



Review

Local anaesthesia and pain management in image-guided breast interventions: Empathy in action

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ARTICLE INFO

Keywords:

Breast Imaging
Image-guided procedures
Local anaesthesia
Pain pathways
Patient experience

ABSTRACT

Effective pain management is critical in image-guided breast interventions, directly contributing to patient comfort and procedural success. This review provides breast radiologists with actionable insights into pain mechanisms, the optimisation of local anaesthetic delivery, and practical supplementary methods to minimise injection discomfort. Evidence-based techniques, including buffering, warming of solutions, and the addition of vasoconstrictors, are explored. Pharmacological properties, safety considerations, and innovative approaches, including patient-centred care and anxiety management strategies, are also discussed. Together, these considerations form a comprehensive framework to advance practices and elevate the standard of care in breast interventions.

1. Introduction

Pain is a complex experience with sensory, emotional, and cognitive dimensions, each contributing to the modulation of nociceptive processing [1]. In image-guided breast procedures, managing both physical and emotional aspects of pain is essential, as discomfort is often accompanied by fear and anxiety [2]. Addressing these factors through effective communication and patient-centred care can enhance the experience and improve procedural efficiency and outcomes [3,4].

Local anaesthetics (LA) are central to percutaneous breast procedures, supporting compliance across diagnostic and therapeutic settings. Despite technical progress, their administration remains one of the least well-tolerated steps, warranting further optimisation [5–7]. Pain during LA injection is multifactorial, shaped by technique, pharmacologic properties, and individual sensitivity [8].

Radiologists performing interventions must demonstrate proficiency not only in safe and effective LA use but also in anticipating patient needs and alleviating distress. While empathy is widely advocated in healthcare, practical strategies for applying it in this context remain limited [9]. Similarly, instruction in pain control and communication is often underemphasised in radiology training [10].

Existing literature on LA primarily relates to dentistry [11], dermatology [12], surgical anaesthesia [13,14], or general interventional radiology [15,16], offering little specific guidance for breast imaging, a field with unique emotional and contextual challenges.

This review addresses that gap by providing a clinically focused synthesis of pain mechanisms, anaesthetic strategies, and patient-centred approaches. It integrates anatomical understanding, technical refinement, and communication principles to support more compassionate and effective care within breast radiology.

2. Background: Pain mechanisms in breast interventions

Effective pain management in breast imaging interventions begins with a sound understanding of breast anatomy and nociceptive pathways.

2.1. Nerve supply

The breast is a subcutaneous organ innervated primarily by the intercostal nerves (T2–T6), with additional input from the supraclavicular nerves [17] (Fig. 1). Intercostal nerves give rise to lateral and

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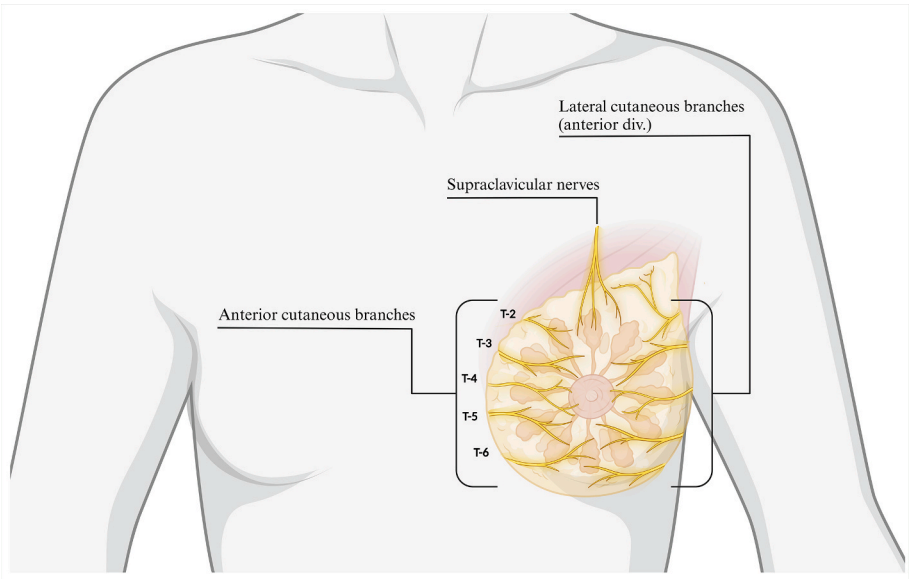


Fig. 1. Sensory innervation of the breast is primarily via the intercostal nerves (T2–T6) and supraclavicular nerves, with lateral and anterior branches innervating the breast and chest wall. The nipple-areola complex is mainly supplied by the T3–T4 intercostal nerves.

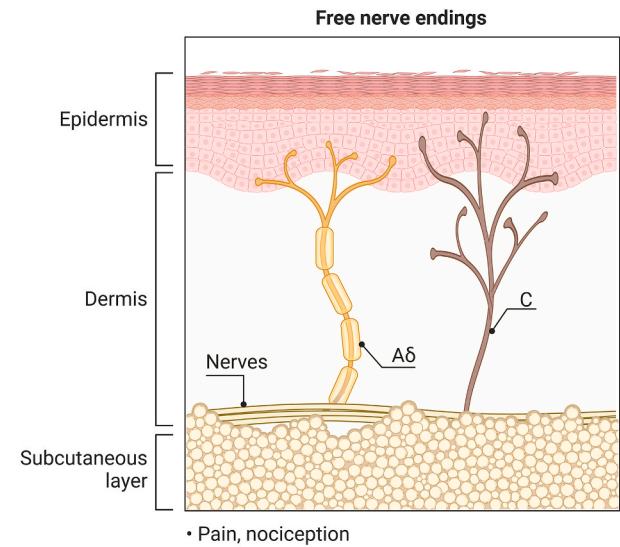


Fig. 2. Nociceptors terminate as free nerve endings in the dermis and epidermis, comprising A-delta fibres (lightly myelinated) for sharp, rapid pain and unmyelinated C-fibres for slow, diffuse pain. Both fibres transduce noxious stimuli into electrical signals interpreted as pain.

anterior cutaneous branches, which supply the lateral and medial breast, respectively. Supraclavicular nerves, from the cervical plexus, cross the clavicle to innervate the superior breast skin.

The nipple-areola complex (NAC) receives overlapping innervation from medial and lateral branches of the T3–T4 intercostal nerves, with variable contributions from T2 and T5 [18]. The intercostobrachial nerve, derived from the T2 lateral cutaneous branch, innervates the axilla and upper medial arm.

2.2. Nociceptors and pain perception

Nociceptors are specialised sensory neurons that detect noxious stimuli, including mechanical, thermal, or chemical [19]. These free nerve endings reside in the dermis and basal epidermis, initiating the pain response [20]. They are classified as A-delta fibres (lightly myelinated; rapid conduction; sharp pain) and C-fibres (unmyelinated; slower conduction; burning or aching pain). A-delta fibres cluster near the dermal–epidermal junction, while C-fibres are more diffusely distributed throughout the dermis and superficial epidermis [21] (Fig. 2).

2.3. Skin and subcutaneous anatomy considerations

Skin structure directly influences the efficacy and comfort of LA delivery. The epidermis (~0.08 mm in females) [22] is poorly permeable and unsuitable for injection. The dermis (1–2 mm), which contains capillaries, glands, and many nociceptors, is particularly sensitive to

Table 1
Overview of anaesthetics commonly used for local infiltration in breast radiology. Adapted from [14,15,17,26].

Local Anaesthetic	Concentrations (%)	Maximum Dose (mg/kg)	Maximum Total Recommended Dose (mg)	Volume of Maximum Recommended Dose	Average Onset (Minutes)	Duration of Action (Minutes)
Lidocaine (plain)	1–2 %	4.5	≤ 300	30 mL of 1 % or 15 mL of 2 %	1–2	30–60
Lidocaine (with epinephrine)	1–2 % (Epinephrine 1:100000 or 1:200000)	7	≤ 500	50 mL of 1 % or 25 mL of 2 %	1–2	60–240
Mepivacaine	1–3 %	5	≤ 400	40 mL of 1 %	3–5	45–90
Bupivacaine (plain)	0.25–0.5 %	2.5	≤ 175	70 mL of 0.25 % or 35 mL of 0.5 %	5	120–240
Bupivacaine (with epinephrine)	0.25–0.5 % (Epinephrine 1:200000)	3	≤ 225	90 mL of 0.25 % or 45 mL of 0.5 %	5	180–360
Ropivacaine	0.2–1 %	3	≤ 200–300	30–40 mL of 0.5 %	5	180–360

injection due to stimulation of A-delta and C-fibres.

Pain during LA administration arises from two mechanisms: needle entry activates A-delta fibres (sharp pain), and tissue distension by the acidic solution stimulates C-fibres (dull, burning sensation). As LA blocks A-delta fibres before C-fibres, the sharp pain typically resolves sooner than the residual burning [23].

In contrast, the hypodermis (subcutaneous tissue), composed mainly of fat and loose connective tissue, provides a more suitable plane for LA delivery. Its greater distensibility facilitates LA diffusion and effective nociceptor blockade [24].

3. Local anaesthetics

3.1. Overview of local anaesthetics

LA act by blocking voltage-gated sodium channels on neuronal membranes, thereby inhibiting nerve impulse conduction and depolarisation [25]. They are broadly classified into amides (e.g. lidocaine, bupivacaine) and esters (e.g. procaine), with amides generally preferred for their longer duration, potency, and lower allergenic potential [8,15]. Most formulations are prepared as water-soluble hydrochloride salts to ensure stability and ease of administration.

Radiologists' choice of LA typically reflects procedural requirements, institutional protocols, and agent availability, although this has not been specifically studied. Duration of action and the potential need for extended analgesia are key considerations. Table 1 summarises commonly used agents and their practical characteristics for use in breast imaging.

3.2. Common agents and properties

Lidocaine.

Lidocaine is the most widely used amide anaesthetic due to its rapid onset (1–2 min) and intermediate duration (30–60 min). Standard concentrations are 1 % (10 mg/mL) and 2 % (20 mg/mL); the 5 % formulation is not recommended in radiology because of the increased risk of systemic toxicity, including cardiovascular and central nervous system (CNS) effects.

Plain lidocaine has a relatively short duration, partly due to its transient vasodilatory effect [27]. However, when combined with epinephrine, the duration can extend up to 240 min. The addition of epinephrine lowers the solution's pH (from ~ 6.0 to 3.9–4.2) due to stabilising preservatives [28].

Maximum recommended doses [29,30]:

- Without epinephrine: 4.5 mg/kg (up to 300 mg; e.g. 30 mL of 1 % or 15 mL of 2 %)
- With epinephrine: 7 mg/kg (up to 500 mg; e.g. 50 mL of 1 % or 25 mL of 2 %)

Mepivacaine.

Mepivacaine has a similar duration to lidocaine (0.5–2 h) and a variable onset (3–20 min) [31]. It is available in 1 %, 2 %, and 3 % concentrations. With a pH range of 4.5–6.8 and moderate lipid solubility, it diffuses efficiently across nerve membranes [29]. Compared to lidocaine, mepivacaine induces less vasodilation [27].

Maximum dose: 400 mg (plain); 500 mg with vasoconstrictors.

Bupivacaine.

Bupivacaine is a long-acting anaesthetic with a slower onset (~5 min) and duration ranging from 2 to 4 h without epinephrine, and up to 6 h with epinephrine [15]. Available concentrations include 0.25 % (2.5 mg/mL), 0.5 % (5 mg/mL), and 0.75 % (7.5 mg/mL); only concentrations up to 0.5 % are typically used with vasoconstrictors. The pH is approximately 5.5 [32].

Its prolonged effect makes bupivacaine particularly useful for

intraparenchymal infiltration during vacuum-assisted procedures, which often require extended analgesia. However, it binds strongly to cardiac sodium channels, increasing the risk of arrhythmias and systemic toxicity if inadvertently injected intravascularly [33,34]. Pre-injection aspiration and cautious dose escalation are essential safety measures.

Maximum recommended doses are:

- Without epinephrine: 2.5 mg/kg (up to 175 mg; e.g. to 70 mL of 0.25 % or 35 mL of 0.5 %).
- With epinephrine: Up to 225 mg (e.g., 90 mL of 0.25 % or 45 mL of 0.5 %).

3.3. Newer Formulations of Local Anaesthetics

Recent advances in anaesthetic formulations have introduced agents with improved safety profiles, expanding their potential role in clinical practice.

Levobupivacaine, the S-enantiomer of bupivacaine, offers lower cardiotoxicity and CNS risk, making it preferable for patients with cardiovascular comorbidities. It is available in concentrations ranging from 0.0625 % (0.625 mg/mL) to 0.75 % (7.5 mg/mL). Although motor block onset is slower than bupivacaine, recovery is faster, which supports its use in ambulatory settings. Comparative studies suggest similar sensory block duration with enhanced safety in high-risk patients [35].

Ropivacaine is a long-acting amide anaesthetic with slightly lower potency than bupivacaine but a more favourable safety profile, including reduced cardiotoxicity [34,36]. Its intrinsic vasoconstrictive properties often eliminate the need for epinephrine [37]. Available concentrations include 0.2 % (2 mg/mL), 0.75 % (7.5 mg/mL), and 1 % (10 mg/mL), with 0.2 % commonly used for nerve blocks requiring moderate analgesia. Neither agent has been specifically evaluated in breast radiology; however, ropivacaine has been used successfully in breast surgeries [38], particularly for reducing postoperative pain [39,40].

3.4. Vasoconstrictors

Most amide LA, except for ropivacaine, induce varying degrees of vasodilation through sympathetic blockade, increasing local perfusion [41]. Adding a vasoconstrictor such as epinephrine counteracts these effects by prolonging anaesthetic duration, reducing systemic absorption, and minimising bleeding [31]. These benefits are particularly relevant in breast interventions that require sustained and precise anaesthesia.

Epinephrine concentrations are typically expressed as dilution ratios. A 1:100,000 epinephrine solution contains 10 µg/mL. For reference, a 1:50,000 solution contains 20 µg/mL (twice the concentration), and a 1:200,000 solution contains 5 µg/mL (half the concentration). When pre-mixed formulations are unavailable, radiologists can prepare the solution manually [42]. For example, adding 0.1 mL of 1:1,000 epinephrine to 10 mL of LA produces a 1:100,000 dilution (equivalent to 0.01 mg/mL) [43]. However, commercial preparations are generally preferred to minimise preparation errors and ensure consistent potency.

Epinephrine use is considered safe even in regions with terminal blood supply, where previous concerns about ischaemia have been refuted by modern evidence [44,45]. Nevertheless, caution is advised in patients with impaired venous or lymphatic drainage (e.g., post-mastectomy flaps), to minimize the risk of ischemic complications [46]. Approximately 2 % of patients receiving lidocaine with epinephrine may experience mild, self-limiting symptoms such as nervousness, tremors, flushing, or palpitations [47]. These adrenaline-related effects are more common in younger individuals or highly vascular regions and can usually be managed with reassurance. Pre-procedural counselling helps distinguish these reactions from true allergic responses.

Table 2
Supplementary approaches for optimising local anaesthesia.

Approach	Practical Details	Key Benefits	Key Considerations
Buffering	Add 1 mL of 8.4 % sodium bicarbonate to 9 mL of 1 % or 2 % lidocaine (9:1 ratio)	Reduces pain; accelerates onset	Best prepared fresh to maintain potency
Warming Solutions	Warm anaesthetic to ~ 37 °C using gel warmers, syringe warmers, or incubators	Reduces injection discomfort; accelerates onset	Requires warming equipment
Topical Anaesthetics	Apply a eutectic lidocaine 2.5 % prilocaine 2.5 % mix under occlusion (e.g., plastic film) for 30–60 min.	Reduce pain in sensitive superficial areas (e.g., nipple)	Requires preparation time before procedure
Vapocoolants	Use ethyl chloride spray for rapid cooling and temporary numbness	Provides fast, temporary relief for quick insertions (e.g., FNA)	Short-acting; avoid use near polycarbonate components (e.g., mammography paddles)

3.5. Combining LA

Combining LA has been proposed to achieve both rapid onset and prolonged duration of action [48]. Among the explored combinations, buffered mixtures of lidocaine and bupivacaine with epinephrine in a 1:1 ratio have been described as effective for producing robust anaesthesia [49]. Although this approach is supported by pharmacological rationale, clinical evidence remains mixed, with no conclusive advantage over single agents in terms of onset time or efficacy [50].

In practice, the decision to mix local anaesthetics often reflects clinician preference, experience, and procedural context. However, manual mixing can introduce challenges, including dilution effects that reduce the potency of the long-acting agent, alter pharmacokinetics, or disrupt workflow [50]. Standalone or pre-mixed formulations are therefore preferred for efficiency, safety, and consistency.

4. Safety considerations

Breast interventions typically involve small volumes of local anaesthetic, lowering the risk of systemic toxicity. Nonetheless, patient assessment and appropriate monitoring remain essential to detect and manage adverse effects. For multiple interventions performed on the same day, anaesthetics can be diluted with sterile saline, as long as total amounts remain within safe limits.

Anaesthetic concentrations are commonly expressed as percentages and can be converted to milligrams per millilitre (mg/mL) by moving the decimal point one place to the right. For example:

- Bupivacaine 0.25 % = 2.5 mg/mL
- Lidocaine 1 % = 10 mg/mL
- Lidocaine 2 % = 20 mg/mL

4.1. Breast procedures during pregnancy and lactation

Breast cancer is the most common malignancy diagnosed during pregnancy, and ultrasound-guided core biopsy is the preferred sampling method [51]. Lidocaine is classified as a category B drug by the US FDA and is considered acceptable in small quantities during pregnancy [29,31,52]. Although animal studies show no foetal harm, use is typically reserved for medically necessary interventions. Elective procedures are usually delayed until after delivery or the second trimester. Data on other anaesthetic agents in this setting are insufficient, and their use is not recommended. [29].

Pregnancy-associated changes in breast tissue, including increased vascularity, may modestly raise bleeding and infection risks. In lactating patients, small traces of lidocaine and blood may enter breast milk but are considered safe for infants. Milk duct fistula, though rare and more often linked to surgery, underscores the importance of careful technique [52]. Risk reduction strategies include breastfeeding or pumping before the procedure and using the smallest appropriate needle. For complex cases, a multidisciplinary approach involving obstetrics and neonatology can maximise safety.

4.2. Allergic reactions

True allergic reactions to LA are rare (<1%) [53]. When they occur, they are usually linked to PABA metabolites in ester-based agents or to preservatives in amide formulations [35]. Although concerns about LA allergy occasionally arise in clinical practice, most suspected reactions are not immune-mediated. They typically reflect vasovagal responses, anxiety-related symptoms, or the pharmacological effects of vasoconstrictors such as adrenaline [54]. In patients with a suspected or confirmed lidocaine allergy, an alternative agent from a different class (e.g. procaine, chloroprocaine) or diphenhydramine may be used [55,56]. Cross-reactivity among amide-type agents is rare and lacks a consistent pattern [56–58]. Complex cases may require oral anxiolysis, conscious sedation, or general anaesthesia [56].

4.3. Local anaesthetic systemic toxicity (LAST)

LAST is a rare but serious event caused by systemic absorption, often due to inadvertent intravascular injection, high vascularity at the injection site, or excessive dosing [59]. Early symptoms include dizziness, tinnitus, and a metallic taste, which can progress to seizures and cardiovascular collapse if left untreated [15]. Management involves immediate airway support, oxygenation, and lipid emulsion therapy in severe cases [60]. Adhering to recommended dosages and employing safe injection techniques significantly reduces the risk of LAST.

5. Supplementary approaches for LA

In addition to agent selection and technique, supplementary methods such as buffering, warming, or topical application can reduce discomfort and enhance the effectiveness of LA injections. Key options are summarised in Table 2 and described below.

5.1. Buffering (neutralising) with sodium bicarbonate

Local anaesthetics are weak bases prepared as acidic hydrochloride salts to ensure solubility and stability. This acidity, especially in epinephrine-containing formulations (pH ~ 4), contributes to injection pain [28]. Buffering with sodium bicarbonate raises the pH, enhancing comfort and speeding onset [61].

A common formula adds 1 mL of 8.4 % sodium bicarbonate to 9 mL of 1 % or 2 % lidocaine (9:1 ratio), though a 3:1 ratio may further reduce pain [62]. Buffered lidocaine is particularly effective for intraparenchymal injections and yields greater benefit in patients with fatty or scattered fibroglandular tissue. In those with denser breasts, often more sensitive, additional strategies may be required, such as higher LA volumes or behavioural interventions [61].

Freshly prepared buffered lidocaine retains > 94 % potency and remains clear and stable [50]. However, data on compatibility with all LA agents are limited, so caution is advised. Despite efficacy, this technique remains underused in radiology.

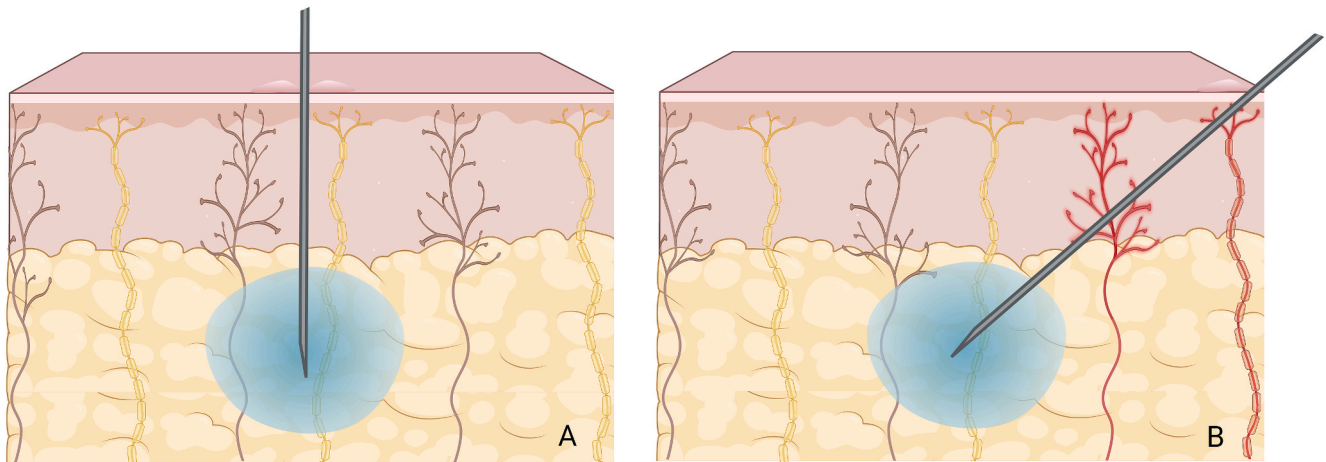


Fig. 3. Schematic representation of injection techniques and anaesthetised zones. Initial needle insertion at a 90-degree angle minimises pain by reducing contact with nociceptor-rich dermal tissue (A). The blue-shaded area represents the anaesthetic zone created by local anaesthetic delivery. A 45-degree entry angle (B) increases contact with nociceptor-dense regions, leading to more painful insertion.

5.2. Warming of solutions

Warming LA to body temperature improves patient comfort and reduces pain compared to room-temperature injections [63,64]. While the mechanism is not fully understood, improved membrane diffusion and faster onset are likely contributors. Heating to 37 °C for brief periods does not compromise lidocaine or epinephrine [65]. Practical ways for warming solutions include the use of medical gel warmers, thermostatic water baths, syringe warmers, or incubators.

5.3. Hyaluronidase

Hyaluronidase facilitates anaesthetic diffusion by breaking down hyaluronic acid, lowering tissue resistance during infiltration [29,66]. It is not routinely used in breast radiology but may be helpful in patients with particularly fibrous tissue or where injection contour distortion is a concern. Allergic reactions are possible, particularly in those with bee venom sensitivity, so selective use is advised [67]. Evidence remains insufficient to support routine application in breast imaging.

5.4. Topical anaesthetics and vapocoolants

Topical anaesthetics and vapocoolants offer non-invasive methods to reduce discomfort in superficial or minimally invasive procedures.

Eutectic mixtures of lidocaine and prilocaine (e.g., 2.5 % each) provide effective surface anaesthesia when applied with an occlusive dressing for 30–60 min [43]. These preparations are especially useful for needle insertions in sensitive regions, including the nipple–areolar complex. Due to the required application time, they are best suited for scheduled procedures.

Vapocoolants, such as ethyl chloride sprays, are not true anaesthetics but induce rapid, temporary skin numbing via evaporative cooling. They are particularly helpful during fine-needle aspiration, pre-surgical wire placement (when LA is omitted), or other quick needle-based interventions [68].

Although nonsterile, studies have shown that vapocoolants applied after antiseptic cleaning do not increase bacterial colonisation [69–71]. However, care is needed during mammographic-guided procedures, as ethyl chloride can react with polycarbonate components like the

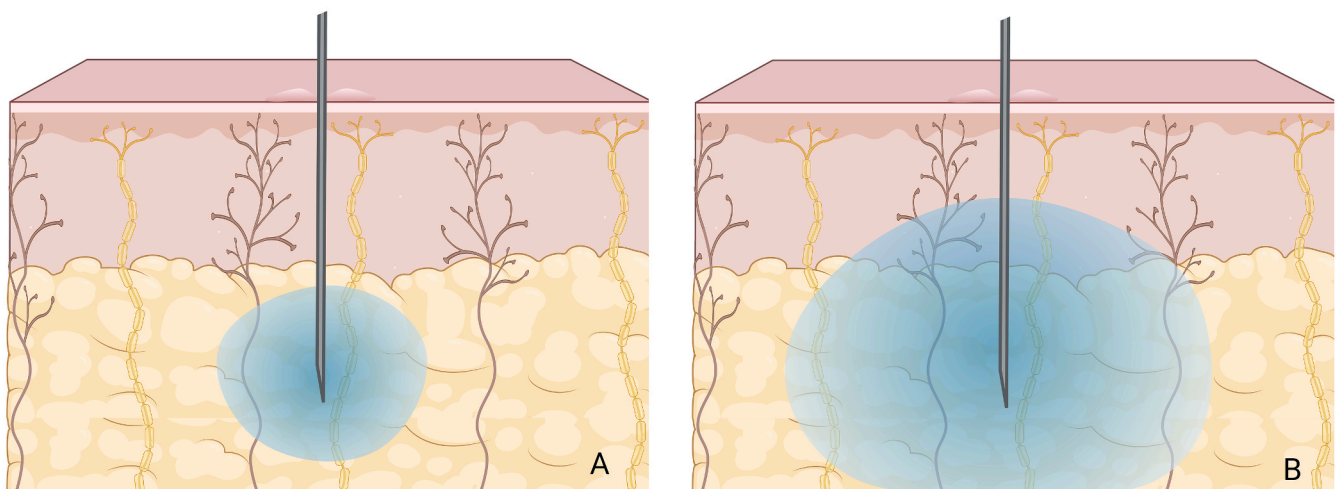


Fig. 4. Subdermal injection of local anaesthetic targets nerve trunks while avoiding the nociceptor-rich dermal layer. This technique improves diffusion into the subcutaneous tissue. Begin with a small subdermal wheal (A), allowing for gradual numbing before advancing the needle and delivering a larger volume (B).

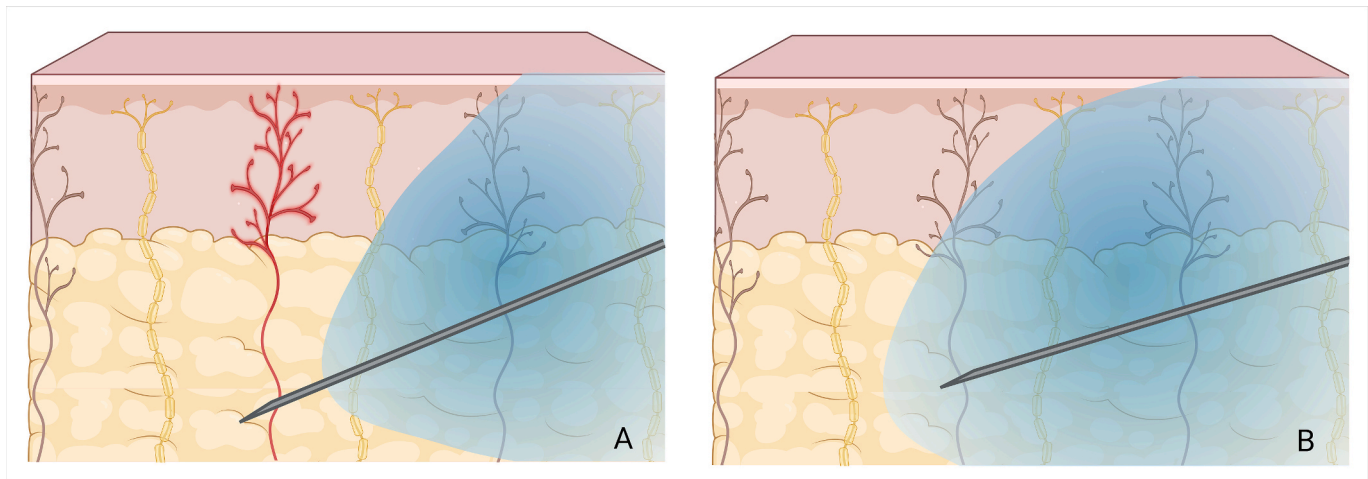


Fig. 5. Slow injection and gradual needle advancement create a “zone of anaesthetic coverage” (blue shade) that ensures effective anaesthesia. Advancing the needle beyond the anaesthetised area (A) can stimulate non-blocked nerve endings and cause pain. In contrast, advancing the needle within the anaesthetised area (B) avoids stimulation of nerve endings, reducing pain and improving patient comfort.

compressor paddle or breast spacer, potentially causing surface damage or visible staining [72].

6. Practical insights for breast interventions

Mastering the administration of LA in breast imaging requires a nuanced understanding of technical adjustments, patient-specific factors, and strategies to reduce injection-related discomfort. The following recommendations aim to support both patient comfort and procedural efficiency.

6.1. Optimising injection techniques

Delivering local anaesthesia effectively in breast imaging calls for both technical precision and thoughtful adaptation to each clinical scenario.

Needle Selection

Finer-gauge needles (e.g., 25–30 gauge) are preferred to minimise insertion pain. Longer needles allow broader coverage with fewer punctures, ensuring consistent deposition over larger areas [73].

Angle of Injection

Although ultrasound-guided procedures typically follow a 45° trajectory, initial insertion at 90° (Fig. 3) can reduce discomfort by limiting nerve fibre disruption and energy transmission through the skin [8,74]. Once anaesthesia is established, the needle can be redirected as needed.

Subdermal injection

Infiltrating the anaesthetic beneath the dermis avoids nociceptor-dense tissue and facilitates diffusion into the more distensible subcutaneous plane (Fig. 4) [43]. Correct placement creates a subcutaneous bleb, in contrast to the blanching and dimpling seen with intradermal injection.

Sequential anaesthesia.

Begin with a small subdermal wheal and pause briefly to allow initial effect. Continue advancing the needle within the anaesthetised field (Fig. 5) to prevent stimulating unblocked nerve endings.

Injection speed.

Slow injection rates (2–4 mL/min) reduce tissue distension and chemical irritation. Higher speeds (≥ 7.5 mL/min) are associated with increased pain [8].

Anaesthetic volume.

Use the lowest effective volume to achieve adequate blockade while

limiting tissue distension and systemic absorption risks [43].

Onset time.

Always allow time for the anaesthetic to take full effect before beginning the intervention, particularly with slower-onset agents like bupivacaine.

6.2. Minimal sedation

In breast imaging, some patients express a preference for sedation or complete unawareness during procedures, often due to fear or anticipatory anxiety. These concerns are frequently alleviated through empathetic communication that fosters trust and reduces distress.

When appropriate, minimal sedation may be considered for patients with significant anxiety, particularly when it could compromise procedural cooperation. This controlled approach reduces emotional strain while maintaining verbal responsiveness and preserving cardiorespiratory function [75]. It can be especially helpful in cases involving vacuum-assisted biopsies.

Midazolam is the most frequently used benzodiazepine in procedural sedation owing to its rapid onset and short elimination half-life (1–4 h). It can be administered intravenously, intramuscularly, or orally. Common dosing includes 1–2.5 mg IV over 2 min, with incremental adjustments as needed (up to 5 mg), or 7.5 mg orally when appropriate [15]. Its hypnotic and amnesic effects help minimizing procedural recall. Its administration is commonly performed by anaesthesiologists, though trained radiologists may also do so in select settings. However, the use of intravenous sedation in outpatient breast imaging is limited by monitoring needs and post-procedural supervision.

Lorazepam, with a longer half-life (~15 h), may be given orally (2 mg), intramuscularly (0.05 mg/kg 2 h pre-procedure), or intravenously (2 mg or 0.044 mg/kg, whichever is smaller) [26]. Its slower onset and variable peak action make it less suitable for short procedures. Compared to midazolam, lorazepam offers stronger anxiolysis but weaker hypnotic and amnesic properties.

Diazepam is a more familiar choice for radiology departments, particularly in oral form. It is widely available, easy to prescribe, and generally well-tolerated when given as a single dose of 2.5–10 mg the night before, and optionally 1 h prior to the procedure [26]. Despite its advantages, diazepam's elimination half-life of 20–100 h may lead to residual sedation in some patients.

6.3. Practical adaptations for specific interventions

Shorter intervention times and strategic use of LA have been shown to reduce pain and improve patient tolerance [6,76]. Ultrasound-guided biopsies are generally better tolerated than mammographic or MRI-guided procedures, highlighting the importance of selecting the most appropriate guidance method when feasible [77,78].

Fine needle aspiration (FNA).

For superficial lesions, FNA may occasionally be performed without LA, thereby reducing procedural time. The decision should consider lesion type, needle gauge, and patient preference. Vapocoolant sprays or distraction techniques may offer additional comfort.

Core needle biopsies (CNB).

Due to the larger needle calibre, CNB requires LA for adequate pain control. A 1 % lidocaine solution, optionally buffered with sodium bicarbonate in a 9:1 ratio, is commonly used to minimise injection pain [79]. Under ultrasound guidance, inject approximately 5 mL along the planned needle path using a 5 cm hypodermic needle for accurate placement.

To avoid discomfort associated with intradermal wheals, begin by piercing the skin directly and infiltrating as the needle advances toward the target. Withdraw slowly while continuing to inject along the tract. To complete anaesthesia, administer 1–2 mL subdermally to ensure adequate skin blockade. Wait 1–2 min before starting the biopsy.

For deeper lesions near the chest wall or implants, consider injecting anaesthetic posterior to the target to facilitate access and reduce discomfort.

Vacuum-assisted biopsy or excision (VAB or VAE).

The same anaesthetic protocol used for CNB can be applied. Buffered lidocaine may be used initially to reduce discomfort during injection. For intraparenchymal delivery, a vasoconstrictor may be added to reduce bleeding and extend anaesthetic duration. In prolonged or higher-volume sampling, a long-acting agent such as bupivacaine (with or without epinephrine) can be used to achieve more sustained analgesia [80].

Ensure the anaesthetic is delivered both around and distal to the lesion to accommodate larger VAB needles and longer sampling times. To account for needle dead space (up to 1 cm), infiltrate at least 1.5 cm beyond the lesion. Volumes of up to 15–20 mL may be required. A long needle, such as a spinal needle, enables effective distal infiltration.

Nipple-Areola Complex (NAC).

For subareolar procedures such as ductograms or core biopsies, a combination of topical and infiltrative anaesthesia is often most effective. Eutectic creams containing lidocaine and prilocaine, or viscous lidocaine, can be applied under occlusive film at least 30 min beforehand to reduce superficial sensitivity.

For deeper anaesthesia, inject 5 mL of local anaesthetic into the retro-glandular space under ultrasound guidance. This approach targets the penetrating branches of the intercostal nerves responsible for subareolar sensation.

7. Patient-centred care

Beyond technical skill, patient-centred care in breast interventions entails empathy and effective communication. This section outlines practical strategies to reduce anxiety, promote trust, and improve the patient experience throughout the imaging process.

7.1. Empathy and communication

Empathy in clinical care involves recognising a patient's experience, conveying that understanding clearly, and responding with appropriate

support [81]. Concerns about pain or diagnostic outcomes may shape how patients experience the encounter and can discourage future attendance [82].

Radiologists should recognise that pain perception varies widely, even under similar conditions. This variability reflects not only psychological factors, but also differences in endogenous analgesia and genetic polymorphisms affecting nociceptive pathways [83,84]. Misinterpreting lower pain tolerance as a lack of resilience can lead to inadequate support. Acknowledging these differences allows for more nuanced, compassionate care.

7.2. Pre-procedural communication and preparation

Pre-procedure conversations play a vital role in reducing anxiety. Although many patients feel apprehensive, most find the procedure more tolerable than expected. Lower anticipated pain and stress levels are strongly linked to better tolerance [85]. Sharing positive experiences from other patients can build confidence and provide reassurance.

Informative brochures, when paired with empathetic dialogue, have been shown to reduce procedural pain, improve patient understanding, and may ease post-biopsy anxiety [86]. Realistic explanations of what to expect, along with emphasis on procedural safety, help lower pre-biopsy stress [87].

Uncertainty about diagnosis is often a stronger driver of distress than the procedure itself [88]. Extended wait times between biopsy can amplify this burden [89]. These findings underscore the value of minimizing delays and equipping patients with effective coping strategies [90].

7.3. Psychological and behavioural interventions

Non-pharmacological techniques can help modulate pain and tension during breast interventions by engaging competing sensory pathways and redirecting attention [91].

Simple methods may offer short-term relief during needle insertion. Gentle vibration near the injection site, widely used in dermatology and paediatrics, activates mechanoreceptors that inhibit nociceptive transmission, offering a low-cost, well-tolerated adjunct [92]. Alternatively, the cough trick, in which the patient performs a brief, voluntary cough during insertion, can distract from momentary discomfort [93]. Although not formally described in radiology literature, this technique may be helpful during mammographic-guided procedures, such as wire placements or initial anaesthetic injection, where the compressed breast remains stable. In ultrasound-guided procedures, however, motion may impair targeting, and caution is advised.

Relaxation techniques and music interventions also reduce tension [94]. Listening to self-selected music has been associated with lower anxiety and improved satisfaction, though its shows limited impact on reported pain intensity [95,96]. One randomised trial found music decreased nervousness but did not significantly affect pain scores [97].

Mindfulness-based approaches, such as guided breathing or meditation, have been shown to lower stress and physiological markers (e.g. heart rate, blood pressure) during imaging-guided biopsies [98]. These methods primarily alleviate emotional distress rather than physical pain.

Virtual reality (VR) is a newer distraction method that immerses patients in a multisensory environment. In breast imaging, VR has been associated with better patient tolerance during FNA [99] and ultrasound guided biopsies [100]. Its value in low-pain settings remains unclear, and comparative studies with music or relaxation are lacking. Still, its potential for anxiety reduction and broad adaptability warrants further study in selected patients.

Table 3

Practical strategies to improve the patient experience in breast interventions.

Aspect	Key Strategies	Benefits
Empathy and communication	<ul style="list-style-type: none"> – Acknowledge concerns with empathy – Provide clear explanations of procedures and sensations – Share positive patient experiences 	<ul style="list-style-type: none"> – Reduces fear and anxiety – Builds trust and cooperation – Fosters a positive procedural experience
Pre-Procedural Preparation	<ul style="list-style-type: none"> – Minimise delays between recommendation and procedure – Use brochures or visual to inform patients – Set expectations about discomfort and safety 	<ul style="list-style-type: none"> – Lowers anticipatory stress – Improves understanding – Encourages engagement.
Psychological and Behavioural Interventions	<ul style="list-style-type: none"> – Offer distraction techniques (e.g., music, mindfulness) – Offer relaxation or breathing exercises 	<ul style="list-style-type: none"> – Reduces tension – Provides brief relief during intervention
Patient-Reported Outcomes (PROMs)	<ul style="list-style-type: none"> – Use PROMs to evaluate pain, anxiety, and satisfaction – Benchmark practices across settings – Adjust care based on patient input 	<ul style="list-style-type: none"> – Identifies improvement areas – Supports personalised care – Enables continuous quality development
Continuous Learning and Training	<ul style="list-style-type: none"> – Integrate patient feedback – Pursue ongoing training in technique and communication – Strengthen teamwork for patient-centred workflows 	<ul style="list-style-type: none"> – Aligns care with best practices – Sustains long-term improvement

VR: virtual reality; PROMS: patient-reported outcome measures.

7.4. Continuous improvement and patient-reported outcomes (PRO)

Radiologists should remain aware of their learning curve when administering LA. Ongoing self-assessment and patient feedback can refine technique and contribute to greater patient comfort and procedural quality.

Validated instruments such as patient-reported outcome measures (PROMs) capture patients' perspectives on symptoms, emotional responses, and procedural burden, generating actionable insights for service evaluation and improvement [101]. Although not yet standard in breast imaging, PROMs present an opportunity to align more closely with patient needs and should be further explored [102]. Their use in routine care could also support consistency in pain management across departments and institutions.

Efforts to strengthen patient-centred care must also recognise the challenge of physician burnout. Increasing workloads and time constraints may reduce clinicians' ability to engage empathetically. Burnout has been linked to diminished empathy and lower patient satisfaction [103]. Addressing structural factors, including time pressure and staffing, is essential to preserve compassionate, high-quality care.

Ongoing education and training can help radiologists integrate patient perspectives and adapt technique in line with evolving best practices. Practical steps for improving the patient experience, grounded in effective communication, psychological support, and feedback-driven refinement of care, are summarised in Table 3.

8. Conclusion

Effective pain management in image-guided breast procedures requires a thorough understanding of pain mechanisms, combined with attention to patient comfort and well-being. Optimising anaesthetic use, refining injection technique, and incorporating methods like buffering and distraction can help make procedures more tolerable.

Patient-centred care, grounded in clear communication and sensitivity to both physical and emotional needs, fosters trust and supports engagement. By integrating patient feedback, reflecting on technique, and maintaining ongoing training, radiologists can adapt to evolving expectations and uphold high standards in breast radiology practice.

CRediT authorship contribution statement

Rodrigo Alcantara: Writing – review & editing, Writing – original

draft, Visualization, Investigation, Conceptualization. **E.Natalia Arenas:** Writing – review & editing, Investigation, Conceptualization. **Javier Azcona:** Writing – review & editing, Conceptualization. **Mireia Pitarch:** Writing – review & editing. **Elisenda Vall:** Writing – review & editing. **Elisabet Vila-Trias:** Writing – review & editing. **Belen Ejarque:** Writing – review & editing, Resources. **José Maria Maiques:** Writing – review & editing, Resources. **Antonio Montes:** Writing – review & editing, Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

The authors acknowledge the use of BioRender.com for the creation of schematics included in this manuscript. Licenses for individual figures have been obtained.

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