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Short communication

How do we FUS? Peri-procedural management of magnetic resonance-guided focused ultrasound: An EMEA regional survey

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ABSTRACT

Background: Magnetic resonance–guided focused ultrasound (MRgFUS) is an established incisionless treatment for essential tremor (ET), Parkinson's disease (PD) and neuropathic pain. Although efficacy and safety are supported by randomised trials and large series, peri-procedural management remains non-standardised.
Methods: We conducted a structured, web-based survey of 41 centres performing MRgFUS for neurological indications across Europe, Middle East, and Africa (EMEA) region. The 35-item questionnaire covered four domains: centre activity and indications, discharge policy and reimbursement, use of corticosteroids and other medications, and team composition. Responses were anonymised and analysed descriptively.
Results: Twenty-seven respondents (28 MRgFUS centres, 68% coverage) answered the questionnaire. Caseloads varied widely, from <50 to >400 cumulative procedures, with ET treated in all centres and PD in 70%. Discharge practice ranged from same-day to >48-h admission, and reimbursement was by national health system in 77.8%, mixed in 7.4%, and borne by patient/insurance in 14.8% of centres. Corticosteroids were used routinely in 63.0% of centres, selectively in 29.6%, and never in 7.4%, with marked heterogeneity in timing and tapering. Analgesics and antiemetics were routinely prescribed in 66.7% and 70.4% of centres, respectively. Sedatives or anaesthetic agents were rarely used, mirroring variability in anaesthesiologist involvement. A dedicated nurse in the MRI suite was reported by 63.0% of centres.
Conclusions: Peri-procedural MRgFUS management is highly heterogeneous across EMEA centres, particularly regarding corticosteroid protocols and anaesthesiologist support. Future consensus work and prospective, registry-based studies will address these issues and define evidence-based, harmonised care pathways.

1. Introduction

Magnetic resonance–guided focused ultrasound (MRgFUS) has become an established incisionless treatment for selected neurological conditions, enabling image-guided thermoablation without craniotomy or implanted hardware, with spatial precision and intra-operative clinical feedback. Randomised controlled trials and large prospective series have demonstrated sustained efficacy and acceptable safety for both unilateral and bilateral-staged thalamotomy in essential tremor (ET) [1,2], and clinical adoption has rapidly expanded across Europe and worldwide to include unilateral treatment of Parkinson's disease (PD) [3–5] and other neurological indications, e.g., neuropathic pain [6].

In contrast to the indications supported by robust multicentre clinical evidence (particularly ET), no standardised guidelines exist for peri-

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procedural management of MRgFUS, which has largely developed through local experience rather than formalised protocols. Centres differ in the use of corticosteroids, symptomatic medications, team composition, discharge pathways, and reimbursement models, potentially affecting patient comfort, workflow organisation, and comparability of outcomes. As MRgFUS is increasingly implemented across diverse healthcare systems, a clearer understanding of current peri-procedural practices may help identify common elements and highlight areas where consensus is required.

To address this gap, we conducted a structured survey of MRgFUS centres across Europe, Middle East, and Africa (EMEA) region, focusing on peri-procedural medication strategies and team composition, with the aim of mapping current practice and identifying areas for future harmonisation.

2. Methods

2.1. Survey design

We developed a structured, web-based questionnaire (Microsoft Forms) consisting of 35 items to collect information on peri-procedural MRgFUS practices. The questionnaire – available as Supplementary Material – was developed by the authors and internally reviewed prior to distribution.

2.2. Participants

The survey was distributed to all centres (n = 41) that had declared active MRgFUS programs as of December 2024. The initial list of active centres was obtained from an overview of MRgFUS programs presented at an international meeting at the end of 2024 and subsequently verified and completed using institutional networks, professional societies, and publicly accessible sources. Eligible centres were those performing MRgFUS procedures for neurological indications with a minimum of 5 treatments performed.

A total of 27 respondents from 28 MRgFUS centres, including one of the authors for our centre, completed the survey. One respondent represented two centres, one public and one private, which share the same multidisciplinary MRgFUS team and follow identical peri-procedural protocols. These two centres were therefore analysed as a single centre. Each response was provided by a clinician directly involved in the MRgFUS workflow.

2.3. Data collection and analysis

Invitations were distributed by e-mail, with up to two reminders sent during the two-month data collection window (February–April 2025). Responses were collected confidentially and reported in anonymised form at centre level.

Categorical variables were summarised as counts and percentages, and free-text responses were reviewed manually. Some questions allowed multiple responses; consequently, totals and percentages may exceed 100%.

The survey did not collect any personal data, identifiable information, or sensitive content, and was therefore exempt from formal ethics review according to institutional policies.

3. Results

3.1. Respondents and coverage

Among the 41 active MRgFUS centres identified across the EMEA region, we received 27 completed survey responses (Supplementary Table S1), corresponding to 27 unique centre-level datasets and capturing practices from 28 centres (overall coverage 68%). Most participating centres were in Europe (26/28, 92.9%), with only a small minority in the Middle East (2/28, 7.1%) and none in Africa.

3.2. Centre activity and indications

Across the 27 centres, total procedures ranged from <50 (n = 6, 22.2%) to > 400 (n = 3, 11.1%), with the majority (n = 9, 33.3%) reporting 101–200 total treatments (Fig. 1A).

Annual activity ranged from <13 to >100 procedures per year, with most centres performing 25–100 cases annually (Fig. 1B).

All centres treated ET, while 19 (70.4%) also treated PD and 6 (22.2%) neuropathic pain. The thalamus was targeted by all centres, followed by the subthalamus (n = 9, 33.3%) and globus pallidus internus (n = 4, 14.8%). Tract-based approaches (i.e. cerebello-thalamic tract, pallido-thalamic tract) had been performed in 9 centres (33.3%).

3.3. Discharge and reimbursement

Discharge practices varied considerably across centres (Fig. 1C), ranging from same-day discharge (25.9%) to hospitalisation for ≥2 days after treatment (18.5%). Most centres (n = 26, 96.3%) discharged patients at home, with only one reporting occasional transfer to inpatient rehabilitation in cases of marked gait impairment.

Reimbursement pathways also differed across centres (Fig. 1D): treatment was fully covered by the national health system in 21 centres (77.8%), partially reimbursed in 2 (7.4%), and entirely borne by the patient or private insurance in 4 (14.8%).

3.4. Peri-procedural medication plan

Steroid protocols showed marked variability (Supplementary Table S2). Seventeen centres (63.0%) reported routine use, 8 centres (29.6%) restricted steroids to selected cases, and 2 centres (7.4%) never used them (Fig. 2A). Among centres routinely/selectively using steroids (n = 25, 92.6%), these agents had been part of the protocol since the beginning in 18 centres (72%), while 7 (28%) introduced them later. The most common agent was dexamethasone (n = 23, 92%), followed by methylprednisolone (n = 3, 11.1%) and prednisolone (n = 1, 3.7%). Timing of administration varied widely (Fig. 2B), as well as tapering regimens (Fig. 2C).

Analgesics were used routinely in 18 centres (66.7%), most commonly paracetamol (n = 22, 81.5%), followed by NSAIDs (n = 6, 22.2%) and opioids (n = 2, 7.4%) (Fig. 2D).

Antiemetic prophylaxis was applied routinely in 19 centres (70.4%) (Fig. 2E), with ondansetron as the preferred agent (n = 21, 77.8%).

Routine intraoperative use of sedatives or anaesthetics was uncommon, with 3 (11.1%), 2 (7.4%) and 22 centres (81.5%) reporting their use rarely, selectively, or never, respectively (Fig. 2F). Agents included remifentanil (2 centres, 7.4%) and other drugs (4 centres, 14.8%).

3.5. Anaesthesiologist and team composition

An anaesthesiologist was routinely present in 11 centres (40.7%), selectively involved in 2 (7.4%) and absent in 14 (51.9%) (Fig. 2G). A dedicated nurse was routinely present in 17 centres (63.0%) (Fig. 2H).

4. Discussion

To the best of our knowledge, this is the first regional survey focused on peri-procedural management of MRgFUS for neurological indications across the EMEA region. Responses from 28 active centres revealed substantial heterogeneity in medication strategies and team composition, highlighting areas where future consensus is needed.

The most striking variability concerns corticosteroid administration, which differed across centres in terms of use, timing, agent, and tapering. Steroids are primarily used to control perilesional vasogenic oedema, a transient phenomenon consistently observed after MRgFUS.

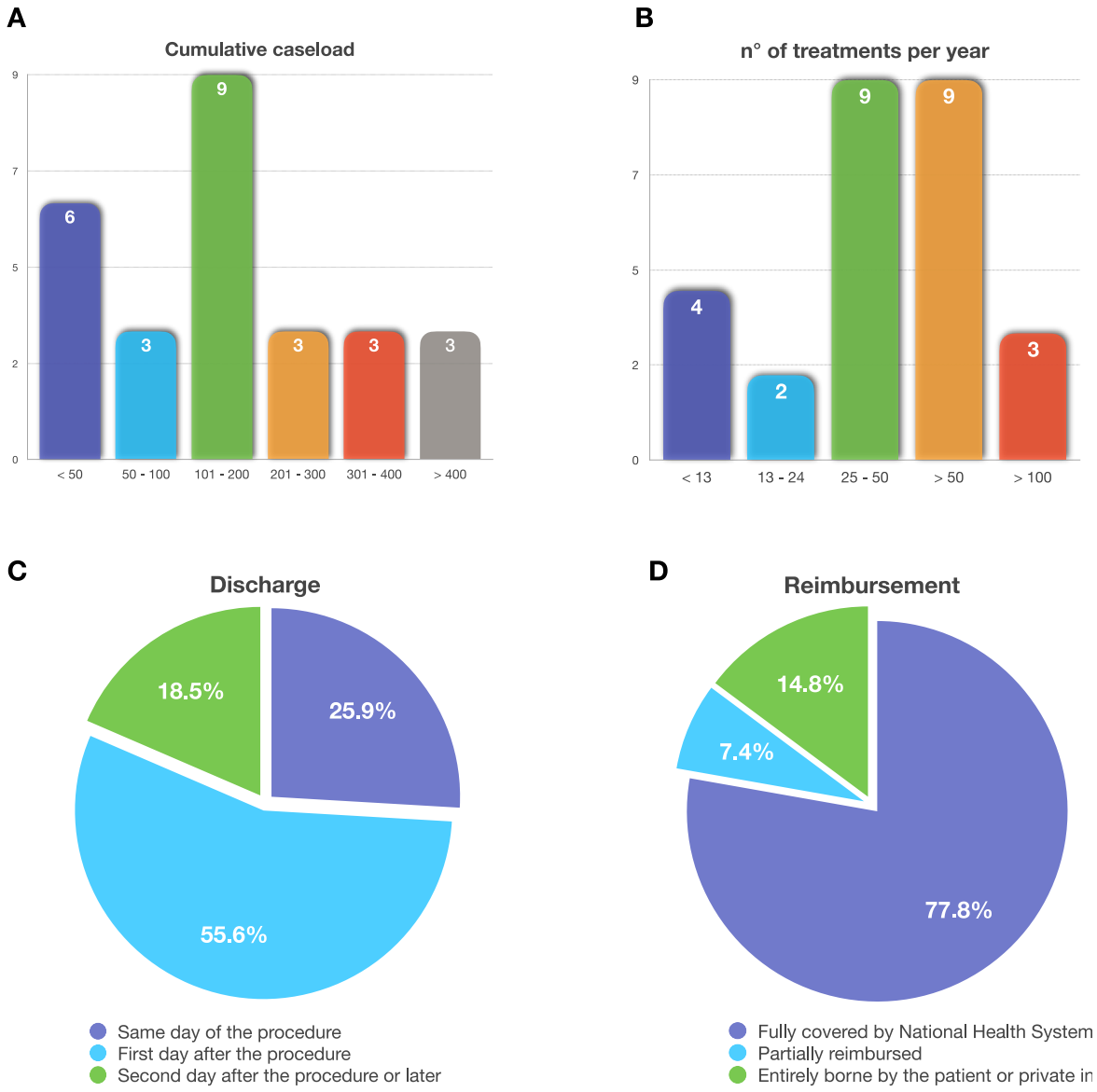

Fig. 1. Centre characteristics and organisation of MRgFUS activity showing distribution of centres according to cumulative caseload (A) and annual number of treatments (B), with the number of centres on the y-axis and caseload categories on the x-axis; timing of patient discharge after the procedure (C) and reimbursement models across centres (D).

MRI studies describe three concentric lesion zones, with the outer zone representing vasogenic oedema due to temporary blood–brain barrier (BBB) disruption [7]. The pathophysiology of MRgFUS-related oedema parallels that of vasogenic tumour oedema, where BBB leakage is mediated by vascular endothelial growth factor (VEGF) and counterbalanced by angiopoietin-1 (Ang-1) in astrocytes and pericytes [8].

Dexamethasone, the standard agent for peritumoral oedema, stabilises the BBB by modulating VEGF, Ang-1, and pro-inflammatory cytokines [9]. Its rapid oral absorption and long biological half-life (36–54 h) allow once- or twice-daily dosing. Although MRgFUS-related oedema is thermally rather than tumour driven, its vasogenic nature and early BBB disruption make dexamethasone a biologically plausible choice, consistent with its widespread use in our survey.

Timing of administration varied widely across centres. BBB disruption occurs within 24 h after MRgFUS, with oedema peaking during the first week and gradually resolving over the following weeks [10], making pre- and/or intra-operative administration biologically plausible by ensuring therapeutic corticosteroid concentrations at the onset of BBB injury. Despite heterogeneous protocols, most centres converged on total daily dexamethasone doses of 4–8 mg, consistent with neuro-oncological regimens and emergency practice, where an intravenous bolus of 8-10 mg is typically used for rapid BBB stabilisation [11]. This relative convergence in dosing may provide a pragmatic starting point for future consensus-building initiatives or task-force–driven efforts aimed at harmonising protocols.

Corticosteroid courses should be limited, as durations exceeding two weeks substantially increase the risk of steroid-related adverse events (AEs) [12]. In our experience, prolonged steroid tapering after MRgFUS treatment increased avoidable AEs [10]. Clinical improvement related to vasogenic oedema resolution (in patients with brain lesion) generally begins within 12 and 24 h, with peaks between 24 and 72 h [12], supporting the rationale for a brief post-operative course (i.e., one week) as already adopted by many centres.

In the primary indication of MRgFUS, (i.e., ET), although the contribution of lesion volume to tremor suppression remains controversial, several studies indicate that larger lesions are associated with a higher incidence of AEs [13,14] with cut-off values for immediate postoperative lesion volume (e.g. >127 mm^3) proposed as predictors of

Fig. 2. Overview of peri-procedural practices. Use of steroids, including whether they are administered (A), timing of administration (B), and tapering (C). Use of additional medications (D–F). Composition of the procedural team, including routine presence of an anaesthesiologist (G) and a dedicated nurse (H).

poorer quality of life [13]. In this regard, steroids may reduce transient oedema-related symptoms and prolonged AEs in selected high-risk patients, improving patient comfort.

Taken together, these considerations support the plausibility, but not the necessity, of steroid use in MRgFUS. Future comparative trials evaluating steroid-based versus steroid-sparing strategies, incorporating MRI volumetrics and standardised clinical assessment, are needed. Whether corticosteroids might also influence final lesion volume remains speculative [10], but warrants formal investigation. Until such data are available, steroid administration should remain guided by clinical judgement, local experience, patient characteristics, and careful monitoring.

Our findings showed marked variability in how centres manage patient comfort and anaesthesiologist support during MRgFUS. Although transient and generally well tolerated, procedural headache, nausea, and anxiety are frequent and may interfere with patient cooperation

[15]. Specific patient subgroups, including individuals with lower skull density ratio, greater skull thickness, or female sex, appear more susceptible to discomfort [16].

The widespread use of paracetamol and ondansetron across centres is consistent with their favourable safety profile and non-sedating properties, which allow unbiased clinical testing. Sedatives or anaesthetic agents were used only in a minority of centres, mirroring reports that anaesthesiologist-free MRgFUS can be performed safely and with high tolerability [17]. Nonetheless, alternative models include structured anaesthesiologist involvement and selective use of minimal sedation or monitored anaesthesia care to manage prolonged high-energy sonications, which are likely to induce headache and nausea, or marked anxiety [18], with some recent reports of procedures performed under general anaesthesia [19].

Our survey yielded high heterogeneity in anaesthesiologist involvement, ranging from systematic presence to complete absence, likely reflecting institutional and logistical factors rather than evidence-based criteria. Even in fully awake workflows, the combination of elderly, multimorbid patients and a procedure performed in an MRI setting with the head blocked by the MRgFUS helmet suggests a structured pre-procedural anaesthetic assessment and rescue procedures for airways obstruction and other emergencies, particularly as MRgFUS indications extend to more complex conditions and more prolonged procedures [20].

Team composition showed large variability, with dedicated MRI-suite nursing support present in most but not all centres. Adequate staffing and minimal safety standards are essential to manage predictable discomfort-related events and ensure procedural flow [21]. Establishing consensus on basic comfort-care measures and defining indications for light sedation could help harmonise practice while preserving local flexibility.

The survey highlighted broader system-level disparities. Although conducted across the EMEA region (i.e., 13 different countries), the distribution of active centres was heavily skewed towards Europe and with marked differences in the number of centres operating in each country, as detailed in Supplementary Table S1. This uneven geographical landscape may reflect structural and health-system characteristics rather than true practice differences. Reimbursement pathways varied substantially, ranging from full public coverage to partial or complete private funding. Given the increasing adoption of MRgFUS for ET, such disparities may translate into unequal patient access. From a health policy perspective, these findings support transparent inclusion of MRgFUS within national reimbursement frameworks and health technology assessment processes. Linking peri-procedural data with national or international registries could further inform policy decisions and support more equitable deployment of this technology.

4.1. Strengths and limitations

The main strength of this study is the provision of real-world data from multiple EMEA centres performing MRgFUS, offering a contemporary snapshot of peri-procedural practices and complementing evidence from randomised trials. The relatively high number of respondents enhances the representativeness of current practice across the region.

Several limitations should be acknowledged. Data were self-reported and not linked to clinical outcomes, and survey coverage was incomplete, with possible over-representation of high-volume centres. The cross-sectional design captures practices at a single time point, while workflows may evolve over time. In addition, the questionnaire did not capture target selection stratified by clinical indication, and it also did not address the management of antiplatelet and anticoagulant therapies, an increasingly debated area requiring systematic evaluation.

5. Conclusion

This regional survey provides the first overview of peri-procedural MRgFUS management across EMEA centres, offering descriptive benchmarks rather than prescriptive guidance. Key open issues include corticosteroid regimens, minimal symptomatic premedication, and standards for anaesthesiologist involvement and team composition. Harmonised, evidence-based, and equitable MRgFUS delivery will require coordinated multicentre efforts combining consensus methodologies with prospective registry-based data.

CRediT authorship contribution statement

Fabio Paio: Writing – review & editing, Writing – original draft, Investigation, Data curation, Conceptualization. **Giorgia Bulgarelli:** Writing – review & editing, Data curation. **Micaela Tagliamonte:** Writing – review & editing, Data curation. **Tommaso Bovi:** Writing – review & editing, Data curation. **Michele Longhi:** Writing – review & editing, Data curation. **Antonio Nicolato:** Writing – review & editing, Data curation. **Francesco Sala:** Writing – review & editing, Data curation. **Benedetto Petralia:** Writing – review & editing, Supervision, Data curation. **Bruno Bonetti:** Writing – review & editing, Supervision, Data curation. **Michele Tinazzi:** Writing – review & editing, Supervision, Data curation. **Giuseppe K. Ricciardi:** Writing – review & editing, Data curation, Conceptualization. **Stefano Tamburin:** Writing – review & editing, Data curation, Conceptualization.

Ethical compliance statement

As this study consisted of an anonymised survey of healthcare professionals and did not involve patient data, formal ethical committee approval was not required, according to local regulations. Participation was entirely voluntary, and completion of the survey implied consent to participate.

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Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Fabio Paio reports a relationship with InSightec Ltd that includes: speaking and lecture fees and travel reimbursement. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.parkreldis.2026.108284.

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