ASSOCIATION BETWEEN CEREBRAL HEMORRHAGE VOLUME AND ACUTE HYDROCEPHALUS IN ANEURYSMAL SUBARACHNOID HEMORRHAGE: A SEMIAUTOMATIC MEASUREMENT STUDY

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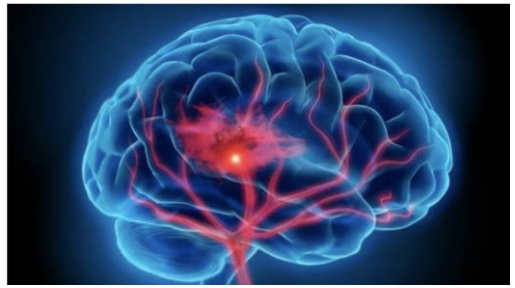
NEW INSIGHTS AND PERSPECTIVES ON INTRACEREBRAL HEMORRHAGE:

A COMPREHENSIVE UPDATE

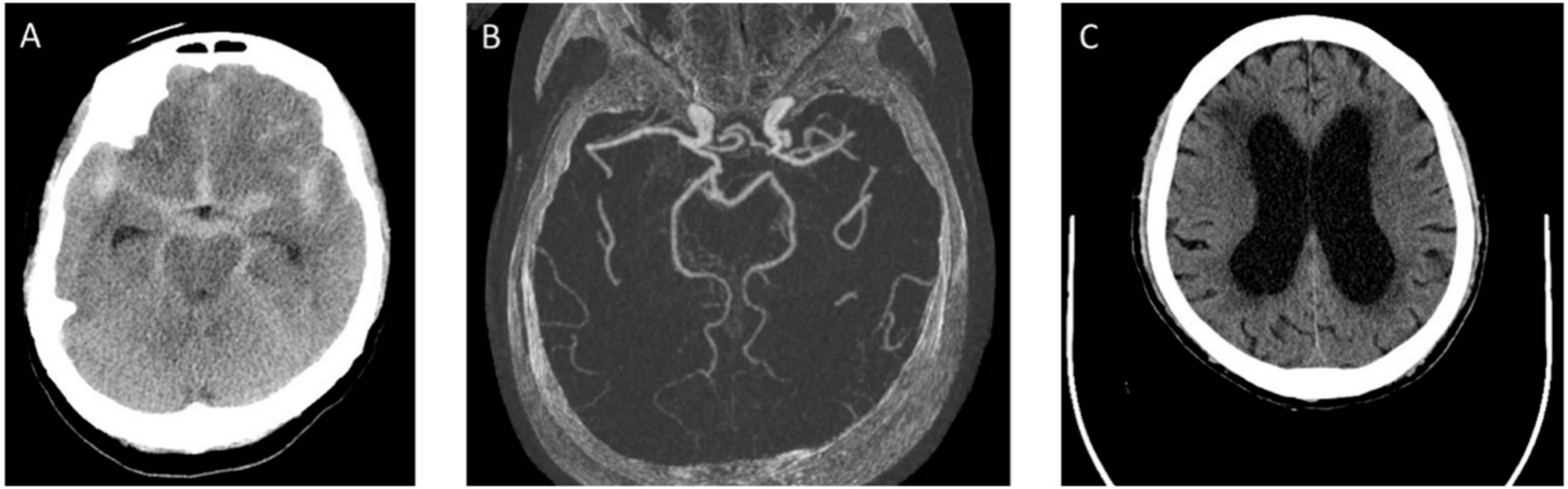
Ischemic Stroke Meeting. Spanish Stroke Research Network

7-9 October 2024 BARCELONA – SPAIN



BACKGROUND

- **Shunt-dependent acute hydrocephalus (SDAHC)** is a common complication that can arise within the first 72 hours following aneurysmal subarachnoid hemorrhage (aSAH).
- Incidence of SDAHC ranges from 20-30%.



Kuo, L.-T.; Huang, A.P.-H. The Pathogenesis of Hydrocephalus Following Aneurysmal Subarachnoid Hemorrhage. *Int. J. Mol. Sci.* **2021**, *22*, 5050.

BACKGROUND

- Potential links between intracranial blood volumes and location and **SDAHC.** No threshold has been established
- Overall, knowledge about predictors of acute hydrocephalus remains limited.

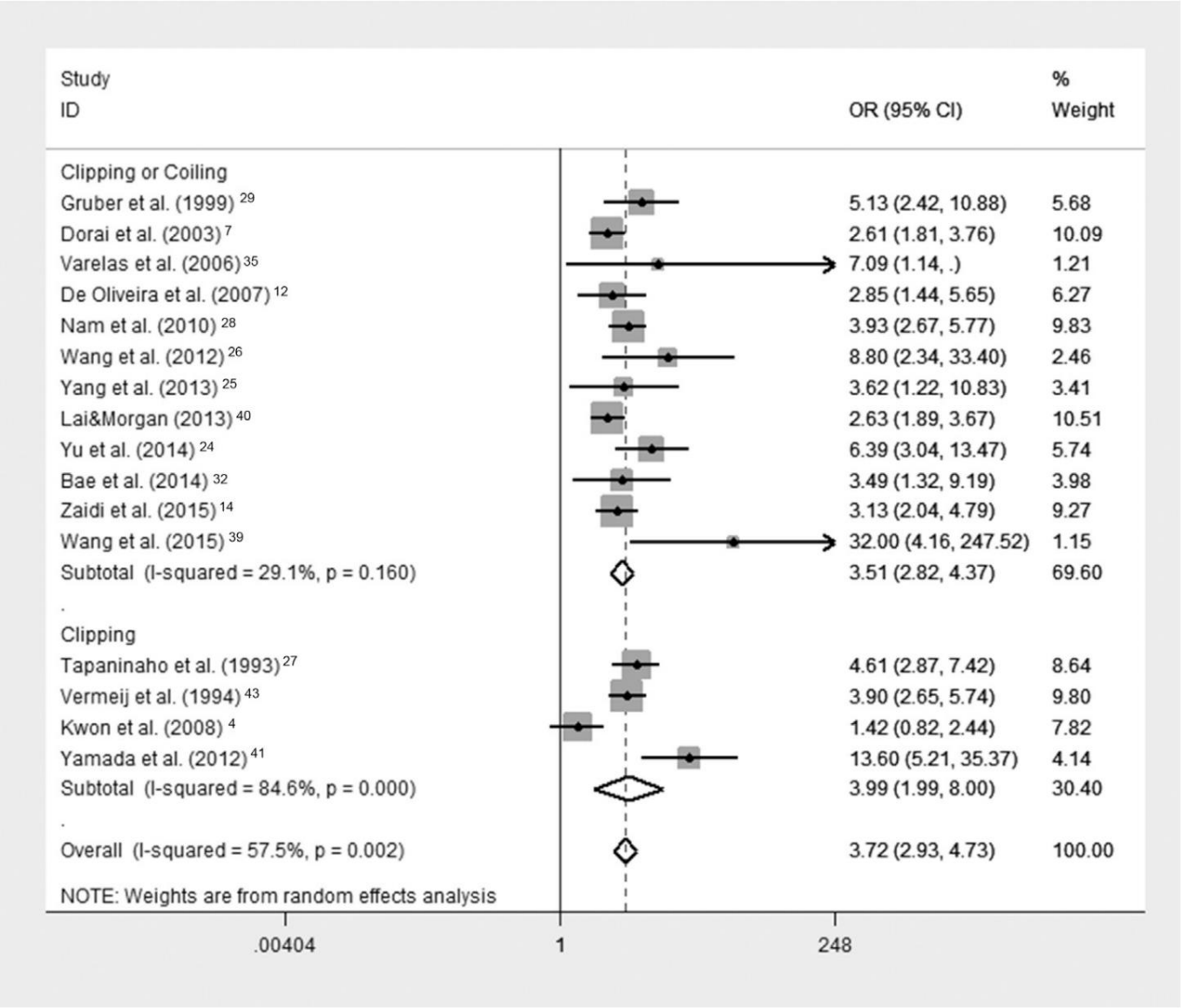


Figure 10. Forest plot of intraventricular hemorrhage as a risk factor for shunt-dependent hydrocephalus after aneurysmal subarachnoid hemorrhage. CI, confidence interval; OR, odds ratio.

Xie Z et al Predictors of Shunt-dependent Hydrocephalus After Aneurysmal Subarachnoid Hemorrhage? A Systematic Review and Meta-Analysis. World Neurosurg. 2017.

HYPOTHESIS

Quantifying cerebral hemorrhage — both in the subarachnoid space and the intraventricular and intraparenchymal regions — on the initial emergency brain-CT could be associated with the development of **SDAHC** within the first 72 hours of symptom onset.

OBJECTIVES

- To investigates the association between **semiautomatic measurement of cerebral hemorrhage volumes** in subjects with aSAH and the onset of **shunt-dependent acute hydrocephalus.**
- To establish a bleeding **volume threshold** associated with SDAHC.

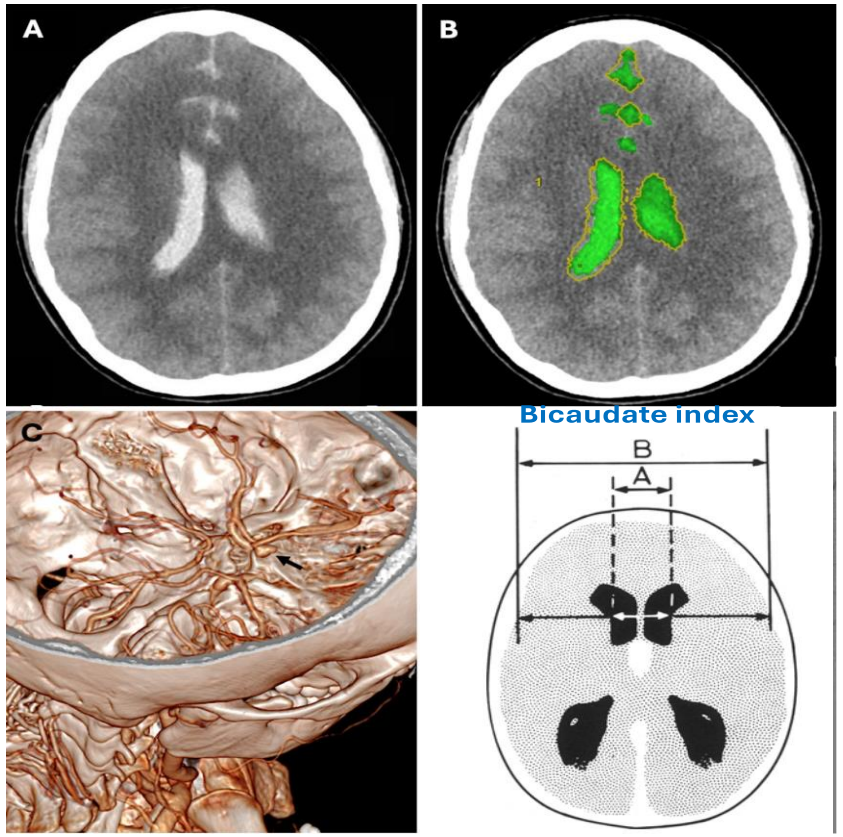
METHODS

Retrospective observational study.

Population:

Consecutive aSAH patients admitted to a specialized referral hospital (2016-2021).

GE HealthCare



METHODS

Variables:

- Severity: GCS, WFNS scale

- Risk of vasospasm at admission: Fisher grade (amount of SAH on CT scans)

- Hemorrhage Volumes (AW Server software):

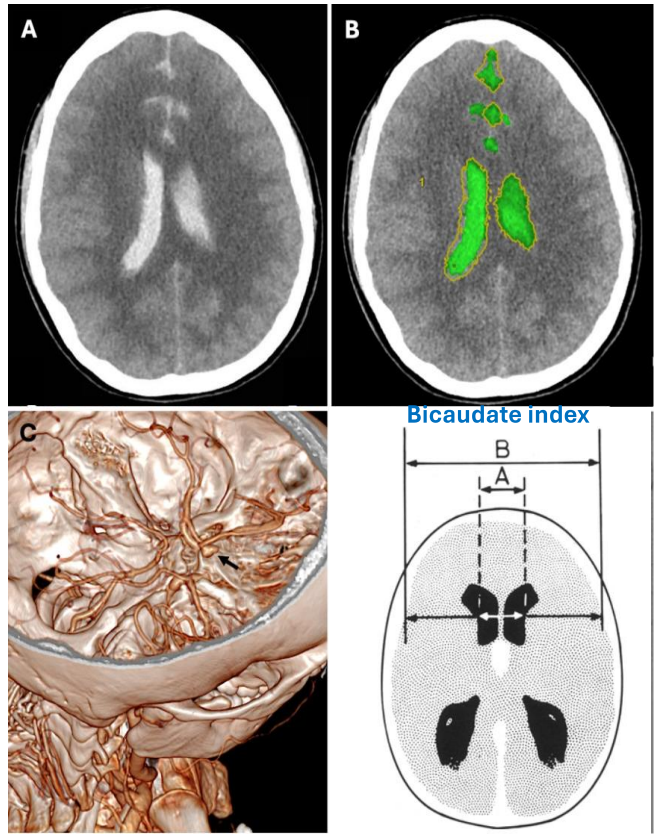
    - Subarachnoid hemorrhage
    - Intraventricular hemorrhage (IVH)
    - Intraparenchymal hemorrhage (IPH)
    - Total hemorrhage (TH)

- Bicaudate index (> 0.2 indicative of the need for shunting)

Main outcome: SDAHC (need for external ventricular drainage (EVD) or ventriculoperitoneal (VP) shunt placement within the first 72 hours post-diagnosis)

Statistical analysis: ROC, Multivariate logistic regression analyses,

GE HealthCare



RESULTS

Patients with first spontaneous SAH admitted to Torrecárdenas University Hospital (2016-2021)
n = 247

→ Patients with non-aneurysmal SAH
n = 72

→ Patients with incomplete data
n = 5

Patients with first aneurysmal SAH included in the study
n = 170

RESULTS

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Patients with first aneurysmal SAH included in the study
n = 170

111 (65.3%) women
Mean age 58.5 years (SD 14.6)
Fifty-five patients (32.4%) presented **SDAHC**

RESULTS

Baseline characteristics

Variable	Total (N=170)	Non-SDAHC (N= 115)	SDAHC (N= 55)	P
Demographic data and comorbidities				
Female, n (%)	111 (65.3)	77 (67)	34 (61.8)	0.510
Age, mean (SD), years	58.5 (14.6)	57.6 (14.4)	60.5 (14.8)	0.120
Smoker, n (%)	64 (37.6)	47 (40.9)	17 (30.9)	0.210
Alcoholism, n (%)	21 (12.4)	13 (11.3)	8 (14.5)	0.548
Drugs, n (%)	5 (2.9)	4 (3.5)	1 (1.8)	0.549
Glycaemia, median (IQR), mg/dL	146.5 (62)	135 (53)	169 (62)	<0.001
Hypertension, n (%)	70 (41.2)	46 (40)	24 (43.6)	0.652
Dyslipidemia, n (%)	47 (27.6)	29 (25.2)	18 (32.7)	0.306
Diabetes mellitus, n (%)	27 (15.9)	16 (13.9)	11 (20)	0.310
Ischemic cardiopathy, n (%)	8 (4.7)	5 (4.3)	3 (5.5)	0.750
Stroke, n (%)	6 (3.5)	3 (2.6)	3 (5.5)	0.347
Atrial fibrillation, n (%)	10 (5.9)	8 (7)	2 (3.6)	0.389
Heart failure, n (%)	6 (3.5)	3 (2.6)	3 (5.5)	0.347
COPD, n (%)	6 (3.5)	3 (2.6)	3 (5.5)	0.347
Kidney failure, n (%)	5 (2.9)	3 (2.6)	2 (3.6)	0.711
Liver disease, n (%)	6 (3.5)	6 (5.2)	0 (0)	0.085
Severity and risk of vasospasm on admission				
GCS on admission, median (IQR)	14 (6)	15 (4)	11 (10)	<0.001
Fisher scale, median (IQR)	4 (1)	3 (2)	4 (0)	<0.001
Fisher grade 3-4, n (%)	125 (73.5)	77 (67)	48 (87.3)	0.005
WFNS scale, median (IQR)	2 (3)	1 (1)	4 (3)	<0.001
Blood Pressure				
SBP, median (IQR)	157.5 (40.3)	159 (40)	170 (42)	0.384
DBP, median (IQR)	88 (24.3)	90 (21)	85 (30)	0.149
Prior treatments				
Statins, n (%)	38 (22.4)	22 (19.1)	16 (29.1)	0.145
Antiplatelet agents, n (%)	21 (12.4)	13 (11.3)	8 (14.5)	0.548
Anticoagulants, n (%)	10 (5.9)	8 (7)	2 (3.6)	0.389
SSRIs, n (%)	26 (15.3)	17 (14.8)	9 (16.4)	0.789

COPD: Chronic Obstructive Pulmonary Disease; GCS: Glasgow Coma Scale; IQR: Interquartile Range; SD: Standard Deviation; SDAHC: shunt-dependent acute hydrocephalus; SSRIs: Selective Serotonin Reuptake Inhibitors; WFNS: World Federation of Neurosurgical Societies Scale.

RESULTS

Neuroimaging data and hemorrhage volumes

Variable	Total (N=170)	Non-SDAHC (N=115)	SDAHC (N=55)	P
*Vascular territory**				
Anterior (vs posterior) circulation, n (%)	145 (85.3)	101 (87.8)	44 (80)	0.178
*Aneurysm characteristics***				
Aneurysm size (median, IQR)	6 (5.1)	8 (3.9)	9 (5.1)	0.34
Multiple aneurysms, n (%)	51 (30)	34 (29.6)	17 (30.9)	0.858
*Bicaudate index**				
Bicaudate index (median, IQR)	0.19 (0.08)	0.17 (0.01)	0.23 (0.01)	<0.001
Bicaudate index > 0.2	73 (43.5)	33 (29.2)	40 (72.7)	<0.001
*Hemorrhage volumetry**				
Total hemorrhage (median, IQR) cm^3	28.5 (33.6)	23.5 (32)	38.27 (38.7)	<0.001
SAH (median, IQR) cm^3	19.7 (27.8)	18.9 (27.4)	24.5 (40)	0.088
IPH (median, IQR) cm^3	0 (0)	0 (0)	0 (0)	0.224
IVH (median, IQR) cm^3	0 (7.2)	0 (2.3)	6.7 (19.3)	<0.001
*Dichotomized volumes**				

IQR: Interquartile Range; SAH: subarachnoid hemorrhage; SDAHC: shunt-dependent acute hydrocephalus; IPH: intraparenchymal hemorrhage; IVH: intraventricular hemorrhage.
* Measured in CT angiography and digital subtraction angiography (DSA)
** Measured in brain-CT

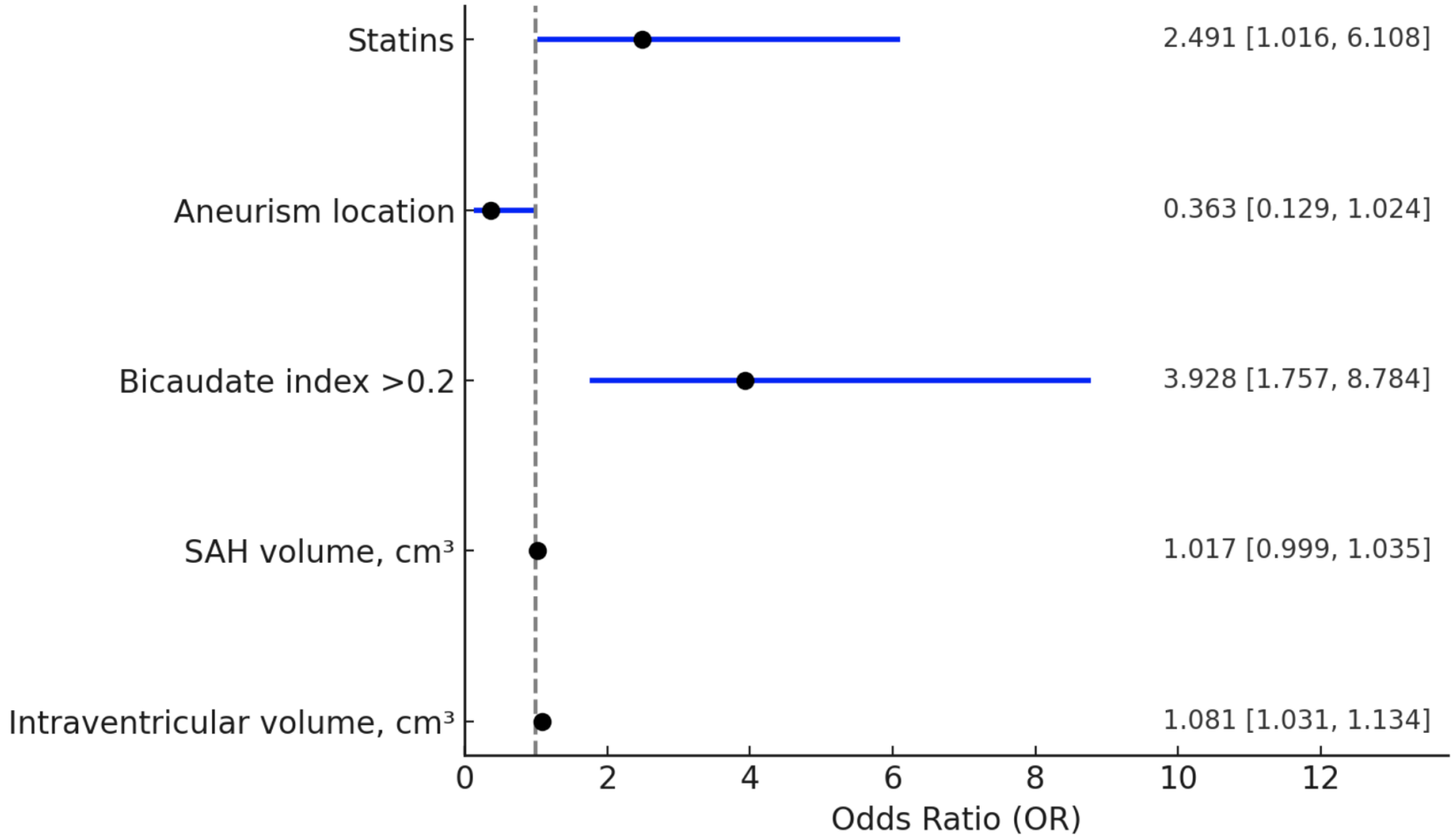
RESULTS

Neurosurgical treatment

Variable	Total (N=170)	Non-SDAHC (N=115)	SDAHC (N=55)	P
Treatment modalities				
Endovascular Coiling, n (%)	146 (85.9)	99 (86.1)	47 (85.5)	0.912
Neurosurgical clipping, n (%)	0 (0)	0 (0)	0 (0)	-
Decompressive craniectomy, n (%)	14 (8.2)	10 (8.7)	4 (7.3)	0.752
Acute stage shunting (<72h)				
EVD alone, n (%)	13 (7,6)	0 (0)	13 (23,6)	<0,001
EVD followed by VP shunt, n (%)	13 (7,6)	0 (0)	13 (23,6)	<0,001
VP shunt alone, n (%)	29 (17,1)	0 (0)	29 (52,7)	<0,001
Subacute stage shunting (3-14 days)				
VP shunt, n (%)	4 (2,4)	4 (3,5)	0 (0)	0,306
Late shunting (>14 days)				
VP shunt, n (%)	9 (5,3)	9 (7,8)	0 (0)	0,032

MULTIVARIATE ANALYSIS OF FACTORS RELATED TO THE DEVELOPMENT OF SHUNT-DEPENDENT ACUTE HYDROCEPHALUS

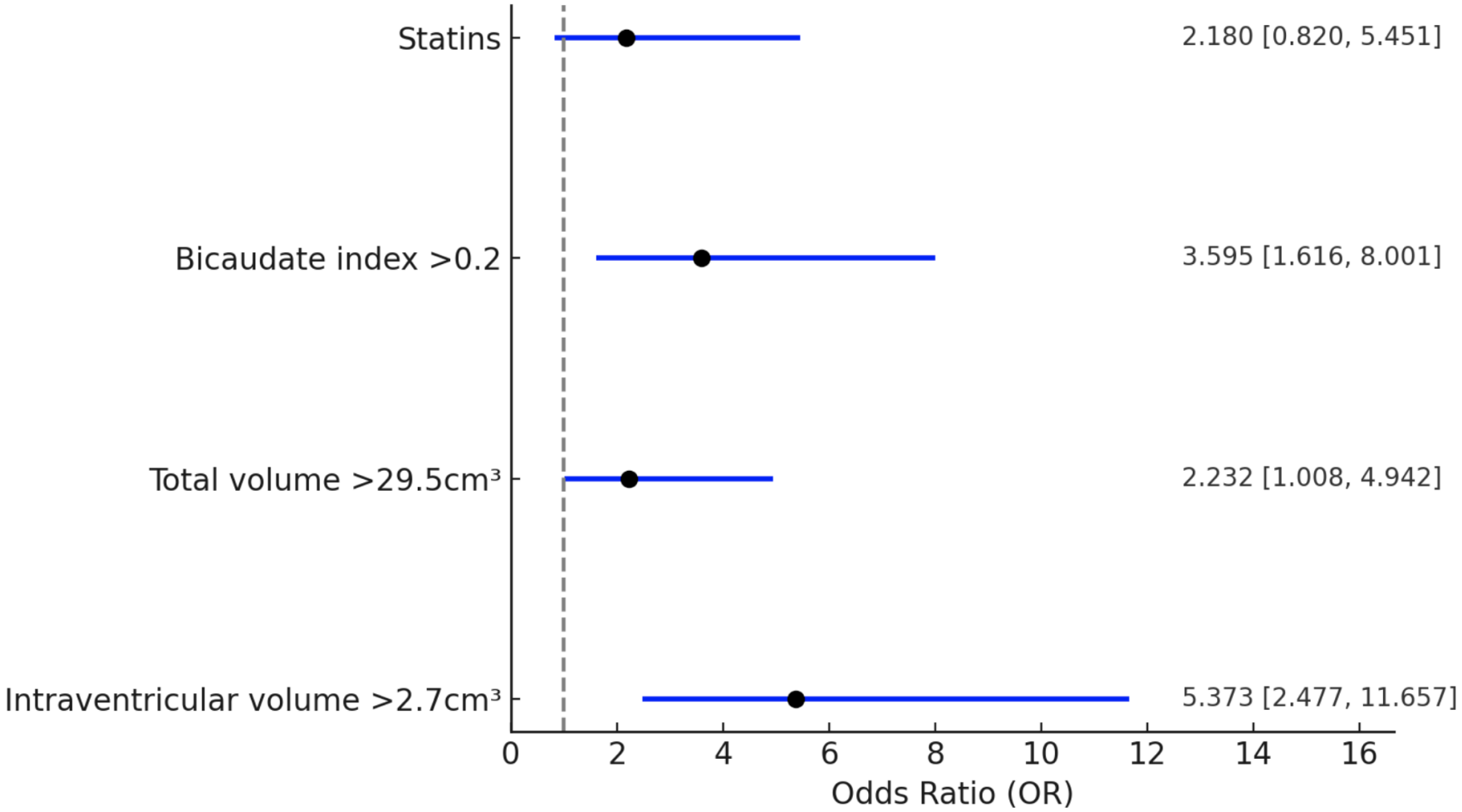
Model 1: Volumetry of the hemorrhage as continuous variable



Adjusted by baseline data and previos treatments, SAH severity (GCS, Fisher grade, WFNS grade), glycaemia, diastolic BP, aneurism locations, bicaudate index, volumetry of the hemorrhage

MULTIVARIATE ANALYSIS OF FACTORS RELATED TO THE DEVELOPMENT OF SHUNT-DEPENDENT ACUTE HYDROCEPHALUS

Model 2: Volumetry of the hemorrhage as volumetry of the hemorrhage as dichotomized variables



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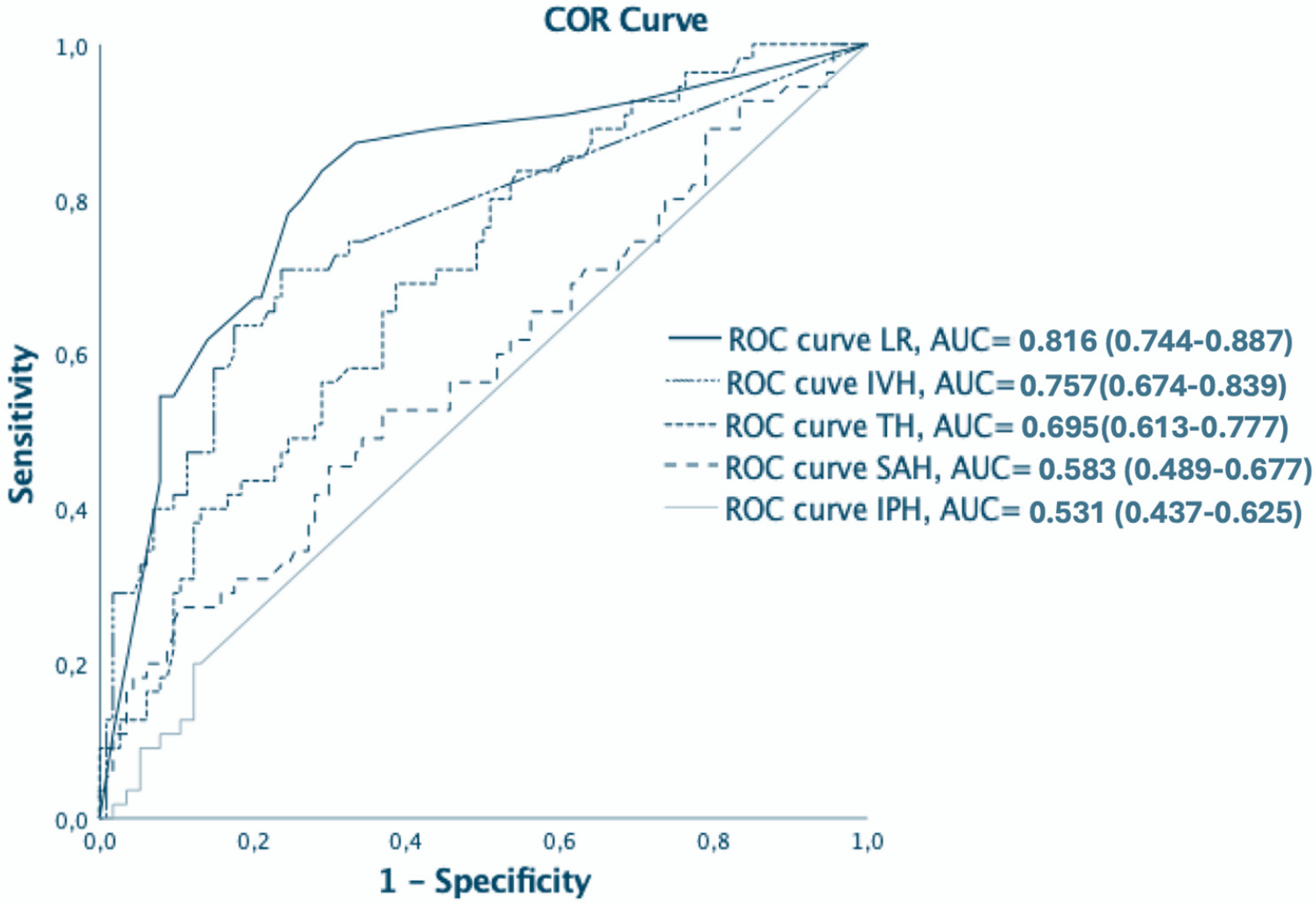
ROC curves



IVH volumes: AUC 0.757 (95% CI: 0.674-0.839; p <0.001).

IVH volume > 2.7 cm: Sensitivity 70.9% and Specificity 77.2% for predicting SDAHC

TH volumes > 29.5 cm: Sensitivity 69.1% and a Specificity 61.4% for predicting SDAHC

CONCLUSIONS

- To the best of our knowledge, this is the first study to demonstrate an association between semiautomated measurement of hemorrhage volume from brain CT and the development of SDAHC in aSAH patients.
- This association was independent of other prognostic factors, including demographic and clinical data.
- Despite the presence of blood in various compartments (cisternal, intraventricular, or intraparenchymal), the most significant prognostic indicators for SDAHC were intraventricular bleeding and the total hemorrhage volume, as well as the bicaudate index.

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Early prediction and timely intervention

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