www.ijarp.com ISSN 2456-9992 Page: 01-08

International Journal Advanced Research Publications

Review Article

Volume: 02
Issue: 08

PROGNOSTIC VALUE OF CONTRAST-ENHANCED CT SCAN IN SUBARACHNOID HEMORRHAGE: A REVIEW

Janvi Kaushal*[1], Sachin Chawla[2], Agam Verma[2], Ramandeep Kaur[2]

[1]M.Sc. Scholar, Medical Radiology and Imaging Technology, Department of Allied & Healthcare, Guru Kashi University.

[2]Assistant Professor, Department of Paramedical Sciences, Guru Kashi University.

Article Received: 05 July 2026, Article Revised: 25 July 2026, Published on: 12 August 2026

***Corresponding Author: Janvi Kaushal**

M.Sc. Scholar, Medical Radiology and Imaging Technology, Department of Allied & Healthcare, Guru Kashi University.

Doi: https://doi-doi.org/101555/ijarp.6731

ABSTRACT

Subarachnoid hemorrhage (SAH) is a neurological emergency characterized by bleeding into the subarachnoid space, most commonly due to rupture of an intracranial aneurysm. Prompt and accurate imaging is central to diagnosis, risk stratification, and prognostication. Non-contrast computed tomography (NCCT) remains the first-line investigation, but contrast-enhanced CT (CECT) — including CT angiography, CT venography, and perfusion CT — has assumed an increasingly important role in identifying the underlying vascular cause, evaluating the extent of hemorrhage, and predicting complications such as vasospasm and delayed cerebral ischemia. This review synthesizes current literature on the diagnostic and prognostic value of CECT in SAH and situates these findings alongside evidence from a clinical case series of 60 patients evaluated with CECT. Across the reviewed literature and the case data, aneurysmal rupture emerges as the leading etiology of SAH, diffuse hemorrhage and intraventricular extension are consistently associated with greater severity, and early CT imaging shows high diagnostic sensitivity, although clinical outcomes remain highly variable even with timely detection. The review concludes that CECT is a valuable tool for early detection and risk assessment in SAH, but that favorable outcomes depend on the integration of imaging findings with clinical grading, prompt intervention, and sustained multidisciplinary follow-up.

KEYWORDS: Subarachnoid hemorrhage; Contrast-enhanced CT; CT angiography;

Prognosis; Vasospasm; Delayed cerebral ischemia.

1. INTRODUCTION

Contrast media are chemical agents used to enhance the contrast resolution of an imaging modality and thereby aid in the characterization of pathology. Iodinated contrast agents, administered chiefly by the intravenous route, remain the mainstay for CT-based vascular and parenchymal imaging, while barium-based agents continue to serve gastrointestinal fluoroscopic and CT applications (Wolbarst, 2005; Gelfand et al., n.d.). Iodine's high atomic number produces differential photoelectric absorption relative to soft tissue, which underlies the enhancement seen on contrast studies (Wolbarst, 2005). Low-osmolality, non-ionic agents such as iopamidol, iohexol, and iodixanol have largely replaced older high-osmolality compounds because of their improved safety profile for intravascular and intrathecal use.

Subarachnoid hemorrhage refers to bleeding into the subarachnoid space, the compartment between the brain and its overlying meninges. It constitutes a neurological emergency requiring immediate evaluation and treatment (Psychogios & Tsivgoulis, 2019). On non-contrast CT, the sensitivity for detecting subarachnoid blood depends heavily on both the volume of hemorrhage and the interval since ictus, with classic signs including hyperattenuation within the Sylvian fissure, interhemispheric fissure, basal cisterns, or around the circle of Willis, and secondary signs such as the hypoattenuating 'berry sign' at the site of a ruptured aneurysm (van Gijn, Kerr & Rinkel, 2007). Because non-contrast CT alone cannot always define the underlying vascular lesion, contrast-enhanced techniques — CT angiography (CTA), CT perfusion, and CT venography — have become integral to the modern work-up of SAH, allowing clinicians to localize aneurysms, arteriovenous malformations, and venous thrombosis, and to assess downstream perfusion deficits (Mayo Clinic Staff, 2025).

This review aims to (i) summarize the role of contrast-enhanced CT in the diagnosis and prognostic evaluation of SAH, (ii) synthesize key findings from the diagnostic-accuracy and outcome literature, and (iii) relate these findings to evidence from a clinical case series in which 60 patients with SAH were evaluated using CECT.

2. Contrast Media in CT Imaging

Contrast agents are broadly classified as negative (radiolucent) or positive (radiopaque). Negative agents such as air, carbon dioxide, and nitrous oxide lower attenuation and are used to outline structures against a dark background, whereas positive agents containing iodine or

barium increase attenuation and appear bright on imaging (Contrast media, n.d.). Iodinated contrast media are further divided by osmolality: high-osmolality ionic agents, now largely restricted to gastrointestinal and cystourethral use, and low-osmolality non-ionic agents, which are preferred for intravascular administration because of a substantially lower rate of adverse reactions (Wolbarst, 2005). Minor reactions to iodinated contrast — warmth, a metallic taste, transient nausea, or itching — are common but self-limited, whereas severe allergic-type reactions occur in fewer than 1 in 1,000 administrations, and nephrotoxicity remains a concern in patients with pre-existing renal impairment (American College of Radiology, cited in Molecular Imaging & Therapeutics, 2025).

In neuroimaging, contrast enhancement improves the sensitivity and specificity of CT for detecting vascular and parenchymal abnormalities. CT angiography highlights the cerebral vasculature to identify aneurysms, arteriovenous malformations, and vessel occlusion; CT perfusion imaging quantifies cerebral blood flow to identify tissue at risk after ischemic injury; and CT venography delineates the dural venous sinuses to detect venous sinus thrombosis, a recognized mimic and occasional cause of SAH (Oppenheim et al., 2005; Mayo Clinic Staff, 2025).

3. Subarachnoid Hemorrhage: Etiology and Clinical Significance

Aneurysmal rupture is the leading cause of spontaneous, non-traumatic SAH, with arteriovenous malformations, perimesencephalic hemorrhage of undetermined origin, and vascular anomalies such as dural sinus thrombosis accounting for the remainder of cases (van Gijn, Kerr & Rinkel, 2007; Oppenheim et al., 2005). The severity of SAH is influenced by the pattern of bleeding — diffuse versus localized — and by the presence of intraventricular extension, both of which correlate with clinical grading scales and with the risk of secondary complications such as cerebral vasospasm and delayed cerebral ischemia (DCI) (Aralasmak et al., 2009; Binaghi et al., 2007; Rabinstein et al., 2004).

4. Role of Contrast-Enhanced CT in Diagnosis and Prognosis of SAH

A substantial body of literature supports the high diagnostic sensitivity of early CT for detecting SAH. Backes et al. (2012) reported that non-contrast CT performed within six hours of symptom onset has a sensitivity approaching 98.5% for excluding SAH, and Gillespie et al. (2022) similarly reported a pooled sensitivity near 99.5% for early CT. Both groups, however, note that sensitivity declines beyond the six-hour window, such that lumbar puncture may still be warranted when clinical suspicion remains high despite a negative early

scan.

Beyond initial detection, contrast-enhanced techniques contribute directly to prognostication. Camargo et al. (2007) demonstrated that CT angiographic source images improve the delineation of acute infarction compared with non-enhanced CT, while Aralasmak et al. (2009) and Binaghi et al. (2007) showed that CT angiography and CT perfusion findings correlate with the degree of vasospasm following SAH, an important predictor of delayed cerebral ischemia and poor outcome. Rabinstein et al. (2004) identified specific imaging and clinical predictors of cerebral infarction after aneurysmal SAH, reinforcing the prognostic value of early, detailed vascular imaging.

Saveland and Sonesson, in a long-term outcome study, documented a mortality rate of approximately 37% and found that only 41% of survivors achieved good physical recovery at one year, noting that patients who appeared clinically stable in the short term often went on to develop cognitive and psychosocial impairment. Their work underscores that integrating CT findings with bedside clinical grading — rather than relying on imaging alone — improves the accuracy of prognostic assessment. Taken together, this literature establishes two complementary points: contrast-enhanced CT is highly sensitive for early detection and etiological work-up of SAH, but detection alone does not guarantee a favorable outcome; the ultimate prognosis is shaped by the extent of hemorrhage, ventricular involvement, vasospasm, and the timeliness of subsequent clinical management.

5. Illustrative Evidence from a Clinical Case Series

To ground this review in clinical practice, findings from a case series of 60 patients with confirmed SAH who underwent CECT of the head over a six-month period are summarized below. Patients were included if they were above 25 years of age and had undergone CECT of the head; those below 25 years, evaluated with non-contrast CT only, or unwilling to participate were excluded.

Table 1. Summary of demographic, imaging, and outcome characteristics in a clinical case series of 60 patients with SAH evaluated by CECT.

Parameter	Category	Frequency	Percentage
Gender	Male	36	60.0%
	Female	24	40.0%
Age group (years)	46–55 (most common)	17	28.3%
	26–35 (least common)	7	11.7%
CECT timing	Early (<24 h)	40	66.7%
	Delayed	20	33.3%

Parameter	Category	Frequency	Percentage
Etiology	Aneurysm	40	66.7%
	Arteriovenous malformation	10	16.7%
	Undetermined	6	10.0%
	Contrast leak	4	6.7%
Hemorrhage pattern	Diffuse	40	66.7%
	Localized	20	33.3%
Intraventricular hemorrhage	Present	36	60.0%
Risk category	High-risk	40	66.7%
	Low-risk	20	33.3%
Clinical outcome	Improved	20	36.7%
	Stable	18	30.0%
	Deteriorated	22	33.3%

These figures mirror the pattern reported in the wider literature: aneurysmal rupture as the dominant etiology, a male and middle-age predominance, and a strong representation of diffuse hemorrhage with intraventricular extension among high-risk patients. Notably, despite early CECT in two-thirds of cases, clinical outcomes were heterogeneous — improvement, stability, and deterioration were seen in roughly similar proportions — echoing the observation that early imaging improves diagnostic yield without, by itself, ensuring a favorable trajectory.

6. DISCUSSION

The convergence of the reviewed literature and case-series evidence supports several conclusions. First, aneurysmal rupture is consistently identified as the principal cause of non-traumatic SAH, and contrast-enhanced CT angiography is central to its rapid localization and characterization, directly informing decisions about surgical clipping versus endovascular coiling. Second, the extent and pattern of hemorrhage — particularly diffuse bleeding and intraventricular extension — carry prognostic weight independent of etiology, aligning imaging severity with established clinical grading systems such as the Hunt and Hess and modified Fisher scales. Third, while early CT (within six hours) offers near-complete sensitivity for excluding SAH (Backes et al., 2012; Gillespie et al., 2022), this diagnostic strength does not translate uniformly into good outcomes, since a substantial proportion of patients still deteriorate despite prompt detection, reflecting the contribution of secondary injury mechanisms such as vasospasm and delayed cerebral ischemia (Rabinstein et al., 2004; Aralasmak et al., 2009).

These observations carry practical implications for radiology and clinical practice. CECT protocols that combine angiography and, where indicated, perfusion imaging can provide a

single-setting assessment of both the causative lesion and the downstream hemodynamic consequences of hemorrhage, supporting more individualized risk stratification. At the same time, the persistence of variable outcomes despite early and accurate imaging reinforces that CECT should be regarded as one component of a broader care pathway that includes vigilant neurological monitoring, timely aneurysm securing, and management of vasospasm, rather than a standalone determinant of prognosis.

Limitations of the underlying evidence base should be acknowledged. Much of the diagnostic-accuracy literature emphasizes sensitivity for detecting SAH rather than long-term functional outcomes, and single-center case series, such as the one summarized here, are subject to selection bias and limited generalizability. Larger, prospective, multicenter studies correlating specific CECT-derived parameters (aneurysm size and location, perfusion deficits, vasospasm severity) with standardized long-term outcome measures would strengthen the evidence for CECT-guided prognostication.

7. CONCLUSION

Contrast-enhanced CT has become an indispensable tool in the evaluation of subarachnoid hemorrhage, offering high sensitivity for early detection, precise localization of the causative vascular lesion, and useful markers of disease severity such as hemorrhage pattern and intraventricular extension. Evidence from both the published literature and a representative clinical case series confirms that aneurysmal rupture is the predominant cause of SAH, that diffuse and intraventricular hemorrhage are associated with higher-risk presentations, and that early imaging — though diagnostically powerful — does not eliminate the unpredictability of clinical outcomes. Optimal management of SAH therefore requires the integration of CECT findings with clinical grading, prompt intervention, and sustained multidisciplinary follow-up to improve patient prognosis.

REFERENCES

1. Backes D, Rinkel GJ, Kemperman H, Linn FH, Vergouwen MD. Time-dependent test characteristics of head computed tomography in patients suspected of nontraumatic subarachnoid hemorrhage. Stroke. 2012;43(8):2115-2119.
2. Gillespie CS, et al. Diagnostic accuracy of early CT for subarachnoid hemorrhage: a systematic review and meta-analysis. J Neurol Neurosurg Psychiatry. 2022.
3. Saveland H, Sonesson B, Ljunggren B, et al. Outcome evaluation following subarachnoid hemorrhage. J Neurosurg.

4. Psychogios K, Tsivgoulis G. Subarachnoid hemorrhage, vasospasm, and delayed cerebral ischemia. Pract Neurol. 2019;9:37-41.
5. van Gijn J, Kerr RS, Rinkel GJ. Subarachnoid haemorrhage. Lancet. 2007;369:306-318.
6. Camargo EC, Furie KL, Singhal AB, Roccatagliata L, Cunnane ME, Halpern EF, Harris GJ, Smith WS, Gonzalez RG, Koroshetz WJ, Lev MH. Acute brain infarct: detection and delineation with CT angiographic source images versus nonenhanced CT scans. Radiology. 2007;244:541-548.
7. Aralasmak A, Akyuz M, Ozkaynak C, Sindel T, Tuncer R. CT angiography and perfusion imaging in patients with subarachnoid hemorrhage: correlation of vasospasm to perfusion abnormality. Neuroradiology. 2009;51:85-93.
8. Binaghi S, Colleoni ML, Maeder P, Uske A, Regli L, Dehdashti AR, Schnyder P, Meuli R. CT angiography and perfusion CT in cerebral vasospasm after subarachnoid hemorrhage. AJNR Am J Neuroradiol. 2007;28:750-758.
9. Rabinstein AA, Friedman JA, Weigand SD, McClelland RL, Fulgham JR, Manno EM, Atkinson JL, Wijdicks EF. Predictors of cerebral infarction in aneurysmal subarachnoid hemorrhage. Stroke. 2004;35:1862-1866.
10. Oppenheim C, Domigo V, Gauvrit J, et al. Subarachnoid hemorrhage as the initial presentation of dural sinus thrombosis. AJNR Am J Neuroradiol. 2005;26(3):614-617.
11. Zhou X, Cai S, Zhang D, et al. Hypo-attenuating berry sign as a novel imaging marker of ruptured aneurysm in patients with subarachnoid hemorrhage: a diagnostic accuracy study. Arch Acad Emerg Med. 2024;12(1):e31.
12. Smirniotopoulos JG, Murphy FM, Rushing EJ, Rees JH, Schroeder JW. Patterns of contrast enhancement in the brain and meninges. RadioGraphics. 2007;27(2):525-551.
13. Wolbarst AB. Physics of Radiology. 2nd ed. Medical Physics Publishing; 2005. ISBN: 9781930524224.
14. Gelfand DW, Sowers JC, DePonte KA, Sumner TE, Ott DJ. Anaphylactic and allergic reactions during double-contrast studies: is glucagon or barium suspension the allergen? AJR Am J Roentgenol. 1985;144(2):405-406.
15. Schmid AA, Morelli JN, Hungerbühler MN, Boehm IB. Cross-reactivity among iodinated contrast agents: should we be concerned? Quant Imaging Med Surg. 2021;11:4028-4041.
16. Brookes I. The Chambers Dictionary. Chambers Harrap; 2006. ISBN: 9780550101853.
17. Brant WE, Helms CA. Fundamentals of Diagnostic Radiology. 4th ed. Lippincott Williams & Wilkins; 2012. ISBN: 9781608319114.

18. Roth EJ. Hemorrhage. In: Kreutzer JS, DeLuca J, Caplan B, eds. Encyclopedia of Clinical Neuropsychology. Springer; 2018.
19. Mayo Clinic Staff. Brain CT scan. Mayo Clinic; 2025. Available from: mayoclinic.org.
20. American College of Radiology / Molecular Imaging & Therapeutics. Contrast in CT scans: why it's used and is it safe. 2025.
21. Life Imaging FLA. What does a non-contrast CT brain scan screen for? Available from: lifeimagingfla.com.