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## Prediction of shunt dependent hydrocephalus following aneurysmal subarachnoid hemorrhage “algorithm based management”

Aneurysmal subarachnoid hemorrhage (aSAH) is a devastating disease with a high rate of mortality and permanent morbidity. An important neurologic complication is hydrocephalus reported to range from 6 to 67% while only 10-20% of them will require permanent CSF diversion. The purpose of this study was to identify predictive factors for the development of shunt dependant hydrocephalus among patients with aSAH.

This is a retrospective study conducted in among 72 patients who underwent clipping of aneurysm for subarachnoid hemorrhage in our institute during 2 years. EVD placement done for acute hydrocephalus while VP shunt was done for chronic hydrocephalus or requiring prolonged EVD placement. Various clinical and radiological factors were registered on admission and during the intensive care stay. Multivariate logistic regression analysis was done to predict risk of shunt dependant hydrocephalus. P value less than 0.05 was considered significant.

Among 72 patients with aSAH. Intraventricular extension of blood was seen in 24 (33.3%) patients while hydrocephalus was seen among 19 (26.4%) patients. Eight patients (11.1%) required EVD placement for acute hydrocephalus while 10 (13.9%) patients required permanent shunt placement for chronic hydrocephalus. In univariate analysis, SAH with fisher grade >2, presence of hydrocephalus, intraventricular extension of hemorrhage and need of EVD placement were found to have significant association in shunt dependency. However multivariate logistic regression model showed EVD requirement for acute hydrocephalus as an independent predictor of

Hydrocephalus is a common complication following aneurysmal subarachnoid hemorrhage (aSAH) reported to range from 6 to 67%.<sup>1</sup> Acute hydrocephalus requiring a temporary external CSF diversion occurs in 15%–87% of aSAH while permanent CSF diversion is required among 6 to 37% requires shunt.<sup>2,3</sup> Advanced age, poor clinical status, aneurysm location, especially in the posterior circulation, initial mental status, and presence of initial intraventricular hemorrhage (IVH), acute hydrocephalus are risk factors for development of SDH.<sup>4-10</sup>

The purpose of this study was to identify predictive factors for the development of SDH among patients with SAH.

**Methods:** This is a retrospective study conducted in Upendra Devkota Memorial National Institute of Neurological and Allied Sciences (UDM-NINAS), Bansbari, Kathmandu, Nepal among patients who underwent clipping of ruptured aneurysm during two years period. Surgically clipped aneurysm patients who survived for at least three months were included. Those who died early, were lost to follow up or denied further treatment were excluded. Ethical clearance was taken from the Institutional Review Board at UDM-NINAS.

All patients were treated according to the standardized protocol, which closely follows international guidelines.<sup>11,12</sup> Patient were monitored in ICU and serial CT scan was done. Evan's ratio  $>0.3$  is considered hydrocephalus and those requiring CSF diversion were managed with external ventricular drainage (EVD). Clipping of aneurysm was done with standard pterional approach. Post operatively patients were managed in Intensive Care Unit (ICU) with triple H therapy including Nimodipine and adequate hydration to maintain central venous pressure (CVP) around 12 mm Hg. Post-operative

shunt dependent hydrocephalus at p value 0.006 (OR=21.3; 95% CI=2.38 to 191.51).

Hydrocephalus is a common complication following aneurysmal subarachnoid hemorrhage. SAH with fisher grade  $>2$ , presence of hydrocephalus, intraventricular extension of hemorrhage and need of EVD placement were found to have significant association in shunt dependency however only EVD requirement is an independent predictor of SDH.

**Keywords:** aneurysm, external ventricular drainage, hydrocephalus, intraventricular extension, subarachnoid hemorrhage, ventriculoperitoneal shunt, WFNS.

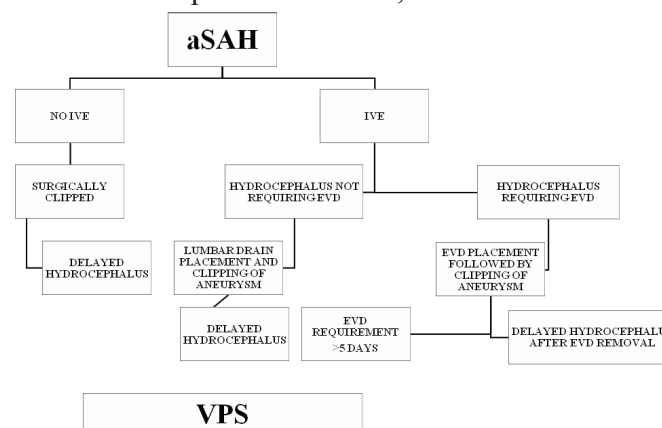


Figure 1. Algorithm of management of hydrocephalus following ASAH

serial CT scans were analyzed. Those requiring persistent drainage of EVD or showing evolving hydrocephalus were addressed with ventriculoperitoneal shunt (VPS) (Figure 1). Supportive medication with analgesics and anti-epileptics were administered as indicated.

Demographic characteristics, comorbidities and risk factors, clinical grade on hospital admission and amount of subarachnoid blood on the admission CT scan were recorded and compared between two groups (shunt dependent and non-shunt dependent) of outcome using one or two tailed student's t-test, Mann-Whitney-U test for continuous variable and Fisher's exact test or chi square test for categorical variables. Univariate analysis was used to create a multivariable model for independent predictors of SDH. Admission predictors were added individually to these models to calculate adjusted odds ratio for the strength of association of SDH. Tests for interactions were performed for all of the significant variables in the multivariable models. P value of 0.05 or less was considered statistically significant. SPSS version 20 was used as data computation tool.

## CSF outflow complication of ASAH

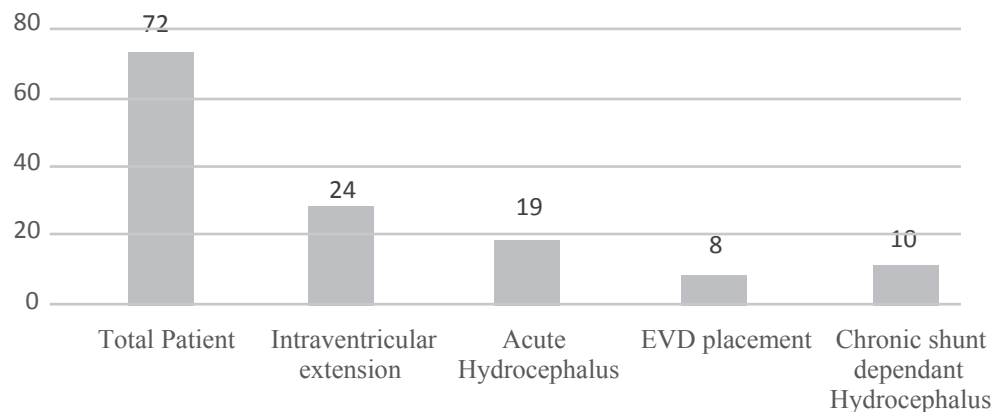


Figure 2. CSF outflow complications of ASAH

Abbreviation: aSAH: Aneurysmal Subarachnoid hemorrhage; IVE: Intraventricular extension; EVD: Extraventricular drainage; VPS: Ventriculoperitoneal shunt.

### Results:

Among the 98 patients angiographically diagnosed as ASAH, 72 patients met the inclusion criteria. Most of them were female (68.1%) with female to male ratio of 2.14. There was no significant sex difference among two study groups ( $p=0.453$ ). Mean age of the patients was  $52.5 \pm 10.3$  years with range from 28 to 74 years, while 62% were between 40-69 years' age group. Intraventricular extension (IVE) was seen among 24 (33.3%) patients while hydrocephalus developed among 19 (26.4%) of them. Moreover, eight patients (11.1%) were treated with EVD placement, two didn't require EVD for more than five days while 6 patients had persistent hydrocephalus with high output in EVD drain requiring VPS. Four patients developed chronic hydrocephalus during follow up which was addressed with VPS placement. Bivariate analysis of variable showed statistical significant association of shunt dependent hydrocephalus with high mean Fisher's grade, IVE, hydrocephalus and EVD placement (Table 1).

On multivariate logistic regression model for predicting SDH in patients with ASAH which was developed from multivariable logistic regression analysis of explanatory variables ( $p < 0.25$ ) namely WFNS, Fisher grade, hydrocephalus, intraventricular extension and EVD placement. The model showed EVD placement was statistically significant predictor of SDH. Patients with EVD placement have 21.3 times higher odds of shunt dependency than those without EVD requirement at  $p = 0.006$  (95% CI=2.38 to 191.5) (Table 2).

### Discussion

Aneurysmal subarachnoid hemorrhage is a devastating disease with a high rate of mortality and permanent morbidity. An important neurologic complication is hydrocephalus, which can be either acute-onset on admission or progressive during the hospital stay.<sup>2,13</sup> The overall risk of hydrocephalus after ASAH varies between 6% to 67% in different series, although only 10-20% of them will require permanent CSF diversion.<sup>13,14</sup> In our series, among 72 patients of ruptured aneurysm, 24 (33.3%) patients had intraventricular extension of which 19 (26.4%) developed hydrocephalus while only 10 (13.8%) required permanent CSF diversion which was comparable to previous series.<sup>13,14</sup>

Patients with age  $\geq 60$ , acute course of HCP, IVH, low initial Glasgow Coma Scale, high Fisher grade, re-hemorrhage and posterior circulation location of ruptured aneurysm have been reported.<sup>15-17</sup> Patients in the SDH group were significantly older than those in the NSDH group (61.0 vs. 54.9 years,  $p < 0.05$ ) in study done by Chang SI et al.<sup>13</sup> Such finding was not observed in our study. Neither gender has influential effect in SDH in our study consistent with the study done by Won Choe et al. Initial high WFNS score and high Fisher grade showed significant association in causation of SDH but independent risk is not established by multivariate study.

Acute blockage of CSF flow produces a pressure gradient leading to enlargement of ventricles producing acute hydrocephalus, whereas subsequent arachnoid adhesions due to meningeal reaction to blood products impairing CSF absorption leads to chronic hydrocephalus. However, presence of hydrocephalus does not always lead to the development of shunt dependency.<sup>18</sup> In our study, only 8 out of 19 patients with hydrocephalus

Variable	Categories	Total (N=72)	Shunt dependent group (N=10)	Non-shunt dependent group (N=62)	P value
<b>Demographic profile</b>					
<b>Age range</b>	<60	47 (65.3%)	6 (60%)	41 (66.1%)	0.481
	>60	25 (34.7%)	4 (40%)	21 (33.9%)	
<b>Sex</b>	M	23 (31.9%)	3 (30%)	20 (32.3%)	0.60
	F	49 (68.1%)	7 (70%)	42 (67.7%)	
<b>WFNS</b>	1	28 (38.9%)	1 (10%)	27 (43.5%)	0.231
	2	6 (8.3%)	1 (10%)	5 (8.1%)	
	3	30 (41.7%)	6 (60%)	24 (38.7%)	
	4	8 (11.1%)	2 (20%)	6 (9.7%)	
<b>Radiological profile</b>					
<b>WFNS grade</b>	<2	34 (47.2%)	2 (20%)	32 (51.6%)	<b>0.062</b>
	>2	38 (52.8%)	8 (80%)	30 (48.4%)	
<b>Mean WFNS</b>		2.25±1.09	2.90±0.87	2.15±1.09	0.029
<b>Aneurysm location</b>	Acomm	32 (44.4%)	3 (30%)	29 (46.8%)	0.634
	MCA	15(20.8%)	2 (20%)	13 (21%)	
	PComm	13(18.1%)	2 (20%)	11 (17.7%)	
	ICA	9(12.5%)	3 (3%)	6 (9.7%)	
	Distal ACA	2(2.8%)	0	2 (1.6 %)	
	PICA	1(1.4%)	(%)	1 (1.6%)	
<b>Fisher grade</b>	<2	24 (33.3%)	1 (10%)	23 (37.1%)	<b>0.087</b>
	>2	48 (66.7%)	9 (90%)	39 (62.9%)	
<b>Mean Fisher grade</b>		3.04±0.879	3.70±0.68	2.90±0.88	0.01
<b>IVE</b>	None	48 (66.7%)	3 (30%)	45 (72.6%)	<b>0.013</b>
	Yes	24(33.3%)	7 (70%)	17 (27.4%)	
<b>ICH</b>	None	55 (76.4%)	6 (60%)	49 (79%)	0.329
	Yes	17 (23.6%)	4 (40%)	13 (21%)	
<b>Initial Hydrocephalus</b>	None	53 (73.6%)	3 (30%)	50 (80.6%)	<b>0.001</b>
	Yes	19 (26.4%)	7 (70%)	12 (19.4%)	
<b>EVD</b>	None	64 (88.9%)	4 (40%)	60 (96.8%)	<b>0.00003</b>
	Yes	8 (11.1%)	6 (60%)	2 (3.2%)	
<b>Vasospasm</b>	None	32 (44.4%)	7 (70%)	25 (40.3%)	<b>0.080</b>
	Yes	40 (55.6%)	3 (30%)	37 (59.7%)	
WFNS: World federation of neurological society; IVE: Intraventricular extension; ICH: Intracerebral hemorrhage; EVD: External ventricular drainage; P-value <0.05					

Table 1. Bivariate analysis of demographic and clinical and radiological profile of patients

Variables	OR	95% CI	P-value
WFNS grade >2	4.3	0.52-34.59	0.177
Fisher grade >2	0.803	0.056-11.60	0.872
IVE	1.01	0.031-32.48	0.997
EVD Placement	21.3	2.38-191.51	0.006
HCP	3.6	0.113-115.4	0.467

IVE: Intraventricular extension; HCP: Hydrocephalus

Table 2. Multivariate logistic regression model for predicting shunt dependant hydrocephalus

(42.1%) required EVD placement, out of which 6 (31.5%) patients required subsequent VPS. Similarly, 4 patients (7.6%) without initial hydrocephalus developed delayed hydrocephalus requiring permanent VPS placement. This was comparable to a study done by Won Choe et al. In their series, 62 patients (34.6%) with IVE underwent shunt operation, compared with 14.5% of the patients without IVH.<sup>18</sup>

Some studies show that the amount of total blood in the sub-arachnoid space was the most consistent predictive factor.<sup>19</sup> The current study demonstrates higher mean Fisher SAH grade on presentation in patients who have SDH similar to study done by Wang YM et al.<sup>20</sup> IVE has been reported to be a risk factor for SDH such findings were not consistent with our study.<sup>15-17</sup> Furthermore, there is evidence in literature suggesting that aggressive external ventricular drainage significantly reduces the need for permanent shunting among these patients. In our experience, initial EVD placement for acute hydrocephalus is found to be a significant predictor of SDH. Six out of eight patients with EVD placement required permanent VPS placement. This could be due to initial severity of blood in the ventricular system which led to subsequent blockade of CSF flow resulting in chronic hydrocephalus. Our finding was consistent with study done by Chang SI et al. who identified initial placement of external ventriculostomy as an independent predictor in patients with SDH following ASAH.<sup>13</sup>

### Conclusions

Hydrocephalus is a common complication following aneurysmal subarachnoid hemorrhage. SAH with fisher grade >2, presence of hydrocephalus, intraventricular extension of hemorrhage and need of EVD for hydrocephalus were found to have statistical significance

in shunt dependent hydrocephalus however, only EVD requirement was independent predictor for shunt requirement.

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