



# **Predictive Accuracy of Black Hole Sign and Spot Sign for Hematoma Expansion in Spontaneous Intracerebral Hemorrhage**

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# Background

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- Spontaneous intracerebral hemorrhage (sICH) is a severe subtype of stroke.
- sICH accounts for 10-15% of all cases of stroke
- sICH has high early mortality and poor outcome.
- Hematoma expansion (HE) is associated with worse clinical outcome.



# Background

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- The computed tomography angiography (CTA) **spot sign** has been found to be significantly associated with HE in previous studies.
- Dr. Li reported a novel HE predictor on non-contrast computed tomography (NCCT), the **black hole sign**.
- However, the predictive values of CTA spot sign and NCCT black hole sign have not been compared in the same cohort of sICH patients.



# Methods

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- This retrospective study was based on database in our department between February 2015 and April 2016.
  
- Inclusion criteria:
  - (1) Adult sICH patients diagnosed by computed tomography (CT);
  - (2) CTA was performed within 6 hours after ictus of sICH;
  - (3) Follow-up NCCT was performed within 24 hours after CTA.
  
- Exclusion criteria:
  - (1) Secondary intracerebral haemorrhage;
  - (2) Insufficient imaging information including initial CTA or follow-up NCCT;
  - (3) Hematoma evacuation before follow-up NCCT.



# Methods

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## ➤ Criteria for spot sign:

- (1) At least 1 focus of contrast pooling within the ICH: high Hounsfield unit (HU) value ( $>120$ );
- (2) Discontinuous from normal or abnormal vasculature adjacent to the ICH;
- (3) Any size and morphology.

## ➤ Criteria for black hole sign:

- (1) relatively hypoattenuated area (black hole) encapsulated within the hyperattenuating hematoma;
- (2) The black hole could be round, oval, or rod-like but was not connected with the adjacent brain tissue;
- (3) The relatively hypoattenuated area should have an identifiable border;
- (4) The hematoma should have at least a 28 Hounsfield unit (HU) difference between the 2 density regions.

A

# Methods

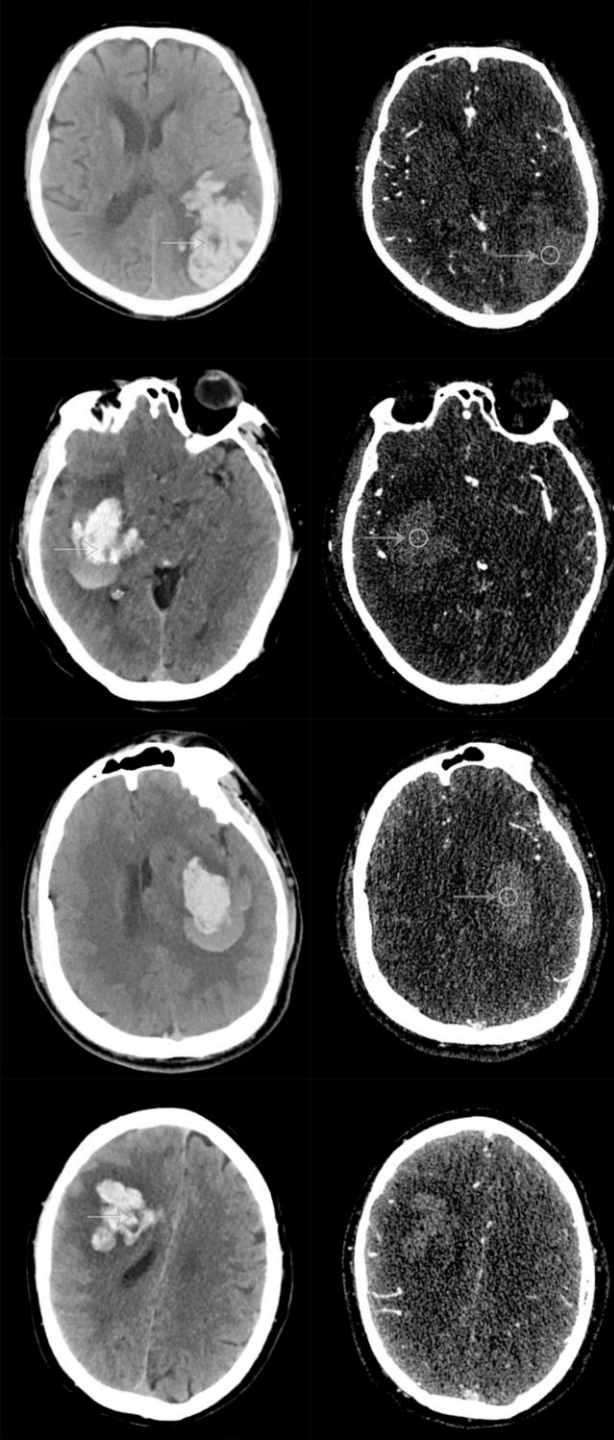
B

**Figure 1:** Illustration of the computed tomographic angiography (CTA) spot sign and the non-contrast computed tomographic (NCCT) black hole sign:

C

A and B, Different locations of hematoma with black hole sign (+) and spot sign (+). C, black hole sign (-) and Spot sign (+). D, black hole sign (+) and Spot sign (-).

D





# Methods

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➤ Volume of hematoma was calculated with  $A*B*C/2$  method:

A: the largest diameter on the largest hemorrhage slice;

B: the maximal diameter perpendicular to A;

C: the vertical hematoma depth.

➤ Hematoma expansion (HE):

An absolute increase  $>12.5$  mL or a relative increase  $>33\%$  in hematoma volume on follow-up NCCT.



# Methods

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- Spearman's correlation analysis: to investigate the association between the spot sign and the black hole sign;
- Multivariable logistic regression: to adjust the odds ratio (OR) and 95% confidence interval (CI) of the black hole sign and the spot sign;
- Receiver-operator analysis : to analyze the roles of the black hole sign and the spot sign in predicting HE;
- Z test: to compare the area under the receiver-operating characteristic(ROC) curves of the black hole sign and the spot sign.





# Results

	Patients with HE (n=32)	Patients without HE (n=97)	P
Mean age (yrs)	58.5±12.0	59.1±11.5	0.799
Sex, male	26	68	0.219
Admission SBP(mmHg)	178±29	170±30	0.137
Admission DBP(mmHg)	106±16	99±19	0.055
Hypertension	16	43	0.577
Diabetes mellitus	4	4	0.088
Previous stroke	1	6	0.508
Smoking	15	31	0.127
Alcohol consumption	16	32	0.084
PLT (10 <sup>9</sup> /L)	144±55	150±56	0.557
PT (s)	11.0±0.8	11.1±1.3	0.659
APTT (s)	27.9±2.6	27.4±6.3	0.669
INR	0.93±0.07	0.94±0.12	0.647
Time to CTA (hrs)	3.16±1.44	4.00±1.35	0.003
Hematoma volume (ml)	32.67±16.02	24.00±23.45	0.054
Black hole sign	14	15	0.001
Spot sign	19	11	<0.001

**Table 1:** Baseline characteristics

Data are mean  $\pm$  SD or number of patients. HE=hematoma expansion; SBP=systolic blood pressure; DBP=diastolic blood pressure; PLT= platelet count; PT= prothrombin time; APTT= activated partial thromboplastin time; INR= international normalized ratio; CTA= computed tomography angiography.



# Results

Predictors	Number of cases	Number of HE (%)
Spot sign(+), Black hole sign(+)	16	12 (75%)
Spot sign(+), Black hole sign(-)	14	7 (50%)
Spot sign(-), Black hole sign(+)	13	2 (15%)
Spot sign(-), Black hole sign(-)	86	11 (13%)

**Table 2:** Hematoma expansion in patients with spot sign or black hole sign.  
HE=hematoma expansion

Significant association between the spot sign and the black hole sign was found (Spearman correlation coefficient=0.407,  $P<0.001$ )



# Results

Values	Hematoma expansion		
	OR	95% CI	P
DBP-for every 1mmHg increase	1.024	0.996-1.051	0.089
Time to CTA – for every 1 hrs increase	0.649	0.446-0.945	0.024
Baseline hematoma volume – for every 1 ml increase	1.012	0.990-1.034	0.298
Diabetes mellitus	0.793	0.082-7.656	0.841
Alcohol consumption	1.942	0.723-5.221	0.188
Spot sign	10.689	3.735-30.585	<0.001

**Table 3:** Multivariate analysis for spot sign

DBP = Diastolic blood pressure; CTA = Computed tomography angiography



# Results

Values	Hematoma expansion		
	OR	95% CI	P
DBP-for every 1mmHg increase	1.024	0.996-1.051	0.089
Time to CTA – for every 1 hrs increase	0.657	0.464-0.930	0.018
Baseline hematoma volume – for every 1 ml increase	1.009	0.990-1.029	0.361
Diabetes mellitus	2.031	0.311-13.248	0.459
Alcohol consumption	2.105	0.841-5.271	0.112
Black hole sign	4.090	1.520-11.002	0.005

**Table 4:** Multivariate analysis for black hole sign

DBP = Diastolic blood pressure; CTA = Computed tomography angiography



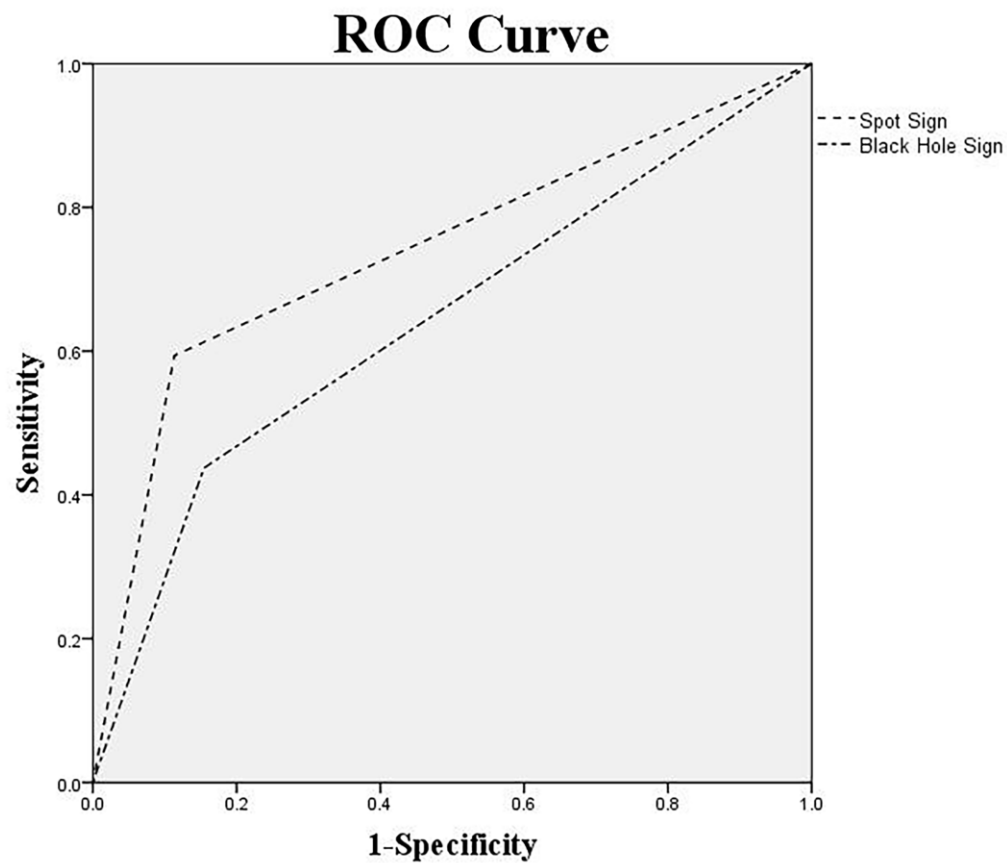
# Results

Predictor	Sensitivity	Specificity	PPV	NPV
Spot sign	59.38%	88.66%	63.33%	86.87%
Black hole sign	43.75%	84.54%	48.28%	82.00%

**Table 5:** Predictive values of spot sign and black hole sign for hematoma expansion  
PPV= positive predictive value; NPV= negative predictive value



# Results



**Figure 2:** Receiver-operating characteristic (ROC) curve by using a binary definition of hematoma expansion. The area under the curve of the spot sign=0.740 and the area under the curve of the black hole sign=0.641;  $P=0.228$ .



# Conclusions

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- ◆ The occurrence of black hole sign is significantly associated with spot sign.
- ◆ Both spot sign and black hole sign seem to have relatively good predictive values for HE.
- ◆ Spot sign appears to be a better predictor for HE.



# References

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**Thanks for attention !**