



Early Biomarkers for Cerebral Palsy in High-Risk Infants: Predictive Validity of General Movements Assessment Versus Magnetic Resonance Imaging.

¹Dr. Pooja Agarwal, ²Dr Sundeep kumar agarwal.

¹MBBS,MD, Assistant professor; Department of Pediatrics, Government medical college ,Haldwani.

²MBBS, MS(ORTHO), Associate Professor, Department of Orthopedics; Varun Arjun Medical College & Rohilkhand Hospital, Banthra, Shahjahanpur (U.P.).



Correspondence:

Dr. Pooja agarwal.

MBBS,MD, Assistant professor;
Department of Pediatrics, Government
medical college ,Haldwani.

Email:

agarwal.pooja.pooja38@gmail.com

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Abstract

Background: Early diagnosis of cerebral palsy (CP) enables timely intervention during periods of maximal neuroplasticity. Among available early biomarkers, General Movements Assessment (GMA) and Magnetic Resonance Imaging (MRI) are the most widely validated tools for identifying infants at high risk of CP. **Objective:** To compare the predictive validity of GMA and MRI for early detection of CP in high-risk infants and to evaluate their combined diagnostic utility. **Methods:** A narrative review of published studies, systematic reviews, meta-analyses, and international clinical practice guidelines evaluating GMA and MRI in high-risk infants was conducted. Data regarding sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy were synthesized. **Results:** GMA demonstrated sensitivity ranging from 95–98% and specificity between 91–94% during the fidgety movement period. MRI demonstrated sensitivity ranging from 86–100% and specificity from 89–97%, depending on timing and lesion type. Combined use of GMA and MRI yielded diagnostic accuracy exceeding 95%, with some studies reporting predictive accuracy greater than 97% when combined with neurological examinations. GMA was particularly useful for functional assessment, whereas MRI provided anatomical characterization of brain injury. **Conclusion:** Both GMA and MRI are highly predictive early biomarkers for CP. GMA appears superior in sensitivity and feasibility, whereas MRI provides essential neuroanatomical information. Combined assessment offers the highest predictive validity and should be considered the gold standard approach for early CP detection in high-risk infants.

Keywords: Cerebral palsy, General Movements Assessment, MRI, early diagnosis, biomarkers, high-risk infants..



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INTRODUCTION

Cerebral palsy (CP) represents the most common cause of physical disability in childhood, affecting approximately 2–3 per 1,000 live births worldwide. Early diagnosis has historically been delayed until 12–24 months of age because definitive motor abnormalities often become clinically apparent only during infancy or early childhood. However, increasing evidence demonstrates that reliable diagnosis can be achieved within the first few months of life using validated biomarkers and standardized assessments.

The concept of early diagnosis has become increasingly important because neuroplasticity is greatest during the first year of life. Earlier identification permits initiation of targeted interventions that may improve motor, cognitive, and functional outcomes. International clinical practice guidelines now recommend early detection pathways based on standardized assessments rather than a “wait-and-see” approach.

Among available early biomarkers, neonatal MRI and Prechtl’s General Movements Assessment (GMA) have emerged as the most reliable tools for predicting CP. MRI identifies structural brain abnormalities associated with motor dysfunction, including white matter injury, periventricular leukomalacia, deep gray matter lesions, cortical abnormalities, and cerebellar injury.

GMA is a non-invasive observational assessment of spontaneous infant movements. During the “fidgety movement” period (9–20 weeks corrected age), absence or abnormality of fidgety movements is strongly associated with later CP diagnosis. Multiple studies have demonstrated excellent predictive validity of GMA across diverse populations of high-risk infants.

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Although both assessments are recommended in clinical practice, uncertainty remains regarding their relative predictive performance and optimal implementation. This review therefore evaluates and compares the predictive validity of GMA and MRI for early diagnosis of CP in high-risk infants.

MATERIALS AND METHODS

Study Design

A narrative review and evidence synthesis were undertaken using published literature evaluating the predictive validity of GMA and MRI for CP diagnosis in high-risk infants.

Literature Sources

- Studies included:
- Systematic reviews.
- Meta-analyses.
- Prospective cohort studies.
- International clinical practice guidelines.
- Diagnostic accuracy studies.

Inclusion Criteria

- High-risk infants (prematurity, neonatal encephalopathy, brain injury).
- Assessment using GMA and/or MRI before 6 months corrected age.
- CP diagnosis confirmed at follow-up ≥ 24 months.
- Reported diagnostic performance measures.

Outcome Measures

- Primary outcomes included:
- Sensitivity
- Specificity
- Positive Predictive Value
- Negative Predictive Value
- Overall diagnostic accuracy.

RESULTS

Table 1. Characteristics of Included Evidence

Characteristic	Value
Studies reviewed	20+
Study designs	Cohort, systematic reviews, meta-analyses
Population	High-risk infants
Follow-up duration	2–5 years
Main assessments	GMA, MRI
Primary outcome	CP diagnosis

Table 2. Predictive Validity of GMA

Parameter	Reported Range
Sensitivity	95–98%
Specificity	91–94%
PPV	85–95%
NPV	95–99%
Diagnostic Accuracy	92–97%

Sources synthesized from systematic reviews and guideline evidence.

Table 3. Predictive Validity of MRI

Parameter	Reported Range
Sensitivity	86–100%
Specificity	89–97%
PPV	78–95%
NPV	90–98%
Diagnostic Accuracy	88–95%

Table 4. Advantages and Limitations of GMA

Advantages	Limitations
Low cost	Requires certified training
Non-invasive	Observer dependent
Video-based	Less anatomical information
High sensitivity	Optimal only during specific age windows
Suitable in low-resource settings	Requires movement recording

Table 5. Advantages and Limitations of MRI

Advantages	Limitations
Anatomical diagnosis	High cost
Lesion characterization	Limited access
Objective imaging	Need for transport/sedation in some cases
Identifies etiology	Resource intensive
Guides prognosis	Not always feasible

Table 6. Predictive Accuracy of Combined Approaches

Assessment Combination	Accuracy
GMA alone	92–97%
MRI alone	88–95%
HINE alone	85–93%
GMA + MRI	95–98%
GMA + MRI + HINE	>97%

Table 7. Clinical Recommendations Based on Age

Age	Recommended Assessment
Birth–Term age	MRI
Term–8 weeks	MRI + Neurological exam
9–20 weeks	GMA
3–6 months	GMA + MRI + HINE
>6 months	MRI + HINE + Developmental assessments

DISCUSSION

The present review demonstrates that both GMA and MRI possess excellent predictive validity for early identification of CP among high-risk infants. However, notable differences exist in their clinical application and diagnostic performance. GMA demonstrated the highest sensitivity among individual assessment tools, with reported values approaching 98% during the fidgety movement period. These findings are consistent with Novak et al. (2017), who identified GMA as the most predictive clinical assessment available before five months corrected age, reporting sensitivity close to 98% (1). Similarly, Einspieler et al. reported sensitivity exceeding 98% and specificity up to 94% in large cohorts, confirming the robustness of absent fidgety movements as a predictor of later CP diagnosis (2).

MRI demonstrated slightly lower but still excellent sensitivity, generally ranging from 86–100%. Morgan et al. found MRI to be highly predictive when performed at term-equivalent age, particularly in infants with white matter injury and deep gray matter lesions (3).

Recent evidence by Sutter et al. (2024) further confirmed MRI's utility in identifying lesion patterns associated with CP risk while simultaneously highlighting the superior functional predictive value of GMA during early infancy (4). Importantly, contemporary studies increasingly support multimodal assessment. Morgan et al. demonstrated diagnostic accuracy exceeding 97% when abnormal MRI findings were combined with absent fidgety movements and abnormal HINE scores (5).

Recent diagnostic investigations by Razak et al. (2024) similarly concluded that early neurodevelopmental assessments reliably predict CP severity and diagnosis at 24–36 months, reinforcing the role of combined assessment pathways (6). Emerging evidence from neonatal follow-up programs also suggests that MRI and GMA provide complementary information rather than competing approaches. MRI identifies the structural substrate of injury, whereas GMA evaluates

the functional consequences of altered neural connectivity. This complementary relationship explains the superior diagnostic performance achieved when both tools are used together (7).

A notable strength of GMA is its feasibility in low-resource settings. Recent implementation studies have demonstrated successful deployment of GMA-based screening programs in resource-constrained environments, where MRI access may be limited (8).

Overall, current evidence strongly supports a combined diagnostic strategy involving MRI, GMA, and neurological examination for optimal early detection of CP.

CONCLUSION

General Movements Assessment and MRI are the most validated early biomarkers for cerebral palsy in high-risk infants. GMA demonstrates superior sensitivity, low cost, and excellent feasibility, making it an ideal screening tool during early infancy. MRI provides valuable anatomical information regarding brain injury and etiology, contributing significantly to prognosis and management planning.

The highest predictive accuracy is achieved when GMA and MRI are used together, particularly when supplemented by standardized neurological examinations such as the HINE. Current evidence supports implementation of combined assessment pathways for early diagnosis and timely intervention in infants at high risk for CP.

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