



Spine MRI Findings in Suspected Non-accidental Trauma: A Retrospective Study

Khalid Al-Dasuqi¹, Moayad Homssi², Nadia Solomon¹, Andrea Asnes³, John Leventhal³ and Ajay Malhotra¹

Yale
NewHaven
Health

¹Department of Radiology and Biomedical Imaging, Yale School of Medicine

²Department of Radiology, Weill Cornell Medicine

³Department of Pediatrics, Yale School of Medicine

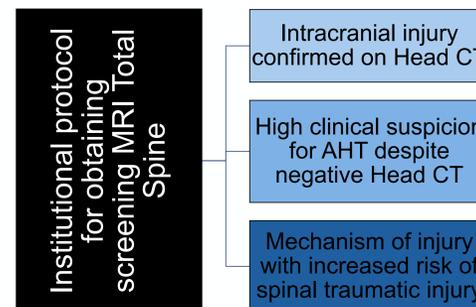
Background

- Abusive head trauma (AHT) is the leading cause of morbidity and mortality in patients below the age of 2 with traumatic brain injury. The incidence of AHT is estimated at 35 cases per 100,000 infants.¹ Subdural hemorrhage is the most common manifestation in AHT and is seen in 89% of cases.
- While brain imaging findings of AHT have been well-documented, the prevalence of spine injury in patients with nonaccidental trauma (NAT) and the clinical utility of spine MRI remain unclear. The incidence of spine injury in a study² involving 76 patients being evaluated for AHT was estimated at 59%, with the majority being ligamentous and paraspinal soft tissue injuries. Spinal subdural hemorrhage, particularly in the thoracolumbar spine, is also commonly reported in patients with AHT. While the presence of spinal subdural hemorrhage may not necessitate intervention, it suggests a traumatic etiology, and is more commonly seen in patients with NAT as compared to accidental trauma.³
- Given the recently growing awareness of spinal injury in the setting of AHT, the current ACR guidelines now strongly recommend performing MRI of the cervical spine at the time of brain MRI, and that MRI of the total spine be considered. However, significant variability exists in the utilization of spine MRI in NAT as well as in the patient selection and study protocols. In this retrospective cross-sectional study, we aim to examine the MRI spine findings in patients hospitalized for suspected NAT to understand the prevalence and clinical significance of spine findings in the setting of NAT.

1. Joyce et al. Pediatric Abusive Head Trauma. [Updated 2021 Aug 26]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2021 Jan-. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK499836/>
 2. Rabbitt et al. Characteristics associated with spine injury on magnetic resonance imaging in children evaluated for abusive head trauma. *Pediatr Radiol.* 2020 Jan;50(1):83-97. doi: 10.1007/s00247-019-04517-y. Epub 2020 Jan 4. PMID: 31901991; PMCID: PMC7223732.
 3. Choudhary et al. Spinal subdural hemorrhage in abusive head trauma: a retrospective study. *Radiology.* 2012 Jan;262(1):216-23. doi: 10.1148/radiol.11102390. Epub 2011 Nov 8. PMID: 22069156.

Materials and Methods

- After obtaining approval of the institutional review board, a retrospective study was performed evaluating the spine MRI findings in patients admitted for suspected or confirmed NAT.
- All infants and young children aged <24 months who had skeletal surveys done at our institution for the evaluation of NAT between January 2017 and December 2021 were identified through retrospective chart review of our radiology database (Nuance mPower). Subsequently, the cohort was screened for patients who had dedicated whole spine MRI during the same admission.
- Clinical data, including patient demographics, clinical presentation, interventions, and clinical outcomes, were collected and analyzed. Additional reports from the Child Abuse specialists and Social Work Services were reviewed when necessary. Cross-sectional images of the brain and spine (specifically MRI of the brain and total spine) were reviewed by a radiologist to confirm the reported findings.
- The MRI study protocol for whole spine imaging in suspected NAT includes sagittal short tau inversion recovery (STIR), axial and sagittal T2, sagittal T2* weighted gradient echo sequence, and sagittal T1 sequences. Axial and sagittal postcontrast T1 fat-suppressed sequences are also frequently obtained.
- No institutional protocol existed to guide the decision to obtain whole spine MRI in NAT cases during the first two years of the study period, and the decision was up to the clinical discretion of the treating physicians. An institutional protocol was later developed by the Child Abuse program.



Results

- A total of 618 patients who had skeletal surveys for the evaluation of NAT were screened, and 24 patients with concurrent MRI of the brain and total spine were identified and included in the study.
- The median age at presentation is 5 months (mean 5.6 months ± 4.9). The vast majority were infants (21/24) and approximately 58% of patients were male.
- The most common clinical presentation is altered mental status, lethargy and/or seizures, which were together observed in more than half of the patients (14/24). Two patients presented with skin burns and two other patients presented for work-up of new-onset macrocephaly. One patient had unexplained bruising, while another patient presented after reported fall. The remaining four patients exhibited signs and symptoms secondary to traumatic injury to the extremities (e.g. fussiness when moving an arm).
- Nearly all patients (96%) had findings compatible with AHT on MRI of the brain. The most common abnormal finding on brain MRI is subdural hemorrhage (83%), as outlined in table 1.

Table 1. Brain MRI Findings:

	Incidence, n (%)
Subdural hemorrhage	20 (83%)
Subarachnoid and/or intraventricular hemorrhage	8 (33%)
Parenchymal hemorrhage	7 (29%)
Hypoxic-ischemic encephalopathy	4 (17%)
Diffuse axonal injury	3 (16%)

- Only 9 had positive findings on whole spine MRI. Of these, the vast majority (89%) had thoracolumbar subdural hemorrhage, necessitating surgical evacuation in only one of them (see Figure 1). One patient had evidence of spinal subarachnoid hemorrhage in addition to subdural hemorrhage. Two patients had evidence of ligamentous injury in the cervical spine, one of which subsequently had a cervical collar placed.



Figure 1. Axial T2 image of the spine demonstrates thoracolumbar subdural hemorrhage (arrow) with complete effacement of the CSF space secondary to mass effect in a 5-month-old infant who presented with lethargy and seizures secondary to abusive head trauma.

- The spine MRI findings for all 9 patients were solely made on sagittal STIR and axial T2 sequences upon retrospective review. While 50% of patients received gadolinium contrast for their whole spine MRI study, no additional findings were seen on the postcontrast sequences.
- All patients with spine MRI findings had evidence of retinal hemorrhage on ophthalmologic examination, while only 27% had retinal hemorrhage in the group without spine MRI findings. Additionally, aside from skull fractures, the skeletal surveys in patients with spine MRI findings were nonrevealing. On the other hand, more than half of patients without spine MRI findings had evidence of injury on the skeletal survey, excluding skull fractures.

Table 2. Clinical and imaging findings for the the group with spine MRI findings compared to the group without spine MRI findings:

	(+ve) spine MRI findings (n=9)	(-ve) spine MRI findings (n=15)
Median age, months	5	3
Male sex, n (%)	5 (56%)	10 (67%)
Retinal hemorrhage, n (%)	9 (100%)	4 (27%)
Skeletal findings, n (%)	2 (22%)	8 (53%)
Skull fractures	2 (100%)	1 (13%)
Rib fractures	-	4 (50%)
Extremity fractures	-	6 (75%)

Discussion

- We observed a high incidence of spinal pathology on whole spine MRI in patients with AHT, which is concordant with recent literature. However, in our cohort, most cases with spine MRI findings had spinal subdural hemorrhage with only 2 patients exhibiting evidence of ligamentous injury in the cervical spine.
- Spinal subdural hemorrhage was exclusively found in the thoracolumbar spine and was only present in patients with intracranial subdural hemorrhage. The findings suggest that the subdural collections may reflect extension/pooling of blood products in the dependent thoracolumbar spine.
- Our findings also support the use of truncated MRI protocols comprising of sagittal STIR and axial T2 sequences in the initial screening MRI spine.
- Spinal subdural hemorrhage on MRI was more likely to be associated with absence of extremity fractures on skeletal survey and presence of retinal hemorrhage on ophthalmologic examination. Specifically, the absence of the latter was predictive of a negative spine MRI in our cohort.
- There are several limitations to our study: (a) our small sample size precludes performance of statistical analysis, (b) we did not assess for inter- and intra-observer variability, which limits the validity of our interpretations, and (c) there is potential for sampling bias due to our screening method, which was dependent on the presence of a skeletal survey.

Conclusion

Thoracolumbar subdural hemorrhage is the most common abnormality seen in patients with suspected NAT who underwent whole spine MRI at our institution. Severe spinal injury necessitating clinical intervention remains rare despite increased utilization of MRI of the spine. Follow up study with larger samples is needed to validate our data and guide future efforts to improve patient selection and study protocols.