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CT angiography spot sign predicts in-hospital mortality in patients with secondary intracerebral hemorrhage

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Abstract

Background and objective—The presence of active contrast extravasation during CT angiography, the spot sign, is a potent predictor of in-hospital mortality in patients with primary intracerebral hemorrhage (ICH). However, its predictive value in patients with ICH due to a vascular abnormality, secondary ICH (SICH), is unknown. The aim of this study was to determine the clinical and radiological predictors of a spot sign and in-hospital mortality in patients with SICH.

Methods—Two experienced readers independently reviewed CT angiograms performed on 215 consecutive patients presenting to the emergency department with SICH over a 10-year period to assess the presence of spot signs according to strict radiological criteria. Differences in reader interpretation were resolved by consensus. Medical records were reviewed for baseline clinical characteristics and in-hospital mortality. Univariate and multivariate logistic regression analyses were performed to determine the clinical and radiological predictors of a spot sign and in-hospital mortality in patients with SICH.

Results—Spot signs were identified in 31 of 215 patients with SICH (14.4%), four of which were delayed spot signs (12.9%). Spot signs were most common in patients with arteriovenous fistulas (42%), Moyamoya (40%), elevated admission blood glucose (23%) and large intraventricular hemorrhage volumes (29%). Spot signs were most predictive of in-hospital mortality in patients with aneurysms of the anterior cerebral artery (100%) and anterior communicating artery (75%). In univariate analysis, the presence of a spot sign significantly

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increased the risk of in-hospital mortality in patients with SICH (38.7%, OR 2.2, 95% CI 1.0 to 4.9, $p=0.0497$). However, in multivariate logistic regression analysis the admission Glasgow Coma Scale was the only independent predictor of in-hospital mortality in patients with SICH (OR 2.8, 95% CI 1.6 to 5.1, $p=0.0004$).

Conclusion—The spot sign identifies patients with SICH at increased risk of in-hospital mortality. However, the admission Glasgow Coma Scale was the only independent predictor of in-hospital mortality in this cohort of patients with SICH.

INTRODUCTION

Non-traumatic intracerebral hemorrhage (ICH) accounts for 10–15% of cases of acute stroke in the USA¹ and has a worse prognosis than ischemic stroke, with a 30-day mortality of up to 50%.² The presence of active contrast extravasation during multidetector CT angiography (MDCTA)—the spot sign—is an indicator of active hemorrhage and has been found to be a potent predictor of hematoma expansion, mortality and poor outcome among survivors in patients with primary ICH.^{3–11}

However, these analyses have excluded patients with ICH due to an underlying vascular abnormality, or secondary ICH (SICH). As a result, the frequency and predictive value of the spot sign in this patient population has not been well established. One report of 24 patients with SICH examined with MDCTA found that none of the patients showed spot signs,¹² so no conclusions regarding the potential value of this finding in SICH could be drawn. It is therefore currently not clear whether this important MDCTA finding, which is a potent predictor of poor outcome in patients with primary ICH, has the same prognostic implications for patients with SICH.

This study aims to determine the clinical and radiological predictors of a spot sign and in-hospital mortality in a large cohort of patients with SICH examined with MDCTA.

METHODS

Patient selection

The study was approved by the hospital institutional review board and conducted in compliance with the Health Insurance Portability and Accountability Act. Informed consent was waived for this observational study. We conducted a retrospective review of all consecutive patients who presented to our emergency department from 1 January 2000 to 13 December 2009 with (1) non-traumatic ICH on a non-contrast CT (NCCT) scan of the head and (2) an underlying vascular etiology for the ICH demonstrated on a CT angiogram (CTA) of the intracranial circulation performed within 24 h of presentation.

Image acquisition

NCCT and MDCTA acquisitions were performed according to standard departmental protocols on 16- or 64-section General Electric helical CT scanners (GE Medical Systems, Waukesha, Wisconsin, USA). NCCT examinations were performed using axial technique with 120–140 kVp, 170 mA and 5 mm slice thickness reconstruction. MDCTA was subsequently performed by scanning from the base of the C1 vertebral body to the vertex using axial technique, 0.5 pitch, 1.25 mm collimation, 350 maximal mA, 120 kVp, 22 cm field of view and 65–85 ml of iodinated contrast material administered by power injector at 4–5 ml/s into an antecubital vein with either a fixed delay of 25 s between the onset of contrast injection and the start of scanning or Smart-Prep, an automatic contrast bolus triggering technique. The decision to perform MDCTA and to obtain delayed CTA acquisitions was at the discretion of the clinical providers. In general, delayed CTA

acquisitions in our patient cohort were performed to assess for delayed spot signs, dural venous sinus thrombosis (DVST) as the ICH etiology, or to differentiate between spot signs and aneurysms in difficult cases.

Image analysis

The NCCT examinations were reviewed by two experienced neuroradiologists to determine the ICH location (categorized as lobar, deep gray matter or infratentorial), the presence of associated intraventricular hemorrhage (IVH) and subarachnoid hemorrhage (SAH) in the basal cisterns and the presence of calcifications within or adjacent to the ICH.

Subsequently, the 1.25 mm axial CTA source images were independently reviewed in Spot Windows (width 200, level 110) by the same two experienced neuroradiologists to determine the presence of active contrast extravasation (the spot sign) according to previously described strict radiological criteria.⁹ If a delayed CTA acquisition was obtained, it was reviewed by the same two experienced neuroradiologists, blinded to the first-pass CTA, to determine the presence of spot signs according to the same strict radiological criteria.⁹ Differences in reader interpretation for the presence of spot signs were adjudicated by consensus.

Determination of the initial ICH and IVH volumes was performed independently and blinded to the CTA categorization with the Analyze 9.0 software (Mayo Clinic, Rochester, Minnesota, USA) by thresholding with manual hematoma outline adjustment in the baseline and first follow-up NCCT examinations. Hematoma expansion was not assessed as an outcome measure in this study because a follow-up NCCT was available in only 80 patients (37.2%), primarily due to the high frequency of surgical and endovascular interventions in this patient population.

Medical record review

Medical records were reviewed for time of ictus, patient age, gender, admission mean arterial blood pressure, admission Glasgow Coma Scale (GCS), international normalized ratio, blood glucose level, history of hypertension, antiplatelet therapy, hematoma evacuation during the hospitalization, length of hospital stay and in-hospital mortality. A known time of ictus was only recorded if the onset of symptoms was either witnessed or self-reported by the patient within a 15 min margin of error, as documented in the Neurology/Neurosurgery Emergency Department consultation note. For all other patients, including those patients who woke up with neurological symptoms, a known time of ictus was not recorded. Hematoma evacuation was categorized as immediate if it was performed within 4 h of admission to the emergency department and delayed if it was performed >4 h from admission to the emergency department (using the time of arrival to the operating room as the hematoma evacuation start time).

Statistical analysis

Statistical analysis was performed with the MedCalc 11.1 software package (MedCalc Software, Mariakerke, Belgium). We first performed univariate analysis with either the Pearson χ^2 test or Fisher exact test to determine the relationship between different clinical and NCCT variables and the presence of a spot sign and in-hospital mortality. We then constructed a multivariate logistic regression model to identify the independent predictors of a spot sign and in-hospital mortality among the NCCT and clinical variables. Finally, the multivariate logistic regression analysis for the prediction of in-hospital mortality was repeated including the presence of a spot sign as an additional variable. Interobserver agreement for the identification of a spot sign was determined with the κ statistic. $p < 0.05$ was considered statistically significant.

RESULTS

From 1 January 2000 to 13 December 2009, a total of 1042 patients presented to our emergency department with non-traumatic ICH on NCCT examination and were evaluated with a CTA of the intracranial circulation within 24 h of presentation. Of these, 215 had an underlying vascular etiology for the ICH demonstrated on the CTA (20.6%). Mean patient age was 52 years (median 53 years, range 10–92). One hundred and thirty one patients were women (60.9%) and 84 were men (39.1%). The vascular ICH etiologies in our cohort were aneurysm in 97 patients (45.1%), arteriovenous malformation (AVM) in 72 patients (33.5%), DVST in 24 patients (11.2%), arteriovenous fistula (AVF) in 12 patients (5.6%), Moyamoya in five patients (2.3%) and vasculitis in five patients (2.3%).

Mean time from emergency department admission to MDCTA evaluation was 2.2 h (median 1 h, range 0.25–24). Ninety-two patients had a known time of ictus (42.8%), with a mean time from ictus to MDCTA evaluation of 7.15 h (median 5 h, range 0.5–93). Delayed CTA images were acquired in 37 patients (17.2%) with a mean delay time of 161 s after the first-pass CTA (median 103 s, range 10–632). Mean initial ICH volume was 28.8 ml (median 19.4 ml, range 0.2–194). One hundred and thirteen patients had associated IVH (52.6%), with a mean initial IVH volume of 18.2 ml (median 7.9 ml, range 0.1–90). Eighty-four patients had associated SAH in the basal cisterns (39.1%).

Fifty-seven patients underwent immediate hematoma evacuation (26.5%), with a mean time from emergency department admission to hematoma evacuation of 1.7 h (median 1.5 h, range 0.5–3.7) and a mean initial ICH volume of 49.7 ml (median 46.6 ml, range 3.4–194). Fifty-nine patients underwent delayed hematoma evacuation during the hospitalization (27.4%), with a mean time from emergency department admission to hematoma evacuation of 56.6 h (median 15.1 h, range 4.3–582.5) and a mean initial ICH volume of 23.8 ml (median 14.4 ml, range 0.2–126.7). Ninety-nine patients did not undergo hematoma evacuation during the hospitalization (46.1%), with a mean initial ICH volume of 19.8 ml (median 12.6 ml, range 0.2–151.2). Mean length of hospital stay was 15 days (median 11 days, range 1–69).

Clinical and NCCT predictors of a spot sign and in-hospital mortality in SICH

Table 1 provides a summary of the clinical and NCCT predictors of a spot sign and in-hospital mortality in our patient population. We identified at least one spot sign in 27 of the 215 first-pass CTAs (12.6%) and in six of the 37 delayed CTA acquisitions (16.2%). Four of the 27 patients with a spot sign identified on the first-pass CTA also had a delayed CTA acquisition performed (14.8%); in these delayed CTA acquisitions, the spot signs were re-demonstrated in two patients and disappeared in the other two patients. Of note, in four patients the spot signs were present in the delayed CTA acquisition only and were designated as delayed spot signs. Overall, we identified at least one spot sign in 31 patients (14.4%), four of which were delayed spot signs (12.9%). Interobserver agreement for the identification of spot signs was excellent ($\kappa=0.84$, 95% CI 0.7 to 0.98).

Spot signs were significantly more common in patients with SICH with elevated admission blood glucose levels, larger initial IVH volumes, and in patients with AVFs (figure 1) and Moyamoya. In multivariate logistic regression analysis, admission blood glucose level (OR 2.57, 95% CI 1.0 to 6.6, $p=0.0496$) and initial IVH volume (OR 1.66, 95% CI 1.1 to 2.5, $p=0.0167$) were the independent predictors of a spot sign in SICH.

In-hospital mortality was significantly higher in patients with SICH with elevated admission mean arterial blood pressure, admission GCS ≤ 8 , elevated admission blood glucose level, larger initial ICH and IVH volumes, associated SAH in the basal cisterns and immediate

hematoma evacuation. In multivariate logistic regression analysis, admission GCS (OR 2.8, 95% CI 1.6 to 5.0, $p=0.0005$) was the only independent predictor of in-hospital mortality in our patient cohort.

The spot sign in the prediction of in-hospital mortality in SICH

Table 2 summarizes the spot sign frequency and its accuracy for the prediction of in-hospital mortality in all patients with SICH as well as by ICH etiology in our cohort. Twelve of the 31 patients with a spot sign died during the hospitalization (38.7%) and 19 survived (61.3%). Of the 184 patients without a spot sign, 41 died during the hospitalization (22.3%) and 143 survived (77.7%). Two of the four patients with a delayed spot sign died during the hospitalization (50%). Of note, the two patients with spot signs identified in both the first-pass and delayed CTA acquisitions died while the two patients with spot signs identified in the first-pass CTA that disappeared in the delayed CTA acquisition survived.

Overall, the presence of a spot sign predicted a significantly increased risk of in-hospital mortality in our patient population (positive predictive value (PPV) 38.7%, OR 2.2, 95% CI 1.0 to 4.9, $p=0.0497$). However, in multivariate logistic regression analysis, the presence of a spot sign was not an independent predictor of in-hospital mortality (OR 1.63, 95% CI 0.6 to 4.7, $p=0.35$) in patients with SICH. Admission GCS remained as the only independent predictor of in-hospital mortality when the spot sign was included in the model (OR 2.8, 95% CI 1.6 to 5.1, $p=0.0004$).

Of note, spot signs were most predictive of in-hospital mortality in patients with anterior cerebral artery aneurysms (PPV 100%, figure 2), anterior communicating artery aneurysms (PPV 75%), DVST (PPV 50%) and Moyamoya (PPV 50%).

Effect of the spot sign on the relationship between hematoma evacuation and in-hospital mortality in patients with SICH

In our cohort, 57 patients underwent immediate hematoma evacuation (26.5%), 59 underwent delayed hematoma evacuation (27.4%) and 99 did not undergo hematoma evacuation (46.1%). Overall, there was no difference in in-hospital mortality between patients who underwent hematoma evacuation (26.7%) and those who did not (22.2%, $p=0.44$). However, we found significantly higher in-hospital mortality in patients who underwent immediate hematoma evacuation (36.8%) compared with the other two patient groups ($p=0.034$, table 1). Of note, patients who underwent immediate hematoma evacuation were significantly more likely to have an admission GCS ≥ 8 (73.7%) than those who underwent either delayed hematoma evacuation (28.8%) or no hematoma evacuation during the hospitalization (30.3%, $p<0.0001$).

In the 184 patients with SICH without spot signs, we found significantly higher in-hospital mortality in the 46 patients who underwent immediate hematoma evacuation (39.1%) than in the 138 patients who underwent either delayed or no hematoma evacuation (16.7%, OR 3.2, 95% CI 1.5 to 6.8, $p=0.0015$). However, among the 31 patients with SICH with spot signs, we found lower in-hospital mortality in the 11 patients who underwent immediate hematoma evacuation (27.3%) than in the 20 patients who underwent either delayed or no hematoma evacuation (45%), although this difference did not reach statistical significance ($p=0.28$).

Effect of the spot sign on length of hospital stay in patients with SICH

Overall, there was no significant difference in mean length of hospital stay between patients with spot signs and those without spot signs (14.3 vs 15.1 days, $p=0.73$). Among the 53 patients who died during the hospitalization, those with spot signs had slightly shorter hospital stays than those without spot signs (5.8 vs 8.2 days, $p=0.32$). Among the 162

patients who survived the hospitalization, those with spot signs had slightly longer hospital stays than those without spot signs (19.7 vs 17.1 days, $p=0.4$).

DISCUSSION

We have shown that, applying strict radiological criteria for the identification of a spot sign,⁹ this important MDCTA finding can be identified in approximately 14% of patients with SICH. The frequency of spot signs in SICH appears to be lower than in primary ICH, which has been reported to range from 19 to 56% in previous studies.^{3–11}

Interobserver agreement for the identification of spot signs in patients with SICH was excellent ($\kappa=0.84$), which was similar to that in patients with primary ICH ($\kappa=0.86–0.92$).¹⁰ We found that, in order to diagnose a spot sign confidently in patients with SICH, careful review of the NCCT is important to exclude an AVM calcification that may mimic a spot sign in the CTA source images, and careful inspection of the CTA source images is crucial to ensure discontinuity of the spot sign from the abnormal vasculature adjacent to the ICH.

The overall accuracy of a spot sign for the prediction of in-hospital mortality in SICH (72%) was similar to that previously reported in patients with primary ICH (71%),¹⁰ with particularly high specificity (88%) and negative predictive value (78%) in the current study. Hence, this MDCTA finding may be valuable in determining the short-term prognosis of patients with SICH. However, due to the high frequency of surgical and endovascular interventions, which resulted in a large proportion of patients without a follow-up NCCT scan available in our study (62.8%), we were unable to assess the predictive value of the spot sign for hematoma expansion in patients with SICH. In fact, it may be that patients with continued bleeding preferentially suffered neurologic deterioration, triggering a rapid surgical or endovascular intervention before a follow-up NCCT scan could be performed. However, our study did not examine the selection criteria for surgical or endovascular interventions. Thus, although hematoma expansion is the most likely mechanism that would explain the effect of the spot sign on in-hospital mortality in patients with SICH, the retrospective design of our study did not allow us to ascertain this relationship. Nevertheless, the fact that, in our study, spot signs were demonstrated relatively frequently in patients with SICH and were predictive of an increased risk of in-hospital mortality supports the notion that this important MDCTA finding denotes ongoing bleeding, regardless of the ICH etiology.

Among the patients with SICH with spot signs in our cohort, we found lower in-hospital mortality in those who underwent immediate hematoma evacuation than in those who did not, although this difference did not reach statistical significance. These findings suggest that patients with SICH with spot signs may benefit from immediate hematoma evacuation since they are likely to be experiencing continued bleeding. However, since the difference in in-hospital mortality did not reach statistical significance, this remains hypothetical in nature. In addition, many other factors such as patient age, admission GCS and initial ICH and IVH volumes are also important when deciding whether to undertake immediate hematoma evacuation in these patients. A future prospective study with a larger patient cohort may help to elucidate the role of the spot sign, if any, in selecting patients with SICH for hematoma evacuation.

The significance of the relationship between the spot sign and in-hospital mortality in univariate analysis disappeared in the multivariate logistic regression model, with the only independent predictor of in-hospital mortality in our cohort being admission GCS. Notably, spot signs were relatively common in patients with low admission GCS. This suggests that the effect of the spot sign on in-hospital mortality may be mediated through its association

with admission GCS—spot signs may mark those patients with more damage to the blood–brain barrier or greater neuronal injury which manifests as a lower GCS score. However, since the relationship between spot signs and admission GCS did not reach statistical significance, this is hypothetical in nature. A future study with a larger patient cohort may help to elucidate these interactions.

Previous studies have underscored the value of delayed CTA acquisitions in increasing the sensitivity and overall accuracy of the spot sign for the prediction of hematoma expansion in patients with primary ICH.⁷¹¹ Unfortunately, the small sample size of patients with SICH with a delayed spot sign in our study does not allow us to draw any conclusions regarding in-hospital mortality. However, delayed CTA acquisitions are useful in differentiating a spot sign from an aneurysm or small AVM in the first-pass CTA. In a delayed CTA acquisition, a spot sign should change in configuration and attenuation relative to the vasculature adjacent to the hematoma since the extravasated contrast mixes with the blood within the hematoma. However, in a delayed CTA acquisition, an aneurysm or small AVM should maintain its morphology and have the same attenuation as the vasculature adjacent to the hematoma.

The limitations of this study are its retrospective design, the inability to assess the predictive value of the spot sign for hematoma expansion and the lack of delayed CTA acquisitions in all patients. The latter may have led to an underestimation of the frequency of spot signs as well as the sensitivity of the spot sign for the prediction of in-hospital mortality in our study group.

CONCLUSION

The spot sign identifies patients with SICH at increased risk of in-hospital mortality. However, admission GCS was the only independent predictor of in-hospital mortality in our cohort of patients with SICH.

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Figure 1.

A 44-year-old woman presented with headache and right-sided weakness. (A) Non-contrast CT scan showing a left parietal intracerebral hemorrhage (18.4 ml) with a small associated left frontal subdural hemorrhage. (B) Coronal maximum intensity projection image of CT angiogram in spot windows showing a left parietal arteriovenous fistula (arrowheads) with a separate small focus of contrast pooling within the intracerebral hemorrhage (arrow), consistent with a spot sign. The patient underwent endovascular embolization of the arteriovenous fistula and was discharged home 9 days after admission.

Figure 2.

A 64-year-old woman presented with the ‘worst headache of her life’ followed by obtundation. (A) Non-contrast CT (NCCT) scan showing a left inferior frontal intracerebral hemorrhage (24.8 ml) with associated intraventricular hemorrhage (55 ml) and subarachnoid hemorrhage in the basal cisterns. (B) CT angiogram source image in spot windows showing an aneurysm of the A2 segment of the right anterior cerebral artery (arrowhead) with a separate focus of contrast pooling within the intracerebral hemorrhage (arrow), consistent with a spot sign. (C) Follow-up NCCT scan 3.5 h after the baseline CT angiogram showing marked interval increase in the size of the intracerebral hemorrhage (72.6 ml) and the intraventricular hemorrhage (215.2 ml). The patient died shortly after the follow-up NCCT scan.

Table 1

Clinical and NCCT predictors of a spot sign and in-hospital mortality in SICH

	Spot sign frequency, n (%)	p Value*	In-hospital mortality, n (%)	p Value*
All patients, n=215	31 (14)	NA	53 (25)	NA
Sex				
Men, n=84	15 (18)	0.25	16 (19)	0.13
Women, n=131	16 (12)		37 (28)	
Age, years				
10–45, n=69	15 (22)	0.067	13 (19)	0.39
46–70, n=116	11 (10)		32 (28)	
71–92, n=30	5 (17)		8 (27)	
Time from ictus to CTA, h				
3, n=28	3 (11)	0.57	6 (21)	0.49
>3– 6, n=32	7 (22)		10 (31)	
>6, n=32	5 (16)		5 (16)	
Unknown, n=123	16 (13)		32 (26)	
Admission MABP, mm Hg				
100, n=143	20 (14)	0.33	26 (18)	0.0078
101–120, n=52	6 (12)		19 (37)	
>120, n=20	5 (25)		8 (40)	
Admission INR				
<1.5, n=202	29 (14)	1.0	48 (24)	0.32
1.5, n=13	2 (15)		5 (39)	
Admission GCS				
8, n=89	17 (19)	0.25	43 (48)	<0.0001 †
9–12, n=30	3 (10)		3 (10)	
13, n=96	11 (12)		7 (7)	
History of hypertension				
Yes, n=72	10 (14)	0.89	20 (28)	0.50
No, n=143	21 (15)		33 (23)	
Antiplatelet therapy				
Yes, n=19	4 (21)	0.49	3 (16)	0.42
No, n=196	27 (14)		50 (26)	
Blood glucose 170 mg/dl				
Yes, n=74	17 (23)	0.014 †	31 (42)	<0.0001
No, n=141	14 (10)		22 (16)	
CTA diagnosis				
Aneurysm, n=97	13 (13)	0.031	32 (33)	0.076
AVM, n=72	9 (13)		11 (15)	
DVST, n=24	2 (8)		4 (17)	
AVF, n=12	5 (42)		2 (17)	

	Spot sign frequency, n (%)	p Value *	In-hospital mortality, n (%)	p Value *
Moyamoya, n=5	2 (40)		1 (20)	
Vasculitis, n=5	0 (0)		3 (60)	
ICH site				
Lobar, n=173	26 (15)	0.8	39 (23)	0.15
Deep gray, n=13	2 (15)		6 (46)	
Infratentorial, n=29	3 (10)		8 (28)	
Initial ICH volume, ml				
<30, n=138	14 (10)	0.056	27 (20)	0.002
30–59.9, n=47	10 (21)		11 (23)	
60, n=30	7 (23)		15 (50)	
Initial IVH volume, ml				
0, n=102	10 (10)	0.006 †	15 (15)	0.0004
0.1–4.9, n=45	3 (7)		11 (24)	
5–14.9, n=27	6 (22)		7 (26)	
15, n=41	12 (29)		20 (49)	
SAH in basal cisterns				
Yes, n=84	13 (16)	0.82	30 (36)	0.0026
No, n=131	18 (14)		23 (18)	
Hematoma evacuation				
Immediate, n=57	11 (19)	0.25	21 (37)	0.034
Delayed, n=59	5 (9)		10 (17)	
None, n=99	15 (15)		22 (22)	

AVF, arteriovenous fistula; AVM, arteriovenous malformation; CTA, CT angiogram; DVST, dural venous sinus thrombosis; GCS, Glasgow Coma Scale; ICH, intracerebral hemorrhage; INR, international normalized ratio; IVH, intraventricular hemorrhage; MABP, mean arterial blood pressure; NA, not applicable; NCCT, non-contrast CT; SAH, subarachnoid hemorrhage; SICH, secondary intracerebral hemorrhage.

Bold value indicates a statistically-significant difference in univariate analysis.

* Univariate analysis using χ^2 test for each of the clinical and NCCT predictors of a spot sign and in-hospital mortality.

† Independent predictor in multivariate logistic regression analysis (p 0.05). The multivariate logistic regression analysis for in-hospital mortality does not include the presence of a spot sign as a variable.

Table 2

Frequency and predictive value of the spot sign for in-hospital mortality in SICH

ICH etiology	Spot sign frequency (%)	Sensitivity	Specificity	PPV	NPV	Accuracy
All, n=215	31 (14)	23	88	39	78	72
Aneurysm, n=97	13 (13)	19	89	46	69	66
MCA, n=39	6 (15)	9	82	17	70	62
ACOM, n=26	4 (15)	33	94	75	73	73
ICA, n=14	0	NA	NA	NA	NA	NA
ACA, n=11	2 (18)	40	100	100	67	73
PCA, n=3	1 (33)	NA	67	0	100	67
PCOM, n=2	0	NA	NA	NA	NA	NA
PICA, n=2	0	NA	NA	NA	NA	NA
AVM, n=72	9 (13)	27	90	33	87	81
DVST, n=24	2 (8)	25	95	50	86	83
AVF, n=12	5 (42)	50	60	20	86	58
Moyamoya, n=5	2 (40)	100	75	50	100	80
Vasculitis, n=5	0	NA	NA	NA	NA	NA

ACA, anterior cerebral artery; ACOM, anterior communicating artery; AVF, arteriovenous fistula; AVM, arteriovenous malformation; DVST, dural venous sinus thrombosis; ICA, internal carotid artery; ICH, intracerebral hemorrhage; MCA, middle cerebral artery; NA, not applicable because either there were no patients with a spot sign or no patients expired during the hospitalization; NPV, negative predictive value; PCA, posterior cerebral artery; PCOM, posterior communicating artery; PICA, posterior inferior cerebellar artery; PPV, positive predictive value; SICH, secondary intracerebral hemorrhage.