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Different origins of hydrocephalus lead to different shunt revision rates

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ABSTRACT

Introduction: Hydrocephalus (HC) occurs due to multiple origins. Time course and dynamic of HC and its therapies differ between underlying pathologies. Different revision rates due to the type of HC are expected. Though hydrocephalus is known to be a life time condition, the lack of shunt malfunction years or decades after initial shunt insertion raises the hope of a superfluous shunt.

Methods: We conducted a retrospective survey of our OR-database during a 10 year period. All newly inserted shunt systems and subsequent shunt revisions are recorded according to quantity and time point. All patients were subdivided according their aetiology of HC.

Results: 260 patients were eligible with a follow-up of 4.5 years. Subgroups were: 90 patients with NPH, 76 patients with posthaemorrhagic and 16 patients had posttraumatic HC. 22 received a shunt as a consequence of a tumour, 41 were children and 15 for other causes. Overall revision rate was 39.5%. During the first 6 months 55.6%, 57.9% and 75% of patients with NPH, posthaemorrhagic and posttraumatic HC had revisions. In contrast only 38.1% of children and 20% of tumour cases required early revision.

Conclusion: Two different patterns of revision are evident: mainly early revisions in morphologically stable diseases such as posthaemorrhagic, posttraumatic and NPH and predominantly late revisions in changing organisms such as children and tumour patients. The conception HC may be transient because of a lack of late revisions cannot be supported by this data.

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1. Introduction

Hydrocephalus (HC) is a frequent entity in daily neurosurgical practice. In addition to endoscopic third ventriculostomie (ETV) CSF shunting is still the most common therapy for HC of different aetiologies. Shunt failure presents a significant medical burden. Studies have shown an overall shunt failure rate up to 45% within the first year [1–3].

Because of this major problem, the concept HC could be transient because of a lack of late revisions is tempting and advocated by O'Kelly et al. especially in the case of post-haemorrhagic HC [4].

This study was undertaken to compare different hydrocephalus types with the revision rates and their time course to give a hint to the question if HC could be a temporary condition especially in the case of posthaemorrhagic HC.

2. Patients and methods

2.1. Study design

This study was approved by the local ethic committee. We conducted a retrospective cohort study of all CSF shunts that were placed in a 10-year period between 1st January 2004 and 31st December 2013. Only patients who had their initial shunt insertion within the 10-year study period were included. Follow-up was extended up to August 2014. For each patient the following was recorded: age at initial shunt insertion, date of initial shunt insertion and all subsequent revisions with date of surgery. Shunt revisions were defined as all surgical procedures related to the shunt system. In case of a shunt infection, removal and replacement were counted as one procedure. All revisions were dichotomised to within the first six month or later.

Patients with a follow-up of less than one year were excluded. Patients were categorised according to their aetiology of HC in: normal pressure HC, posthaemorrhagic HC following subarachnoid or intraventricular haemorrhage, HC following traumatic brain injury, HC in the consequence of an intracranial tumour and miscellaneous. Children were counted as a separate group up to the age of 14 years regardless of their underlying aetiology.

Revision rates were calculated as the percentage of patients needing at least one shunt revision. Furthermore we calculated the average number of shunt revisions per patient as the ratio of all initial shunt insertions divided by the number of revisions.

2.2. Data sources

Data were derived from administrative and surgical databases maintained at Klinikum Kassel in Kassel, Germany. Patients were identified via ICD-9, ICD-10 for hydrocephalus and OPS-codes for shunt insertion and revisions. All subsequent patient charts were reviewed. Contemporary follow-up was accomplished by yearly routine follow-up or by telephone interview.

2.3. Statistical analysis

Statistical analyses were performed using SSPS statistical software (version 19). *T*-test was used to calculate the mean time to first revision. For comparison of revision rates between the groups Chi-square test was used. Correlation between revisions and age was done with Spearman Rank test. Survival curves were constructed using the Kaplan–Meier method.

2.4. Surgical technique and shunt hardware

Ventriculo-atrial shunting was the standard procedure in adults up to June 2005. After June 2005 ventriculo-peritoneal shunting was the most common procedure. Whenever possible a right frontal burrhole was used for insertion of the ventricular catheter.

The following valves were used: Pro-GAV, Miethke, Germany in 106 patients (40.8%), Hakim Medos programmable valve, Codman, USA in 92 patients (35.4%), GAV, Miethke, Germany in 36 patients (13.8%), Hakim Precision medium–low, Codman, USA in 22 patients (8.5%) and Certas, Codman, USA in 4 patients (1.5%).

3. Results

333 patients received a newly inserted shunt system within the 10 year period. 56 patients died in the first year after shunt insertion. 17 patients were lost to follow-up. According to the inclusion criteria 260 had at least one year follow-up and were eligible for this study with a mean follow-up period of 1656 days = 4.5 years (range 366–4369 days).

122 patients were men, 134 women. 75.7% had ventriculo-peritoneal shunts. 23.5% had ventriculo-atrial shunts. Two patients (0.8%) received a cystoperitoneal shunt.

Table 1 – Complications and revisions in itemised subgroups.

Subgroup	No. of patients	Operations performed	Follow up (years)	At least 1 revision	Infection rate	Revisions first 6 months
NPH	90	120	3.6	24.4%	5.6%	55.6%
Posthaemorrhagic HC	76	122	4.9	40.5%	17.8%	57.9%
Posttraumatic HC	16	29	4.8	60%	26.7%	83.3%
Tumour-HC	22	35	4.3	40%	5%	20.0%
Children	41	105	5.9	59.5%	14.3%	38.1%
Miscellaneous	15	34	4.4			
All	260	448	4.5	39.5%	12.2%	56.0%

90 patients had normal pressure HC, 76 patients received their shunts for posthaemorrhagic conditions, 16 patients were shunted following traumatic brain injury. 22 patients had a HC as a consequence of an intracranial tumour and 41 were children up to the age of 14 years. 15 patients had miscellaneous causes for their shunting procedure such as unknown origin, following meningitis or failed ETV's for congenital malformations (data shown in Table 1).

Overall 39.5% experienced at least one surgical shunt complication due to mechanical shunt failure such as obstruction or migration. 14.5% had multiple (two or more) shunt complications.

Between the subgroups follow-up periods differ a lot with the shortest follow-up in NPH patients (3.6 years) and the longest in children (5.9 years). After adjustment for follow-up revision rates ranged from 24.4% to 60%. NPH had the lowest, posttraumatic HC and children the highest revision rates (Fig. 1). In Chi square test

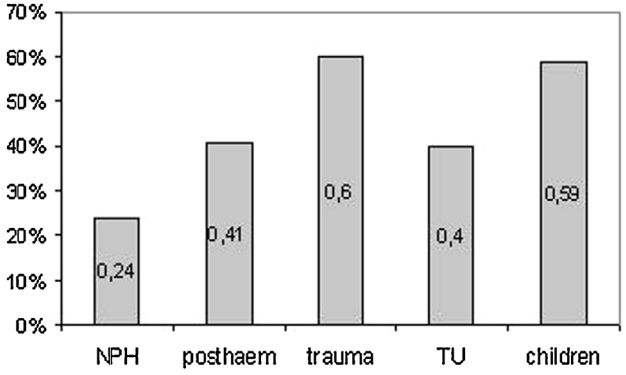

Fig. 1 – Overall revision rates in the different hydrocephalus subgroups.

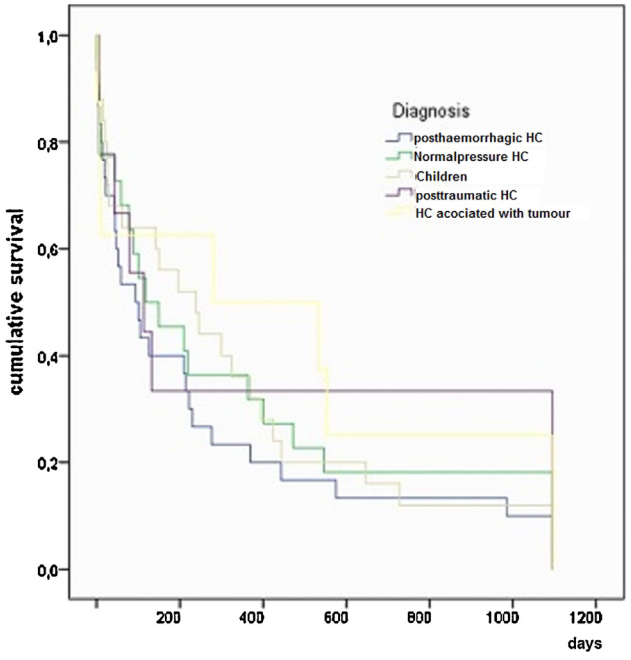

Fig. 2 – Kaplan–Meier-curve of shunt survival in the different hydrocephalus subgroups.

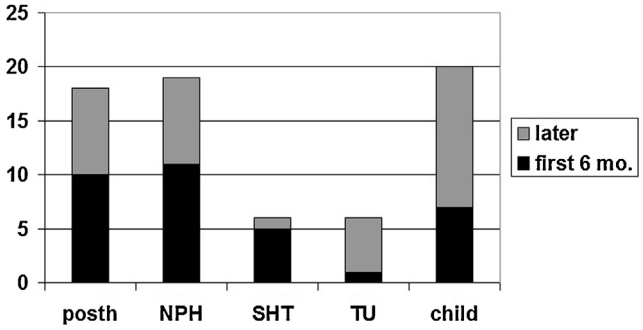

Fig. 3 – Distribution of early and late revisions in the different hydrocephalus subgroups

the differences between the groups turned out to be significant ($p = 0.002$). Furthermore age is a strong predictor for shunt revision. Younger patients experience shunt revisions more frequently than adults ($p = 0.05$). Furthermore the younger a patient, the more revisions were necessary ($p = 0.0001$). But shunt failure was not associated with gender.

Affiliation to a HC subgroup was another strong predictor for shunt failure ($p = 0.021$). The Kaplan–Meier shunt survival curves for the subgroups are shown in Fig. 2.

The mean time interval to the first revision differs a lot between the groups ranging from 373 days in children to 693 days in posttraumatic HC. But these data do not reach statistical significance because of high standard deviations.

Overall infection rate was 12.2% with highest rates in posttraumatic HC (26.7%) and lowest rates in NPH patients (5.6%). Infection rates also differ significantly between the groups ($p = 0.0001$). The alarmingly high infection rate prompted a protocol of safety measures before and during the OR-procedure especially in ICU patients which was able to cut down the overall infection rate to 3.6% in the following two years. Measures included a standardised washing procedure the day before shunt insertion, complete hair shave in patients with EVD, a change in stitching technique and further more.

In NPH, posthaemorrhagic and posttraumatic HC most revisions occurred within the first 6 months (75%, 57.9% and 55.6% resp.). In contrast to that in children and tumour patients most revisions took place in the later course (65% and 71% resp.) (Fig. 3). This does not reach statistical significance because of small sample sizes in some subgroups ($p = 0.131$).

4. Discussion

Shunt dependency is supposed to be a lifelong condition. But due to an unacceptable high rate of true or suspected shunt failure the concept that HC could be transient in special cases is tempting to embrace. The often observed fact that shunts are functioning well for decades after numerous revisions in the early time course raise the question if this shunt is still necessary in the later course. Particularly in posthaemorrhagic HC the discussion is raised perpetually in the literature [4]. Therefore we compared the time course of shunt revisions in posthaemorrhagic HC with other hydrocephalic entities.

Outcome measurements following shunt placement in patients with HC has been evaluated in numerous studies since the 1960s. But studies comparing revision rates in different HC types are rare and mainly address the paediatric population or special aspects such as risk factors, shunt type or experience of surgeons [5–10]. Studies comparing different time courses of revisions are especially scarce.

Overall revision rate is high with 39.5% in our series. However, this is in keeping with large population based evaluations of shunt complications with similar follow-up demonstrating 32–45% revisions [6,1,10].

As expected by common sense revision rates differ significantly between the subgroups.

In NPH numerous studies evaluated outcome after shunting with low revision rates such as ours [11–15].

In contrast to that patients with posthaemorrhagic HC are as prone to shunt complications as the posttraumatic patients which resulted in similar revision rates in the literature and in our series [4,16–20].

Evaluation of shunt complications in tumour patients revealed revision rates from 10.4% to 40% but the follow up period rarely exceed two years [21–23]. Our follow-up period is more than doubled with a 40% revision rate with predominantly benign tumours.

Malignant tumours are known to have less revisions because of reduced survival time [22,23].

A considerable amount of shunting-literature is paediatric and it is well known that children experience the highest revision rates of all hydrocephalic patients ranging from 37% up to 82% [3,5,13,24–26]. The creation of a subgroup of children regardless of their underlying pathology seems somewhat arbitrary. Nevertheless a new-born with a posthaemorrhagic HC is totally different in all aspects from an adult following subarachnoid or intraventricular haemorrhage. The shared characteristic in the subgroup of children is an ongoing development of a growing organism.

''The younger the child the more revisions are necessary'' is the conclusion of nearly every paediatric shunt-study [3,5,7,25,27–29]. Our study confirms that this phenomenon can be transposed even to an adult population, concluding the older a patient the less shunt revisions are necessary.

Comparing the time course of revisions the subgroups showed major differences in the chronological need for revisions. In posttraumatic hydrocephalus 3/4 of all revisions took place in the first 6 months. In posthaemorrhagic hydrocephalus and in NPH more than half of the revisions needed to be done during the first 6 months. On the other hand in tumour patients 80% and in children nearly 70% of all revisions took place after 6 months.

Children as well as tumour patients experience fundamental changes in their intra- and/or extracranial morphology over time. So subsequent revisions are necessary to adjust the shunt to a changing morphology. In contrast NPH or posthaemorrhagic hydrocephalus, once occurred, does not change in morphology. The permanent or transient nature of HC cannot be deduced from the time course of revisions. Especially NPH is known to be a chronic disease, which will not reach shunt independence by resolution of the pathological process [12,30,31]. We observe the same revision patterns according to early and late revisions in NPH and posthaemorrhagic hydrocephalus. Hence the permanent or transient nature of HC cannot be deduced from the time course of revisions.

This study is subject to some important limitations. The largest limitation is its retrospective nature and a large number of patients who were lost to follow up. This could certainly affect the revision rates by omitting the patients who were not available for further follow up or telephone interview. Small sample sizes in tumour patients and posttraumatic patients limits statistical analysis. And finally many variables are dependent on our hospital policy or the decision of individual surgeons leading to biases that we were not able to control for.

5. Conclusion

Different aetiology of HC leads to significantly different revision rates even after correction for follow-up. Age is another strong predictor for revisions. The older a patient, the less likely shunt revisions are performed.

There are two different patterns of shunt revisions: mainly early revisions were performed in a morphologically stable disease such as posthaemorrhagic, posttraumatic and NPH. On the other hand a high proportion of late shunt revisions embodies a morphologically dynamic system with growing tumours or growing children. The conception that posthaemorrhagic HC may be transient because of a lack of late revisions, cannot be supported by this data.

Conflict of interest

None declared.

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None declared.

Ethics

The work described in this article has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans; Uniform Requirements for manuscripts submitted to Biomedical journals.

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