Journal of Neuro-Oncology (2026) 179:15
https://doi.org/10.1007/s11060-026-05728-8

REVIEW

Beyond motor: clinical manifestations of right hemisphere gliomas — a systematic review

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Received: 3 June 2026 / Accepted: 20 July 2026

Abstract

Purpose Right-hemisphere gliomas have traditionally been regarded as less eloquent than left-sided lesions, influencing surgical decision-making and anesthetic approach. However, these tumors produce diverse non-motor manifestations affecting cognition, behavior, and socio-emotional functioning with important consequences for quality of life. This review aimed to characterize these manifestations and their implications for functional eloquence.

Methods Following PRISMA guidelines, PubMed, Scopus, and Embase were searched using predefined terms for right-hemisphere gliomas and their manifestations. Eligible studies included patients with supratentorial right-hemisphere gliomas reporting motor and/or non-motor clinical manifestations. Studies were excluded if the clinical presentation was incompletely described or if glioma pathology lacked histopathological confirmation. Extracted data included tumor location, histopathology, clinical manifestations, neuropsychological assessments, and functional outcomes.

Results A total of 372 patients from 88 studies were included. Median age was 42 years (range, 11–87), with slight male predominance (49% vs. 48% female). Preoperative non-motor manifestations were common and heterogeneous, most frequently compromising cognition and executive performance (43%), followed by vision and visuospatial deficits (28.4%) and language deficits (24%). Postoperatively, the most common deficits involved language (46%), followed by vision and visuospatial deficits (40%), and cognition and executive dysfunction (23.1%). Analyses relating extent of resection to postoperative deficits were considered exploratory because reporting of extent of resection and postoperative outcome assessment were incomplete and heterogeneous.

Conclusions Right-hemisphere gliomas carry a substantial and under-recognized burden of non-motor manifestations that challenge conventional definitions of functional eloquence and support the expansion of functional assessment and surgical planning encompassing right-hemisphere cognitive and behavioral networks.

Keywords Glioma · Right hemisphere · Non-motor manifestations · Eloquent cortex · Neuropsychological tests · Outcomes

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Published online: 27 July 2026

Introduction

Historically, hemisphere dominance has been defined largely by language lateralization, with approximately 90–95% of right-handed and 70–80% of left-handed individuals showing left-hemisphere dominance [1]. Together with motor function, the term *eloquence* has been largely reserved for the primary motor cortex and the dominant-hemisphere cortical language areas, which in most cases are situated on the left hemisphere [1]. As a consequence, lesions involving the right hemisphere have often been underestimated from a functional perspective in neurosurgery. Surgical decision-making has historically been influenced by the perception that the "*non-dominant*" hemisphere carries lower functional risk, which has contributed to more permissive surgical strategies and less systematic evaluation of non-motor functions in this population [2, 3].

However, this traditional model—largely centered on hemispheric dominance and language lateralization—does not fully capture the functional complexity of the right hemisphere and has increasingly been challenged in recent years. The right hemisphere subserves a wide range of higher-order functions beyond gross motor control, including visuospatial cognition, attentional processing, executive functions, nonverbal and verbal memory, emotional processing, language prosody and semantics, and, more recently, social cognition [2, 4–6].

Not surprisingly, in glioma surgery, the right hemisphere has been significantly underestimated, with neurosurgeons traditionally advocating for more aggressive resections based on the misconception that this "*non-dominant*" hemisphere lacks eloquence [7]. This misconception stems from the well-established finding that over 90% of the general population exhibits left-hemispheric dominance for language — a figure that, while accurate for language lateralization specifically, has been inappropriately extrapolated to imply that the right hemisphere is functionally silent [8]. Consequently, right hemisphere tumors have been resected less frequently under awake functional mapping, which has been shown to contribute to higher rates of postoperative neurological and cognitive deficits and lower return to work rates compared with right hemisphere lesions treated under awake monitoring [9, 10].

Despite their clinical relevance, non-motor manifestations of right-hemisphere gliomas are reported inconsistently and assessed heterogeneously in the surgical literature, limiting accurate functional risk stratification and outcome interpretation. Accordingly, this systematic review aims to characterize the spectrum of clinical manifestations associated with right hemisphere gliomas, with particular emphasis on non-motor deficits, and to explore their implications for evolving concepts of cortical eloquence and surgical decision-making.

Methods

Study design and population

This study was conducted as a systematic review in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines and was registered on Prospero (CRD420251181135). The review protocol was developed a priori to identify studies that report clinical manifestations associated with right-hemisphere gliomas. Eligible studies included patients with supratentorial right-hemisphere gliomas confirmed by histopathological analysis. Studies reporting both motor and non-motor clinical manifestations were eligible for inclusion. Studies were excluded if the medical record was incompletely described, tumor laterality was not specified, only an abstract was available without full-text, or glioma pathology was absent or lacked histopathological confirmation.

Additionally, studies were excluded if they did not provide laterality-stratified reporting of clinical manifestations or lacked structured perioperative follow-up of neurological outcomes specific to patients with right-hemisphere lesions. This criterion was applied regardless of sample size or methodological quality, as studies primarily designed to assess oncological outcomes (i.e., overall survival [OS], progression-free survival [PFS], extent of resection, or global functional autonomy) do not permit meaningful extraction of right-hemisphere-specific non-motor clinical data, even when neuropsychological assessments are included as secondary outcomes. Accordingly, several large, methodologically rigorous cohorts were excluded on this basis, despite their significant contributions to the broader low-grade glioma literature.

Tumor diagnoses and grades were extracted as reported in the original publications. Because the aim of this review was to characterize right-hemisphere clinical manifestations and their implications for surgical planning and functional monitoring, rather than to compare tumor-specific biology, retrospective molecular reclassification was not attempted.

For the purposes of this review, right-hemisphere gliomas were defined anatomically as supratentorial gliomas located in the right cerebral hemisphere, irrespective of handedness or language dominance. The terms "right hemisphere" and "right-sided" were used anatomically and were not considered synonymous with "non-dominant hemisphere." Handedness was extracted when reported; however, language dominance was inconsistently documented and therefore could not be used for stratified analysis.

Data collection

A comprehensive literature search was performed in PubMed, Scopus, and Embase from database inception through September 2025. The search strategy included terms related to pathology (glioma, brain tumor), anatomical location (right hemisphere and lobes), and clinical manifestations. Boolean operators were used to combine terms within concepts (OR) and between terms (AND). Titles and abstracts were screened independently by three reviewers, followed by full-text reviews of potentially eligible studies. Discrepancies were resolved by consensus, and study quality was assessed using the Joanna Briggs Institute's (JBI) Critical appraisal checklist [11] (Supplementary material Table 1) selected according to the design of each included study when possible. Case reports, case series, and cohort-type studies were appraised using the corresponding JBI checklists. Quality appraisal was used to characterize the strength and limitations of the available evidence and was not used as an exclusion criterion for studies that otherwise met eligibility criteria.

Data were extracted using a standardized form and included study characteristics, patient demographics, tumor location and histopathology, reported preoperative and postoperative clinical manifestations, methods of clinical or neuropsychological assessment, and reported functional outcomes. Non-motor clinical manifestations were categorized into predefined domains, including language, auditory, visuospatial deficits, cognitive and executive dysfunction, attention and memory, and socio-emotional changes. Reported manifestations were categorized according to the construct assessed or, when only clinical descriptions were available, by reviewer consensus. Also, when formal neuropsychological testing was reported, the deficit was categorized according to the assessed construct. When only clinical descriptions were available, three reviewers assigned the manifestation to the most appropriate predefined domain by consensus. Ambiguous findings were not forced into a domain and were retained as "other" or not pooled when insufficiently described. Disagreements regarding eligibility, extraction, or categorization were resolved by consensus. Formal inter-rater agreement was not calculated. Overall perioperative deficit status was coded as "no deficit" only when the original publication explicitly described the absence of neurological, neuropsychological, or relevant perioperative deficits. When clinical status was not described, the case was coded as "not reported." Domain-specific manifestations were recorded only when explicitly reported in the source article; lack of mention of a specific domain was not interpreted as evidence of normal performance in that domain.

Potential cohort overlap was assessed by comparing author groups, institutions, recruitment periods, tumor locations, clinical presentations, and reported operative or neuropsychological details. When duplicate or overlapping cases were explicitly identified or strongly suggested, the most comprehensive report was prioritized for extraction. Studies from the same institution or author group were not excluded solely on that basis if patient-level overlap could not be confirmed.

Statistical analysis

Given the heterogeneity of study designs, assessment tools, and outcome reporting across the included studies, a quantitative meta-analysis was not performed. Descriptive statistics were used to summarize patient characteristics, tumor features, and the frequency of reported clinical manifestations. Categorical variables were reported as counts and percentages, and continuous variables were summarized using medians and ranges when available. Preoperative and postoperative clinical manifestations were compared descriptively to assess differences in the reporting of non-motor deficits. All statistical analyses were performed using SPSS software (IBM Corp., Armonk, NY, USA).

Results

Study selection

A comprehensive literature search was performed in PubMed, Scopus, and Embase, yielding a total of 4,315 records. After removal of duplicates, titles and abstracts were screened for relevance. Following full-text review, 88 studies met eligibility criteria and were included in the final qualitative synthesis **(**Fig. 1**)**. These studies comprised 372 patients with histopathologically confirmed right-hemisphere gliomas. Included studies are listed in (Supplementary material Table 2).

Patient demographic, tumor diagnosis, location and performance status

A total of 372 patients with right hemisphere gliomas were included. The mean age was 42.6 years (CI 95% 40.5–44.6), with a slight male predominance (49%). Gender was not documented in 12 cases (3%). Handedness was reported in 279 patients, of whom 60% were right-handed, 13% left-handed, 1.9% ambidextrous, and handedness was not reported in 25% of cases **(**Table 1**)**.

Tumor location was most frequently documented in the insular lobe (26%), followed by the frontal lobe (20%) and

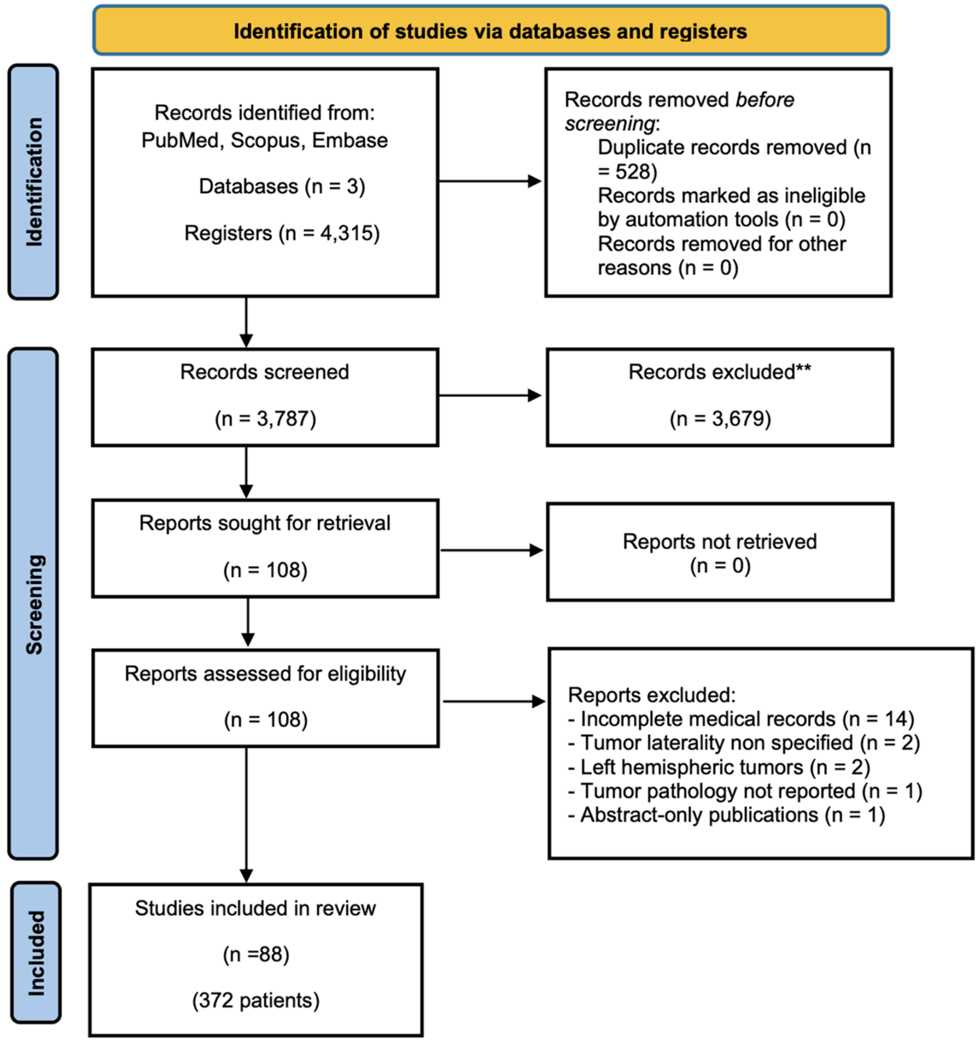

Fig. 1 PRISMA flow diagram of study selection. Flow diagram illustrating the identification, screening, and inclusion process for studies reporting clinical manifestations associated with right-hemisphere gliomas, in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines. A total of 88 studies comprising 372 patients with histopathologically confirmed right-hemisphere gliomas were included in the final qualitative synthesis

multicompartmental fronto-temporo-insular lobes (19%). Less common locations included multicompartmental fronto-parietal (1.8%), temporo-occipital (1.6%), temporo-parietal (0.8%), and fronto-temporal (0.8%). The occipital lobe and basal ganglia were rare (0.3%). Regarding tumor diagnosis, 81% were low-grade gliomas (LGGs) and 19% were high-grade gliomas (HGGs). Among the included studies, 119 patients had a specific diagnosis reported. Of these, the most common tumors were Glioblastoma (10%) and Oligodendroglioma WHO grade 2 (5%) **(**Table 1**)**. A Sankey diagram **(**Fig. 2A**)** illustrating the proportional relationships between tumor grade and perioperative non-motor neurological deficits showed that high-grade tumors accounted for a greater burden of deficits, both before and after surgery. Nevertheless, low-grade gliomas (LGGs) were not exempt from perioperative morbidity, as a considerable proportion also presented with neurological deficits in the perioperative period.

Preoperative performance status, showed a preserved baseline performance (i.e., KPS ≥ 70) in 43%, and was not reported in 57% of the cohort **(**Table 1**).**

Perioperative clinical manifestations

Preoperative motor function was documented on 316 (85%) patients, of whom 218 (59%) had preoperative motor deficits. In contrast, postoperative motor deficits were reported less frequently, occurring in 15 patients (4%) (Table 1).

Additionally, new postoperative deficits (i.e., patients preoperatively intact with postoperative deficits) were documented in 26 of 61 patients in whom this follow up was reported (Table 1).

Non-motor clinical manifestations and intraoperative tests

Complete preoperative clinical status, including non-motor function, was available in 334 (90%) patients. Among these,

Table 1 Demographics, handedness, location, tumor grade, pathology, KPS, outcomes

Variable	*n* (%) or median [range] or mean {CI 95%}$^{\beta}$
Age	
Mean (CI 95)	42.6 (40.5–44.6)
Gender	
Male n (%)	182 (48.9)
Female n (%)	178 (47.8)
Not reported	12 (3.2)
Handedness	
Right-handed	222 (59.6)
Left-handed	50 (13.4)
Ambidextrous	7 (1.9)
Not reported	93 (25)
Location	
Insular	97 (26.1)
Frontal lobe	74 (19.8)
Fronto-temporo-insular	70 (18.8)
Temporal lobe	57 (15.3)
Parietal lobe	40 (10.7)
Fronto-parietal	7 (1.8)
Temporo-occipital	6 (1.6)
Temporo-insular	3 (0.8)
Fronto-insular	3 (0.8)
Parieto-occipital	3(0.8)
Fronto-temporal	3(0.8)
Temporo-parieto-occipital	3(0.8)
Temporo-parietal	3(0.8)
Fronto-temporo-parietal	1 (0.3)
Occipital lobe	1(0.3)
Basal ganglia	1(0.3)
Tumor grade	
Low-grade gliomas	300 (80.6)
High-grade gliomas	72 (19.4)
Specified Tumor pathology	
Glioblastoma WHO grade 4	38 (10.2)
Astrocytoma WHO grade 4	7 (1.9)
Gliosarcoma WHO grade 4	5 (1.3)
Astrocytoma WHO grade 3	7 (1.9)
Oligodendroglioma WHO grade 3	8 (2.2)
Oligoastrocytoma WHO grade 3*	1 (0.3)
Ganglioglioma WHO grade 3	1 (0.3)
Oligodendroglioma WHO grade 2	20 (5.4)
Astrocytoma WHO grade 2	14 (3.8)
Oligoastrocytoma WHO grade 2*	3 (0.8)
Pleomorphic Xantoastrocytoma WHO grade 2	3 (0.8)
Pilocytic Astrocytoma WHO grade 1	3 (0.8)
Ganglioglioma WHO grade 1	9 (2.4)
Preoperative KPS	
≥70	159 (42.7)
<70	1 (0.3)
Not reported	212 (57)
Preoperative Motor Deficit	
Yes	218 (58.6)
No	98 (26.3)
Not reported	56 (15.1)
Preoperative Non-Motor Deficit	
Yes	116 (31.2)

Table 1 (continued)

Variable	*n* (%) or median [range] or mean {CI 95%}[β]
No	218 (58.6)
Not reported	38 (10.2)
Postoperative Motor Deficit	
Yes	15 (4.0)
No	196 (52.7)
Not reported	161 (43.3)
Postoperative Non-Motor Deficit	
Transient	40 (10.8)
Permanent	12 (3.2)
No deficit	189 (50.8)
Not reported	131 (35.2)
Patients without preoperative deficit	
No postoperative deficit	35 (9.4)
Postoperative deficit	26 (7.0)
Not reported	311 (372)
Postoperative Rehabilitation	
Yes	28 (7.5)
No	344 (92.5)
Patients who had postoperative rehabilitation (*n*=28)	
Improvement after rehabilitation	14 (50)
No improvement after rehabilitation	1 (3.6)
Not reported outcome after rehabilitation	13 (46.4)
Extent of Resection	
Supratotal resection	8 (2.2)
Gross total resection	62 (16.7)
Near-total resection	18 (4.8)
Subtotal resection	126 (33.9)
Biopsy	4 (1.1)
Not reported	154 (41.4)
Progression Free Survival (months)	
Median (range)	12 [1-168]
Overall survival (months)	
Median (range)	6 [0-168]
Return to work	
Yes	142 (38.2)
No	0 (0)
Not reported	219 (58.9)
Did not work and were reported	11 (3.0)
Time to RTW (months)	3.5 [1–48]

[β], Percentages represent reported frequencies among published cases and should not be interpreted as incidence or prevalence estimates, given heterogeneous reporting, incomplete assessment, and case-report enrichment.*, diagnosis retained as reported in the original publication and based on prior WHO CNS tumor classifications; retrospective reclassification according to WHO 2021 molecular criteria was not possible; KPS, Karnofsky Performance Status; NOS, Not Otherwise Specified, according to the WHO classification.

preoperative non-motor deficits were reported in 116 (31%) patients and were absent in 218 (59%). In 38 cases (10%), preoperative non-motor status was not reported **(**Table 1**)**.

Among published cases with extractable preoperative non-motor manifestations, the most frequently reported domains included visuospatial cognitive impairment (23%), combined language deficits (17%), and social cognition dysfunction (14.7%), including deficits in theory of mind and social perception. Other manifestations included working memory impairment (10%) and executive dysfunction (7%), whereas visual disturbances such as visual hallucinations or alterations in acuity and perception, speech apraxia, and auditory or somatosensory phenomena were reported less frequently **(**Table 2**).**

Postoperative non-motor clinical status was documented in 241 patients (65%), of whom 52 (15%) presented with deficits. Among those with postoperative deficits, 26 patients (7%) were neurologically intact preoperatively, representing new surgical morbidity, and 23% (12 out of 52) of the patients with reported postoperative deficits were permanent (Table 1). The most common postoperative deficits included visuospatial cognition deficits (27%) and combined (phonological plus semantic) language deficits (23%). Other deficits included semantic (12%) and social-cognitive (12%) dysfunctions (Table 3). A Sankey diagram (Fig. 3) maps the proportional relationships across three variables — preoperative non-motor neurological status, lesion location within the right hemisphere, and postoperative non-motor outcomes — highlighting how deficit burden distributes across tumor locations. Most patients had no documented preoperative or postoperative deficits, although tumors involving the frontal, insular, temporal, and parietal lobes were associated with a broad range of higher-order impairments. The most frequent postoperative deficits, involving visuospatial, social cognition, and phonological/semantic functions, were primarily associated with the parietal, temporal, and frontal lobes. Collectively, these findings underscore the heterogeneity of right-hemisphere dysfunction and its network-based clinical expression (Fig. 2B).

Right-sided gliomas are infrequently resected under awake craniotomy. Intraoperative neuropsychological testing was reported in 185 cases, of which 102 originated from a single large retrospective study [12]. Because this study contributed a substantial proportion of the tested cases and used a specific testing strategy, we separately described the remaining reports to avoid overrepresenting its paradigms. After excluding the large retrospective study — which exclusively employed mentalizing tasks and the Pyramids and Palm Trees test — the most commonly reported tests across the remaining studies were line bisection (70%), naming (27%), counting (24%), and reading (12%) (Supplementary Material, Table .3). Testing categories were not mutually exclusive, as more than one paradigm could be used in the same patient. These findings should therefore be interpreted as a descriptive summary of reported intraoperative testing practices rather than pooled estimates of task utilization.

Postoperative rehabilitation, extent of resection and functional outcomes

Postoperative rehabilitation and return-to-work outcomes were inconsistently reported across the included literature. Rehabilitation was reported in 28 patients, of whom 14 had documented improvement, 1 had no improvement, and 13 had no reported rehabilitation outcome. Return to work was explicitly reported in 142 patients, while most cases lacked sufficient information to determine occupational outcome (Table 1). Therefore, these data should be interpreted as descriptive reported outcomes among published cases rather than true functional recovery or return-to-work rates.

Near-total to supratotal resection (including gross total resection) was achieved in 24% of cases, with a median PFS of 12 months and OS of 6 months (Table 1). Because extent of resection, postoperative deficit assessment, and follow-up timing were incompletely and heterogeneously reported, analyses evaluating the relationship between extent of resection and postoperative deficits were considered exploratory. In this limited analysis, no statistically significant association was observed between the extent of resection and postoperative non-motor or motor deficits; however, these findings should be interpreted with caution and should not be considered evidence of the absence of risk.

Discussion

This systematic review summarizes the reported spectrum of clinically meaningful perioperative non-motor manifestations associated with right-hemisphere gliomas in a heterogeneous and selected published literature. Although these data do not provide robust estimates of prevalence, perioperative trajectory, or long-term burden, they highlight non-motor domains that may be insufficiently captured by traditional motor- and language-centered assessment frameworks. Across 88 studies comprising 372 patients, preoperative non-motor deficits were identified in 35% of cases and postoperative deficits in 22%, of whom 23% were permanent. Strikingly, among patients who were neurologically intact before surgery, 43% developed new non-motor deficits postoperatively — underscoring the surgical vulnerability of right-hemisphere networks and the critical need for comprehensive perioperative neuropsychological monitoring. Nevertheless, functional recovery, rehabilitation response, return to work, and survival outcomes were too inconsistently reported to support reliable pooled interpretation.

The anatomical substrate underlying this vulnerability lies in the organization of the right hemisphere's white matter, which comprises a complex system of association, projection, and commissural pathways subserving higher-order cognitive and behavioral functions [13]. Among the principal association tracts, the superior longitudinal fasciculus/arcuate complex is involved in attentional control, visuospatial processing, and prosodic and pragmatic aspects of communication [14]. The inferior fronto-occipital fasciculus and inferior longitudinal fasciculus connect frontal, temporal, and occipital regions and contribute to semantic integration, visual processing, and socio-emotional interpretation [15]. The uncinate fasciculus links the orbitofrontal cortex with the anterior temporal lobe and is relevant for emotional regulation and social cognition, whereas the cingulum participates in executive and limbic network integration [16]. The right uncinate fasciculus, in particular, plays a critical

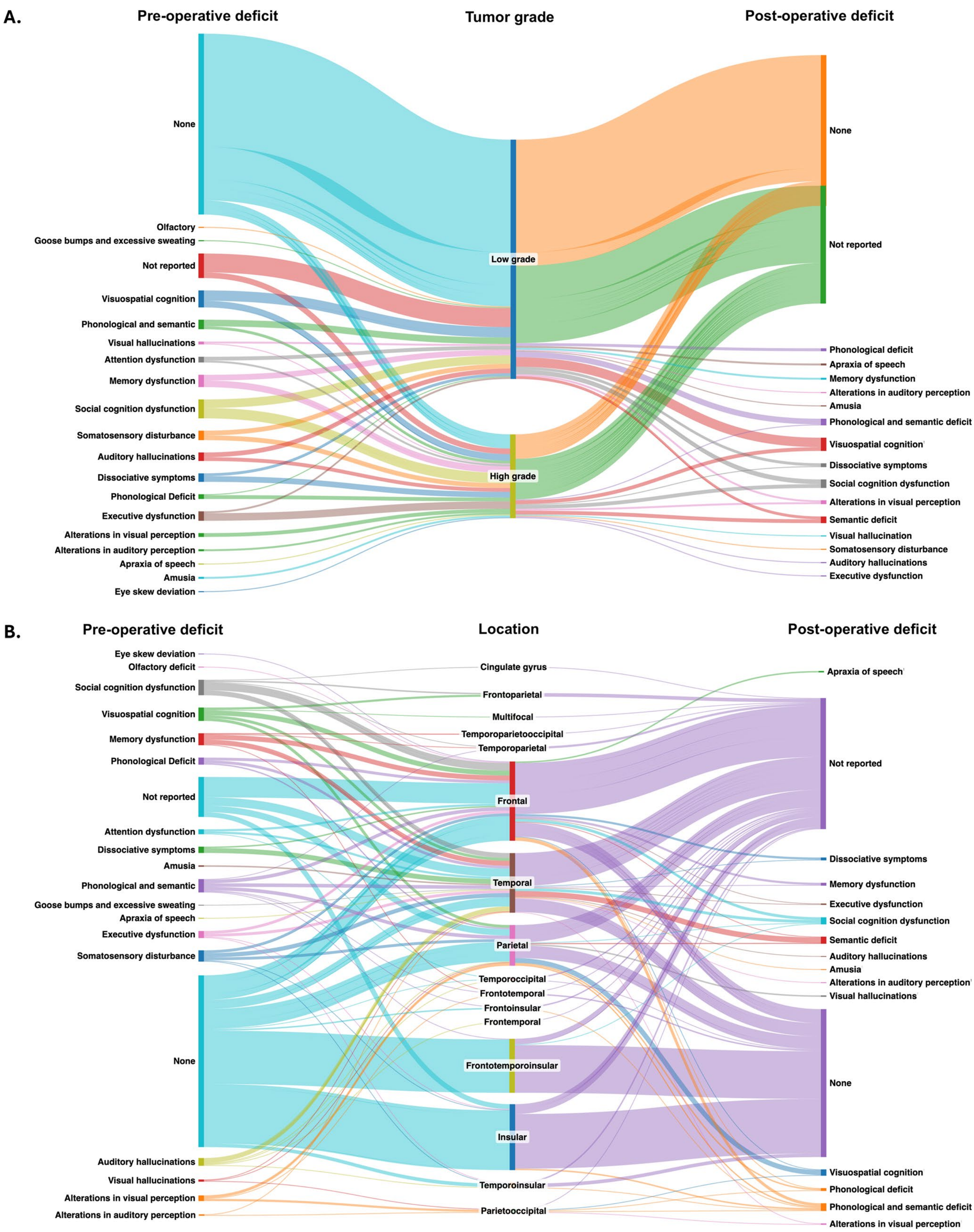
A.
Pre-operative deficit
Tumor grade
Post-operative deficit
None
Olfactory
Goose bumps and excessive sweating
Not reported
Visuospatial cognition
Phonological and semantic
Visual hallucinations
Attention dysfunction
Memory dysfunction
Social cognition dysfunction
Somatosensory disturbance
Auditory hallucinations
Dissociative symptoms
Phonological Deficit
Executive dysfunction
Alterations in visual perception
Alterations in auditory perception
Apraxia of speech
Amusia
Eye skew deviation
Low grade
High grade
None
Not reported
Phonological deficit
Apraxia of speech
Memory dysfunction
Alterations in auditory perception
Amusia
Phonological and semantic deficit
Visuospatial cognition
Dissociative symptoms
Social cognition dysfunction
Alterations in visual perception
Semantic deficit
Visual hallucination
Somatosensory disturbance
Auditory hallucinations
Executive dysfunction
B.
Pre-operative deficit
Location
Post-operative deficit
Eye skew deviation
Olfactory deficit
Social cognition dysfunction
Visuospatial cognition
Memory dysfunction
Phonological Deficit
Not reported
Attention dysfunction
Dissociative symptoms
Amusia
Phonological and semantic
Goose bumps and excessive sweating
Apraxia of speech
Executive dysfunction
Somatosensory disturbance
None
Auditory hallucinations
Visual hallucinations
Alterations in visual perception
Alterations in auditory perception
Cingulate gyrus
Frontoparietal
Multifocal
Temporoparietooccipital
Temporoparietal
Frontal
Temporal
Parietal
Temporoccipital
Frontotemporal
Frontoinsular
Frontemporal
Frontotemporoinsular
Insular
Temporoinsular
Parietooccipital
Apraxia of speech
Not reported
Dissociative symptoms
Memory dysfunction
Executive dysfunction
Social cognition dysfunction
Semantic deficit
Auditory hallucinations
Amusia
Alterations in auditory perception
Visual hallucinations
None
Visuospatial cognition
Phonological deficit
Phonological and semantic deficit
Alterations in visual perception

Fig. 2 (**A**) Sankey diagram of preoperative non-motor deficits, tumor grade, and postoperative non-motor deficits in patients with right-hemisphere gliomas. Sankey diagram illustrating the proportional flow between preoperative non-motor deficits (left), tumor grade (center), and postoperative non-motor deficits (right) across the 372 patients included in the review. The width of each flow is proportional to the number of patients transitioning between categories. High-grade gliomas accounted for a disproportionate share of perioperative non-motor deficits relative to low-grade gliomas, though both groups contributed to postoperative morbidity. The most frequent postoperative manifestations included visuospatial cognition, phonological and semantic language deficits, and social cognition dysfunction. A substantial proportion of patients who were neurologically intact preoperatively transitioned to documented postoperative deficits, reflecting the surgical vulnerability of right-hemisphere networks across tumor grades. (**B**) Sankey diagram of preoperative non-motor deficits, lesion location, and postoperative non-motor deficits in patients with right-hemisphere gliomas. Sankey diagram mapping the proportional relationships between preoperative non-motor deficits (left), lesion location within the right hemisphere (center), and postoperative non-motor deficits (right). The width of each flow is proportional to the number of patients transitioning between categories. While most patients had no documented preoperative or postoperative deficits, tumors involving the frontal, insular, temporal, and parietal lobes were associated with a broad spectrum of higher-order impairments. The most frequent postoperative deficits — involving visuospatial cognition, social cognition, and phonological/semantic functions — were predominantly associated with parietal, temporal, and frontal lobe involvement, highlighting the heterogeneity of right-hemisphere dysfunction and its network-based clinical expression

role in emotional empathy—percentage damage to this tract independently predicts error rates on emotional empathy tasks after right hemisphere stroke—and its microstructure correlates with the ability to decode facial expressions of emotion and socioemotional sensitivity during face-to-face interactions [17]. In parallel, projection fibers such as the corticospinal tract and thalamocortical radiations remain essential for motor and sensory function. Collectively, these pathways establish that right-hemisphere eloquence is not restricted to cortical topography but reflects the integrity of distributed subcortical networks subserving language, visuospatial awareness, attention, self-monitoring, and socio-emotional behavior — precisely the domains most frequently compromised in the patients captured by this review.

The most commonly identified manifestations in this review (language, visuospatial cognition, attention and neglect, and social cognition deficits) are precisely those expected from disruption of the association networks described above, reinforcing the direct clinical relevance of right-hemisphere subcortical anatomy to perioperative morbidity [18–20]. Importantly, these deficits are not merely ancillary findings; in addition to their impact on functional independence and return to work, they carry measurable consequences for patients' social and interpersonal lives, including documented increases in marital separations [10, 21, 22]. Their presence underscores the limitations of neurological examinations and outcome measures that prioritize motor strength and language fluency while overlooking higher-order cognitive and behavioral domains that are mediated by the right hemisphere. Taken together, these findings suggest that non-motor right hemisphere dysfunction remains underassessed across the perioperative period and that current reporting practices limit accurate estimation of its true prevalence, trajectory, and long-term significance.

The heterogeneity of this clinical profile — spanning language, visuospatial, attentional, and socio-emotional domains across varying tumor locations and grades — is not incidental but reflects the diffusely infiltrative biological behavior that distinguishes gliomas from focal lesions such as metastases or extra-axial tumors [23–25]. Unlike discrete mass lesions that displace functional tissue, gliomas infiltrate and progressively remodel cortical and subcortical networks, producing a clinical phenotype that is inherently distributed and difficult to predict from anatomical location alone. This disruption is unsurprisingly more pronounced in higher-grade tumors, whose aggressive growth and greater infiltrative burden accelerate network-level dysfunction. Experimental evidence of synaptic coupling between glioma cells and neurons provides a compelling mechanistic framework for understanding how tumor growth may alter network function even in the absence of discrete focal deficits [26]. Within the right hemisphere, where function is characteristically distributed rather than focally localized, such tumor–network interactions may produce subtle yet functionally significant impairments that elude conventional mapping and assessment paradigms [27, 28].

These findings carry important implications for contemporary concepts of cortical eloquence and surgical decision-making. The observation that non-motor deficits are common, heterogeneous, and clinically meaningful directly challenges the long-standing notion of the right hemisphere as functionally permissive, a conception that has historically justified more aggressive resection strategies with less rigorous functional monitoring. Rather, eloquence in the right hemisphere must be understood in network-based terms, encompassing language, attentional, visuospatial, executive, and socio-emotional domains whose disruption carries measurable consequences for patients' quality of life and functional recovery. This reconceptualization has concrete clinical implications: it supports the routine integration of standardized neuropsychological assessment into preoperative evaluation and advocates for the development of intraoperative mapping strategies specifically tailored to non-motor domains — particularly in patients undergoing resection of right-hemisphere gliomas [29].

Table 2 Preoperative non-motor deficit

Variable	$n = 116$ n (%)*
Language	28 (24.1)
Phonological deficit	7 (6.0)
Semantic deficit	0
Speech apraxia	1 (0.9)
Phonological and semantic deficit	20 (17.2)
Auditory	**11 (9.5)**
Hallucinations	7 (6.0)
Alterations in auditory perception	2 (1.7)
Amusia	2 (1.7)
Vision and visuospatial	**33 (28.4)**
Visuospatial cognition	27 (23.3)
Visual hallucination	1 (0.9)
Alterations in visual perception (including impairment)	5 (4.3)
Cognition and Executive	**50 (43.1)**
Executive dysfunction	8 (6.9)
Working memory dysfunction	12 (10.3)
Attention dysfunction	5 (4.3)
Social cognition dysfunction	17 (14.7)
Dissociative symptoms	8 (6.9)
Other	**14 (12.1)**
Olfactory	1 (0.9)
Eye skew deviation	1 (0.9)
Somatosensory disturbance	12 (10.3)

*, percentages represent reported frequencies among published cases and should not be interpreted as incidence or prevalence estimates, given heterogeneous reporting, incomplete assessment, and case-report enrichment.

Table 3 Postoperative non-motor deficit

Variable	$n = 52$ n (%)*
Language	24 (46.2)
Phonological deficit	4 (7.7)
Semantic deficit	6 (11.5)
Apraxia of speech	2 (3.8)
Phonological and semantic deficit	12 (23.1)
Auditory	**3 (5.8)**
Auditory hallucinations	1 (1.9)
Alterations in auditory perception	1 (1.9)
Amusia	1 (1.9)
Vision and visuospatial	21 (40.4)
Visuospatial cognition	14 (26.9)
Visual hallucination	1 (1.9)
Alterations in visual perception (including impairment)	6 (11.5)
Cognition and Executive	**12 (23.1)**
Executive dysfunction	2 (3.8)
Memory dysfunction	2 (3.8)
Attention dysfunction	0 (0)
Social cognition dysfunction	6 (11.5)
Dissociative symptoms	2 (3.8)
Other	**1 (1.9)**
Olfactory	0
Eye skew deviation	0
Somatosensory disturbance	1 (1.9)

*, percentages represent reported frequencies among published cases and should not be interpreted as incidence or prevalence estimates, given heterogeneous reporting, incomplete assessment, and case-report enrichment.

Clinical implications

The findings of this systematic review have several important implications for the clinical management of patients with right hemisphere gliomas. First, the high prevalence and heterogeneity of non-motor manifestations underscore the limitations of conventional neurological assessment strategies that focus predominantly on motor strength and language function. Attentional, visuospatial, behavioral, and higher-order cognitive alterations can substantially affect functional independence and quality of life, with recent work suggesting that impairment in memory and executive functioning accounts for over 40% of variance in patients' ability to perform instrumental activities of daily living [30]. Unfortunately, deficits in these functions remain under-recognized and without targeted evaluation, especially in patients with non-dominant hemisphere glioma. Incorporating standardized neuropsychological screening into the preoperative assessment of right-hemisphere gliomas may therefore improve baseline characterization, enable more informed surgical risk counseling, and provide the intra-individual reference framework necessary for meaningful interpretation of cognitive outcomes across repeated post-operative assessments.

Second, these findings have direct relevance for surgical planning and intraoperative decision-making. The traditional perception of the right hemisphere as functionally permissive may lead to underestimation of functional risk, particularly in tumors involving association cortices and network hubs [31]. A network-based understanding of right hemisphere eloquence supports the selective use of awake surgery and tailored intraoperative mapping paradigms aimed at non-motor domains, such as attention, visuospatial processing, and socio-emotional function [19]. While standardized protocols for non-motor mapping remain limited, emerging paradigms suggest that functional preservation in the right hemisphere requires approaches distinct from those used for motor and language networks.

Finally, postoperative evaluation and outcome reporting should extend beyond motor and language endpoints. The observed increase in documented non-motor deficits after surgery likely reflects both unmasking of network vulnerability and improved detection. Systematic postoperative assessment may allow earlier identification of deficits amenable to rehabilitation and provide a more comprehensive framework for measuring surgical success in right hemisphere glioma patients.

In this context, awake surgery should not be considered only a left-hemisphere or language-dominant strategy, but rather a selective tool for preserving individualized right-hemisphere networks. This review supports that rationale, as preoperative non-motor deficits were present in 34.7% of patients with documented status, and 43% of initially intact patients developed new postoperative deficits. Intraoperative testing should therefore be tailored to lesion location and baseline neuropsychological profile. Based on the domains most frequently affected in this review, practical tasks may include line bisection or cancellation for visuospatial neglect; naming, reading aloud, and semantic-association tasks for language and semantic processing; facial emotion recognition or theory-of-mind paradigms for social cognition; and dual-tasking or working-memory tasks for executive control. This domain-mapped approach may help balance maximal safe resection with preservation of cognition, social functioning, and quality of life.

Limitations and future directions

Several methodological limitations of the surveyed literature warrant consideration, as they likely contribute to an underestimation of the true prevalence of perioperative non-motor functional decline. Most included studies employed outcome assessments focused on relatively narrow cognitive domains (typically those historically associated with presumed non-dominant-hemisphere functions) rather than broad neuropsychological batteries that sample diverse functional domains simultaneously. Furthermore, a substantial proportion of the evidence base consists of case reports and small case series, limiting the generalizability of findings and precluding standardized cross-study comparisons. Our eligibility criteria required extractable, laterality-specific clinical manifestations in patients with right-hemisphere gliomas. As a result, several large and methodologically robust glioma cohorts were excluded because they reported oncological outcomes, global neurocognitive outcomes, or mixed-hemisphere results without right-hemisphere-specific perioperative manifestations. Although this criterion was necessary to preserve the clinical specificity of the review question, it may have reduced representativeness and enriched the dataset for studies focused on cognitive or unusual clinical deficits.

This is particularly consequential given that even studies employing relatively comprehensive assessment approaches reveal a substantial burden of postoperative cognitive morbidity: evidence suggests that up to 40% of patients with right temporal gliomas exhibit worsening in at least one cognitive domain following resection, most frequently in processing speed (40%), executive functioning (40%), and verbal learning and memory (30%) [32]. Notably, even this estimate is likely conservative, as the battery employed did not include non-verbal memory or social cognition assessments — domains particularly susceptible to disruption of right-hemisphere network integrity.

An additional limitation relates to changes in glioma classification over time. The included studies span multiple decades, and many were published before the adoption of the 2021 WHO Classification of Tumors of the Central Nervous System and before routine integration of molecular markers into glioma diagnosis. Consequently, historical diagnostic entities, including oligoastrocytoma, are represented in the dataset, and retrospective reclassification according to current molecular criteria was not possible in many cases. Therefore, tumor diagnoses and grades were retained as reported in the original publications, which limits direct generalizability to contemporary molecularly defined glioma populations. Also, molecular markers such as IDH mutation status, 1p/19q codeletion, MGMT promoter methylation, and CDKN2A/B alterations were inconsistently reported or unavailable across the included studies. Because contemporary glioma classification, prognosis, treatment response, and clinical behavior are strongly influenced by these molecular features, the relationship between molecular subtype and right-hemisphere clinical manifestations could not be assessed. As a result, the generalizability of the reported manifestations to current molecularly defined glioma subgroups remains uncertain.

Finally, potential cohort overlap represents another limitation, particularly among reports from high-volume awake-mapping centers and right-insular glioma series. Although studies were reviewed for overlapping authorship, institutions, recruitment periods, and case characteristics, patient-level overlap could not always be excluded. Unrecognized overlap may therefore influence descriptive patient counts and reported frequencies.

Despite these limitations, this review highlights critical gaps and opportunities for future research. Prospective studies incorporating standardized, domain-specific neuropsychological assessments are needed to better characterize the true prevalence and trajectory of non-motor deficits in right hemisphere gliomas. Integration of network-based imaging, functional mapping, and longitudinal cognitive outcomes may further refine risk stratification and surgical planning. Ultimately, developing consensus-driven definitions and assessment frameworks for right hemisphere eloquence will be essential to advancing patient-centered care and improving functional outcomes in this population.

Conclusions

Right-hemisphere gliomas are associated with a broad spectrum of clinically meaningful non-motor manifestations involving cognitive, visuospatial, language, executive, and socio-emotional domains. Although the available evidence is heterogeneous and largely derived from selected published cases, these findings challenge traditional concepts of cortical eloquence based primarily on motor and dominant-hemisphere language function. More systematic perioperative neuropsychological assessment and domain-specific intraoperative monitoring may refine surgical planning, outcome evaluation, and patient counseling in patients with right-hemisphere gliomas.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s11060-026-05728-8.

Author contributions Conception and design: ERF, KN, SSP. Acquisition of data: ERF, JM, MS. Data analysis and interpretation: ERF, KN, JM, MS, SSP. Manuscritp drafting: ERF, KN, HD, SSP. Critically revising the article: ERF, KN, JPZ, PA, CE, SSF, JW, FL, HD, SSP. Reviewed submitted version of manuscript: ERF, KN, CE, SSF, JW, FL, HD, SSP. Study supervision: SSP, KN, FL, JW, SSF.

Funding None.

Data availability The data underlying this systematic review were extracted from previously published, publicly accessible peer-reviewed articles, all of which are cited within the manuscript and listed in Table 1. The extraction database and supporting analytic files generated during this study are available from the corresponding author upon reasonable request.

Declarations

Ethical approval This study is a systematic review of previously published literature and did not involve direct investigation of human or animal subjects; institutional review board approval and informed consent were therefore not required. All data were extracted from peer-reviewed publications in which the original investigators were responsible for obtaining the appropriate ethical approvals and patient consents. The review was conducted in accordance with the ethical principles outlined in the World Medical Association Declaration of Helsinki.

Competing interest The authors declare no competing interests.

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