**Standards for Detecting, Interpreting and Reporting NCCT Markers of ICH Expansion**

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**ABSTRACT**

Significant hematoma expansion (HE) affects one-fifth of people within 24 hours after acute intracerebral hemorrhage (ICH) and its prevention is an appealing treatment target. Although the CT-Angiography spot sign predicts HE, only a minority of ICH patients receives contrast injection. Conversely, non-contrast CT (NCCT) is used to diagnose nearly all ICH, so NCCT markers represent a widely-available alternative for prediction of HE. However, different NCCT signs describe similar features, with lack of consensus on the optimal image acquisition protocol, assessment, terminology and diagnostic criteria. In this review we propose practical guidelines for detecting, interpreting and reporting NCCT predictors of HE.

# INTRODUCTION

Spontaneous intracerebral hemorrhage (ICH) remains a major cause of morbidity and mortality worldwide.1,2 Unlike acute ischemic stroke, few interventions have been shown conclusively to improve clinical outcome after ICH.3,4 Amongst therapeutic targets, limiting significant hemorrhage expansion (HE) is an appealing goal in ICH acute care.5 Several lines of evidence converge to suggest that HE following admission is a potentially preventable independent predictor of early neurological deterioration and worse long-term outcomes.6,7 However, randomized clinical trials (RCT) using interventions to reduce HE have not been successful in providing a definitive therapy with significant impact on the extent of bleeding and functional outcome.8–11 Hitherto, many RCT employed an inclusive, unselected “all-comers” approach, where the intervention was applied regardless of HE risk. The overall estimate of treatment effect represented large heterogeneous populations,5 an approach which permits investigation of heterogeneity of treatment effect by baseline predicted risk of HE (e.g. by spot sign presence/absence). This highlights the importance of easy-to-use and widely available prediction models to stratify HE risk, to either target recruitment to selective RCTs, or investigate treatment effect modification. The spot sign provides a small improvement in the discrimination of a HE prediction model based on four simple clinical predictors (ICH volume, time since ICH onset, and antiplatelet/anticoagulant use).12Around 11-25% of ICH patients undergo CT angiography (CTA) during the acute phase in a RCT in high income countries,10,13 but very few if any patients will undergo this test in low-middle income countries. In this context, several non-contrast CT (NCCT) markers may be alternatives to the CTA spot sign to add discrimination to simple models for HE prediction.12,14 While many NCCT aspects of acute ICH have been shown to be associated with HE and poor outcome, there is no consensus on the methodology and diagnostic criteria to identify these markers, representing a major gap in the field. Furthermore, most of the currently available prediction models incorporating NCCT markers have not been externally validated, making it difficult to appreciate the incremental diagnostic value of every new sign.15,16 Therefore, we sought to comprehensively review the available evidence regarding NCCT markers and HE, propose and harmonize relevant terminology, and provide clear systematic guidelines for detection, interpretation and reporting of NCCT markers of HE in future research studies. Although the majority of ICH patients experience some degree of hematoma enlargement, in this review the term HE is used referring to significant (>33% and/or >6 mL) hemorrhage growth.

# METHODS

## Authors Selection

Potential contributors were identified by the coordinating team (AM, GB, JNG, AC) based on previous collaborations, known expertise in acute ICH imaging and a systematic literature review, as described in the supplemental material, where we also provided a systematic appraisal of quality and risk of bias of the currently available evidence. First and last authors of all relevant papers on the topic were contacted. The coordinating team drafted and circulated a study proposal and coauthors were contacted by email and asked to participate in February 2018. The expert panel formulating the recommendations was finalized in April 2018. Three additional coauthors were identified in October 2018, (AS, PS, RA-SS) and acted as internal reviewers of the consensus output.

## Consensus modified Delphi method

Working groups comprised of 2-4 coauthor teams were allocated specific subsections to draft, based on their most relevant expertise. After receiving sections drafts, the coordinating team built tables summarizing key aspects of consensus. A modified Delphi approach was then implemented to reach consensus.17,18 All contributors were asked to vote (agreement/disagreement) on every point of the tables, providing feedback and comments for improvement, especially in case of disagreement. Points that reached an agreement >80% were approved and included in the present guideline. Conversely, topics that did not reach an 80% agreement were revised by the responsible authors following feedback provided by the study group. A second round of consensus voting was performed asking all participants to rate the updated points that were not approved in the previous round. After a total of two rounds of voting all the recommendations were approved with a >90% agreement. The coordinating team drafted and circulated the final version of the manuscript and participants were asked to provide comments, disclosures and other relevant information. All coauthors approved the revised version of the paper in June 2019.

# IMAGE ACQUISITION

There is no consensus on the optimal acquisition parameters for NCCT markers detection, and NCCT acquisition protocols are inconsistently reported across publications. However, contrary to CTA acquisition parameters for spot sign detection, there is no evidence that NCCT acquisition parameters influence NCCT markers detection. Therefore, image acquisition should achieve the best balance possible between dose reduction and image quality as recommended by international guidelines19–21.

The majority of NCCT markers have been reported on standard 5-mm thickness axial slices and hence can be derived from sequential axial acquisitions. Swirl sign should be observed on axial and coronal planes. Thinner slices (3-mm) and coronal/sagittal reconstructions may help to distinguish hypodensities from partial volume effect.

# TERMINOLOGY AND DIAGNOSTIC CRITERIA

Figure 1 shows an illustrative image of all the NCCT markers described below and table 1 summarizes the suggested diagnostic criteria for each marker.

## Heterogeneous Density

Heterogeneous density of ICH is defined along an incremental continuum depicted on a five-point visual analog scale.22 For descriptive purposes, ICH are described as ‘heterogeneous’ when there are at least three foci of hypodensity within the hyperdense hematoma, assessed on the axial slice showing the largest cross-sectional area of hematoma (Barras density scale of III,IV and V).

## Swirl Sign

The swirl sign can be defined as the presence of one or more rounded, streak-like or irregular regions of hypoattenuation or isoattenuation (compared to the attenuation of brain parenchyma) within the hemorrhage.23,24 The swirl sign is not necessarily encapsulated within the bleeding margins and can connect with the surrounding brain structures. The identification of a swirl sign is based on visual inspection of the scan and does not require quantified attenuation values of the hypodense region. This sign should be observed on axial and coronal images.

## Hypodensities

Hypodensities are defined as any hypodense region (compared with the surrounding acute blood) encapsulated within the hemorrhage and lacking a clear connection with the brain parenchyma around the bleeding.25,26 Hypodensities can have any shape and dimension with clear-cut or poorly defined margins. Their detection should rely on visual inspection of axial NCCT images and does not require objective quantification of the attenuation values in HU. There is no evidence that greater density reduction or specific patterns of hypodensities correlate with HE.25 When a hypodense region is identified, the rater should follow its course through all the available NCCT slices to exclude the presence of a connection with areas surrounding the hemorrhage. When the rater cannot rule out a connection between the hypodensity and the surface of the hemorrhage using axial NCCT images, coronal and sagittal reconstruction should be used in the differential diagnosis and distinguish true hypodensities from partial volume effect.

## Black Hole Sign

The Black hole sign is defined as a relatively hypoattenuating area encapsulated within a hyperattenuating hematoma.27,28 The rater should identify a well-defined margin between the 2 regions and a density difference of at least 28 Hounsfield units. The hypoattenuating area (black hole) should not connect with the hematoma outer surface and can have any dimension and morphology. Of note, hypodense regions inside the hemorrhage with blurred unclear margins do not qualify as black holes. The rater should draw two ROIs to obtain an accurate measure of the density difference between the hypodense area and the surrounding hyperattenuating hemorrhage. The ROI in the hypodense region presumed to be a black hole sign should be delineated to cover the largest surface possible. The density measure of the hemorrhage containing a possible black hole should be obtained with a ROI placed in the most hyperattenuating area. The two ROIs should be placed in the same axial CT slice.

## Blend sign

The blend sign is defined as a relatively hypoattenuating area next to a hyperattenuating area of the hematoma, with a well-defined margin between the two regions and a density difference of at least 18 Hounsfield units.29–32 This density difference can be measured in a single point of each area or drawing a ROI of any size to automatically calculate the average density measured in HU. The relatively hypoattenuating area should not be encapsulated by the hyperattenuating region and can have any shape and dimension. The two regions with different density have to be easily recognizable with direct visual inspection of the scan without image zooming.

## Fluid Level

A fluid sedimentation level is the presence of at least one distinct area of ICH containing an area of low CT attenuation (hypodense to the brain) above and high CT attenuation (hyperdense compared to the brain) below a discrete straight line of separation, irrespective of its density appearance.33,34 The presence of a fluid level can be assessed with visual inspection of axial NCCT images without a quantification of the attenuation difference between the two regions.

## Irregular Shape

Irregularity of shape in ICH is defined along an incremental continuum of hematoma margin irregularity, depicted on a five point visual analog shape scale.22,35 In the original article introducing this sign, irregular shape was defined as the presence of 2 or more irregularities at the edge of a hematoma, joined or separate.22 This parameter is assessed on the axial slice showing the largest hematoma cross-sectional area. Irregular ICH are defined as those with ratings on the Barras shape scale of III, IV or V.

## Island Sign

The island sign consists of (1) ≥3 scattered small hematomas all separated from the main hematoma or (2) ≥4 small hematomas some or all of which may be connected with the main hemorrhage on one axial slice of hematoma.36–38 The scattered small hematomas (separate islands) can have a round or oval morphology and are disconnected from the main hematoma. The small hematomas that connect with the main hematoma (connected islands) should be bubble-like or sprout-like but cannot be lobulated, otherwise it may be confused with margins irregularity.

## Satellite Sign

The satellite sign depicts a hyperdense small hematoma (maximum diameter <10 mm) that is clearly separated from the main hemorrhage in at least one CT slice.39 The satellite sign has to be close to the main hematoma (maximum distance 20 mm) and can have any shape. Intraventricular hemorrhage (IVH) or subarachnoid extension of the main hematoma do not qualify as satellite sign. Satellite sign should not be confused with multiple simultaneous spontaneous hemorrhages seen in 1-2% of ICH cases, usually located in bilateral deep structures.40

## Overlap between different signs

The nomenclature and overlap between different ICH shape and density features is illustrated through a Venn diagram in figure 2.

### Overlap between ICH density features

* All swirl signs that are not connected with the brain parenchyma surrounding the hemorrhage qualify also for hypodensities.
* All black hole signs are also swirl signs and hypodensities. The inverse may not be true because hypoattenuating regions encapsulated in the hemorrhage are hypodensities positive but do not qualify as black hole signs if the density difference between the hypodense region and the surrounding hemorrhage does not reach the 28 HU cutoff. Likewise, hypodense regions that connect with the outer surface are swirl positive but cannot be defined as black hole signs.
* Fluid levels that are encapsulated in the hemorrhage without any connection with hematoma margins also qualify as hypodensities.
* Fluid levels can be considered blend sign positive as long as the density difference between the two regions reaches the 18 HU threshold proposed for blend sign detection.
* Hemorrhages with one or two hypodense regions have homogeneous density (Barras grade I or II) whereas patients with at least 3 hypodensities (irrespectively from size or degree of hypoattenuation) qualify as heterogeneous according to Barras (Barras Grade > III).
* Hemorrhages having just a blend sign should be categorized as homogeneous density (Barras I-II with two regions of different attenuation). The same applies for fluid level.

### Potential overlap between ICH shape features

* Hemorrhages with just one satellite sign are categorized as regular shape (Barras grade II) whereas hemorrhages with at least two satellites qualify as irregularly shaped hematomas (Barras grade> III).
* ICH shape variation with the Barras scale has to be evaluated on the largest axial NCCT slice. Therefore satellite signs identified on other slices should not be considered when grading ICH shape according to Barras scale.
* Island signs always qualify as irregular shape according to Barras (Barras grade> III for presence of at least three regions of irregularity in shape).
* Hemorrhages with at least three satellite signs are also considered island sign positive.
* Island sign positive ICH do not necessarily have satellite signs as wells. Diagnostic criteria for satellite sign require a clear separation from the main hemorrhage whereas multiple small hematomas that are connected and originate from the main hemorrhage may qualify as island sign.

# INTERPRETATION

## Pathophysiology

The CT imaging appearance of an ICH varies according to a number of factors that include the degree of hematoma “maturity” (e.g. bleeding at the time of image acquisition, time since blood extravasation) and other biological factors such as hematocrit and protein concentration.41 Acute bleedings are, however, almost constantly seen as hyperattenuating areas by comparison to the adjacent brain tissue, driven by the presence of intact globin within the extravasated red blood cells trapped in the hemorrhage.42

The most commonly accepted model for HE is the avalanche model: the initial vessel rupture is responsible for peripheral vessels shearing that rupture secondarily and maintain an active source of bleeding.43 In this model, the CT appearance of the hemorrhage results from a matrix of acute and subacute blood. Fresh blood coexists with a more subacute clot resulting in higher hemorrhage heterogeneity. Hyper-attenuating regions constitute more stable bleed areas and lower attenuating regions more immature areas, potentially explaining the higher prevalence of density heterogeneity in cases with subsequent HE. This sequential model is also supported by the observation that growing hemorrhages commonly assume irregular shape and can expand in different axial directions over time.44 Irregular hemorrhages may therefore be at an intermediate stage of maturity, with persisting bleeding or increased intrahemorrhage pressure favoring the bulging of the hematoma into surrounding brain structures. An alternative HE model is ongoing bleeding from the original source. The continuous bleeding from a single source follows a path of least resistance within and surrounding the hematoma which could also produce some of the various NCCT markers.45

## Association with ICH expansion and clinical outcomes

The association between NCCT signs and HE has been described in observational studies, RCT populations and meta-analyses based on summary data25,46–51. Table 2 illustrates the prevalence and test characteristics of different NCCT markers of HE. For clinical translation and use of NCCT markers, in addition to a strong independent association with HE,22,49 a relationship with clinical outcomes needs to be demonstrated. Some NCCT ICH features predictive of mortality and poor functional outcome have been described in observational ICH cohorts and in two large clinical trial populations (ATACH-II and INTERACT2). 26,49,51 The emerging picture is therefore that NCCT markers might be reliable predictors of HE and poor outcome in ICH, but with different effect size and strength of association.

Some limitations should be considered when interpreting the currently available evidence. First, most of the NCCT markers have been reported in single center cohorts with relatively small sample size. Second, different definitions of HE and poor prognosis have been used. Third, some studies excluded patients with ICH occurring during oral anticoagulant treatment and restricted the study population to subjects receiving a NCCT within 6 hours from onset. Fourth, several NCCT signs lack prospective validation and assessment of their inter and intra-rater reliability. Fifth, few studies compared the diagnostic performance of NCCT markers and it remains difficult to appreciate the added value of every newly described sign. Finally, it remains to be determined whether NCCT markers provide additional diagnostic value compared to the currently available models to predict HE and unfavorable outcome.52,53

## Relationship with the CT angiography Spot Sign

The relationship between the CTA spot sign and NCCT markers remains poorly characterized. Hypodensities and spot sign are more common in patients with large hemorrhages, coagulopathy and shorter time from onset to NCCT suggesting that these markers may reflect the same biological process.54 However, in a large retrospective single-center study the simultaneous presence of these markers was uncommon (less than 1 in 5 patients) and when included together in a logistic regression model, both hypodensities and spot sign remained independently associated with HE.54 Conversely, Sporns and colleagues showed that a significant proportion of blend sign positive patients also showed evidence of a spot sign.55 In summary, the limited available evidence suggests that there is some correlation between spot sign and NCCT markers but the direction and strength of this association may be different across NCCT signs. Spot sign may be further refined by evaluation with multiphase CTA. The more arterial the pattern of spot sign presentation, the greater the frequency of HE.56 The presence of early spot sign (<23 seconds after contrast injection) is a strong independent predictor of HE and this redefined early-occurring spot sign maintained a higher specificity for HE (91% vs 74%).57 Time resolved CTA can also be evaluated for progressive enhancing foci ("dynamic spot sign") that enlarges over time on successive phases.58 No studies comparing NCCT markers with early-appearing or dynamic spot signs has been performed.

Few studies compared the diagnostic performance of NCCT markers and spot sign for HE prediction.30,59,60 Validated NCCT-based scores to predict HE had a discriminative ability non-inferior to the CTA spot sign61,62. However, given the great heterogeneity in terminology, diagnostic criteria, HE definition, NCCT and CTA acquisition protocol63,64, a clear superiority of one approach over the others cannot be established at this stage. NCCT markers are not supposed to completely replace the CTA spot sign and there is preliminary evidence that a combined analysis of hypodensities and spot sign provides additional yield in the stratification of HE54. Further studies are needed to 1) compare the diagnostic performance of NCCT markers and spot sign and 2) explore whether the integration of these radiological markers improves the discriminative ability of the currently available models to predict HE.12

## Implications for clinical practice and future trials

NCCT is a reliable and widely available alternative to CTA for HE risk stratification65. Subjects with NCCT markers of HE are more likely to experience clinical deterioration and therefore closer neurological monitoring may be warranted. The lack of these NCCT signs may thus identify patients at lower risk of unfavorable clinical evolution, being more suitable for admission to general neurology wards, especially in settings with limited intensive care resources. Of note, CTA is a good screening tool for detection of vascular malformations in clinical practice and therefore ICH patients may receive iodine contrast to rule out a secondary cause of the bleeding66. In this case, CTA analysis for spot sign detection may provide useful information in the identification of patients at high risk of experiencing HE and clinical deterioration. Accurate estimation of ICH prognosis remains an unmet need and NCCT markers may provide clinicians67 with more insights into the natural history and long term consequences of the disease. However, the currently available evidence does not justify and support an extensive evaluation of NCCT ICH features in everyday clinical practice. From a therapeutic point of view, there is no evidence so far that subjects having NCCT signs derive benefit from anti-expansion therapies.49 NCCT markers may guide patients’ selection for future RCT targeting HE, as described in the priorities for future research section. Finally, time is brain in ICH as HE is a very early event in the natural history of the disease. Rapid prehospital diagnosis and treatment of ICH through mobile stroke units equipped with NCCT seems a feasible approach68. Conversely there are no data on CTA, feasibility, safety and diagnostic yield in the pre-hospital setting.

# **REPORTING STANDARDS**

## Reporting on NCCT Markers in the acute phase of ICH

NCCT markers of HE fall into two broad categories: a) density and b) shape variations, with an important degree of overlap amongst them in each category (Figure 2). Given the simplicity of the descriptors used to define NCCT markers, unified terminology will be critical for future research studies. We propose the following guidelines for NCCT markers rating and reporting:

* Categorize the NCCT marker as being an ICH shape feature or an ICH density feature.
* Provide a comparative analysis with existing markers in the descriptors category and compare new findings with existing literature.
* Report the methodology of training for every rater involved in NCCT scans evaluation. We suggest using the illustrative cases provided in the supplemental material for the raters’ training. These images may also be kept as reference templates during NCCT analysis.
* Clarify whether the raters are blinded to the outcome of interest.
* Clarify how disagreements are handled in case of multiple raters analyzing the same scans, and in this case quantify and report the inter- and intra-rater reliability.
* Provide details about NCCT acquisition protocol, adherence to the imaging recommendations and parameters described in the dedicated section of this manuscript.

## Reporting an association with Hematoma Expansion

### Intraparenchymal component

It has been shown that HE is associated with worse clinical course, regardless of how expansion or poor outcome are defined.6 However, to promote reproducibility across studies and harmonize the reporting of HE, we recommend the following points when reporting ICH volume evolution over time (e.g. hemorrhage stability or expansion/growth on longitudinal imaging):

* Hemorrhage volume should be ideally assessed using a semi-automated planimetric method, because the error margin of ellipsoid volume approximations (ABC/2 method) is too important relative to the hemorrhage volume change to be used in studies assessing hemorrhage growth.69
* Hemorrhage volume growth should be expressed in absolute and relative values, that is the absolute/relative increase in follow up hemorrhage volume by comparison to the baseline imaging (*Follow-upVolume – BaselineVolume*, in cube centimeters and *[Follow-upVolume – BaselineVolume]/BaselineVolume*, in %).
* The following dichotomous cut offs, having been most commonly used to define a clinically relevant hemorrhage growth, and therefore should be used in studies reporting hemorrhage growth *: increase in 6mL, 12.5 mL, 33%.*6
* A combined relative/absolute cut-off such as >6mL and/or >33%”6 is ideal to better consider hemorrhage volume increases in smaller (relative growth) and larger (absolute growth) ICH.
* We recommend that studies reporting HE should select one primary metric (absolute/relative/combined) and explore other definitions of HE as secondary outcomes of interest.6
* The ideal timing for assessing HE is unknown, however since HE is more common before 24 h, we recommend a minimum of 24 h before repeat imaging to assess final hemorrhage volume (if the patient is clinically stable); conversely, since edema and hemorrhage changes potentially influencing planimetric measurements begin to develop early after onset,70 we recommend that patients should not be re-scanned after 72 h with purpose of detecting HE.

### Intraventricular component

The presence and development of IVH poses additional challenges. IVH can distort anatomical landmarks and obscure the boundaries between parenchymal and ventricular hematomas, thereby contributing to measurement error.71 Furthermore, decompression of a parenchymal hematoma into the ventricular space can mask HE if only the parenchymal component is measured and reported, thereby underestimating the predictive performance of a radiological marker.72 For these reasons, outcome reporting should include the absolute total intracranial hematoma volume increase (parenchymal+ventricular), and where possible, the absolute increase of the respective parenchymal and ventricular components. An arbitrary cut-off of >2 mL has been used to define IVH growth73 but the ideal threshold for IVH expansion remains to be determined.

The recommended standards for detection of NCCT markers and reporting an association with HE are summarized in Table 3.

# CONCLUSION AND PRIORITIES FOR FUTURE RESEARCH

Although based on several studies with an overall low level of evidence and important limitations, our standards for detecting, reporting and interpreting NCCT markers of HE are intended as the first step to harmonize terminology, definitions and imaging rating methods. We encourage other clinical researchers in the field to consider these standards in the design of future studies on HE. Our critical next step would be to select, among almost a dozen markers already published with different definitions and findings, the 2-3 most clinically useful. We recommend to measure the diagnostic performance of NCCT markers using prediction models (model discrimination and calibration)74, and accuracy diagnostic statistics (sensitivity, specificity etc.).75,76 In particular, future studies should test the ability of NCCT signs to improve the discrimination of currently available models, based on simple and rapidly available predictors (ICH volume, NCCT timing, antiplatelet and anticoagulant treatment).12 Future studies should also prospectively evaluate the inter and intra-rater reliability of NCCT markers.

This approach, in combination with the current standards will allow cross-study comparisons and accelerate clinical translation of new findings in the acute ICH field. Standardized approaches could enable individual patient-data meta-analyses of RCT, which are increasingly needed to obtain the sample sizes necessary. We hereby invite other researchers to join us in this effort.

As a first step, previous RCT of expansion therapies should look back at NCCT scans and see if there is data on any findings that modify the effects of treatments. The currently available studies using the spot sign to select patients more likely to benefit from hemostatic treatment or intensive blood pressure lowering were underpowered because of recruitment challenges (STOP-IT, NCT00810888; SPOTLIGHT, NCT01359202)13. Therefore, a plausible next step may be a new trial using NCCT markers to guide therapy. Another exciting opportunity to optimize the use of NCCT markers is through artificial intelligence.77,78 Artificial intelligence algorithms may analyze NCCT and develop machine learning algorithms to predict HE.

Finally, the standards suggested in our paper, were developed on the basis of consensus from an expert panel of clinical researchers, active in the field, using a standardized approach. However, this is a rapidly evolving area, and some of our recommendations are based on evidence from small studies, and occasionally less validated findings. The fact that there are so many NCCT markers suggests that a signal for a significant association with HE is there, but more work is essential to clarify this, refine and validate these standards. As more data become available we will undertake periodic revisions and refinement of NCCT consensus standards. The proposed priorities for future efforts are summarized in Table 4. In the meanwhile, these standards and recommendations might facilitate a more consistent approach to the identification of NCCT markers in acute ICH patients in research studies and clinical practice.

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**AUTHOR CONTRIBUTIONS**

AM, GB, JNG and AC contributed to the conception and design of the study.

AM, GB, DD and AC drafted the manuscript and figures.

All Authors contributed to the acquisition and analysis of data.

**POTENTIAL CONFLICTS OF INTEREST**

None.

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**FIGURES**

**Figure 1.**

**Title.** Representative examples of NCCT markers of ICH expansion.

**Legend**

1. Regular shape (grade I) and homogeneous density (grade I).
2. Irregular shape (grade V) and heterogeneous density (grade V). Swirl sign (arrow).
3. Island sign (all arrows), satellite sign (black arrow only).
4. Fluid level (arrow).
5. Blend sign (arrow).
6. Hypodensities (all arrows), swirl sign (all arrows), black hole sign (dashed arrow only).

**Figure 2.**

**Title.** Venn Diagram of the potential overlap between the shape and density NCCT features of acute ICH.

**Legend.** NCCT indicates non contrast CT; ICH intracerebral hemorrhage.

# TABLES

**Table 1.** Diagnostic Criteria for NCCT markers

|  |  |
| --- | --- |
| **DENSITY MARKERS** | |
| **Heterogeneous Density** | At least 3 foci of hypoattenuation compared with the surrounding hematoma, evaluated on the axial NCCT slice showing largest ICH area. (Barras density scale III, IV or V). |
| **Swirl Sign** | Rounded, streak-like or irregular region of hypo or isoattenuation compared with the brain parenchyma. Does not have to be encapsulated in the ICH. |
| **Hypodensity** | Any hypodense region strictly encapsulated within the hemorrhage with any shape, size and density. Does not require density measurement. |
| **Black Hole Sign** | Hypoattenuating area with a density difference > 28 HU compared with the surrounding hematoma. No connection with surface outside the hematoma. |
| **Blend Sign** | Relatively hypoattenuating area next to a hyperattenuating area of the hematoma, with a well-defined margin and a density difference >18 HU between the two areas. |
| **Fluid Level** | Presence of one distinct hypoattenuating area (hypodense to the brain) above and one hyperattenuating area (hyperdense to the brain) below a discrete straight line of separation, irrespective of its density appearance. |
| **SHAPE MARKERS** | |
| **Irregular Shape** | 2 or more focal hematoma margin irregularities, joined or separate from the hematoma edge, evaluated on the axial NCCT slice showing the largest ICH area (Barras shape scale III, IV, V ). |
| **Island Sign** | At least 3 scattered small hematomas all separate from the main ICH or at least 4 small hematomas some or all of which may connect with the ICH |
| **Satellite Sign** | A small hematoma (diameter <10 mm) separate from the main hemorrhage in at least one slice and distinct from main hematoma by 1-20 mm separation. |

NCCT indicates non-contrast computed tomography; HU Hounsfield units; ICH intracerebral hemorrhage.

**Table 2.** Test Characteristics of NCCT markers of ICH expansion

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | |  |  |  |  |  |
| **NCCT marker** | **Prevalence, n (%)** | **ICH expansion** | **Sensitivity** | **Specificity** | **PPV** | **NPV** |
| **Hypodensities** |  |  |  |  |  |  |
| Boulouis et al 2016 | 321/1029 (31) | >33% or >6mL | 0.62 | 0.77 | 0.40 | 0.89 |
| Morotti et al 2017 | 264/989 (27) | >33% | 0.40 | 0.78 | 0.33 | 0.83 |
| **Black Hole Sign** |  |  |  |  |  |  |
| Li et al 2017 | 38/228 (17) | >33% or >12.5 mL | 0.34 | 0.90 | 0.58 | 0.77 |
| Li et al 2015 | 30/206 (15) | >33% or >12.5 mL | 0.32 | 0.94 | 0.73 | 0.73 |
| Yu et al 2017 | 29/129 (23) | >33% or >12.5 mL | 0.44 | 0.85 | 0.48 | 0.82 |
| **Swirl Sign** |  |  |  |  |  |  |
| Boulouis et al 2016 | 207/1029 (20) | >33% or >6mL | 0.62 | 0.16 | 0.16 | 0.62 |
| Morotti et al 2017 | 203/989 (21) | >33% | 0.33 | 0.83 | 0.34 | 0.82 |
| Connor et al 2015 | 33/71 (46) | >33% or >6mL | 0.67 | 0.62 | 0.42 | 0.82 |
| **Blend sign** |  |  |  |  |  |  |
| Boulouis et al 2016 | 141/1029 (14) | >33% or >6mL | 0.15 | 0.87 | 0.23 | 0.80 |
| Morotti et al 2017 | 86/989 (9) | >33% | 0.13 | 0.93 | 0.33 | 0.80 |
| Li et al 2017 | 46/228 (20) | >33% or >12.5 mL | 0.43 | 0.89 | 0.61 | 0.80 |
| Li et al 2015 | 29 /172 (17) | >33% or >12.5 mL | 0.39 | 0.96 | 0.83 | 0.74 |
| Zheng et al 2016 | 22/115 (19) | >33% or >12.5 mL | 0.43 | 0.89 | 0.55 | 0.83 |
| Wu et al 2017 | 13/63 (21) | >33% | 0.39 | 0.94 | 0.85 | 0.66 |
| **Irregular Shape** |  |  |  |  |  |  |
| Boulouis et al 2016 \* | 502/1029 (49) | >33% or >6mL | 0.66 | 0.56 | 0.28 | 0.87 |
| Morotti et al 2017 \* | 390/989 (39) | >33% | 0.49 | 0.64 | 0.27 | 0.82 |
| Blacquiere et al. 2015 \*\* | 178/311 (57) | >33% or >6mL | 0.69 | 0.46 | 0.35 | 0.78 |
| **Heterogeneous Density** |  |  |  |  |  |  |
| Boulouis et al 2016 \* | 282/1029 (27) | >33% or >6mL | 0.50 | 0.78 | 0.37 | 0.86 |
| Morotti et al 2017 \* | 310/989 (31) | >33% | 0.44 | 0.72 | 0.30 | 0.83 |
| Blacquiere et al. 2015 \*\* | 100 /311 (32) | >33% or >6mL | 0.44 | 0.72 | 0.40 | 0.76 |
| Yu et al 2017 \* | 40/137 (29) | >33% or >12.5 mL | 0.56 | 0.71 | 0.40 | 0.83 |
| **Fluid Level** |  |  |  |  |  |  |
| Blacquiere et al. 2015 | 22/311 (7) | >33% or >6mL | 0.15 | 0.94 | 0.50 | 0.73 |
| **Satellite Sign** |  |  |  |  |  |  |
| Yu et al 2017 | 58/153 (39) | >33% or >12.5 mL | 0.60 | 0.69 | 0.38 | 0.84 |
| **Island Sign** |  |  |  |  |  |  |
| Li et al 2017 | 41/252 (16) | >33% or >6 mL | 0.45 | 0.98 | 0.92 | 0.77 |
| Huang et al 2018 | 61/226 (23) | >33% or >6 mL | 0.48 | 0.92 | 0.54 | 0.68 |
| Zheng et al 2018 | 33/165 (20) | >33% or >12.5 mL | 0.46 | 0.89 | 0.58 | 0.83 |
| Zhang et al 2018 | 81/322 (25) | >33% or >12.5 mL | 0.45 | 0.88 | 0.70 | 0.71 |
| Zhang et al 2018 | 32/187 (17) | >33% or >12.5 mL | 0.49 | 0.98 | 0.94 | 0.80 |

ICH indicates intracerebral hemorrhage; NCCT, non-contrast CT; PPV positive predictive value; NPV, negative predictive value. \* Barras Grade > III. \*\* Barras Grade > IV.

**Table 3.** Reporting Standards for Future Research Studies

|  |
| --- |
| **IDENTIFICATION OF NCCT MARKERS** |
| Categorize the NCCT marker as being an ICH shape feature or an ICH density feature. |
| Provide a comparative analysis with existing literature. |
| Report the training duration and methodology of every rater |
| Clarify whether the raters were blinded to the outcome of interest. |
| In case of multiple raters measure and report the inter- and intra-rater reliability and clarify how disagreements in imaging analysis were adjudicated. |
| Provide details about the NCCT acquisition protocol. |
| **REPORTING AN ASSOCIATION WITH HEMATOMA EXPANSION** |
| Measure ICH volume with a semi-automated planimetric method. |
| Calculate ICH volume growth as absolute and relative values compared with baseline volume. |
| Use the following thresholds for clinically relevant ICH growth: > 6 mL, > 12.5 mL and > 33%. |
| For a dichotomized definition of ICH expansion combine relative and absolute metrics: ICH. growth > 6 mL and/or > 33% / ICH growth > 12.5 mL and/or > 33%. |
| Select one definition of ICH expansion (absolute, relative or combined) as the primary outcome of interest and test other definitions in secondary analyses. |
| Assess ICH expansion with a follow up scan at 24 to 72 h from symptom onset. |
| Measure also the extent of total intracranial hemorrhage growth (parenchymal + ventricular bleeding). |
| Report the absolute increase of the parenchymal and ventricular components. |

NCCT indicates non-contrast computed tomography; ICH, intracerebral hemorrhage; IVH, intraventricular hemorrhage.

**Table 4.** Priorities for Future Research

|  |
| --- |
| Investigate whether NCCT markers can improve the discriminative ability of currently available prediction models. |
| Prospective validation of all NCCT markers and assessment of inter and intra-rater reliability. |
| Research into the pathophysiological mechanisms underlying NCCT markers |
| Compare the diagnostic performance of different NCCT markers. |
| Compare NCCT markers with the both single phase CTA spot sign and temporal based early appearing and/or dynamic CTA spot signs. |
| Integrate different NCCT markers and CTA spot sign. |
| Measure the performance of NCCT markers using prediction statistics (model discrimination and calibration) and diagnostic accuracy statistics (sensitivity, specificity, positive and negative predictive values, positive and negative likelihood ratios). |
| Retrospective analysis of previous trials targeting ICH expansion, to investigate whether the presence of some NCCT markers identify those patients more likely to benefit. |
| Use NCCT markers to select patients for future clinical trials. |
| Development and validation of artificial intelligence and machine learning tools to predict expansion based on NCCT images. |
| Perform individual patient-data meta-analyses. |
| Periodic update of the NCCT markers consensus standards. |

ICH indicates intracerebral hemorrhage; NCCT, non-contrast CT; CTA, CT angiography.

**Standards for Detecting, Interpreting and Reporting NCCT markers of ICH expansion**

**SUPPLEMENTAL MATERIAL**

**Table 1.** Systematic appraisal of study quality and risk of bias 1

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Study / Criterion** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** | **Overall** |
| Kim et al. 2008 2 | Y | Y | U | Y | Y | Y | Y | Y | Y | Y | Y | U | U | Y | Y | Y | N | Unclear |
| Barras et al. 2009 3 | Y | Y | U | Y | Y | Y | Y | Y | Y | Y | Y | U | U | Y | Y | Y | N | Low |
| Selariu et al. 2012 4 | Y | Y | U | Y | Y | Y | Y | Y | Y | Y | Y | U | U | Y | Y | Y | N | Unclear |
| Galbois et al. 2013 5 | Y | Y | U | Y | Y | Y | Y | Y | Y | Y | Y | U | U | Y | Y | Y | N | Unclear |
| Takeda et al. 2013 6 | Y | Y | U | Y | Y | Y | Y | Y | Y | Y | Y | U | U | Y | Y | Y | N | Unclear |
| Gökçe et al. 2014 7 | Y | Y | U | Y | Y | Y | Y | Y | Y | Y | Y | U | U | Y | Y | Y | N | Unclear |
| Blacquiere et al. 2015 8 | Y | Y | U | Y | Y | Y | Y | Y | Y | Y | Y | U | Y | Y | Y | Y | N | Low |
| Connor et al. 2015 9 | Y | Y | U | Y | Y | Y | Y | Y | Y | Y | Y | U | U | Y | Y | Y | N | Unclear |
| Li et al. 2015 10 | Y | Y | U | Y | Y | Y | Y | Y | Y | Y | Y | U | U | Y | Y | Y | N | Unclear |
| Yao et al. 2015 11 | Y | Y | U | Y | Y | Y | Y | Y | Y | Y | Y | Y | U | Y | Y | Y | N | Unclear |
| Boulouis et al. 2016 12 | Y | Y | U | Y | Y | Y | Y | Y | Y | Y | Y | Y | U | Y | Y | Y | N | Unclear |
| Boulouis et al. 2016 13 | Y | Y | U | Y | Y | Y | Y | Y | Y | Y | Y | Y | U | Y | Y | Y | N | Unclear |
| Delcourt et al. 2016 14 | Y | Y | U | Y | Y | Y | Y | Y | Y | Y | Y | Y | U | Y | Y | Y | N | Low |
| Li et al. 2016 15 | Y | Y | U | Y | Y | Y | Y | Y | Y | Y | Y | U | U | Y | Y | Y | N | Unclear |
| Li and Yang 2017 16 | Y | Y | U | Y | Y | Y | Y | Y | Y | Y | Y | U | U | Y | Y | Y | N | Unclear |
| Li et al. 2017 17 | Y | Y | U | Y | Y | Y | Y | Y | Y | Y | Y | U | U | Y | Y | Y | N | Low |
| Morotti et al. 2017 18 | Y | Y | U | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | N | Unclear |
| Ng et al. 2017 19 | Y | Y | U | Y | Y | Y | Y | Y | Y | Y | Y | U | U | Y | Y | Y | N | Unclear |
| Sporns et al. 2017 20 | Y | Y | U | Y | Y | Y | Y | Y | Y | Y | Y | U | U | Y | Y | Y | N | Unclear |
| Yu et al. 2017 21 | Y | Y | U | Y | Y | Y | Y | Y | Y | Y | Y | U | U | Y | Y | Y | N | Unclear |
| Yu et al. 2017 22 | Y | Y | U | Y | Y | Y | Y | Y | Y | Y | Y | U | U | Y | Y | Y | N | Unclear |
| Zheng et al. 2017 23 | Y | Y | U | Y | Y | Y | Y | Y | Y | Y | Y | U | U | Y | Y | Y | N | Unclear |
| Morotti et al. 2018 24 | Y | Y | U | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | N | Low |
| Morotti et al. 2018 25 | Y | Y | U | Y | Y | Y | Y | Y | Y | Y | Y | Y | U | Y | Y | Y | N | Low |
| Yu et al. 2018 26 | Y | Y | U | Y | Y | Y | Y | Y | Y | Y | Y | U | U | Y | Y | Y | N | Unclear |
| Zhang et al. 2018 27 | Y | Y | U | Y | Y | Y | Y | Y | Y | Y | Y | U | U | Y | Y | Y | N | Unclear |
| Elkhatib et al. 2019 28 | Y | Y | U | Y | Y | Y | Y | Y | Y | Y | Y | U | U | Y | Y | Y | N | Unclear |
| Yogendrakumar et al. 2019 29 | Y | Y | U | Y | Y | Y | Y | Y | Y | Y | Y | U | U | Y | Y | Y | N | Unclear |
| Park et al. 2019 30 | Y | Y | U | Y | Y | Y | Y | Y | Y | Y | Y | U | U | Y | Y | Y | N | Unclear |
| Yu et al. 2019 31 | Y | Y | U | Y | Y | Y | Y | Y | Y | Y | Y | U | U | Y | Y | Y | N | Unclear |
| Zhang et al. 2019 32 | Y | Y | U | Y | Y | Y | Y | Y | Y | Y | Y | U | U | Y | Y | Y | N | Unclear |
| Yu et al. 2019 33 | Y | Y | U | Y | Y | Y | Y | Y | Y | Y | Y | U | U | Y | Y | Y | N | Unclear |

**Criteria Used:**

1. Were the selection criteria clearly defined?

2. Similar point in the course of their disease?

3. Was the study population representative of the population of interest?

4. Was the follow-up period adequate?

5. Was completeness of follow-up described?

6. Was completeness of follow-up adequate?

7. Were prognostic factors clearly defined?

8. Were prognostic factors measured appropriately?

9. Were prognostic data available for an adequate proportion of the included participants?

10. Was the outcome of interest clearly defined?

11. Was the outcome determined appropriately?

12. Were outcomes determined blind to prognostic information?

13. Were important confounding factors adequately accounted for?

14. Were any treatments given to participants during the follow-up period standardised, or randomised?

15. Were the analysis methods adequate?

16. Was the reporting independent of results?

17. Study free of other aspects that have potential risk of bias?

**Ratings:**

Yes (Y)

No (N)

Unclear (U)

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**Table 2.** Summary of the operational NCCT settings and criteria for detecting NCCT markers

|  |
| --- |
| **NCCT SETTINGS** |
| * Axial 5mm thickness slices. * Thinner slices or coronal/sagittal reconstruction may help the recognition of NCCT markers that need to be encapsulated in the hemorrhage * Optimize the balance between radiation delivery and image quality |
| **NCCT MARKERS DIAGNOSTIC CRITERIA** |
| * **Heterogenous Density:** 3 or more foci of hypoattenuation (compared with the hemorrhage), evaluated on the axial NCCT slice showing largest hemorrhage area. * **Swirl Sign:** area of hypo or isoattenuation (compared with the brain parenchyma). Any shape and dimension. Can be connected with brain tissue around the hemorrhage. * **Hypodensity:** any hypodense region strictly encapsulated within the hemorrhage with any shape, size and density. * **Black hole Sign:** hypodense area with a density difference > 28 HU compared with the surrounding hematoma. No connection with structures outside the hemorrhage * **Blend sign:** hypoattenuating area next to a hyperattenuating area of the hematoma. Sharp distinction and density difference >18 HU between the two regions. * **Fluid level:** hypoattenuating area (hypodense to the brain) above and one hyperattenuating area (hyperdense to the brain) below a clear straight line of separation. * **Irregular Shape:** 2 or more focal hematoma margin irregularities, joined or separate from the hematoma edge, evaluated on the axial NCCT slice showing the largest ICH area. * **Island Sign:** At least 3scattered small hematomas all separate from the main ICH or at least 4 small hematomas some or all of which may connect with the ICH * **Satellite sign:** hematoma with diameter <10 mm, separate but located within 20 mm from the main hemorrhage. |

NCCT indicates non contrast computed tomography; ICH, intracerebral hemorrhage; HU, Hounsfield Unit.

**Table 3.** NCCT ICH features in training cases

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| **TRAINING CASE 1** | | | | | | | | | | | | | | | | | | | |
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| **Hypodensities** | **Black Hole Sign** | | **Swirl**  **Sign** | | | **Satellite**  **Sign** | | | **Island**  **Sign** | | **Fluid**  **Level** | | | **Blend**  **Sign** | | | **Irregular Shape** | | **Heterogeneous Density** |
| **P** B2 – B3 | **P** B3 | | **P** B1–B2–B3 | | | **P** A1 | | | **N** | | **N** | | | **N** | | | **IV** | | **IV** |
| **TRAINING CASE 2** | | | | | | | | | | | | | | | | | | | |
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| **Hypodensities** | **Black Hole Sign** | | **Swirl**  **Sign** | | | **Satellite**  **Sign** | | | **Island**  **Sign** | | **Fluid**  **Level** | | | **Blend**  **Sign** | | | **Irregular Shape** | | **Heterogeneous Density** |
| **N** | **N** | | **N** | | | **N** | | | **N** | | **N** | | | **N** | | | **I** | | **I** |
| **TRAINING CASE 3** | | | | | | | | | | | | | | | | | | | |
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| **Hypodensities** | **Black Hole Sign** | | **Swirl**  **Sign** | | | **Satellite**  **Sign** | | | **Island**  **Sign** | | **Fluid**  **Level** | | | **Blend**  **Sign** | | | **Irregular Shape** | | **Heterogeneous Density** |
| **N** (A1 mimics: connection with brain parenchyma in B1-B2) | **N** (A1 mimics: connection with brain parenchyma in B1-B2) | | **P** A1–B1-B2 | | | **N** | | | **N** | | **N** | | | **N** | | | **IV** | | **III** |
| **TRAINING CASE 4** | | | | | | | | | | | | | | | | | | | |
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| **Hypodensities** | **Black Hole Sign** | | **Swirl**  **Sign** | | | **Satellite**  **Sign** | | | **Island**  **Sign** | | **Fluid**  **Level** | | | **Blend**  **Sign** | | | **Irregular Shape** | | **Heterogeneous Density** |
| **P** A1 | **N** | | **P** A1 | | | **N** | | | **N** | | **N** | | | **P** A2–A3–A4–B1–B2 | | | **III** | | **III** |
| **TRAINING CASE 5** | | | | | | | | | | | | | | | | | | | |
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| **Hypodensities** | **Black Hole Sign** | | **Swirl**  **Sign** | | | **Satellite**  **Sign** | | | **Island**  **Sign** | | **Fluid**  **Level** | | | **Blend**  **Sign** | | | **Irregular Shape** | | **Heterogeneous Density** |
| **N** | **N** | | **N** | | | **N** | | | **N** | | **P** A1 | | | **P** A1 | | | **I** | | **I-II** |
| **TRAINING CASE 6** | | | | | | | | | | | | | | | | | | | |
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| **Hypodensities** | **Black Hole Sign** | | **Swirl**  **Sign** | | | **Satellite**  **Sign** | | | **Island**  **Sign** | | **Fluid**  **Level** | | | **Blend**  **Sign** | | | **Irregular Shape** | | **Heterogeneous Density** |
| **P** A5-A6. (Not A7 because connected with brain parenchyma) | **P** A5 | | **P** A5–A6-A7 | | | **P** A1–A2–A3-A4 | | | **P** A1–A2–A3-A4 | | **N** | | | **N** | | | **V** | | **IV** |
| **TRAINING CASE 7** | | | | | | | | | | | | | | | | | | | |
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| **Hypodensities** | **Black Hole Sign** | | **Swirl**  **Sign** | | | **Satellite**  **Sign** | | | **Island**  **Sign** | | **Fluid**  **Level** | | | **Blend**  **Sign** | | | **Irregular Shape** | | **Heterogeneous Density** |
| **N** | **N** | | **N** | | | **N** | | | **N** | | **N** | | | **N** | | | **I** | | **I** |
| **TRAINING CASE 8** | | | | | | | | | | | | | | | | | | | |
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| **Hypodensities** | **Black Hole Sign** | | **Swirl**  **Sign** | | | **Satellite**  **Sign** | | | **Island**  **Sign** | | | **Fluid**  **Level** | | | **Blend**  **Sign** | | **Irregular Shape** | | **Heterogeneous Density** |
| **N** | **N** | | **P** A3 | | | **P** A1–A2–B1 | | | **N** (All the small hematomas, are not visible on the same axial slice) | | | **N** | | | **N** | | **V** | | **II** |
| **TRAINING CASE 9** | | | | | | | | | | | | | | | | | | | |
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| **Hypodensities** | **Black Hole Sign** | | | **Swirl**  **Sign** | | **Satellite**  **Sign** | | | **Island**  **Sign** | | **Fluid**  **Level** | | | **Blend**  **Sign** | | | | **Irregular Shape** | **Heterogeneous Density** |
| **P** A1 (hypodense fluid level is encapsulated in the ICH) | **P** A1  (hypodense fluid level encapsulated in the ICH) | | | **P** A1 | | **N** | | | **N** | | **P** A1 | | | **N** (hypoattenuating area cannot be encapsulated in the ICH) | | | | **III** | **III** |
| **TRAINING CASE 10** | | | | | | | | | | | | | | | | | | | |
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| **Hypodensities** | **Black Hole Sign** | | **Swirl**  **Sign** | | | **Satellite**  **Sign** | | | **Island**  **Sign** | | **Fluid**  **Level** | | | **Blend**  **Sign** | | | **Irregular Shape** | | **Heterogeneous Density** |
| **N** | **N** | | **N** | | | **N** | | | **N** | | **N** | | | **N** | | | **I** | | **I** |
| **TRAINING CASE 11** | | | | | | | | | | | | | | | | | | | |
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| **Hypodensities** | | **Black Hole Sign** | | | **Swirl**  **Sign** | | **Satellite**  **Sign** | | | **Island**  **Sign** | | | **Fluid**  **Level** | | | **Blend**  **Sign** | | **Irregular Shape** | **Heterogeneous Density** |
| **P** A1–A2–A3– A4. (B1 does not qualify for connection with brain parenchyma) | | **P** A1–A3–A4. (A2 does not meet the 28 HU density delta cutoff) | | | **P** A1-A2–A3–A4–B1 | | **N** | | | **N** | | | **N** | | | **N** | | **V** | **V** |
| **TRAINING CASE 12** | | | | | | | | | | | | | | | | | | | |
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| **Hypodensities** | | **Black Hole Sign** | | | **Swirl**  **Sign** | | | **Satellite**  **Sign** | | **Island**  **Sign** | | | **Fluid**  **Level** | | | **Blend**  **Sign** | | **Irregular Shape** | **Heterogeneous Density** |
| **P** A1 – A2 (B1 does not qualify for connection with brain parenchyma) | | **P** A1 (A2 does not meet the 28 HU density delta cutoff) | | | **P** A1 - A2 –B1 | | | **N** | | **N** | | | **N** | | | **N** | | **II** | **V** |

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| **TRAINING CASE 13** | | | | | | | | | | | | | | |
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| **Hypodensities** | **Black Hole Sign** | **Swirl**  **Sign** | | **Satellite**  **Sign** | | **Island**  **Sign** | | **Fluid**  **Level** | | **Blend**  **Sign** | | **Irregular Shape** | | **Heterogeneous Density** |
| **N** | **N** | **N** | | **N** | | **N** | | **N** | | **N** | | **I** | | **I** |
| **TRAINING CASE 14** | | | | | | | | | | | | | | |
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| **Hypodensities** | **Black Hole Sign** | **Swirl**  **Sign** | | **Satellite**  **Sign** | | **Island**  **Sign** | | **Fluid**  **Level** | | **Blend**  **Sign** | | **Irregular Shape** | | **Heterogeneous Density** |
| **P** A1 | **N** | **P** A1 | | **N** | | **N** | | **N** | | **N** | | **I** | | **I** |
| **TRAINING CASE 15** | | | | | | | | | | | | | | |
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| **Hypodensities** | **Black Hole Sign** | **Swirl**  **Sign** | | **Satellite**  **Sign** | | **Island**  **Sign** | | **Fluid**  **Level** | | **Blend**  **Sign** | | **Irregular Shape** | | **Heterogeneous Density** |
| **N** | **N** | **N** | | **N** | | **N** | | **N** | | **N** | | **I** | | **I** |
| **TRAINING CASE 16** | | | | | | | | | | | | | | |
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| **Hypodensities** | **Black Hole Sign** | | **Swirl**  **Sign** | | **Satellite**  **Sign** | | **Island**  **Sign** | | **Fluid**  **Level** | | **Blend**  **Sign** | | **Irregular Shape** | **Heterogeneous Density** |
| **N** None of the multiple hypodensities is clearly encapsulated in the hemorrhage | **N** None of the multiple hypodensities is clearly encapsulated in the hemorrhage | | **P** A3–B2 | | **P** A1-A2–B1 | | **P** A1–A2-A4–B1–B3–B4–B5 | | **N** | | **N** | | **V** | **I** |

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| **TRAINING CASE 17** | | | | | | | | |
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| **Hypodensities** | **Black Hole Sign** | **Swirl**  **Sign** | **Satellite**  **Sign** | **Island**  **Sign** | **Fluid**  **Level** | **Blend**  **Sign** | **Irregular Shape** | **Heterogeneous Density** |
| **N** | **N** | **N** | **N** | **N** | **N** | **N** | **I** | **I** |
| **TRAINING CASE 18** | | | | | | | | |
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| **Hypodensities** | **Black Hole Sign** | **Swirl**  **Sign** | **Satellite**  **Sign** | **Island**  **Sign** | **Fluid**  **Level** | **Blend**  **Sign** | **Irregular Shape** | **Heterogeneous Density** |
| **N** | **N** | **N** | **N** | **N** | **P** A1 | **P** A1 – A2 – B1 | **I** | **II** |

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| **TRAINING CASE 19** | | | | | | | | | | | | |
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| **Hypodensities** | **Black Hole Sign** | **Swirl**  **Sign** | **Satellite**  **Sign** | | **Island**  **Sign** | | **Fluid**  **Level** | | **Blend**  **Sign** | **Irregular Shape** | | **Heterogeneous Density** |
| **N** | **N** | **N** | **N** | | **N** | | **N** | | **N** | **I** | | **I** |
| **TRAINING CASE 20** | | | | | | | | | | | | |
|  | | | | | | | | | | | | |
| **Hypodensities** | **Black Hole Sign** | **Swirl**  **Sign** | **Satellite**  **Sign** | **Island**  **Sign** | | **Fluid**  **Level** | | **Blend**  **Sign** | | | **Irregular Shape** | **Heterogeneous Density** |
| **P** A1 | **N** | **P** A1 | **N** | **N** | | **N** | | **N** (No clear separation between the hyper and hypoattenuating ICH areas) | | | **II** | **III** |

**P** indicates positive; **N** indicates negative; ICH indicates intracerebral hemorrhage; NCCT indicates non-contrast computed tomography; irregular shape and heterogeneous density rated using a categorical scale proposed by Barras and Colleagues, ranging from **I** (regular shape and homogeneous density) to **V** (maximal degree of shape irregularity and heterogeneous density).