



## NARRATIVE REVIEW

# Clinical Applications of Portable Low-Field MRI in Pediatric Neuroimaging: A Narrative Review

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### Abstract

**Background:** Portable low-field magnetic resonance imaging (MRI) has emerged as an innovative solution to challenges in pediatric neuroimaging, including radiation exposure, sedation requirements, limited accessibility, and the burden of transporting critically ill patients. The Hyperfine Swoop portable MRI system allows for bedside imaging in intensive care and neurosurgical settings, offering a new approach to point-of-care neurodiagnostics. As clinical usage expands, understanding its applications, advantages, and implementation considerations within pediatric practice is increasingly important.

**Methods:** This narrative review uses data from published studies, institutional case reports, and manufacturer specifications regarding the Swoop MRI's capabilities and its use in pediatric settings. It examines imaging performance, logistics, safety, and cost-effectiveness in comparison to conventional MRI, while focusing on its role in intensive care units, epilepsy monitoring units, outpatient clinics, and intraoperative environments. A formal systematic review or meta-analysis was not performed due to the heterogeneity of available studies and evolving clinical indications.

**Results:** The Swoop MRI, operating at 0.064 Tesla, delivers rapid T1, T2, FLAIR, and DWI images in under 20 minutes and offers bedside functioning. Its compact and portable design eliminates the need for dedicated MRI rooms, sedation, and shielding. Clinically, it demonstrated high sensitivity in identifying hydrocephalus, strokes, hemorrhages, and intracranial lesions. In pediatric care, the system has allowed for timely point of care neuroimaging with improved pediatric patient comfort. Economically, the system is about one-quarter of the cost of conventional MRI and reduces the resource burdens associated with sedation, transport, and anesthesia.

**Conclusions:** Portable MRIs represent a major advancement in pediatric neuroimaging. It provides a safe, accessible, and cost-effective alternative to conventional MRI with specific advantages in bedside examination, faster diagnosis, and reduced sedation need. Its expanding application in pediatric neurosurgical and critical care contexts suggests a future in the field for broader clinical adoption, especially in low-resource or high-volume environments.

### Keywords

Swoop MRI, Portable MRI, Pediatric radiology, Magnetic resonance imaging, Health technology assessment

### Abbreviations

MRI: Magnetic Resonance Imaging; FDA: Food and Drug Administration; CT: Computed Tomography; DWI: Diffusion-Weighted Imaging; EEG: Electroencephalography; EMU: Epilepsy Monitoring Unit; FLAIR: Fluid Attenuated Inversion Recovery; ICU: Intensive Care Unit; OR: Operating Room; PACS: Picture Archiving and Communication System; PICU: Pediatric Intensive Care Unit; SEEG: Stereoelectroencephalography

## Introduction

Approved by the FDA in 2020, the Hyperfine Swoop Portable MRI became the first and currently only portable MRI approved by the FDA for point of care evaluations. Capable of performing T1 (standard and gray/white), T2/Fast T2, Fluid-Attenuated Inversion Recovery (FLAIR), Diffusion-Weighted Imaging (DWI) sequences, and generating Apparent Diffusion Coefficient (ADC) maps, this system delivers 3D axial,

sagittal, and coronal images in under 30 minutes [1]. Compared to conventional MRI scanners, which typically operate at 1.5 Tesla or higher, the Swoop MRI operates using a 0.064 Tesla magnet, making it a viable option to be used bedside, unrestricted by metal proximity.

Neuroimaging in the pediatric population has traditionally been done using ultrasound, CT, and conventional MRI, each with inherent disadvantages. Although a cranial ultrasound is the safest option with no associated risks of radiation for newborns, its utility for intracranial evaluation becomes obsolete as fontanelles close, due to the bones blocking the passage of ultrasound waves [2-4]. Though they are widely available, CT scans expose children to ionizing radiation, posing cumulative risks, especially those requiring repeated imaging, such as patients with shunted hydrocephalus, epilepsy, vascular, or oncological pathologies. MRI, though radiation-free, comes with challenges related to accessibility, cost, and the need for sedation in the pediatric population. Children see a higher risk for developing radiation-related cancer over their lifetime, due to increased sensitivity to radiation [5]. A potential solution is offered by the Swoop Portable MRI, enabling clinicians to carry out quick bedside neuroimaging under minimal danger, reducing the necessity for sedation, and providing real-time decision support in both outpatient and inpatient settings.

Given these considerations, the portable MRI represents a promising alternative for pediatric neuroimaging. Its bedside and intraoperative capabilities minimize the need for sedation, eliminates radiation exposure, offers real-time inpatient and outpatient diagnostic support, and avoids the logistical barriers associated with conventional MRI. This paper aims to comprehensively explore the indications for the Swoop portable MRI in pediatric care, particularly in neurosurgical and critical care settings. Through the assessment of its clinical applications, advantages, and limitations, this review seeks to provide insight into how this new imaging technology may improve diagnostic and treatment strategies for pediatric patients.

## Methods

A targeted literature search was conducted using PubMed, Google Scholar, and reference lists of relevant articles published between January 2015 and April 2025, allowing inclusion of foundational low-field and portable MRI studies that predate FDA approval of the Hyperfine Swoop system but informed its technical development and early clinical adoption.

Given the limited number of peer-reviewed studies specifically evaluating portable low-field MRI in pediatric neurosurgical populations, as well as different study designs, patient populations, and reported outcomes, a systematic review or meta-analysis was not the best option for this manuscript. The available literature largely consists of observational studies, technical

reports, feasibility analyses, and early implementation experiences. Therefore, this study was designed as a narrative review to synthesize emerging evidence and clinical applications rather than to perform quantitative pooled analysis.

## Data extraction and synthesis

Data extracted from eligible sources included imaging indications, scan sequences, diagnostic utility, patient safety considerations, logistical workflow factors, and economic implications. Findings were synthesized qualitatively and organized by clinical domain, including pediatric intensive care, epilepsy monitoring, vascular pathology, outpatient care, and intraoperative use. Representative de-identified images were included for illustrative purposes only, with institutional approval, and were not used as patient-level data or as a basis for outcome analysis.

## Ethical considerations

As this study did not involve human subject's research or identifiable patient data, institutional review board approval was not required.

## Results

### Function and comparison

The Swoop MRI can be used in both pediatric (> 24 months) and adult settings. Although their uses may vary between these groups, the overall function of the device is the same. The 59-inch-tall portable brain imaging system weighs around 1,400 pounds, and the imaging sequences (T1, T2, FLAIR, and DWI) can be directed using an iPad device, demonstrating the ease of use and transferring data into a centralized imaging system (i.e. PACS).

The device's lower magnetic field strength (0.064T) reduces the need for shielding and cooling systems, which are normally required in MRI rooms to prevent external electromagnetic radiation from interfering with the scanner's operation. The permanent magnet used by the device does not require helium, unlike high-field MRIs, making it safer and cheaper [1]. Once plugged in, the device can produce an image within 2 minutes, unlike a conventional MRI, which can take anywhere from 15-90 minutes depending on the size of the area being scanned [1,6]. The entire device is wheelable, allowing for rapid imaging in operating rooms, emergency departments, ICUs, and outpatient clinics without transporting clinically ill patients. Lastly, the use of the Swoop MRI allows for broad national and international use, expanding the global neurological and neurosurgical workup needed in anticipation of treatment.

### Advantages of the portable MRI in a pediatric setting

**Faster imaging time:** The Swoop MRI can produce images in less than two minutes after being plugged into

a standard outlet [7]. On the other hand, a conventional MRI can take anywhere from 15 to 90 minutes, based on the size of the area being scanned and the number of images being taken<sup>6</sup>. This major reduction in scanning time is very important in pediatric patients, as it minimizes the need for sedation and reduces the duration they are required to remain still. Additionally, the imaging capabilities are modifiable, and series can be obtained or omitted as needed, as the pathology dictates.

**Less space requirement/portability:** The size and mobile nature of this device eliminates the need for dedicated real estate within a busy hospital environment while allowing all departments to use the device when needed [8]. It is built with powered drive wheels, which allows the system to be driven around. It also fits through typical doorways, facilitating easy and effortless transportation to the bedside (even in critical care settings) [7]. In contrast to other MRI scanners, the portable MRI requires no external cooling systems or specialized shielding, meaning that it is not necessary to have a designated imaging room [9,10]. Such flexibility and portability are useful in a pediatric setting, where reducing delays and patient transport is essential to timely diagnosis and treatment.

**Lower cost:** The portable MRI costs approximately one-quarter as much as conventional MRI equipment [11]. It is also cheaper to operate than a conventional MRI machine, demonstrating yet another element in minimizing long-term expense. By contrast, a conventional MRI requires a trained technician, whereas the portable MRI can be operated by bedside nurses, physicians, or trained technicians. Additionally, the burden on hospital transport and respiratory therapy is alleviated given that there is no need to mobilize patients. This reduced expense makes it more accessible to pediatric hospitals, particularly in lower income communities that do not have the capabilities to expand elective programs.

**Safer for patients:** Given the low magnetic field of a portable MRI, adverse events due to surrounding metals are negligible. Simultaneously, since the device can be brought directly to the patient, adverse events associated with patient mobilization are drastically decreased. Time to diagnosis can significantly decrease since the device is readily available. Patients who are otherwise unsafe to undergo conventional MRI due to cardiac hardware in the CICU, hemodynamic instability, or the trauma setting can easily be scanned.

**Point-of-care imaging:** The portable MRI is ideal for bedside imaging, especially in conditions like hydrocephalus where rapid diagnosis and follow-up are important in all age groups. Its portability allows physicians to obtain images in real time and perform preliminary evaluation, even prior to having a formal radiological read. Point of care ultrasound is a perfect

example of real time information in outpatient, inpatient, and procedural settings that are run by a physician who is otherwise an expert in a particular subspecialty without need for immediate interpretation of data from a radiologist. In a way, there is an element of the portable MRI that is invaluable as a point of care imaging.

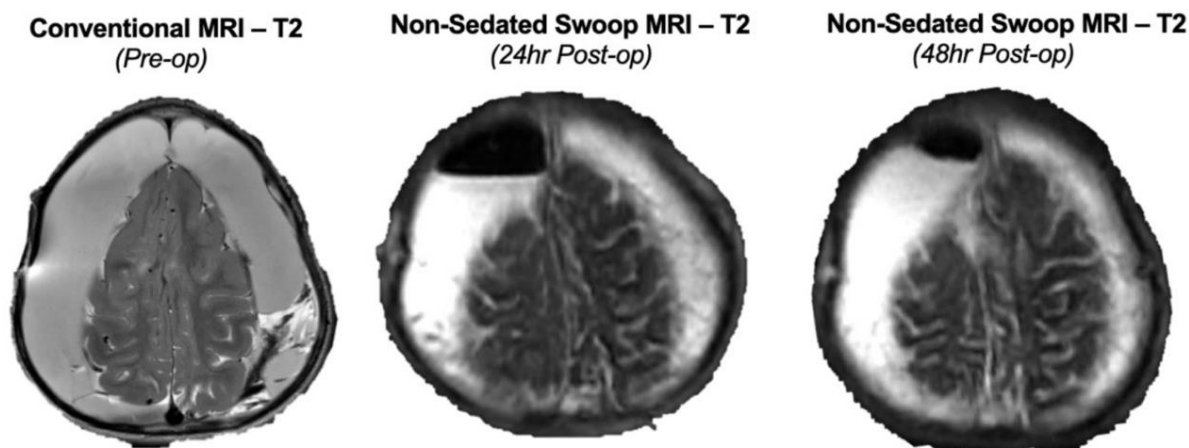
**Reduced noise & sedation requirement:** The portable MRI results in significantly quieter scans in comparison to conventional MRI machines due to the ultra-low magnetic field strength of 0.064T. Its improved and openness around the head coils allows for alleviation of claustrophobia related anxiety. Furthermore, in the pediatric population, the ability to bring electronic devices within the field of vision of the patient to distract them, provides an environment akin to that of having child life to mitigate need for sedation, minimize motion artifact, and improve patient experience. The open and accessible design of the portable MRI system allows parents and family members to remain at the child's side throughout the procedure, helping to reduce anxiety and create a more comforting environment during imaging [7]. The reduced noise makes the experience of getting a scan less intimidating for pediatric patients, often eliminating the need for sedation and hearing protection [12].

International experience supports these applications. For example, the University of Bonn has reported performing approximately 75 pediatric Swoop MRI scans across diverse indications, including hydrocephalus (ventricular size monitoring, VP-shunt dysfunction), seizures/status epilepticus, stroke, severe trauma, and post-tumor resection follow-up. In their PICU, Swoop has been used nearly weekly, either as a first-line bedside modality or as a follow-up to conventional 3T imaging, underscoring its versatility in critical pediatric care.

Together, these findings highlight the feasibility of bedside portable low-field MRI for postoperative neuroimaging in pediatric neurosurgical care, with representative image quality illustrated in [figure 1](#). A summary of these advantages is listed in [table 1](#).

## Discussion

Portable MRI systems have been increasingly incorporated into neurosurgical practice, particularly in pediatric care environments where minimizing radiation exposure, sedation, and patient transport is critically important. This narrative review synthesizes reported clinical experience across multiple practice settings and supports the feasibility of portable MRI as a complementary imaging modality in pediatric neurosurgical and critical care settings. Institutional experiences referenced are descriptive and derived from published reports and implementation narratives; no patient-level data were collected or analyzed in this review.



**Figure 1:** Representative axial T2-weighted images from conventional MRI and bedside low-field portable MRI

Representative axial T2-weighted images comparing conventional high-field magnetic resonance imaging (MRI) and bedside portable low-field MRI acquired without sedation in the postoperative setting. The left panel shows a preoperative conventional high-field axial T2-weighted MRI. The middle panel shows a non-sedated bedside Swoop portable MRI obtained 24 hours postoperatively, and the right panel shows a non-sedated bedside Swoop portable MRI obtained 48 hours postoperatively. Images are shown for illustrative purposes only and demonstrate visualization of postoperative intracranial fluid collections and cortical anatomy without the need for patient transport. No arrows or lettered annotations are present.

**Table 1:** Summary of advantages of portable MRI in a pediatric setting.

Advantages	Description	Significance
Faster Imaging Time	Produces images within 2 minutes compared to 15-90 minutes for conventional MRI.	Reduces need for sedation in young children.
Less Space Requirement / Portability	The device is compact and wheelable for bedside use in PICUs, EDs, ORs, and outpatient clinics. No need for extensive shielding and cooling systems → no separate room required for MRI imaging.	Enables immediate imaging of critically ill infants and children without moving them to a separate imaging suite.
Lower Cost	Significantly cheaper than traditional MRI scanners.	Makes advanced neuroimaging more accessible in pediatric hospitals, especially in low-resource areas such as the Bronx.
Safer for Patients	Lower magnetic field reduces risks, especially in pediatric patients or individuals with metal implants.	Reduces risk of radiation in pediatric patients with shunts or other metallic devices.
Point-of-Care Imaging	Ideal for bedside imaging of conditions like hydrocephalus.	Supports rapid diagnosis and monitoring of neurological conditions in premature infants and critically ill children.
Reduced Noise & Sedation Requirements	Quieter operation than conventional MRIs, making it less intimidating.	Helps reduce possible anxiety in young children, especially with avoiding sedation.

Summary of the key clinical, logistical, and patient-centered advantages of portable magnetic resonance imaging (MRI) compared with conventional MRI in pediatric care settings. The table highlights how portable MRI improves imaging speed, accessibility, safety, and feasibility of point-of-care neuroimaging, particularly for critically ill infants and children in environments such as the pediatric intensive care unit (PICU), emergency department (ED), operating room (OR), and resource-limited hospitals.

### Pediatric intensive care units (PICU)

Pediatric traumas account for approximately 332 cases per 100,000 person-years in the United States. While most of these are managed nonoperatively, the accepted modality of initial evaluation is a CT, followed by additional CT or MRI scans to assess stability. Although CT remains the superior modality in assessment of bony fractures and defects, subsequent soft tissue and intracranial evaluation can easily be accomplished with the portable MRI, minimizing radiation exposure and avoiding repeated CT scans. Although lacking GRE at

this time, proper utilization of T1 and T2 can provide insights into hemorrhagic pathologies and temporal relationships.

This is consistent with international practice. At the University of Bonn, pediatric intensivists have adopted Swoop nearly weekly in their PICU for children on ECMO, post-resuscitation, and severe head trauma. Clinicians emphasized that organizational speed and patient acceptance were key advantages, while DWI was particularly valuable for stroke assessment and rapid T2 sequences (~6 minutes) provided immediate

hydrocephalus evaluation. These experiences highlight how Swoop integrates into pediatric critical care workflows beyond the U.S.

### **Epilepsy monitoring units (EMU)**

The number of EMUs has been rapidly growing within the United States, reaching up to 260 centers across the nation for both pediatrics and adults. In the pediatric context, addition of portable MRI to a surgical EMU post stereotactic EEG implantation provides not only safety, but also extreme efficiency in assessing post implantation monitoring, exam changes, post radiofrequency ablation evaluation, and post SEEG removal. Exam changes requiring imaging evaluation, particularly in the first 24 hours post implantation and explanation, would benefit immensely from a portable MRI rather than mobilizing patients for CT. Importantly, the reduced need for sedation and the elimination of cumulative ionizing radiation make portable MRI particularly useful in pediatric EMUs, where patient stability and neurodevelopmental considerations are critical. Bedside radiofrequency ablation requires post-op imaging that can be achieved in real time.

### **Pediatric vascular pathologies**

Pediatric vascular pathologies, as seen in patients with strokes, sickle cell disease, Moyamoya, vasculitis, AVMs and aneurysms, require imaging as the foundation for formulating a proper management strategy. In these cases, the use of Swoop MRI can expedite diagnostic imaging bypassing sedation protocols and providing rapid data bedside. Sedation drastically prolongs diagnosis and risks hemodynamic changes that could have negative clinical outcomes due to anesthesia-associated hemodynamic changes.

### **Outpatient and intraoperative settings**

Outpatient settings such as seen in hydrocephalus clinics, neuro-oncology clinics, and postoperative clinics often have innate reliance on cranial imaging. Portable MRIs enable convenient and timely clinical evaluation that can highlight the need for intervention versus monitoring. In the US-based system, a pre-authorization can be submitted the week prior to a patient's clinic visit, and data can be obtained by clinic staff prior to their appointment time, at which point the specialist will review the results with the patient. In intraoperative neurosurgical cases, specifically low-grade gliomas that are non-enhancing and most prominently seen on FLAIR sequences, portable MRIs can assist in real-time assessment of residual tumors and inform decisions regarding re-resection, particularly in resource-constrained or ambulatory surgical settings. Furthermore, fusion of images into neuro-navigational devices can allow guided resection of residual lesions.

### **Economic considerations**

From a radiology compensation perspective, the portable MRI offers a cost-effective alternative to

traditional MRI, particularly in pediatric settings where sedation and transport can be resource intensive. Conventional MRI machines can cost over \$3 million to purchase, with additional expenses for installation and annual maintenance, potentially bringing the total to over \$5 million. In contrast, the portable MRI is priced at approximately \$250,000, requiring no specialized infrastructure, space, shielding, or additional personnel. From a productivity standpoint, radiologists can interpret portable MRI images asynchronously or during off hours, adding reimbursable reads with relatively minimal marginal labor. In a high-volume pediatric neurosurgical environment, the ability to complete follow-up imaging efficiently with the portable MRI can help preserve traditional MRI resources for more complex cases, optimizing clinical care and radiologist efficiency.

### **Limitations**

This review has several limitations, including the lack of available literature on portable MRI in pediatric neurosurgical populations, with most reports consisting of observational studies or experiences rather than comparisons. Diagnostic performance varies by pathology and imaging sequence, and portable MRI is not intended to replace conventional high-field MRI in cases requiring advanced sequences. Additionally, institutional experiences cited in this paper are descriptive and may not be generalizable across practice settings. Further prospective studies are needed to better define clinical indications, diagnostic performance, and cost-effectiveness in pediatric neurosurgical care.

### **Conclusions**

The use of portable MRIs has been a breakthrough in pediatric neuroimaging, providing a safe, cost-effective, and accessible alternative to conventional imaging methods. The device's elimination of ionizing radiation is especially useful in pediatric patients, where minimizing the use of sedation and avoiding radiation exposure is crucial. Clinical applications across pediatric ICUs, epilepsy monitoring units, outpatient clinics, and intraoperative settings underscore the device's growing utility in both emergent settings and routine outpatient care. Additionally, the economic benefits support its broader implementation in resource-limited environments. As more hospitals use the device, the Swoop portable MRI has the potential to redefine pediatric neuroimaging standards by bringing traditional capabilities to the bedside [13-18].

### **Competing Interests**

All authors have completed the ICMJE uniform disclosure form and declare no conflict of interest.

### **Ethical Approval**

Ethical approval is not required for this article type.

## Contributors

All authors contributed to the conception or design of the work, the acquisition, analysis, or interpretation of the data. All authors were involved in drafting and commenting on the paper and have approved the final version.

## Funding

This study did not receive any funding.

## Acknowledgements

None.

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