

Anaesthetic Management During High-Intensity Focused Ultrasound for Uterine Fibroids and Adenomyosis: A Narrative Review.

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Abstract

High-intensity focused ultrasound (HIFU) is a non-invasive treatment option for uterine fibroids and adenomyosis. The procedure requires prolonged patient immobility while maintaining adequate analgesia and, where possible, communication with the operator. The choice of anaesthetic technique is therefore important, but evidence regarding optimal anaesthetic management remains limited. This narrative review aimed to identify and compare anaesthetic and analgesic techniques used during HIFU treatment of uterine fibroids and adenomyosis, with consideration of their efficacy, safety and reported clinical outcomes. An electronic literature search was conducted using PubMed, MEDLINE, Google Scholar and the Cochrane Library. Studies were included if they reported an anaesthetic or analgesic technique used during HIFU for uterine fibroids or adenomyosis and described relevant outcomes or adverse effects. The available evidence included systemic analgesia, conscious sedation, regional anaesthesia and general anaesthesia. Systemic analgesia alone appeared insufficient to provide consistent pain relief. Opioid and sedative combinations allowed communication but ongoing pain was reported in several studies. Dexmedetomidine-remifentanyl was associated with less respiratory depression, improved sedation and recovery compared with midazolam-remifentanyl in one randomised controlled trial. Regional techniques, particularly epidural anaesthesia, provided effective analgesia and reduced opioid requirements, although rescue analgesia and neuraxial complications were reported. General anaesthesia was less frequently described and may limit communication during treatment. Overall, the evidence was heterogeneous, with inconsistent reporting of pain, sedation, patient satisfaction and adverse outcomes. Current evidence does not establish the superiority of any one anaesthetic technique. Future prospective studies should directly compare techniques using standardised measures of pain, sedation, patient comfort, respiratory and cardiovascular safety, rescue analgesia, and treatment-related outcomes. Such evidence may help guide anaesthetic practice and improve the safety and patient experience of HIFU treatment.

Keywords: High-Intensity focused ultrasound, Uterine Fibroids, Adenomyosis, Anaesthesia, Sedation, Analgesia, Regional Anaesthesia, Patient safety.

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Introduction

HIFU has been used as a treatment modality for uterine fibroids and adenomyosis. Despite its potential as a non-invasive treatment option, its widespread adoption remains limited, with factors such as clinical availability, technical expertise, and familiarity with the technique potentially contributing to this. HIFU can be performed under ultrasound or magnetic resonance imaging (MRI) guidance to map and target the tissue (1).

Although HIFU is non-invasive, the procedure requires prolonged periods of patient immobility and carries a risk of thermal injury if patient movement results in displacement of the ultrasound beam from the intended target. Patients must therefore remain sufficiently still while maintaining adequate communication with the operator to report sensations such as pain or discomfort (2). These requirements present a particular challenge for anaesthetic

management. A variety of techniques including monitored anaesthesia care, regional and general anaesthesia based on the location of the targeted tissue and patient positioning (2). General anaesthesia may impair the patient's ability to communicate and report these sensations (3). In contrast, excessive sedation can result in respiratory depression and loss of cooperation, while inadequate anaesthesia may result in intraoperative pain. (4,5) The anaesthetic goal is therefore to provide adequate analgesia and sedation while maintaining patient cooperation, spontaneous ventilation and the ability to communicate with the operator. (2,4) Despite the importance of these considerations, the anaesthetic and sedation techniques used during HIFU for uterine fibroids and adenomyosis have not been widely studied or systematically evaluated.

Uterine fibroids, or leiomyomas, are benign tumours that occur in approximately 20–40% of women of reproductive

age (6). Adenomyosis is characterised by the presence of ectopic endometrial tissue within the myometrium (7). Traditionally, the management of these conditions has included surgical treatment such as myomectomy or hysterectomy. These procedures may be associated with significant postoperative pain, increased blood loss and, in the case of hysterectomy, loss of future fertility (6). HIFU provides a non-invasive treatment option that aims to treat fibroids while preserving the uterus and potentially avoiding some of the morbidity associated with conventional surgery. This narrative review aims to compare anaesthetic and analgesic techniques used during HIFU treatment for uterine fibroids and adenomyosis, with particular consideration of their efficacy, patient safety and procedural outcomes.

Methodology

The methodology of this narrative review included an extensive search of electronic databases, including PubMed, MEDLINE, Google Scholar and the Cochrane Library. Articles were searched using keywords such as “sedation”, “high-intensity focused ultrasound”, “anaesthesia” and “gynaecology”. Studies were included if they reported on an anaesthetic or analgesic technique used for HIFU of fibroids and/or adenomyosis, if they reported on the adverse outcomes of these techniques, if they were written in English, published in a peer-reviewed journal, and published between 2006 and 2025. Studies were excluded if they were unpublished, not written in English or did not report on anaesthetic technique efficacy or safety of the anaesthetic technique. The selected articles were then reviewed and synthesised to describe the important findings regarding the anaesthetic techniques used for anaesthesia for HIFU and their respective benefits and/or adverse outcomes.

How does HIFU work?

HIFU is a non-invasive treatment modality that has been shown to reduce the size of fibroids and adenomyotic lesions while limiting damage to surrounding structures and preserving the uterus. The mechanism of HIFU is primarily based on thermal effects and cavitation. HIFU waves are focused on the target tissue, where the acoustic energy is absorbed and converted into heat. This results in a rapid increase in tissue temperature, leading to coagulative necrosis and subsequent cell death within the targeted lesion. In addition, exposure to HIFU can result in the formation of gas bubbles within the tissue. The collapse of these bubbles produces mechanical tissue damage and contributes to the therapeutic effect of HIFU (8,9).

Different approaches may be used to deliver HIFU depending on the accessibility of the target organ. For the treatment of uterine fibroids, patients are generally positioned prone, with coupling gel or a water balloon used to facilitate the transmission of acoustic energy between the

transducer and the skin and minimise interruption of the ultrasound beam (9).

Treatment can take approximately 3–4 hours, during which patients are required to remain relatively immobile while maintaining the ability to communicate pain or burning sensations. Patients may experience abdominal cramping, as well as back and leg pain related to prolonged positioning and the effects of treatment on the uterus. Burning sensations of the skin may also occur. When these symptoms arise, the patient needs to communicate with the operator so that treatment can be interrupted or adjusted to reduce the risk of thermal injury (2). Following the procedure, patients are generally monitored in a recovery area and may be discharged on the same day.

These procedural requirements highlight the need for an anaesthetic technique that provides adequate analgesia and patient comfort while maintaining immobility, spontaneous ventilation and the ability to communicate with the HIFU operator.

Conscious Sedation and Systemic Analgesia

Various analgesic and sedation techniques have been described for patients undergoing HIFU. In a prospective study involving 22 patients, participants received Ultracet (37.5 mg tramadol hydrochloride and 375 mg paracetamol) preoperatively. Eighteen of the 22 patients reported pain during the procedure (10). Although systemic analgesia alone appeared insufficient to provide adequate pain control, it allowed patients to remain fully conscious and able to communicate with the operator.

Fentanyl and midazolam are commonly used agents for conscious sedation. Both have relatively short durations of action and, when administered together, provide analgesic and sedative effects. Three studies have described their use during HIFU treatment. The first study did not report the exact doses administered but found that the technique allowed patients to maintain communication during the procedure. However, patients continued to report pain, including abdominal, groin, leg, and sacrococcygeal pain (11).

The second study described the use of fentanyl at 0.8–1 µg/kg and midazolam at 0.02–0.03 mg/kg, with repeated administration of both agents at 30–40-minute intervals. However, the study provided limited reporting of pain and sedation scores during the procedure (12). Similarly, a third study evaluated patients undergoing HIFU for adenomyosis using fentanyl at 0.8–1 µg/kg and midazolam at 0.02–0.03 mg/kg, administered at 30–40-minute intervals. Sedation scores were not reported, although ongoing pain was reported in 31–56% of patients depending on the type and severity of adenomyosis (13).

Dexmedetomidine–remifentanyl has also been compared with midazolam–remifentanyl in an 80-patient randomised

controlled trial. The dexmedetomidine–remifentanyl group demonstrated less respiratory depression, shorter pauses during ablation and a greater proportion of patients achieving a Ramsay Sedation Scale score of 3–4. Postoperatively, patients in this group also reported higher satisfaction scores and improved recovery times (5). Within this study, dexmedetomidine–remifentanyl therefore appeared to provide advantages over midazolam–remifentanyl in terms of respiratory safety, sedation and recovery.

Regional Anaesthesia

Regional anaesthesia provides analgesia by interrupting nerve conduction to the target organs or tissues while preserving spontaneous ventilation and, where appropriate, consciousness (14).

A retrospective analysis of 2173 women, of whom 311 underwent a paracervical block prior to HIFU treatment, demonstrated reductions in treatment duration, total ablation time and the total energy required during treatment (15). A paracervical block involves the administration of local anaesthetic around the cervix. It reduces pain transmission from the uterus through the uterine plexus but does not adequately block pain transmitted through the ovarian plexus. Although the use of a paracervical block was associated with favourable procedural outcomes, it was not sufficient to prevent pain completely and required supplementation with systemic analgesia. The study did not clearly document whether rescue analgesia was required or which agents were used.

Epidural anaesthesia is a neuraxial technique that can provide effective analgesia while reducing the requirement for general anaesthesia and systemic analgesic agents. A case-control study compared epidural anaesthesia with conscious sedation using remifentanyl during HIFU. In the epidural group, 6 mL of 0.5% ropivacaine was administered into the epidural space using fluoroscopy-guided insertion. In the remifentanyl group, an effect-site concentration of 3 ng/mL was used. Pain scores were significantly lower in the epidural group (4).

Adverse effects were reported in both groups. Two patients in the epidural group experienced tingling sensations in the lower extremities, both of which resolved before discharge. Urinary retention was more common in the epidural group; however, this also resolved before discharge. One patient developed a lumbosacral plexus injury requiring treatment with gabapentin for six months following the procedure. Thermal burns occurred in both groups but were reported more frequently in the conscious sedation group. There was no significant difference in postoperative nausea and vomiting between the groups, although patients in the conscious sedation group required more antiemetic medication in the recovery area (4). Overall, the study

suggested that epidural anaesthesia provided superior analgesia and reduced the requirement for postoperative antiemetic treatment, although the increased incidence of urinary retention and the potential for neuraxial complications remain considerations.

Another prospective study evaluated the effectiveness of epidural anaesthesia during HIFU treatment in 29 participants using ropivacaine and sufentanil. An up-and-down sequential method was used to determine the effective concentrations required to achieve adequate analgesia. An initial bolus of 5 mL of 0.06% ropivacaine with sufentanil 0.5 µg/mL was administered, followed by 10 mL boluses every 40 minutes. The primary outcome was the determination of the EC50 and EC95, which were found to be 0.079% (95% CI 0.075–0.084%) and 0.089% (95% CI 0.084–0.118%), respectively. Adequate analgesia was achieved with epidural anaesthesia alone in 13 patients, while 16 patients required rescue analgesia with midazolam 0.5 mg and fentanyl 50 µg. Positive outcomes included maintenance of patient immobility, consciousness and communication throughout the procedure (16).

General Anaesthesia

General anaesthesia is not routinely used for HIFU treatment of uterine fibroids or adenomyosis because of the specific requirements of the procedure. General anaesthesia introduces additional risks, tachycardia, hypertension, hypotension, nausea and vomiting, and drowsiness, which were shown to be higher in women than men (17). Furthermore, loss of consciousness prevents the patient from communicating pain or burning sensations during treatment, which may increase the risk of undetected thermal injury.

However, patient-specific factors may make general anaesthesia necessary when regional or conscious sedation techniques are contraindicated or unsuitable. General anaesthesia has been described during HIFU treatment of prostate tumours, where the use of a rectal probe, prolonged treatment duration and patient factors may make general anaesthesia preferable. Examples of patient factors include local anaesthetic allergy and ankylosing spondylitis (3).

Safety of Anaesthetic Techniques

Respiratory Compromise

Patients undergoing HIFU are generally required to breathe spontaneously. The choice of anaesthetic technique may therefore affect respiratory drive and the patient's ability to communicate effectively with the operator. Opioids and sedative-hypnotic agents may cause respiratory depression, particularly when used in combination or when sedation becomes deeper than intended. This is particularly relevant because airway access may be limited by the prone position during treatment, making airway intervention more difficult.

Prevention of excessive sedation and respiratory compromise is therefore an important consideration. Across the studies reviewed, conscious sedation techniques commonly involved fentanyl and midazolam, both of which can cause respiratory depression. However, no significant respiratory adverse outcomes were reported in these studies. Dexmedetomidine, an alpha-2 adrenergic agonist, provides sedative and analgesic effects with relatively limited respiratory depression (18). This was demonstrated in the study comparing dexmedetomidine–remifentanyl with midazolam–remifentanyl, where the dexmedetomidine group experienced less respiratory depression. Regional anaesthesia can provide effective analgesia while preserving spontaneous ventilation (17). Conversely, general anaesthesia can impair airway reflexes, require airway instrumentation and impair respiratory drive (3).

Cardiovascular stability

Although cardiovascular stability is not a primary outcome of HIFU treatment, maintaining haemodynamic stability remains important to prevent complications such as hypotension and bradycardia. Several agents used for sedation and analgesia may cause hypotension or bradycardia. In a randomised controlled trial of adults undergoing general anaesthesia, hypotension was found to be more frequent in those who received remifentanyl and dexmedetomidine at the infusion rates that were studied. (19) This is particularly relevant during HIFU because intravenous access and patient positioning may make intervention more difficult.

Dexmedetomidine has previously been associated with hypotension and bradycardia due to its sympatholytic effects (18). Epidural anaesthesia may also result in sympathetic blockade and subsequent hypotension; however, significant haemodynamic instability was not reported in the studies included in this review.

Nausea and vomiting

The prevention of nausea and vomiting is important to maintain patient comfort, prevent interruptions to the procedure and facilitate recovery. Only one study included in this review specifically assessed postoperative nausea and vomiting and reported a greater requirement for antiemetic medication in patients receiving remifentanyl-based conscious sedation compared with those receiving epidural anaesthesia (4). This may suggest an advantage of regional anaesthesia; however, the limited reporting of nausea and vomiting across the remaining studies prevents meaningful comparison between techniques.

Efficacy

The efficacy of anaesthetic and analgesic techniques can be assessed using several outcomes, including patient

satisfaction, pain scores, the requirement for rescue analgesia, treatment interruptions and procedural outcomes. However, only a limited number of studies reported outcomes that directly assessed the efficacy of the anaesthetic technique.

In the randomised controlled trial comparing dexmedetomidine–remifentanyl with midazolam–remifentanyl, the dexmedetomidine–remifentanyl group demonstrated less respiratory depression, more favourable sedation scores, improved recovery times and higher patient satisfaction (5). These findings suggest that dexmedetomidine–remifentanyl may provide an effective balance between sedation, analgesia and preservation of respiratory function.

Similarly, the study comparing epidural anaesthesia with remifentanyl-based conscious sedation demonstrated lower pain scores and reduced requirements for antiemetic medication in the epidural group (4). However, the limited number of studies directly comparing anaesthetic techniques makes it difficult to determine whether these findings are reproducible across different patient populations and HIFU protocols.

Strength and Quality of Evidence

The strength of the available evidence is variable. The included studies used different designs, including randomised controlled trials, prospective studies and retrospective studies. Although the randomised controlled trial comparing dexmedetomidine–remifentanyl with midazolam–remifentanyl provides stronger evidence for a direct comparison, it was based on a relatively small sample and represents a single anaesthetic comparison. Several prospective studies also included relatively small sample sizes, limiting the generalisability of their findings. In contrast, the large retrospective study evaluating paracervical block provided a larger sample size; however, its retrospective design introduces the risk of selection bias and unmeasured confounding. The non-randomised comparative studies are similarly susceptible to confounding, as the choice of anaesthetic technique may have been influenced by patient or procedural factors. These methodological differences, together with variation in anaesthetic protocols and outcome measures, limit the strength of comparisons between techniques.

Evidence Gaps

The available evidence regarding the anaesthetic management of patients undergoing HIFU treatment for uterine fibroids and adenomyosis is heterogeneous and limited. The current literature provides insufficient assessment of the efficacy and safety of the different techniques. Consequently, it is difficult to determine whether reported outcomes are attributable to the

anaesthetic technique itself or to differences in patient populations, HIFU protocols, and outcome measures. Furthermore, most studies primarily assessed procedural outcomes rather than anaesthetic outcomes. Although measures such as successful ablation and treatment duration provide information regarding the effectiveness of HIFU, they do not adequately assess the efficacy of the sedation or analgesic technique used to facilitate the procedure.

This limitation is further demonstrated by the lack of standardised outcome measures. Only two studies used comparable pain assessment scales, while only one study reported a formal sedation scale. This limits the ability to compare the adequacy and depth of sedation between techniques. Similarly, nausea and vomiting were assessed in only one study, providing limited information regarding postoperative recovery and patient comfort.

Overall, the findings of this narrative review do not allow a definitive conclusion regarding which sedation or analgesic modality provides the most appropriate balance between analgesia, patient comfort, safety, and preservation of communication during HIFU treatment.

Conclusion

Current evidence describes several techniques that can provide analgesia and sedation during HIFU treatment for uterine fibroids and adenomyosis. No single technique was found to be superior; however, the findings can provide guidance for anaesthetic decision-making based on procedural requirements, patient factors and the need to maintain communication with the operator. Conscious sedation may be beneficial when preserving spontaneous ventilation and patient cooperation and communication is a priority, while regional techniques such as epidural anaesthesia may provide more effective analgesia for those patients requiring greater pain control. However, the potential adverse effects of these techniques need to be considered, including respiratory depression with conscious sedation and hypotension, urinary retention, and other complications associated with neuraxial anaesthesia. General anaesthesia may be considered in patient populations where other techniques are unsuitable, although HIFU still limits patient communication. Regardless of the technique selected, careful titration of sedation, continuous monitoring of respiratory and cardiovascular function and the ongoing ability of the patient to communicate are important to minimise procedure-related risks. The lack of standardised assessment of pain, sedation and adverse outcomes limits direct comparison between different techniques and emphasises the need for prospective studies using consistent sedation and pain scales and clinically relevant outcome measures to establish safety and efficacy and better inform clinical practice.

Recommendations/ Further Research

Future studies should use standardised measures of pain, depth of sedation, patient satisfaction scores, adverse events and rescue analgesia requirements. Prospective studies need to provide direct comparisons between anaesthetic techniques using similar protocols and clearly defined outcome measures to provide more reproducible evidence. In particular, studies need to compare conscious sedation, neuraxial anaesthesia and general anaesthesia within similar populations and HIFU protocols. Clinically relevant outcomes such as completion of treatment, treatment interruptions, recovery times, respiratory and cardiovascular complications, nausea and vomiting, and thermal injury need to be assessed. Furthermore, standardised reporting of anaesthetic drug dosing and sedation targets would further improve comparison. Larger, multi-centre studies may help determine how differences in HIFU technique and treatment duration influence the choice and effectiveness of the anaesthetic technique. Ultimately, future research should aim to establish an evidence-based approach that balances sedation and analgesia with patient immobility, preservation of communication and respiratory and cardiovascular stability.

Abbreviations

HIFU- High-Intensity Focused Ultrasound
MRI-Magnetic Resonance Imaging
EC50- Effective concentration producing the desired effect in 50% of patients
EC95- Effective concentration producing the desired effect in 95% of patients
CI- Confidence interval
PONV- postoperative nausea and vomiting
MEDLINE- Medical Literature Analysis and Retrieval System Online

Conflict of Interest

The authors report no conflict of interest.

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Data Availability

All data included in this review are available from the publicly accessible sources cited in the manuscript.

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