Clinics of Neurosurgery and Neurology, Rigshospitalet, Copenhagen and Department of Magnetic Resonance, Hvidovre Hospital, Copenhagen, Denmark): *Measurement of Water Self Diffusion by Magnetic Resonance Imaging in Patients with Benign Intracranial Hypertension (Pseudotumor Cerebri).*

Seven patients with benign intracranial hypertension (pseudotumor cerebri) had in vivo measurement of water self diffusion in the human brain by magnetic resonance imaging. All the patients fulfilled the definition of BIH as a syndrome of increased intracranial pressure in the absence of space-occupying lesion or hydrocephalus and no signs of intracranial infection or sinus thrombosis. By lumbar measurement of resistance to cerebrospinal fluid outflow all the patients had an increased resistance to cerebrospinal fluid absorption and a subsequent interstitial oedema are thought to be of pathogenetic significance.

By *in vivo* measurement of water self diffusion pronounced changes in brain water self diffusion were observed in all 7 patients with BIH. The diffusion was higher than the normal brain with a pronounced increased periventricular diffusion closed to the self diffusion of water. Thus this increase in periventricular diffusion may be due to the abnormal dynamics of the cerebrospinal fluid in patients with benign intracranial hypertension.

22. Kuurne, T., Helén, P. (Department of Neurosurgery, University Central Hospital of Tampere, Finland): *Lumboperitoneal Shunt-Treatment for Normal Pressure Hydrocephalus Patients?*

During the period of October 1985–December 1986 22 patients (mean age 66 years) were evaluated clinically and neuropsychologically before and after lumbar cerebrospinal fluid (CSF) drainage for 2–6 days.

Fifteen patients, who improved during the draining, were treated with a lumboperitoneal shunt (Cordis; horizontal pressure 85–125 mm H_2O or 50–80 mm H_2O and vertical pressure 265–365 mm H_2O or 290–400 mm H_2O, respectively). The mean follow up time was 8 months (range 3–15 months).

Results:	Improved	6 patients
	No change	6 patients
	Worsened	3 patients

Six of 15 lumboperitoneal shunts needed 1–4 revisions during this period of follow up. Lumbar CSF drainage and lumboperitoneal shunt are alternatives to diagnose and treat especially old normal pressure hydrocephalus patients.

23. Rasmussen, G., Kruse, A., Børgesen, S. I. (Department of Neurosurgery, Glostrup Hospital, Copenhagen, Denmark): *Intracranial Pressure and Resistance to Outflow of CSF in Syringomyelia.*

It has become more accepted that syringomyelia (S) is not due to a single pathogenetic process. The different opinions about the pathogenesis have lead to an abundance of surgical procedures with generally disappointing results. The few reports of S treated with ventricular CSF diversion have never been based on investigations of CSF-dynamics.

This study presents three patients with classical clinical S, verified by MRI. Two patients had impaired CSF absorption. One had normal cranial CT without hydrocephalus. Large ventricles and hindbrain anomalies were found in the other patients. Both were treated successfully with a ventriculoperitoneal shunt. The third patient had normal CSF absorption, no hydrocephalus and was treated with fossa posterior decompression.

We believe that in a subgroup of patients with S, the disease is caused by impaired CSF absorption. This group, who might benefit from CSF diversion, can only be identified by investigation of CSF-dynamics.

24. Langmoen, I. A., Hovind, K. H., Lundar, T., Vatne, K. (Departments of Neurosurgery and Radiology, Rikshospitalet, University of Oslo, Oslo, Norway): *Peripheral Drain Fracture in CSF Shunts.*

Fracture of the distal drain was observed in 18 ventriculo-atrial (VA) and 10 ventriculo-peritoneal (VP) shunts. The age of the VA shunt at the time of fracture was from less than 1 month to 11 years (mean 5 years), and the age of the VP shunt was from 1 month to almost 5 years (mean 2 years). The break was usually situated 2–4 cm above the neck incision in the VA shunts and just above the clavicule in the VP shunts. All these failures occurred in Pudenz catheters. The dislodged atrial catheters were most frequently found in the right cardiac ventricle or in one of the pulmonary arteries. As this may have serious complications, catheters which could be lcoated radiologically were removed by a percutanous transvascular (femoral vein) snare technique. Thirteen such drains were removed without complications. All VP catheters were left untouched in the abdomen, except for one removed through a laparotomy. The shunts left in the abdomen seemd to cause no complications.

25. Wester, K. (Department of Neurosurgery, Haukeland sykehus, Bergen, Norway): *Preliminary Experiences with Syringo-peritoneal Shunting in Syringomyelia.*

Four patients with pronounced syringomyelia were treated by attempting to shunt the syrinx to the peritoneum by means of a peritoneal T-drain a.m. Barbaro *et al.* 1984.

All patients had more than one syrinx, only one being shunted. Postoperative MRI scanning revealed in all patients a marked reduction of all compartments, even those that seemingly were not connected with the shunted cavity.

One patient experienced an immediate and substantial improvement of fine motor activities in the lower extremities, whereas 2 patients noticed a slight numbness on one side of the body distal to the shunted level.

During the short observation time (1–3 months), no improvement of pain symptoms were observed.

26. Zierski, J., Müller, H., Hoffmann, O., Dralle, D. (Department of Neurosurgery, Department of Anesthesiology and Intensive Care and Department of Neuropediatrics, University of Giessen, Giessen, Federal Republic of Germany): *Management of Spasticity with Implanted Pump System.*

In about one third of patients with violent spasticity due to spinal trauma, multiple sclerosis and diffuse brain injury adequate control with oral antispastic medication can not be achieved and successful rehabilitation is severely handicaped.

The authors present the results of management of uncontrolable spasticity be means of continuous intrathecal administration of baclofen with a totally implantable gas driven pump system (Infusaid). 30 patients were treated between June 1985 and January 1987. The indication was incapacitating spasticity caused by spinal cord trauma or disease (11 pat.), multiple sclerosis (11 pat.), infantile cerebral palsy (3 pat.) and cerebral injury, hypoxia or ischaemia (5 pat.). Clinical assessment including spasticity scores, integrated electromyography (IEMG) and motography were used for evaluation of the results. Effective control of spasticity with mean reduction of IEMG by 44%, average decrease of Ashworth's score from 3 to 0 and improvement of life quality was obtained in all patients with daily dose of 10–800 micrograms of Baclofen. Voluntary resting motoricity was not impaired and there were no untoward central side effects.

Intrathecal long term infusion of baclofen is an alternative to surgery in treatment of spasticity.

27. Zygmunt, S., Säveland, H., Brattström, H., Ljunggren, B., Ålund, M., Larsson, E. M. (Departments of Neurosurgery, Orthopaedic Surgery and Neuroradiology, University Hospital, Lund, Sweden): *Operative Realignment of Dislocations in the Cervical Spine in Rheumatoid Arthritis.*

For more than 15 years we have in collaboration between the departments of Neurosurgery and Orthopaedics in Lund and the departments of Radiology in Lund and Malmö investigated and treated patients with chronic rheumatoid arthritis (RA) and dislocations of the cervical spine, mainly atlanta-axial dislocations. Over 200 patients ahve been referred to us for assessment and more than 50% have been operated on. With few exeptions an occipito-cervical fusion has been performed using wire, bone cement and bone chips. With this method it is possible to mobilize the patient directly after surgery without support of external fixation. The indications for surgery have been severe pain in the occipito-cervical region with/or signs of medullary compression.

The longterm follow-up results of the first 100 surgically treated cases have been analysed. The preliminary results are: Few complications and total or considerable pain relief in about 80%; Prevention of further neurological deterioration. In conclusion surgery in *horizontal subluxations* are recommended early in order to prevent the more difficult dislocation, *i.e. vertical dislocation* or *odontoid upward migration.*

Magnetic resonance imaging (MRI) has provided important information about the soft tissues around the odontoid peg and its restriction of the spinal canal prior to and after surgical fixation, *i.e.* occipito-cervical posterior fusion. Different anterior approaches have been attempted for fixation of *subaxial dislocations*, anterior fusion may turn out successful but in many cases these dislocations still remain an unsolved clinical problem.

28. Levander, B., Kofoed, H. (Department of Orthopaedic Surgery, Eksjö-Nässjö Hospital, Eksjö, Sweden, Rigshospitalet, Copenhagen and the Institute for Experimental Research in Surgery, University of Copenhagen, Denmark): *Stabilization of the Cervical Spine by Flexible Carbon Fibre. A Clinical Study.*

In stabilization procedures breakage of wire is a well known post operative complication. In the cervical spine it occurs with a frequency of 7–8% (Brattström and Granholm 1976, Larsson and Toolanen 1981).

Flexible carbon fibre implants have been used as tendon and ligament substitutes in clinical practice since the mid-seventies (Jenkins and McKibbin 1980).

In 1982 we reported a new technique using flexible carbon fibre instead of wire for internal fixation in the cervical spine. It has since then been used in clinical practice and published (Clinical Orthopaedics and Related Research 1984 and Clinical Biomechanics 1986).

Since 1982 24 patients have been treated with this procedure. There have been 22 rheumatoid dislocations of the upper cervical spine and two traumatic dislocations of the lower cervical spine.

The implant was well tolerated by all patients without any infections and the fixation has been stable throughout the observation period.

29. Dahl, P. E., Trumpy, J. H., Lindal, S. (Department of Neurosurgery, Tromsø University Hospital, Tromsø, Norway): *Hypertrophic Mononeuropathy. A Rare Condition Simulating Tumour of Peripheral Nerve.*

A 13-year old boy suffered an increasing paresis of his right peroneal nerve. At the age of 16 a total paralysis of dorsiflexion of the foot was regarded as a contraindication for surgical treatment. He was operated on in the neurosurgical department in Tromsø, however. A thickening of the nerve to a length of 20 cm, just proximal to the capitulum fibulae was observed. The changes did not seem to interfere with an intact tibial nerve. A biopsy was made which showed a rare condition of hypertrophic mononeuropathy.

A further operation for grafting of the nerve was undertaken at a later date. In the main peripheral nerve lesions should be treated surgically.

30. Zwetnow, N. N. (Division of Experimental Neurosurgery, Institute of Surgical Research, Rikshospitalet, Oslo, Norway): *Intracranial Fluid Infusion Tamponade Therapy, (Infit) Leads to Arrest of Induced Lethal Intracranial Bleeding.*

Earlier studies from our group (Løfgren & Zwetnow 1971, 1972, Steiner, Løfgren & Zwetnow 1975a and b, Steiner, Bergvall & Zwetnow 1975) have demonstrated how intracranial bleeding may be arrested due to the interplay of 5 survival factors. These factors include a rising intracranial pressure, which reduces the bleeding pressure. However, intracranial bleeding still kills the animal when the total bleeding volume exceeds the lethal volume, characteristic for each anatomical site.

In the present study we have tried to treat our lethal dog models (Løfgren & Zwetnow 1971) of intraventricular and subarachnoid bleeding with Intracranial Fluid Infusion Tamponade (INFIT); infusing mock C.S.F. into the C.S.F. space. 7 ventilated barbiturized animals, in each bleeding control group, invariably died. Conversely in 8/8 animals, in each treated group, INFIT promptly decreased the bleeding rate and led to the cessation of bleeding. This was followed by a reduction of intracranial pressure, recovery of spontaneous breathing, reestablishment of coordingated motor activity in the extremities and recovery of the EEG to control amplitude.

Experiments are in progress to test the possible use of the INFIT method for clinical purposes.

31. Orlin, J., Zwetnow, N. N. (Division of Experimental Neurosurgery, Institute of Surgical Research, The National Hospital, Oslo, Norway): *Dynamics of Experimental Arterial Subdural Bleeding.*

Lethal arterial subdural bleeding was induced in barbiturized swine, by leading arterial blood from the aorta, through an electronic drop recorder, into the subdural space over the left cerebral hemisphere. Both spontaneously breathing and artificially ventilated animals were studied.

12 vital physiological parameters were recorded, including rate and volume of bleeding, 5 cerebrospinal fluid pressures, systemic arterial and central venous pressure, respiration, EEG and ECG. Local cerebral blood flows and acid-base parameters were measured at intervals, during the course of the bleeding. Each experiment led to a rapid rise in intracranial pressure with ensuing herniation, corresponding to a decrease in local perfusion pressures and a local reduction in the cortial CBF.

The subdural bleeding volume was 30% less in the ventilated group than in the group with spontaneously breathing animals; the values being $32+/-12$ ml and $46+/-12$ ml respectively. On the other hand the duration of the subdural bleeding was 20% longer and the time to cardiovascular collapse 30% greater when a ventilator was in use. 7 ventilated animals, which were treated acutely, with Intracranial Fluid Infusion Tamponade (INFIT), all survived. These animals bled only 7.5 ml while the EEG, respiration and motor activity reappeared a few minutes after the bleeding had stopped. It is concluded that INFIT seems to be effective in stopping subdural bleeding with a naturally lethal course.

32. Ganz, J. C., Ponten, U., Zwetnow, N. N., Thuomas, K.-Å., Bergstrøm, K. (Departments of Diagnostic Radiology, Akademiska Sjukhuset, Uppsala Sweden, and Division of Experimental Neurosurgery, Institute of Surgical Research, Rikshospitalet, Oslo, Norway): *Progressive Cerebral Distortion and Changes in Local Tissue Water and Vital Physiological Parameters, During Continous Epidural Bleeding: An Experimental MRI Study in Dogs.*

Brain displacement, vital physiological parameters and local brain water content were studied in dogs, during induced progressive

extradural haemorrhage and during expansion of extradural rubber balloons. Central venous, systemic arterial and local C.S.F. pressures were monitored continously together with heart rate, respiration rate and rate and volume of bleeding. MRI was performed in two planes at 90 second intervals and evaluated with respect to bran shift, haematoma size, herniation and local C.S.F. pathway obstruction. Moreover, changes in the local tissue water were expressed in terms of normalized signal intensity.

Extradural haemorrhage could continue for hours and exceed the toal intracranial volume several times, due to the formation of an extradural arteriovenous shunt. The rate of haematoma formation was dependent on the area of stripped dura nad led to respiratory arrest within 20 minutes when stripping was maximal. Midline shift, herniation and lateral ventricle compression occurred early but in the same sequence as during balloon expansion.

The experiments confirm the hypothesis that extradural bleeding may obtain a large volume rapidly depending on the interplay of 3 factors, initial dura stripping, the size of the extradural arteriovenous shunt and secondary dura stripping. The correlation between local tissue water increase and local perfusion pressure supports the notion of an ischaemic brain oedema developing during extradural bleeding.

33. Vlajcovic, S., Zwetnow, N. N., Ponten, U., Thuomas, K.-Å., Bergstrøm, K. (Departments of Diagnostic Radiology, Akademiska Sjukhuset, Uppsala, Sweden, and Division of Experimental Neurosurgery, Institute for Surgical Research, Rikshospitalet, Oslo, Norway): *Cerebral Dysfunction in Acute Water Intoxication: An Experimental Study in Dogs.*

Acute Water Intoxication (AWI) was produced in barbiturized dogs by the intravenous infusion of distilled water at a constant rate, while 10 vital physiological parameters were monitored.

AWI led to an immediate and progressive rise in the C.S.F. pressures measured at 5 different sites. Pressure gradients developed early. The EEG became isoelectric at $11.2+/-2.8\%$ H_2O/body weight, while respiration arrest occurred at $11.9+/-1.7\%$ H_2O/body weight.

Concomitant with the rise in C.S.F. pressures the local cerebral perfusion pressures decreased reaching critical values (29 mmHg), supreatentorially at respiratory arrest. Cerebral blood flow, as measured with radioactive microspheres progressively decreased. Ischaemia was most pronounced in the supratentorial compartment, where CBF was only 10% of normal at respiratory arrest.

Magnetic Resonance Imaging during water loading showed a continous increase in C.N.S. tissue water content. The greatest increase in water content was found in the cerebral cortex and the next greatest in the cerebral white matter. The correlation between physiological and morphologial data had a predictive nature.

It is concluded that AWI leads to death by affecting each of three factors controlling CSF steady state pressure—CSF flow, CSF outflow resistance and sagittal sinus pressure. A marked cerebral oedema occurs leading to intracranial hypertension and a critical degree of cerebral ischaemia.

34. Berger, E. (Neurosurgery Institute, Montreal, Canada): *Neurosurgical Implication of AIDS*

Very early observations in the Montreal area indicated that AIDS (Acquired Immuno-Deficiency Syndrome) was not a disease afflicting only homosexuals since, in an early series, we had among the first ten patients, two heterosexual couples (Revue clinique de dix patients atteints du syndrome immunodéficitaire acquis, L. Pelletier, M. Laurin-Joly, C. Auger, E. Berger, et Y. Mayrand, Union Médicale du Canada, vol 116, janvier 1987, p. 8–13). Recent statistics point to the fact that 10% of AIDS patients in North America are heterosexual.

Neurosurgeons may be called in more frequently to perform biopsies if North American trends in the spread of AIDS will affect European countries. Based on presently available statistics about 40% of AIDS patients are neurologically ill and about 10.5% of this group will develop central nervous system space occupying lesions. Slightly more than half of these neurologically afflicted AIDS patients will present mass lesions secondary to toxoplasmosis. In about close to 4%, a space occupying lesion will be found without evidence of AIDS, and about 3% of patients with mass lesions will not react to toxoplasma treatment. This therefore might give a figure of close to 7% of patients where neurosurgeons might be asked to perform a biopsy to arrive at a definitive diagnosis so that patients may receive specific treatment for their opportunistic diseases. Based on population studies and present statistics relating to the spread of this disease, it is possible that by 1991 on the North American continent, neurosurgeons will be asked to perform biopsies in about seven thousand patients. It is furthermore estimated that by 1991, indications for brain biopsies in acquired immuno-deficiency syndromes might exceed the number of biopsies requested or done for malignant astrocytomas.

35. Bosnes, V., Hirschberg, H., Gaudernack, G., Vartdal F. (Institute of Transplantation Immunology and Department of Neurosurgery, Rikshospitalet, Oslo, Norway): *Isolation of Human Glioma-infiltrating T Lymphocytes by Paramagnetic Particles Coated with T Cell Specific Monoclonal Antibodies.*

A rapid method of isolating viable glioma-infiltrating T cells is presented. A cell suspension was obtained from tumour biopsies by mechanical disaggregation. Paramagnetic polystyrene microspheres (M-450, Dynal, Oslo, Norway) coated with antibodies specific for the T cell antigens CD2 or CD3 were added at a bead to cell ratio of 0.2 to 0.5. This mixture was incubated at 4 °C for 20 minutes under gentle shaking. Rosetted T cells were subsequently isolated using a magnet. The number of T cells extracted ranged from 480 to 18,000 per million tumour cells. The T cells were put into culture with autologous feeder cells and 50 U/ml recombinant interleukin-2 (IL-2). Feeder cells and fresh IL-2 supplemented medium were added weekly after 2–3 weeks, the cells had reached sufficient numbers to allow analysis by flow cytometry.

At this time, virtually all the cells were positive for the T cell markers CD2 and CD3. Most of the cells (78–92%) were HLA class II positive, and a varying proportion (6–68%) were positive for the Tac antigen (IL-2 receptor). In conclusion, immunomagnetic separation appears to be useful technique for isolating a small subset of infiltrating cells from the heterogeneous mixture of cells present in a tumour.

36. Helseth, E., Unsgaard, G., Dalen, A., Vik, R. (The Institute of Cancer Research, Department of Neurosurgery, University Hospital of Trondheim, Norway): *T-CAR1, a Human Cell Line Derived from a Brain Metastasis, has an Extremely High Number of Epidermal Growth Factor Receptors.*

It has been well documented that enhanced expression of several oncogenes is linked to the manifestation of the malignant phenotypes. Among them, the epidermal growth factor (EGF) receptor gene, a homologue to the v-erbB oncogene, is overexpressed in several cultured cell lines as well as in primary tumours.

The cell line, T-CAR1, was derived from a brain metastasis of a 33-year old female. The primary tumour was a carcinoma in the left adrenal cortex and autopsy showed multiple metastases, among them three brain metastases. This cell line contained an enormous number of EGF receptors (7 mill per cell). Northern blot analysis showed enhanced level of EGF receptor mRNA and indicated that mRNA for the EGF receptor in T-CAR1 cells was transcribed from a gene family with multiple members localized on several chromosomes.

Addition of EGF to monolayer cultures of T-CAR1 cells caused cell rounding, cell detachment and increased proteolytic acticvity. This abnormal behaviour to EGF has also been seen in other tumour cell lines with overabundance of EGF receptors. It is tempting to believe that enhanced expression of the EGF receptor gene was responsible for the malignant properties of T-CAR1 cells. The increased proteolytic activity in response to EGF may have contributed to the invasiveness of the tumour. Cell rounding and detachment in response to EGF many explain the metastatic potential of the tumour.

37. Ellemann, K.[1], Kruse-Larsen, Chr.[2], Christensen, L.[3] ([1] Department of Neurology, Rigshopitalet Copenhagen, [2] Department of Surgery Neurology, Hvidovre Hospital Copenhagen, [3] Department of Neurosurgery, Glostrup County Hospital, Copenhagen, Denmark): *Glucocorticoid Receptors in Glioblastoma Multiforme. Prognostic Value.*

In 12 operated glioblastomas glucocorticoid receptors (GLU) have been found in every case. In two cases with GLU concentrations, high dose methylprednisolon pulse therapy has given encouraging result. CT-controls have shown tumour-regression during treatment and the survival-time so far has been 18 resp. 10 month with Karnofsky scale of 70 or more. At reoperation GLU-concentration has been decreasing, suggesting that methylprednisolone has a direct cytotoxic effect on GLU-pos. cells in glioblastoma multiforme.

38. Astrup, J., Lindholm, J. (Department of Neurosurgery and Neuroendocrinology, Rigshospitalet, Copenhagen, Denmark): *Transphenoidal Re-Operation for Acromegaly.*

Of 58 patients with GH secreting pituitary adenoma and clinical acromegaly, 13 were considered for transphenoidal re-operation due to unsatisfactory acromegaly control after the first transphenoidal operation. 2 were excluded since CT and MP images indicated extensive parasellar growth around the carotid artery. 11 were re-operated upon. 9 had normal pituitary function, 1 had complete, and 1 had partial pituitary insufficiency. Residual adenoma were found in 10. 5 were clinically and biochemically cured of their acromegaly, 3 were significantly improved, while 3 were unchanged. 1 patient developed a sixth nerve palsy clearing completely after three months, and 2 developed pituitary insufficiency (one partial, and one complete). All of these were cured.

We conclude, that transphenoidal re-operation may compare favourably with radiotherapy in the management of persisting acromegaly or acromegaly recurrence after primary transsphenoidal surgery.

39. Hariz, M. I., Laitinen, L. V., Löfroth, P.-O., Säterborg, N.-E. ([1] Departments of Neurosurgery, Radiation Physics and Oncology, University Hospital, Umeå, Sweden): *A Non-invasive Adapter in the Stereotactic Irradiation of Brain Tumours with Linear Accelerator.*

A non-invasive stereoadapter has been used for localization of brain tumours scheduled for biopsy, open surery or stereotactic irradiation. The stereotactic radiological study (CI, MRI or angiography) permits an accurate and reproducible determination of the target which is defined with X, Y, and Z coordinates in relation to the adapter.

Small brain tumours (metastasis, gliomas) in six patients and an arteriovenous malformation in one patient were irradiated with a 6 MV linear accelerator. The dose distributions were calculated for 5–6 photon beams directed isocentrically against the target. The coordinates of the isocentre were taken from CT-scans or angiograms. The patient with the stereoadapter remounted to the head was immobilized on the accelerator table. The table was then moved into such a position that the brain target coincided with the isocenter of the accelerator, as indicated by laser beams. The treatment was given in two to five sessions with two to four days intervals.

The technique and the preliminary results will be described in detail.

40. Astrup, J., Gjerris, F. (Department of Neurosurgery, Rigshospitalet, Copenhagen, Denmark): *Peroperative Ultrasound Imaging in Neurosurgery.*

For the past two years we have used the Bruel and Kjaer 7 Mhz sector transducer for preoperative ultrasound (US) imaging. Of a total of 156 relevant surgical procedures performed in 1986 (tumour removal, tumour biopsy, abscess, cyst or haematoma evacuation) US was applied in 40 occasions (26%). US is unique in localizing pathology, in particular small deep lesions, but also low grade gliomas are clearly imaged. When used with a fixation frame, US guided needle biopsies and punctures can be safely performed.

41. Salford, L. G., Baldetorp, B., Brun, A., Hallencreutz, G., Stenstam, B. (Department of Neurosurgery, Neuropathology and Oncology, Lund University Hospital, Lund, Sweden): *DNA Content in Human Astrocytomas and Surrounding Brain Tissue.*

Flow cytometric DNA analysis has been developed into a convenient method to evaluate the ploidity of tumours biopsied during operation. We have used a Cytofluorograph 50 H, interfaced with

a data device 2,140 (Ortho Instruments, Westwood, MA), for the examination of 18 astrocytomas grade III-IV (Kernohan) and 4 astrocytomas grade II, resected under the microscope during surgery. In 9 of the operations a portion of the oedematous, but otherwise normal looking, surrounding brain tissue had to be resected. This tissue was sampled separately and the distance from the easily distinguishable tumour frontier, with its "raw fish meat" appearance in the astrocytomas grade III–IV, was measured. All samples were immediately frozen in liquid nitrogen after resection and were later processed in a one-step procedure to get a suspension of stained, (propidium iodide) isolated nuclei for flow cytometri. Neighbouring samples were placed in formalin for histopathological examination.

Results: Ten astrocytomas grade III–IV were resected without surrounding brain tissue. Four had normal diploid nuclear DNA content, while 6 were non-diploid with DNA-index 1.21, 1.29, 1.53, 1.55, 1.97, and 1.98. Eight astrocytomas grade III–IV were resected with surrounding brain tissue. Three tumour frontiers were diploid with surrounding diploid brain tissue. Four tumour frontiers were non-diploid with DNA-index 1.65, 1.67, 1.84, and 1.93. The surrounding brain tissue was shown to have a non-diploid portion, as well, with corresponding DNA-index 1.37, 1.66, 1.36, and 1.81 at a distance of 1 to 2 cm outside the tumour frontier. The tumour frontier from the fifth patient was lost but 3 samples form the surrounding tissue at a distance of 1 to 3 cm outside the frontier had DNA-indices 1.17, 1.79, and 1.17.

Three astrocytomas grade II were resected without surrounding brain tissue. One tumour was diploid and two were non-deploid with DNA-index 1.74 and 1.73, respectively. The fourth astrocytoma grade II was resected with surrounding brain tissue. This as well as the tumour tissue was diploid.

Conclusion: The presented cytofluometrical method revealed that 11/18 (61%) of the examined astrocytomas grade III–IV had a distinct DNA abnormality. It is noteworthy that normal-looking brain surrounding nondiploid tumours contained a distinct portion of cells with pathological DNA content as far as 2 cm outside the tumour frontier. Flow cytometrical DNA analysis may be a more sensitive method than histopathology for evaluation of tumour infiltration in the brain surrounding the tumour. The clinical outcome for the examined patients will tell the prognostic value of this flow cytometrical CNA analysis.

42. Berg-Johnsen, J., Langmoen, I. A. (Departments of Neurosurgery, Ullevål Hospital and * Rikshospitalet, Oslo, Norway): *Isofluorane Anaesthesia—the Cellular Mechanism of Action.*

In order to investigate the mechanism of action of isoflurane on neuronal excitability and on synaptic transmission in the central nervous system, we have examined the action of isoflurane on slices form the cerebral cortex.

The effect of isoflurane was due to the combined effects on unmyelinated afferent fibres, excitatory synapses and postsynaptic neurones. In contrast to the marked depression of the excitatory postsynaptic potential, the response evoked by applying the transmitter directly to the postsynaptic membrane was not unchanged. This effect is thus presumably presynaptic.

Isoflurane reveribly hyperpolarized the cell membrane in a dose dependent manner. The hyperpolarization was reversed at a potential close to the equilibrium potential for K^+ and was blocked by K^+ channel blockers. The rising phase of the action potential was slower and subthreshold inward rectification reduced during isoflurane administration. These results suggest that isoflurane acts on neurones in the central nervous system by increasing a K^+ current and reducing at least one Na^+ current.

43. Sorteberg, W., Langmoen, I., Lindegaard, K.-F. (Department of Neurosurgery, Rikshospitalet, Oslo, Norway): *Reliability and Reproducibility of Transcranial Doppler Blood Velocity Recordings in Normal Persons.*

The following study was conducted in order to assess the reliability and reproducibility of Transcranial Doppler (TCD) investigations on a day to day basis. We investigated 16 healthy persons aged 26–66 years (mean 40 years) with documented normal CBF findings. Independent TCD recordings were obtained on three different occasions (denoted Day 1, 2, and 8, respectively). Identification of the middle and anterior cerebral arteries (MCA and ACA) was easy in these normal persons, but the posterior cerebral artery (PCA) was missed in 18 of the 96 examinations.

Blood velocity was measured in every 5 mm segment of the MCA, ACA, and PCA and in the distal extracranial internal carotid artery (ICA). The following velocities were found: MCA: 72 ± 13 cm/s, ACA: 57 ± 11 cm/s, PCA 43 ± 11 cm/s, ICA: 38 ± 8 cm/s. There were no significant side differences. Comparing blood velocity in identical vessel segments in each individual revealed day-to-day variation of less than $\pm 15\%$, whether correction for end-tidal PCO2 was introduced or not. These results demonstrate that blood velocity in the basal cerebral arteries in healthy individuals do not change on a day to day basis. In patients with cerebrovascular disorders, therefore, even quite small changes in blood velocity are indicative of haemodynamic alterations.

44. Lindegaard, K.-F., Wiberg, J., Lundar, T., Aaslid, R., Nornes, H. (Department of Neurosurgery, Rikshospitalet, Oslo, Norway): *Doppler Assessment of Middle Cerebral Artery Blood Flow.*

Recordings of the middle cerebral artery (MCA) blood velocity were obtained in seven patients in whom blood flow in the ipsilateral internal carotid artery (ICA) was measured electromagnetically after carotid endarterectomy. Two of the patients were investigated during steady-state cardiopulmonary bypass. The patients were selected to permit the assumption that ICA blood flow remained proportional to MCA flow throughout the period of data collection.

The integrated time-averages from consecutive 5-second periods were computed. The relationship between volume flow and blood velocity was near the linear under these defined conditions. Normalization of the data as percentages of the individual means permitted a composite analysis of data from all patients. Regression analysis of relative changes in MCA blood velocity (V') von concomitant relative changes in volume flow (Q') showed $V' = 1.05\,Q' - 5.08$ ($r^2 = 0.898$). Thus, a given relative change in MCA blood velocity seemed to indicate a nearly similar change in MCA blood flow under these defined conditions. Using the regression line as a calibration curve, the 95% confidence interval for estimating the change in volume flow for a given observed change in blood velocity was $\pm 5.3\%$. This accuracy could be considered as being adequate for clinical monitoring purposes.

45. Astrup, J., Andersen, P., Schmidt, J. (Departments of Neurosurgery and Neurology, Rigshospitalet, Copenhagen, Denmark): *Chronic Ischaemic "Penumbra". Internal Carotid Artery Occlusion and Focal Symptoms with Haemodynamic Aggravation in a CT and MR Normal Patient Studied by SPECT.*

A 56-year-old female patient complained of haemodynamic TIA (left eye blindness, paraesthesia, weakness, and incoordination of her right hand, and occasional motor aphasia when rising suddenly or walking stairs) for about one year. Mild dementia was present. For about three months the focal symptoms were permanently present, but with some day to day variation. Angiography indicated a left int. carotid art. occlusion with poor collateral filling. CT and MR images were normal. SPECT (CBF tomography by 133-Xe inhalation) indicated low flow in the left anterior and middle cerebral circulation on the occluded side, "steal" of flow by Diamox-test, and a pressure passive flow. Before scheduled STA-MCA bypass surgery she developed a completed stroke on the occluded side.

In conclusion, this patient had a long lasting ischaemia with "penumbra" indicated by low flow, neuronal dysfunction, but no infarct. This condition is rare. It may be critical as indicated by our case due to progression to stroke. Revascularization surgery should be considered.

46. Luukkonen, M., Hersio, K., Takala, J., Hernesniemi, J., Kari, A., Tapaninaho, A., Vapalahti, M. (Departments of Neurosurgery and Intensive Care, University Central Hospital, Kuopio, Finland): *Pulmonary Wedge Pressure in the Early Surgery and Intensive Treatment of Ruptured Intracranial Aneurysms.*

Pulmonary wedge pressure (PWP) was measured in 21 consecutive subarachnoid haemorrhage (SAH) patients treated early for their intracranial aneurysms. Swan-Ganz catheter was inserted before the operation and left for two postoperative days in the Intensive care unit to measure PWP continuously. The aim of the study was to keep the PWP between 8–12 mm Hg postoperatively with extra infusion of 4% albumin (PPL) or fresh frozen plasma (FFP) if needed to prevent early hypovolaemia. Mean operating day ways two days after the SAH. Mean grade of the patients at the time of operation was II (Hunt and Hess), five patients were grade III or IV.

Mean PWP before the operation was 7.2 (± 3.3) mm Hg and decreased during the operation to 6.2 (± 3.6) mm Hg. To get a mean postoperative PWP of 10 mm Hg we had to increase our earlier routine infusion volume mean 907 cc postoperatively and further 1,043 cc during two days stay in the Intensive care unit.

Three patients had later symptoms of delayed ischaemic neurological deficit (DIND), but the time of follow-up is not long enough to evaluate the permanent DIND. We did not use Ca-antagonists.

We seem to have a relative early hypovolaemia in our SAH-patients. If the 2 litre volume correction means a better outcome it has not yet been shown. There seem to be large individual variations in PWP and a possibility for complications. The measurement could be useful in risk groups, and then for a longer period of time.

47. Hersio, K., Luukkonen, M., Kari., A., Takala, J., Vapalahti, M., Hernesniemi, J., Tapaninaho, A. (Department of Anaesthesia and Intensive Care and Department of Neurosurgery, Kuopio, University Central Hospital, Kuopio, Finland): *Corticoids Impair Nitrogen Utilization After Surgery for Aneurysmal Subarachnoid Haemorrhage.*

We studied the metabolic response to surgery after acute subarachnoid haemorrhage (SAH) and its modification by parenteral nutrition.

25 patients, all receiving corticoids for five days after early aneurysm operation were randomly assigned to receive: glucose alone (7.2 kcal/kg/day, Control, 11 patients), glucose with balanced amino acid solution (0.13 gN/kg/day, CAA, 7 patients) or with high branched chain amino acid solution (0.13 gN/kg/day, BCAA, 7 patients). The infusions were started perioperatively and continued for two days.

Results (mean ± SD)	Nitrogen excretion (g/day)		Nitrogen balance (g/day)	
Group	Day 1	Day 7	Day 1	Day 2
Control	11.2 ± 4.8	12.0 ± 4.7	−11.6 ± 4.7	−9.1 ± 4.7
CAA	*24.1 ± 9.2	15.2 ± 7.4	−13.6 ± 9.4	−12.8 ± 13.9
BCAA	*20.0 ± 6.0	7.9 ± 3.8	−12.8 ± 13.4	−5.5 ± 7.3

* Significantly different from Control, $p < 0.01$, t-test.

Conclusions: Early sugery for aneurysm SAH induces similar moderate catabolic response as colorectal surgery. Perioperative parenteral nutrition either with balanced amino acid solution or with branched chain amino acid enriched solution fails to improve nitrogen balance. The difference in nitrogen excretion between the groups disappears after the cessation of corticoids which suggests that they impair nitrogen utilization.

48. Schmidt, K.[1], Eskesen, V.[2], Rosenørn, J.[1] (University Clinics of Neurosurgery, [1] Copenhagen Municipal Hospital, Hvidovre, Denmark): *The Lifetime Risk of Rebleeding from Ruptured Intracranial Aneurysm in Different Age-Groups.*

From the literature it is documented that the risk of rebleeding from an untreated ruptured aneurysm is approximately 50% within the first 6 months and then approximately 3% per year. The mortality in connection with rebleeding is 70–80%. Using these parameters and expected lifetime for different ages the risk of rebleeding and mortality has been evaluated for men and women in different age-groups.

Examples of results: The probability of survival after rebleeding for a 20-year-old man with an untreated ruptured aneurysm is at 30 year of age 51% (99%) (normal survival rate of age-groups is shown in brackets). At 40 year of age 45% (97%). 50 year 40% (93%). 60 year 36% (84%). 70 year 34% (64%). For a 50-year-old man the result is: At 60 year 51% (90%) and at 70 year 46% (68%). For a 70-year-old man with an untreated ruptured aneurysm the probability of survival after rebleeding at 75 year is 56% (76%) and at 80 year 53% (50%). For women the results after rebleeding only differ a few per cent compared to men, while normal survival rate is substantial higher.

49. Summary not received.

50. Heiskanen, O., Öhman, J. (Neurosurgical Department, Helsinki University Central Hospital, Helsinki, Finland): *Timing of Aneurysm Surgery.*

This is a prospective randomized study on 216 patients of grade I–III according to the classification of Hunt and Hess with a subarachnoid haemorrhage verified by lumbar puncture or CT scan and between 16 and 65 years of age. Patients with large expanding intracerebral haematomas and patients with vertebrobasilar aneurysms were excluded. After the angiographic studies the patient was randomized into one of three groups. Patients in group I were operated on days 1–3 after the bleeding, patients in group II on days 4–7 and patients in group III on days 8–15. Postoperative carotid angiography was performed on all patients. Routine CT scan was performed before the patient left the hospital. All patients were seen at the outpatients department two months and one year after the surgery. The outcome was assessed using the Glasgow Outcome Scale.

51. Rosenørn, J.[1], Eskesen, V.[2], Schmidt, K.[1] (University Clinics of Neurosurgery, [1] Copenhagen County Hospital, Glostrup and [2] Copenhagen Municipal Hospital, Hvidovre, Denmark): *Outcome in Different Age-groups After Intracranial Aneurysm Rupture.*

To elucidate possible differences in the outcome between age-groups after aneurysm rupture, data from the 1,076 patients in the Danish Aneurysm Study have been used. Three clinical grade-groups (Hunt I + II, II and the best of grade IV, IV + V) according to clinical condition on admission are used for comparability between 7 age-groups (2nd to 8th decades). A 4-grade mental outcome scale was used at the 2-year follow-up examination. The over-all results showed no significant difference in normal mental outcome and mortality between 8th decade and 7th, 6th and 5th decades. No significant difference of the same parameters between 7th decade and 6th and 5th decades was seen, and the difference regarding mortality was insignificant between 7th decade and 4th decade too. In operated patients (N = 670) no significant difference in mortality between 7th decade and the 6 other decades was observed in the 3 clinical grade-groups. Only in the 4th and 3rd decades in the Hunt I + II group a significant better normal mental outcome was seen compared to the 7th decade. In all comparable age- and clinical grade-groups a highly significant better outcome was registered in patients who underwent surgery compared to patients who were not treated surgically.

52. Öhman, J., Heiskanen, O. (Department of Neurosurgery, Helsinki University Central Hospital, Helsinki, Finland): *The Effect of Nimodipine on Cerebrovascular Spasm After Aneurysmal Subarachnoid Haemorrhage—a Randomized, Double-Blind Study.*

A total of 256 patients were admitted to this study. The patients were in grades I to V according to the classification of Hunt and Hess. Patients with life-threatening haematoma were operated acutely, others were operated upon at different intervals from the bleed. The morbidity and mortality were assessed at discharge and three months after the SAH using the Glasgow Outcome Scale. The effect of the initial bleed, vasospasm, rebleed and other causes on final outcome were analyzed and are discussed separately.

53. Solem, O. J., Nygaard, Ø., Trumpy, J. H., Anke, I. M. (Department of Neurosurgery and Section of Neuroradiology, Tromsø University Hospital, Tromsø, Norway): *The First Year of a Neurosurgical Department; Treatment of Vascular Malformations.*

In this initial phase the department has been the referral neurosurgical unit for a population of 250,000. With the concept of operating in the early period after rupture, a total of 23 patients have been treated.

Three patients died before planned surgery could be undertaken. In the 20 surgically treated cases all the aneurysms were clipped. One patient with a giant aneurysm was operated upon in hypothermia with the assistance of extracorporeal circulation. Three of the 20 patients who were operated upon died: one from a large primary haematoma, one from a myocardial infarction, and one from accidental occlusion of a major artery during profuse bleeding. One of the patients had an AVM which was excised. Of the operated patients two are dependant on supportive care. Fifteen are without serious sequelae.