Blood clearing rate and need for ventriculo-peritoneal shunt in patients with a subarachnoid hemorrhage.

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We have nothing to disclose

Abstracts

Objective:

After aneurysmatic subarachnoid hemorrhage blood disappears from the subarachnoid spaces in various rates from case to case. 30% of patients become hydrocephalic and need a ventriculo-peritoneal shunt. We studied the association between the wash out rate from the subarachnoid space and indication for ventriculo-peritoneal shunting.

Methods:

Retrospective study of N=227 patients with aneurysmatic subarachnoid haemorrhage Fisher 1-4 treated in our department from 2015-2017 (2 years). Cranial CT was performed on days 1, 3, 6, 9 and 12 after haemorrhage. We evaluated the CT for disappearance of blood in the subarachnoid spaces (basal and external) in the time periods 0-3, 4-6, 7-9 and 10-12 and >12 days (qualitative analysis with two parameters: no blood or blood). Other parameters analysed were, need for ventriculo-peritoneal shunting, external ventricular drain, endovascular or microsurgical treatment, vasospasms ventricular hemorhage, intracerebral haemorrhage and craniectomy.

Results:

Fisher grade 3-4 bleedings were significantly associated with hydrocephalus compared to Fisher 1-2 bleedings. A faster wash out rate was significantly associated with less incidence of hydrocephalus(5 vs 7 days). Ventricular haemorrhage was associated with a significantly higher rate of hydrocephalus and shunting. There was no difference in the clearing rates of blood between surgically or endovascularly treated cases. Patients with intracerebral haemorrhage had a higher incidence of craniectomies. However, there was no correlation of craniectomy and shunting. In patients with hydrocephalus (indication for shunting or external drain) the time of wash out between basal and peripheral blood increased significantly before treatment (6 days vs 4 days). The difference remained higher after external drainage.

Conclusion:

The wash out rate of blood in the basal cysterns and the external (peripheral) subarachnoid spaces is significantly associated with hydrocephalic states in patients with subarachnoid hemorrhages Fisher grade 3 and 4. The circulation of the blood from the basal cysterns to the outer surface of the cortex is also prolonged in cases which will become hydrocephalic. The longer the blood stays in the subarachnoid spaces and the greater the time difference between washout from the basal cisterns and the peripheral CSF space is, the greater the incidence of hydrocephalus after subarachnoid haemorrhage and need of ventriculoperitoneal shunting. Intraventricular haemorrhage significantly increased the risk of shunting.

Introduction

Chronic hydrocephalus, i.e. hydrocephalus that needs to be shunted permanently, is a well-known complication in aSAH patients with reported frequencies ranging from 18 to 64%. Chronic hydrocephalus leads to significant patient burden including longer hospital and intensive care unit stays. Consequently, there is an urgent need to identify patients at risk for chronic hydrocephalus in time paving the way for early interventions.

Multiple studies have aimed to find significant prognostic factors that predict shunt-dependency after aSAH, e.g. volume of subarachnoid blood, treatment modality of aneurysm repair, and clinical presentation at admission. However, the results of the studies are heterogeneous. To date, no study has quantified the clearance of blood in the cerebrospinal fluid (CSF) spaces in relation to chronic shunt-dependent hydrocephalus. Therefore, in addition to the well-known candidate prognostic factors, we hypothesized that blood clearance of the CSF spaces in days might have prognostic potential in predicting shunt-dependency. If blood clearance in the CSF spaces is a significant prognostic factor, this may have considerable impact as this factor is likely modifiable.

Material and Methods

We performed a retrospective cohort study of all patients treated for aneurysm repair at our single tertiary institution between January 2012 and January 2016. We included all patients who survived the first month after bleeding (N=227).

The time in days until the blood in the basal and peripheral cerebrospinal fluid (CSF) spaces was washed out was assessed. Therefore, the clearance of blood was quantified in Hounsfield Units (HU). The highest value of five regions of interest was taken. Complete blood clearance was defined as <12 HU. All cranial computerized tomography (CT) scans were analysed for the presence of blood in the basal cisterns and the peripheral CSF space. Cranial CT scans were performed every 3 days after the ictus according to our daily clinical routine.

Results

	No shunt	Shunt
Age (mean)	55.7 years	59.6 years
Gender	M : F, 43 :94	M : F, 34 : 56
Surgical vs endovascular treatment	81 vs 56	43 vs 47
Fisher grade (mean)	**3.4**	**3.8 (**)**
WFNS grade (mean)	**2.2**	**3.7 (**)**
HU basal cistern initially (mean)	**54.7**	**59.9 (**)**
HU periphery initially (mean)	55	57.3
HU basal after clearance (mean)	9.7	9.2
HU periphery after clearance (mean)	10.8	11.5
HU basal cist. initially - HU basal cist. after clearance (mean)	**44.9**	**50.7 (**)**
Days to basal cist. blood clearance (mean)	**5.6**	**7.4 (**)**
Days to peripheral CSF space blood clearance (mean)	**10**	**13.15 (**)**
Vasospasms (%, N)	27.7%, 38 /137	36.6%, N= 33 /90
External ventricular drainage (%, N)	**48.9%, N= 67 / 137**	**99%, N=89 /90 (**)**
Ventricular bleeding	**56.2%, N= 77 / 137**	**86.6%, N=78 / 90 (**)**
Intracerebral bleeding	29.9%, N=41 / 137	45.5%, N=41 / 90
Craniectomy	18.2%, N= 25 / 137	23.3%, N=21 / 90

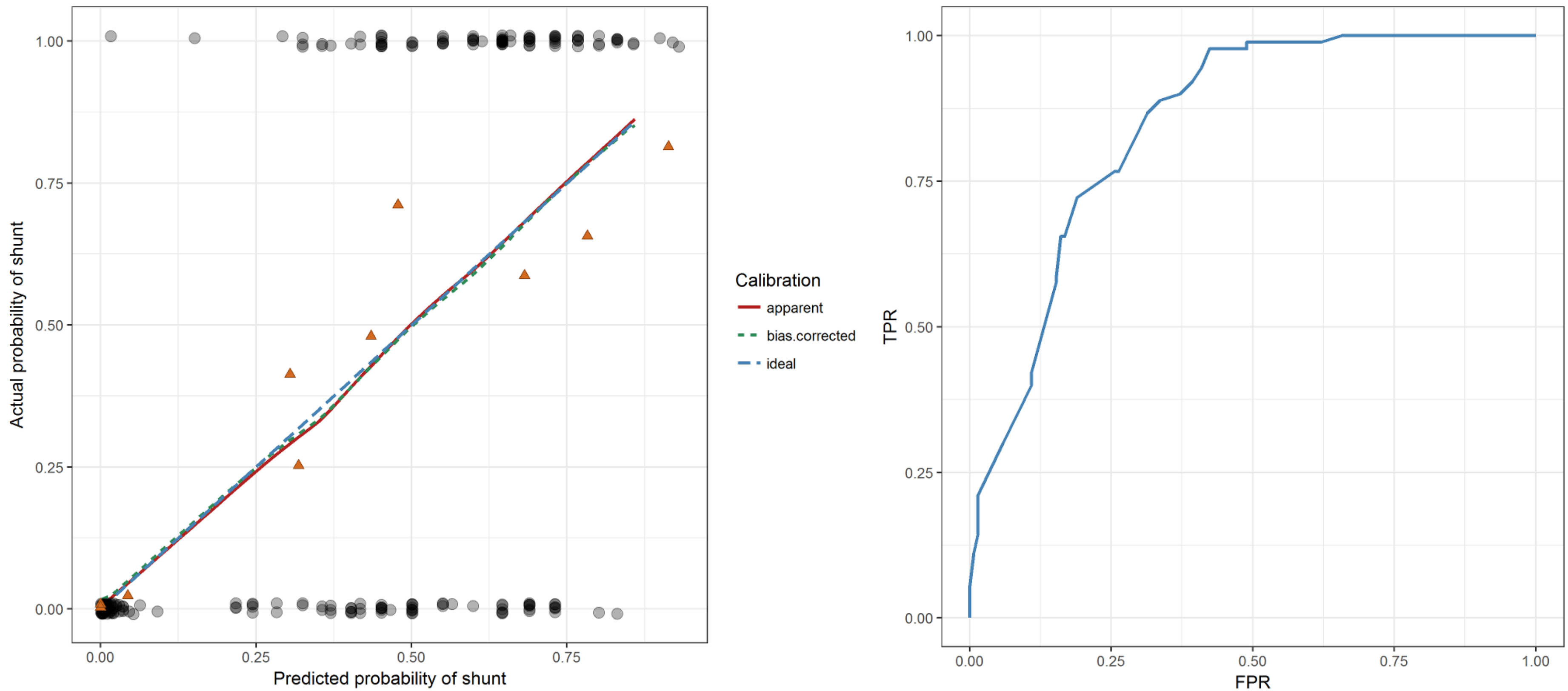
Table: Parameters analysed in the study and their differences between patients with hydrocephalus and shunt treatment and non-hydrocephalic patients. The statistically highly significant differences are marked in red. (**)= highly statistically significance after Bonferroni, Holm and Bonferroni-Holm corrections for evaluation of multiple parameters.

Results

	Test	p.raw	p.Bonferroni	p.Holm	p.BH
1	Correlation Fischer Score und VP-shunt	9,60E-07	2,21E-05	1,92E-05	4,82E-06
2	Correlation surgical vs. endovascular treatment and VP-shunt	0,16073437	1	1	0,21746415
3	Correlation Vasospas and Fischer grade	0,06300456	1	0,56704102	0,09660699
4	Correlation vasospasms and VP-shunt	0,18794748	1	1	0,23484281
5	Correlation localisation and HU basal initially	0,05166305	1	0,51663051	0,08487501
6	Correlation localisation and HU peripheral initially	0,21063246	1	1	0,24222732
7	Correlation localisation and VP-shunt	0,14391929	1	1	0,20688397
8	Correlation WFNS and VP-shunt	2,76E-11	6,34E-10	5,79E-10	2,11E-10
9	Correlation age andVP-shunt	0,01638342	0,37681868	0,21298447	0,03425624
10	Correlation gender and VP-shunt	0,3899787	1	1	0,39982323
11	Correlation EVD and VP-shunt	1,10E-18	2,53E-17	2,53E-17	2,21E-17
12	Correlation ventricular bleeding and VP-shunt	1,05E-06	2,41E-05	1,99E-05	4,82E-06
13	Correlation ICB and VP-shunt	0,02351688	0,54088817	0,28220253	0,04507401
14	Correlation ICBs and ventricular bleeding	0,00106964	0,02460166	0,01497492	0,00246017
15	Correlation craniectomy and VP-shunt	0,39982323	1	1	0,39982323
16	Correlation craniectomy and clearance of blood in peripheral CSF in days	0,19400058	1	1	0,23484281
17	Correlation HU basal initially and VP-shunt	0,00018672	0,00429452	0,00280077	0,00047717
18	Correlation HU peripheral initially and VP-shunt	0,02991248	0,68798708	0,3290373	0,05292208
19	Correlation blood clearance in days basal cisterns and VP-shunt	0,00010384	0,00238843	0,00166152	0,00029855
20	Correlation blood clearance in days peripheral CSF spaces and VP-shunt	2,60E-06	5,99E-05	4,69E-05	9,98E-06
21	Correlation blood clearance basal cisterns and peripheral CSF space	1,93E-18	4,43E-17	4,24E-17	2,21E-17
22	HU basal initially - HU basal after clearance and VP-shunt	6,57E-05	0,00151185	0,00111746	0,00021598
23	HU periph. initially - HU periph. after clearance and VP-shunt	0,272366	1	1	0,29830561

Table :
Statistical significance of the evaluated parameters in correlation with hydrocephalus after correction with Bonferroni, Holm, and Bonferonni Holm (BH). In red the statistically highly significant correlation can be seen.

Results



Visualisation of model calibration (left) and model discrimination (right) of the final prognostic model. The calibration plot shows the actual outcome versus prediction. The distribution of the actual shunt (1) and no shunt (0) observations is depicted as thick grey dots at the bottom and at the top of the chart. The ideal line (dashed blue line) is the 45 degree straight line that corresponds to the line of perfect calibration. The apparent line (red) shows the bootstrap-estimated probability on the training subset. The bias.corrected line represents the same probability corrected for optimism (i.e. taking into account the model's performance on the test set). The actual outcome (probability of shunt) by deciles of risk is shown by the amber triangles.

The receiver operating characteristic (ROC) curve of the final model displays the model discrimination. The *c*-statistic is 0.85 and is equivalent to the area und the ROC curve.

TPR: True Positive Rate = sensitivity; FPR: False Positive Rate = 1-specificity.

Conclusions

We provide an internal validated prognostic model including a new promising prognostic variable, i.e. blood clearance of the basal cisterns, that adequately predicts 30 day chronic shunt-dependent hydrocephalus following aSAH, although additional modification and external validation is needed. Furthermore, according to the constructed model, neurosurgical interventions that accelerate blood clearance in the basal cisterns seem to have potential to prevent VP-Shunt placement in patients following aSAH.

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