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Value of MRI Spine in the Diagnostic Workup of Non-Traumatic Non-Aneurysm Subarachnoid Hemorrhage (SAH)

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ABSTRACT

Background: There is disagreement over the best way to diagnose non-traumatic angiographically negative subarachnoid haemorrhage (AN-SAH).

Objective: This study aimed to evaluate the added value of spine MRI in identifying causes of non-traumatic, non-AN-SAH.

Methods: This retrospective study analyzed 86 consecutive patients, all aged 18 years or older, who were diagnosed with non-traumatic SAH and had negative results on cerebrovascular catheter angiography. Following this, spinal magnetic resonance imaging (MRI) was performed for each patient. Two physicians, who were blinded to the study, independently reviewed all the MRI scans. The study aimed to determine the diagnostic utility of spina l MRI in these cases.

Results: The comprised subjects' mean age was 52 ± 2.83 years. There were 50 (58.14%) male patients and 36 female patients. There were no patients with any family history. The median value of WFNs was 1 with an IQR of 1-1.75, that of Hunt, and Hess (H & H) classification was 1 with an IQR of 1-2, and that of GSC was 15 with an IQR of 14-15. Out of 86 patients with SAH that underwent MRI, only one patient was detected to have cervical abnormality by MRI.

Conclusion: In scenarios devoid of clinical or neurological indicators that would imply a spinal pathology, the employment of spinal MRI subsequent to AN-SAH demonstrated a markedly diminished diagnostic efficacy. Consequently, the habitual utilization of MRI to ascertain potential spinal origins of intracranial AN-SAH lacks substantiation from an evidence-based perspective.

Keywords: MRI spine, Diagnostic, Non-traumatic, Non-aneurysm, SAH.

INTRODUCTION

Most often, intracranial diseases such as aneurysms or vascular abnormalities cause subarachnoid haemorrhage (SAH) [1]. Non-traumatic SAH affects around 9 out of every 100,000 people annually [2]. Approximately 15–25% of spontaneous subarachnoid hemorrhages do not exhibit any signs of cerebral vascular disease [3]. There is a growing number of patients with non-aneurysmal SAH (NASAH), according to recently released statistics [4]. Therefore, it is crucial to evaluate patients with subarachnoid haemorrhage using negative digital subtraction angiography (DSA), which can occasionally present a diagnostic problem.

The diagnostic protocol for individuals presenting with non-traumatic angiographically negative subarachnoid hemorrhage (AN-SAH) exhibits variability across different medical institutions, and the establishment of an optimal algorithm for diagnosis continues to be a matter of ongoing discussion and scrutiny [5, 6]. Individuals exhibiting a peri-mesencephalic distribution of SAH on initial non-contrast cranial computed tomography (CT) typically demonstrate a more favorable clinical trajectory. Additionally, certain investigations propose that the concomitant absence of pathological findings on CT angiography (CTA) of the cranial and cervical regions, along with negative results from DSA, is adequate to preclude vascular causative factors within this cohort [7]. Nonetheless, for individuals presenting with non-peri-mesencephalic, non-aneurysmal manifestations of SAH, the definitive diagnostic approach remains unresolved. While there are occasional mentions in literature of potential vascular causes in patients showing a peri-mesencephalic pattern of SAH, diagnosing such a condition typically involves ruling out other possibilities [8].

At various medical facilities, individuals with non-traumatic, NASAH, confirmed by negative DSA and CTA of the head and neck, receive simultaneous magnetic resonance imaging (MRI) of both the brain and cervical spine. This diagnostic approach is adopted regardless of specific clinical or neurological signs suggesting a spinal etiology [9]. Prior investigations have revealed a diagnostic efficacy ranging from 0% to 4% for cervical magnetic resonance imaging (c-MRI) within this patient cohort. Nonetheless, the methodological approaches across these studies have varied, and each study has encompassed only a limited number of participants [7, 9-11]. This study aimed to evaluate the added value of spine MRI in identifying a cause for non-traumatic, non-AN-SAH.

MATERIALS AND METHODS

We conducted a retrospective analysis of our SAH database from February 1, 2020, to October 31, 2023. We extracted a series of 86 consecutive patients who were 18 years of age or older and diagnosed with acute non-traumatic intracranial SAH based on non-

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contrast head CT or xanthochromia on lumbar puncture. Additionally, MRI of the spine was performed.

Inclusion criteria: Patients with spinal MRI (s-MRI) whose initial cerebral vascular catheter angiography did not identify a cause for the SAH (classified as non-aneurysmal SAH patients).

Exclusion criteria: Patients presenting with incomplete datasets and a recent history of spinal surgery trauma, or acute cerebral contusion.

Spine MRI Technique: Every participant in this investigation underwent s-MRI without intravenous contrast, with the exception of those suspected of having a pathology, for whom intravenous contrast was administered. MRI was performed using either a 3.0-T (TIM Trio, Siemens Healthcare) or 1.5-T (Avanto, Siemens Healthcare; or Intera, Phillips) system, with a head-neck array coil used for cervical spine imaging. A standard dose (0.1 mmol/kg) of Gd-BOPTA (MultiHance, Bracco Diagnostics) was injected at a rate of 2–3 ml/sec. The standardized MRI protocol included pre-contrast sagittal T1-weighted (TE 10 msec, TR 400 msec, FA 90°, slice thickness 3 mm), sagittal T2-weighted (TE 90 msec, TR 2500 msec, FA 90°, slice thickness 3 mm), axial T2-weighted (TE 90 msec, TR 5300 msec, FA 90°, slice thickness 3 mm), and/or post-contrast sagittal T1-weighted (TE 10 msec, TR 400 msec, FA 90°, slice thickness 3 mm) and axial T1-weighted (TE 10 msec, TR 1600 msec, FA 90°, slice thickness 3 mm) images of the cervical spine.

In the intensive care unit, every patient got conventional treatment for aneurysmal SAH along with usual monitoring. The World Federation and Hunt and Hess (H & H) classifications were used to score the clinical condition at the time of presentation.

Information encompassing demographics (sex, age, and race), SAH diagnostic modality (LP vs NC-HCT), time intervals from symptom onset to admission, catheter angiography, and s-MRI, WFNS and H & H classification at presentation, along with the history of the current illness as documented in the EMR, were all extracted. SAH diagnosis was also confirmed through the EMR.

The initial non-contrast head CT scan, conducted within 24 hours of admission and preceding a brain MRI in our study group, was analyzed to assess the distribution pattern of SAH.

Exclusion criteria were applied to non-contrast head CT images acquired later during the hospital stay, as they might not accurately depict the initial SAH pattern due to potential redistribution. The spine MRI scans were independently reviewed by two physicians who were blinded to the outcomes of the spinal MRI and previous imaging studies but were aware that the patient had SAH. Each spine MRI was evaluated for potential pathologies that could explain the SAH, such as vascular malformations and intradural masses.

Measurements:

Patients' characteristics, World Federation of Neurological Surgeons scale (WFNs), Hunt and Hess scale (H & H) and Glasgow Coma Scale (GCS)., presence of neurological deficit and forms of neurological deficit, site of bleeding, and detection of spine abnormality by MRI as a cause of bleeding.

Ethical considerations: The study was done after being accepted by The Research Ethics Committee. The study did not require any consent from the patients as it was a retrospective study, which was done on previously taken data. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical analysis

Statistical evaluation was performed employing SPSS v26 (IBM Inc., Chicago, IL, USA). For the prevalence and quantitative variables, descriptive statistics were used. The chi-square test was used to report the correlations among the included variables. Means and standard deviations (SD) were used to describe some categorical data. A p-value less than 0.05 indicated statistical significance. The interquartile range and median (IQR) were used to display quantitative non-parametric data. Frequency and percentage were used to display the qualitative factors (%).

RESULTS

Demographic data: The age distribution of the analyzed patients varied between 37-84 years, with an average age of 52 ± 2.83 years. There were 50 (58.14%) male patients and 36 (41.86%) female patients. There were no patients with any family history **(Table 1)**.

Table (1): Patients' characteristics in the studied patients

Parameters		Study patients (n = 86)
Age	Mean ± SD	52 ± 2.83
	Range	37-84
Gender	Male	50 (58.14%)
	Female	36 (41.86%)
Family history		0 (0%)

Clinical data: The median value of WFNs was 1 with an IQR of 1-1.75, that of H & H was 1 with an IQR of 1-2, and that of GSC was 15 with an IQR of 14-15 **(Table 2).**

Table (2): WFNs, H&H, and GCS in the studied patients

		Study patients (n = 86)
WFNs	**Median**	1
	IQR	1-1.75
H&H	**Median**	1
	IQR	1-2
GCS	**Median**	15
	IQR	14-15

WFNs: World Federation of Neurological Surgeons scale, H&H: Hunt and Hess scale, GCS: Glasgow Coma Scale, IQR: interquartile range.

There were 8 (9.30%) patients with neurological deficit: two patients (2.32%) with LT hemiparesis, one patient (1.16%) with RT hemiparesis, two patients (2.32%) with dysarthria, one patient (1.16%) with 6^{th} & 7^{th} nerve paresis, one patient (1.16%) with LT hypoglossal palsy and ataxia and one patient (1.16%) with ptosis **(Table 3).**

Table (3): Presence of neurological deficit in the studied patients

		Study patients (n =86)
Neurological deficit	**Yes**	8 (9.30%)
	No	78 (90.70%)
		Study patients (n =8)
Forms of neurological deficit	**hemiparesis**	3 (37.5%)
	Dysarthria	2 (25%)
	12^{th} paresis&ataxia	1(12.5%)
	6^{th} & 7^{th} nerve paresis	1 (12.5%)
	Ptosis	1 (12.5%)

Site of bleeding: Apart from one patient diagnosed with lumbar puncture, all patients were diagnosed with CT brain. Regarding the site of bleeding, the distribution of SAH was in descending order as follows: 57 (67.05%) patients were prepontine, 9 (10.58%) patients were perimesencephailc, 4 (4.70%) patients were basal with frontal ICH, and 3 (3.52%) patients were basal with Sylvian extension. Two patient (2.35%) was prepontine with Lt CPA, two patients (2.35%) was prepontine with franto-obasal ICH, two patients (2.35%) were prepontine and perimesencephalic, two patients (2.35%) were basal, two patients (2.35%) were bihemispheric. Two patients (2.35%) were occipital with rim SDH **(Table 4).**

Table (4): Site of bleeding in the studied patients

	Study patients (n =85)
Prepontine	57 (67.05%)
Prepontin & CPA	2 (2.35%)
Prepontin & ICHg	2(2.35%)
Perimesencephalic	9 (10.58%)
Perimesencephalic & prepontin	2(2.35%)
Basal	2 (2.35%)
Basal & Sylvian cistern	3 (3.52%)
Basal &frantal ICHg	4 (4.70%)
bihemispheric	2 (2.35%)
Occipital&SDH	2 (2.35%)

ICH: Intracerebral hemorrhage, CPA: Cerebellopontine angle, SDH: subdural hemorrhage.

MRI finding: Out of 86 patients with SAH who underwent MRI, only two patients were detected to have cervical abnormality by MRI **(Table 5).**

Table (3): Detection of spine abnormality by MRI in the studied patients.

	Study patients (n = 52)
Absence of MRI abnormality	84 (97.67%)
Presence of MRI abnormality	2 (2.32%)

MRI: Magnetic Resonance Imaging.

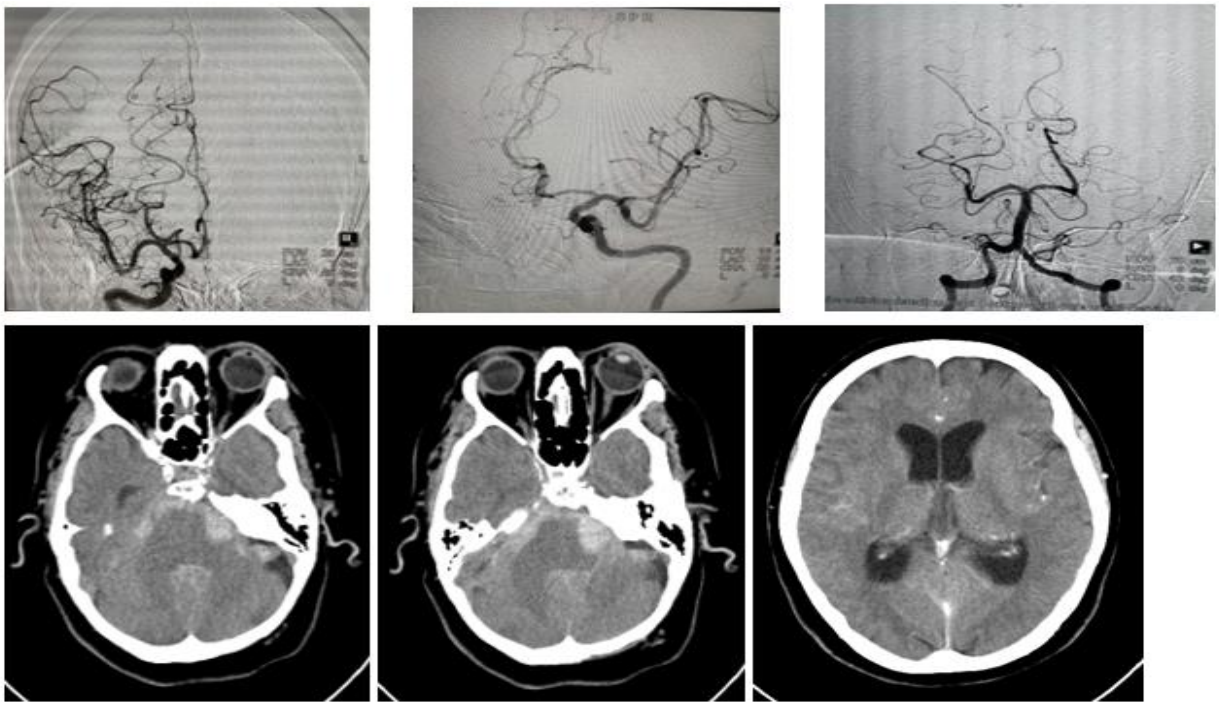

Figure (1): Angiography (a), plain CT brain (b, c, d) of the case No (1).

For the first case: 67-year-old female patient, -ve family history, GCS 15, no neurological deficit, WF 1, H & H 2, CT premesencephalic SAH, -ve cerebral angiography, MRI showed anterior spinal artery aneurysm.

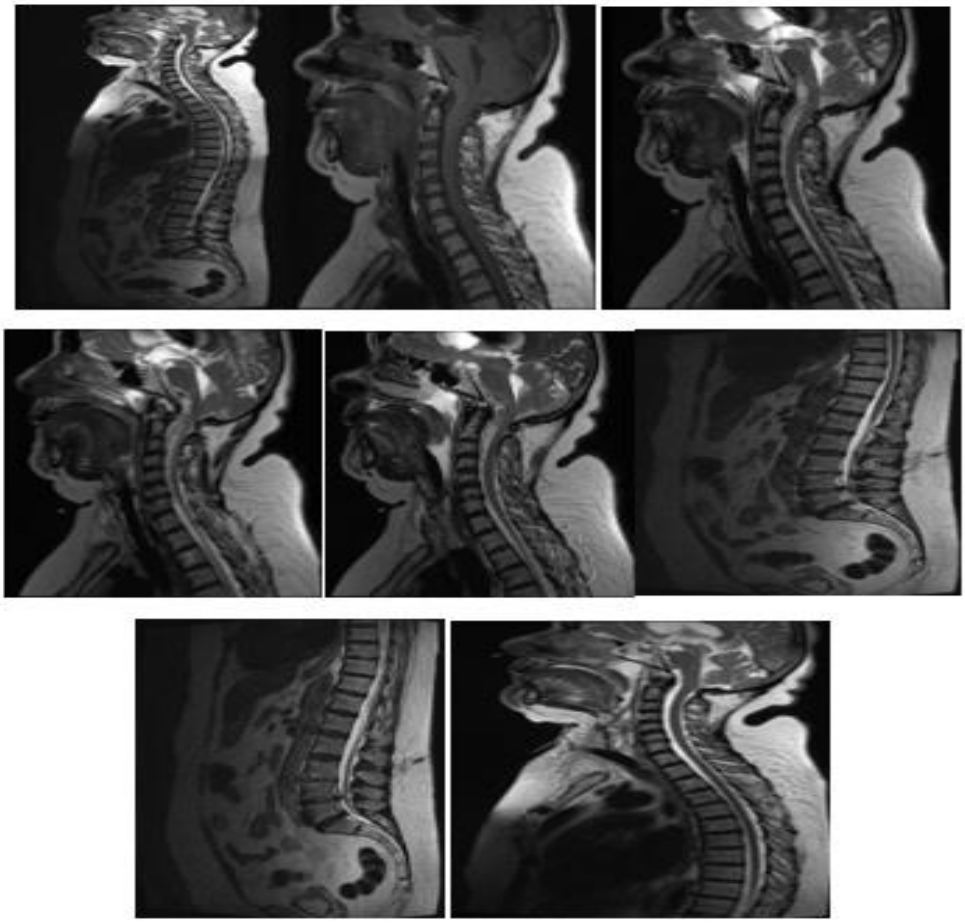

Figure (2): MRI spine, different sequences (T1, T2, DWI) of the case No (1).

For the second case: 71-year-old male patient, -ve family history, GCS15, no neurological deficit, WF 1, H & H 1, -ve cerebral angiography, MRI spine showed bleeding within the spinal canal without source for the SAH.

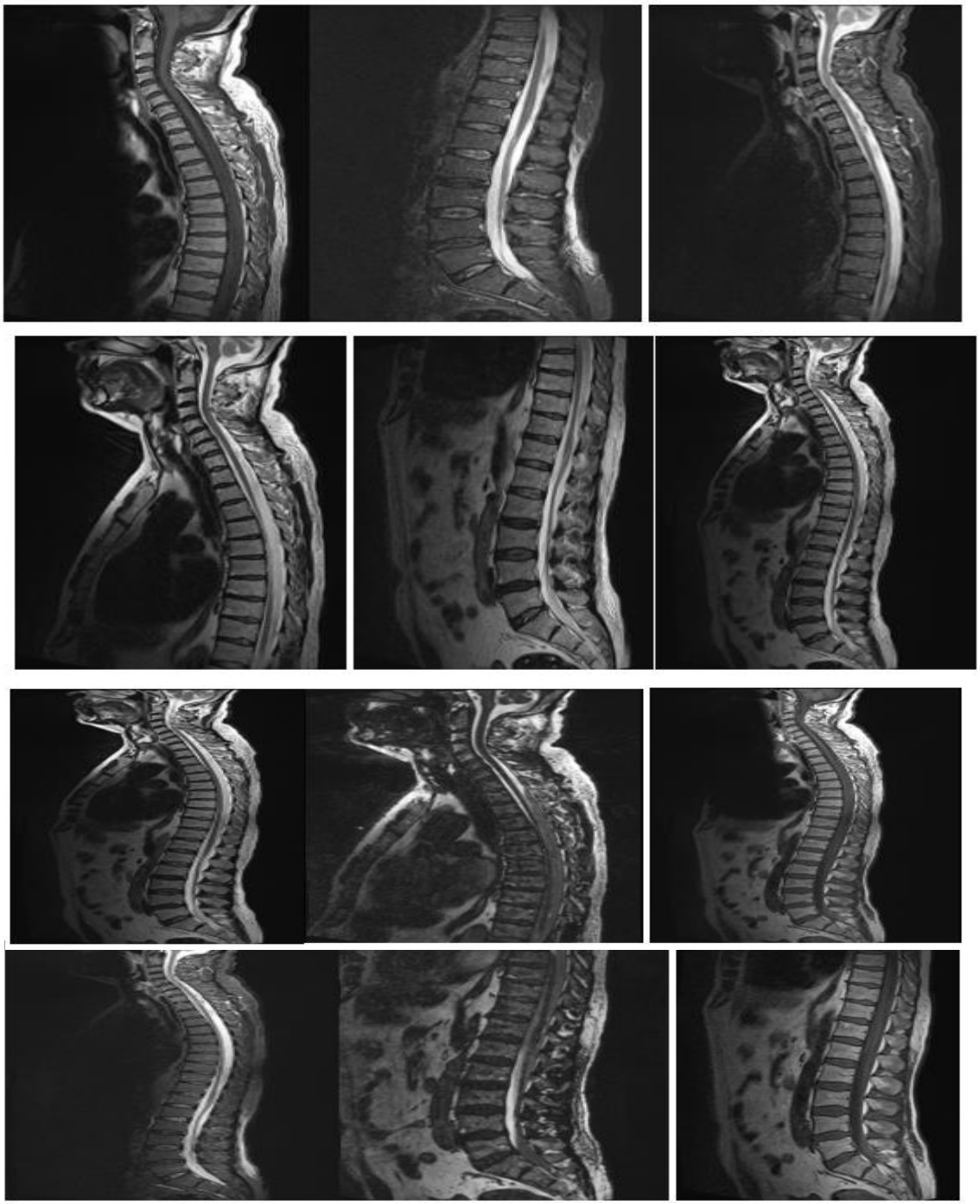

Figure (3): MRI spine different sequences (T1, T2, DWI) of the case No (2).

DISCUSSION

Initial recommendations for employing s-MRI in the AN-SAH cohort emerged from a handful of case reports documenting individuals with AN-SAH where spinal pathology was detected on c-spine MRI scans [12].

In the present study, the age of the studied patients ranged from 37-84 years, with a mean value of 52 ± 2.83 years. There were 50 (58.14%) male and 36 (41.86%) female patients. There were no patients with any family history. Consistent with our study focus, **Lin *et al.*** [10] present their experience from a single center in treating patients with SAH and a negative initial DSA result. Among these patients, 68 (19.3%) had a negative initial DSA. The average age was 59.5 ± 14 years, and 33 were females.

In the current study, the median value of WFNs was 1 with an IQR of 1-1.75, that of H & H was 1 with an IQR of 1-2, and that of GSC was 15 with an IQR of 14-15. In line with our results, **Lin *et al.*** [10] noted that most patients (55 out of 68, 85.3%) had a Glasgow Coma Scale score of 14–15. Sixty-one patients (89.7%) had favorable Hunt and Hess (H & H) grades (I–III), while seven had poor grades (IV–V).

In the present study, out of 86 patients with SAH who underwent MRI, only one patient was detected to have cervical abnormality as a source of bleeding by MRI. In line with our study, **Lin *et al.*** [10] observed that the effectiveness of diagnosis varied depending on the initial pattern of hemorrhage. Additional imaging investigations included repeat angiograms (54), brain and cervical spine MRIs (20), and repeat CTAs (15). In cases of diffuse SAH, three patients (9.1%) were found to have a structural cause for the hemorrhage (2 aneurysms, one vasculitis), with two requiring surgical intervention. In contrast, only one patient (3.7%) with a peri-mesencephalic non-aneurysmal SAH received a definitive diagnosis in subsequent studies (mesial temporal hemorrhagic infarction), which did not require surgery. Repeat cerebral angiography was the most informative diagnostic tool, with four out of six (66.7%) eventual diagnoses made from the repeat DSA. The remaining two diagnoses were identified from brain MRIs. Consistent with our findings, **Germans *et al.*** [5] evaluated the yield of MRI of the spinal neuraxis in individuals with non-perimesencephalic subarachnoid hemorrhage (NPSAH). Utilizing intracranial vascular imaging, they conducted T1- and T2-weighted MRI of the spinal axis in a sequential cohort of patients with spontaneous NPSAH devoid of intracranial vascular disease. They revealed that in patients who present with NPSAH, MRI of the spinal axis had low yield and clinical significance. Therefore, they did not advise routine spinal axis MRI in this patient population, albeit in a smaller subset of patients, it might be warranted. Similarly, **Little *et al.*** [9] conducted research on 100 individuals who had SAH with an initial negative catheter-based angiography. The "classic" aneurysmal pattern that filled the posterior fossa or basal cisterns was the most frequent distribution of bleeding (44 cases). They found that one cervical ependymoma had been identified by MRI of the brain and cervical spine. Also, **Maslehaty *et al.*** [13] assessed MR imaging's diagnostic utility in cases of SAH with an unknown cause that was perimesencephalic (PM) and non-perimesencephalic (non-PM). Their study comprised 1226 cases of spontaneous SAH. They revealed that the magnetic resonance imaging revealed no signs of haemorrhage (100% negative). Treatment was administered for both PM SAH and non-PM SAH (100% negative), and it was also found that MRI of the brain and craniocervical region did not provide additional benefit in identifying the source of bleeding.

Little *et al.* [9] and **Woodfield *et al.*** [7] advised against using c-MRI except in specific circumstances where symptoms and indicators point to possible spinal pathology. Also, **Yap *et al.*** [14] suggested that patients who had experienced a second clinical episode use c-MRI. Nevertheless, the small sample sizes in all of these investigations have been a limitation.

Several limitations need to be considered when interpreting these results. The study was conducted as a retrospective case series with limited sample sizes. Additionally, the investigators assessing the clinical outcome parameters were not blinded to the assignment of bleeding patterns.

CONCLUSION

Performing spinal MRI after a non-AN-SAH without clinical or neurological indications of a spinal cause has very limited diagnostic value. There is currently no evidence to support routine MRI screening for potential spinal causes of AN-SAH.

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