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Review Article

Anaesthesia Section

Optimising Pain Control: A Narrative Review of Anaesthesia Modalities in Brachytherapy

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ABSTRACT

Brachytherapy (BT), offers focused radiation administration while preserving nearby healthy tissues and is a crucial therapeutic option for a number of cancers. On the other hand, patient tolerance, precise placement and total treatment results can all be greatly impacted by procedural pain and discomfort. Current anaesthetic techniques utilised in BT, including topical, local infiltration, regional blocks and General Anaesthesia (GA), are assessed in the present narrative review. Research indicates that the tumour site, procedure complexity, patient co-morbidities and institutional expertise all have an impact on the choice of anaesthetic. While neuraxial and GA enhance comfort in more extensive intracavitary and interstitial implants, especially in gynaecologic and prostate malignancies, Local Anaesthesia (LA), sometimes in conjunction with conscious sedation, is helpful for low-complexity operations. New developments like ultrasound-guided localised methods provide better analgesia with less systemic side-effects. Although there are many possibilities, there is no standard anaesthetic procedure and practice varies greatly. In order to maximise pain management, reduce peri-procedural anxiety; and enhance procedural success, future research will focus on customised multimodal analgesia. Future research is necessary to provide evidence-based anaesthetic recommendations for BT.

Keywords: Pain management,Radiotherapy treatment for cancer, Sedation, Techniques

INTRODUCTION

The BT is a kind of radiotherapy in which sealed radioactive sources are introduced adjacent to, or directly within, the tumour to provide high doses of radiation while sparing normal tissues. The term “brachy,” derived from the Greek word for “short distance,” reflects the basic premise of this approach. Alexandre Danlos and Paul Bloch created BT in 1901, using radioactive material given by Marie Sklodowska Curie and Pierre Curie to cure lupus. Margareth A. Cleaves published the first report on BT for cervical cancer in 1903. Since these early uses, BT has grown significantly and has become an essential component in the treatment of a variety of malignancies, including cervical, breast and prostate cancer. One of the key advantages of BT over external beam radiotherapy is its ability to deliver higher, localised radiation doses with minimal exposure to adjacent organs at risk, thereby improving tumour control while reducing treatment-related toxicity.

A number of well-known, modern scientists and medical professionals have tried to anticipate the clinical procedures and technological methods that would eventually become standard [1]. With the increased use of BT, especially High-Dose-Rate (HDR) procedures, new clinical and peri-procedural problems have evolved, notably in the anaesthetic field. Unlike traditional surgical treatments performed in operating rooms, BT operations are frequently performed in radiation suites and include older patients with various co-morbidities. These characteristics considerably enhance the risk of perioperative and anaesthetic complications, demanding careful pre-procedure assessment and individualised anaesthetic planning [2,3].

The length of BT treatments varies greatly. X-rays, Computed Tomography (CT) and increasingly Magnetic Resonance Imaging (MRI) techniques are used to image the applicator. While the applicator is in place, computer-based planning is crucial for the entire process. Each treatment portion is prolonged as a result of all these processes. Managing lengthy operations in individuals who are old or have several medical conditions can be challenging. The BT treatment sessions take place in several locations, such as operating rooms, X-ray rooms, radiology units for CT or MRI, and radiation rooms [4]. It is difficult to provide and oversee GA in various settings [5]. Another issue is the lack of qualified staff to monitor patients between the units and the postoperative recovery area [6].

Radiation and radioactivity transformed medicine within a few years of their discovery, leading to advancements in both medical imaging and therapy. The oldest type of radiation treatment is BT, which marked its 100th anniversary of usage over 20 years ago. BT’s transition from manually positioned radioactive sources to image-guided, remote after loading reflects more than a century of advancements in science and technology [7].

The primary goal of the present review was to evaluate the anaesthetic challenges associated with BT, specifically HDR intracavitary procedures, as well as to assess the effectiveness and safety of various analgesia and sedation techniques in improving patient comfort, procedural feasibility, and overall treatment outcomes. This understanding is critical for improving multidisciplinary cooperation between radiation oncologists and anaesthesiologists.

Radiobiological Principles and Dose-rate Effects in Brachytherapy (BT)

The BT provides various advantages over typical external beam treatments, particularly high conformality, high dose rate and short overall treatment times. Ionising radiation damages both single and double-strand Deoxyribonucleic Acid (DNA) resulting in cell death by apoptosis or mitotic catastrophe, with the G2/M phase of the cell cycle being the most sensitive. In classical radiobiology, tumour response to radiation is based on reoxygenation, repair, redistribution and repopulation, often known as “the Four Rs” [8]. The speed of these processes and the rate of dosage delivery {Low-dose Rate (LDR) vs. High-dose Rate (HDR)} dictate their range of occurrence and importance [1]. When the treatment duration is brief, repopulation usually becomes unimportant. Sublethal damage repair is more important at low dose rates because the rate of repair is closer to the rate of DNA damage accumulation, however at high dose rates, the damage rate far exceeds the cell’s ability to repair DNA. Reoxygenation and redistribution have a modest function in LDR BT and have been proposed to increase cell sensitivity to radiation [9].

The biological effects of BT can be anticipated using a modified Linear Quadratic model (LQ model), which associates cell survival with dose. Due to dose rate differences, sublethal damage repair is more critical in LDR than in HDR BT. LDR BT dose rates range from 0.4 to 2 Gy/hr and the administration is continuous, in contrast to HDR BT, which is administered over several minutes with fractions separated by hours to days [10]. In LDR techniques, the G function, with values that range from 0 to 1, is used to consider for damage repair and reduce cell susceptibility to radiation. G function is governed by DNA repair rate, irradiation duration and repair half-life. For HDR treatments, where repair is negligible, G is set to one [11]. Some LQ models may also include reoxygenation and redistribution, which can increase radiation sensitivity. Despite theoretical radiobiological differences between HDR and LDR, both treatment regimens have produced comparable clinical results in terms of tumour reduction as well as toxicity [10].

Types of Sedation [Table/Fig-1,2]

Sedation and systemic analgesics: Patient comfort, immobilisation and procedural tolerance are crucial in BT treatments, especially those that involve intracavitary or interstitial applicator implantation. Sedation (rather than complete GA) is commonly used in centres for less uncomfortable or short-duration procedures. For instance, inhalational sedation with nitrous oxide/oxygen has been used to alleviate pain during cervical HDR applicator implantation and removal [12]. The benefits include faster recovery, lesser resource utilisation and the avoidance of airway instrumentation. Sedation must meet the same safety criteria as anaesthesia, including proper monitoring, equipment, post-procedural recovery care and adequately educated staff [13].

Beyond inhalation sedation, systemic analgesics and sedo-analgesia (a mix of sedative and analgesic) are the foundations of pain treatment in BT. Opioids (e.g., fentanyl), benzodiazepines (e.g., midazolam) and, in severe situations, propofol infusion combined with sedoanalgesic procedures have all been used effectively [14]. These guidelines guarantee that patients stay comfortable and immobile during protracted insertion durations, imaging relocation and dose-delivery periods, which is especially important in HDR treatments where applicators may be left in place for an extended period. Pain management measures vary somewhat in LDR BT applications, when the source is left in place for extended periods of time [15]. According to studies, mild analgesics such as paracetamol and Non Steroidal Anti-Inflammatory Drugs (NSAIDs) can effectively alleviate discomfort while the applicator is still in place. While the analgesic load might be reduced, the difficulty is to ensure the comfort during prolonged immobilisation while still permitting safe mobilisation, repositioning and removal of the applicator [10,14].

Despite the widespread use of sedation and systemic analgesics in BT, they should not be used without sufficient institutional infrastructure and guidelines. For example, the American BT Association and other expert bodies highlight the need for qualified staff, monitoring equipment, airway intervention preparedness and post-sedation recovery facilities when performing conscious sedation or deeper sedoanalgesia [5]. Patients having repeated fractions (e.g., cervical cancer HDR) may have co-morbidities and several transportation between table, CT/MR imaging and radiation suite, increasing anaesthetic risk. Institutional guidelines should thus stratify patients based on their American Society of Anaesthesiologists (ASA) status, procedure complexity and projected duration, with higher-risk people undergoing regional or GA instead of sedation alone [14].

General Anaesthesia (GA): The GA is recommended when the procedure is likely to be uncomfortable, lengthy, or necessitates complete immobility and airway protection. Complex interstitial implants (head and neck, extremity), combined intracavitary-interstitial pelvic procedures, salvage or re-implantation cases and patients who cannot cooperate using regional techniques or sedation (severe anxiety, claustrophobia, obstructive sleep apnoea, or inability to lie flat) are common scenarios [5,6]. GA is also used when neuraxial blockade is contraindicated or insufficient to alleviate the predicted pain [1].

S. No.	Type of anaesthetic technique	Indications	Contraindications	Advantages	Disadvantages
1.	General Anaesthesia (GA)	• Complex interstitial implants (head and neck, extremity) • Combined intracavitary–interstitial pelvic procedures • Salvage or re-implantation cases • Uncooperative patients (severe anxiety, claustrophobia, OSA, inability to lie flat) • When neuraxial blockade is contraindicated or inadequate • Upper body tumours (bronchial, hepatic, breast)	• High anaesthetic risk patients • Limited resources or lack of trained personnel • Situations where rapid turnover is required	• Complete analgesia and immobility • Excellent patient comfort • Precise applicator/needle placement • Reproducible implant geometry • Facilitates high-quality CT/MRI imaging	• Longer recovery time • Increased resource utilisation • Airway-related risks • Requires specialised equipment and skilled staff • Careful monitoring needed during inter-department transfers
2.	Local Anaesthesia (LA)	Simple procedures • Superficial interstitial implants • Dermatologic BT • Minor gynaecological HDR insertions • Applicator insertion or removal • Resource-limited settings	• Deep pelvic or complex interstitial implants • Highly anxious or non-cooperative patients • Prolonged procedures • Extensive cervical dilatation or needle placement	• Easy to administer • Minimal monitoring required • Rapid recovery and turnover • Low cost • Safe when used appropriately	• Inadequate analgesia for deep manipulation • Increased patient discomfort and anxiety • Risk of movement affecting implant accuracy • Lower patient satisfaction • Risk of local anaesthetic toxicity if overdosed
3.	Regional Anaesthesia (RA)	• Gynaecological, urological, rectal and prostate BT • Lower body procedures • PDR/LDR BT requiring prolonged analgesia • Patients unsuitable for GA	• Coagulopathy • Infection at injection site • Severe spinal deformity • Lack of experienced staff or 24-hour monitoring	• Excellent analgesia and partial immobilisation • Reduced systemic opioid use • Lower risk than GA • Allows patient transfer between units • Extended analgesia with catheter techniques	• Incomplete immobilisation (risk of applicator displacement) • Technical difficulty in elderly patients • Slower onset (epidural) • Requires trained staff and monitoring • Limited utility when absolute immobility is required

[Table/Fig-1]: Comparison of anaesthetic techniques in BT.

Parameters	General Anaesthesia (GA)	Local Anaesthesia (LA)	Regional Anaesthesia (Spinal/Epidural)
Level of analgesia	Complete analgesia	Limited, superficial analgesia	Excellent segmental analgesia
Patient immobility	Complete immobility	Incomplete; patient movement possible	Good but not absolute
Airway control	Secured (LMA/ET tube)	Not required	Not required
Indications	Complex interstitial implants, head and neck, upper body tumours, long procedures, anxious/uncooperative patients	Simple, superficial procedures, applicator placement/removal	Pelvic, gynaecological, urological, lower rectal BT
Procedure duration suitability	Ideal for long and complex procedures	Suitable only for short procedures	Suitable for short to moderately long procedures
Pain control reliability	Highly reliable	Often inadequate for deep manipulation	Reliable for pelvic procedures
Patient comfort	Excellent	Variable and often poor	Good to excellent
Recovery time	Longer	Very short	Moderate
Resource requirement	High (anaesthesia team, equipment, monitoring)	Low	Moderate
Monitoring needs	Full ASA monitoring, capnography	Minimal	Standard monitoring
Risk profile	Higher (airway, haemodynamics)	Low but risk of inadequate analgesia	Lower than GA but risk of hypotension
Effect on implant accuracy	Optimal precision and reproducibility	Risk of movement affecting geometry	Good but risk during transfers
Suitability for imaging (CT/MRI)	Excellent	Limited due to motion	Good
Use in LDR/PDR BT	Less preferred alone	Not suitable	Highly suitable with catheter techniques
Limitations	Increased cost, recovery time, logistics	Insufficient analgesia, poor tolerance	Requires expertise, prolonged monitoring
Preferred settings	High-volume, complex cases	Resource-limited centers	Specialised centers with anaesthesia support

[Table/Fig-2]: Comparative table enumerating the differences between General Anaesthesia (GA), Local Anaesthesia (LA) and Regional Anaesthesia (RA).

The BT typically involves i.v., induction with propofol or opioid, airway securing with a laryngeal mask or endotracheal tube and maintenance with volatile agents (sevoflurane/isoflurane) or Total Intravenous Anaesthesia (TIVA) (propofol infusion) for a smooth emergence [12]. Neuromuscular inhibition is employed selectively (to facilitate instrumentation or when total immobility is required). For pelvic implants, combination methods (GA + epidural/spinal) are frequently employed to offer good intraoperative and postoperative analgesia while reducing systemic opioid intake [16]. Monitoring should include typical ASA monitors, as well as capnography and temperature monitoring for lengthier operations; vascular access and preparedness for haemodynamic assistance are critical [17].

The GA consistently offers analgesia, muscular relaxation and full immobility, allowing for precise applicator/needle insertion and high-quality imaging (CT/MRI) during planning [5]. Comparative studies and institutional series show that GA provides excellent patient comfort and reproducible implant geometry, particularly for complex or lengthy procedures; neuraxial blocks or conscious sedation may provide equivalent analgesia in some pelvic cases but are less predictable for long interstitial implants [18]. GA may extend recovery time and resource utilisation compared to sedation or spinal anaesthesia; thus its use is best kept for circumstances where its advantages significantly enhance implant quality or safety [19].

The GA is typically used in BT for upper body tumours (e.g., bronchial, hepatic and breast carcinoma) or when Regional Anaesthesia (RA) is not appropriate. BT for oropharyngeal tumours involves fibreoptic bronchoscopy and GA intubation. GA requires all necessary equipment in the field of application. Although GA is used and the application area remains the same, the follow-up of patients who have had GA during X-ray, CT, MRI and irradiation room transfers need careful attention and competent health staff [6].

Local Anaesthesia (LA): The LA is commonly utilised in BT, especially in settings with inadequate anaesthesiology assistance or when the procedure is simple. Because of its ease of administration and lack of the need for specialised monitoring, radiation oncologists are more likely to administer it than anaesthesiologists [6]. Topical medications, local infiltration and, less typically, peripheral nerve blocks are all examples of LA procedures. Local anaesthetics, most frequently lidocaine and bupivacaine, act by obstructing voltage-gated sodium channels in peripheral nerves, which inhibits impulse transmission and causes localised sensory blockage [20]. They are useful for applicator installation and removal, modest gynaecological insertions, superficial interstitial implants and dermatologic BT. Topical anaesthetics can be used for cervical anaesthesia in HDR BT, with or without additional paracervical block [18].

Tornblom-Paulander S et al., found that topical lidocaine considerably decreased pain in gynaecologic BT compared to placebo; nonetheless, clinically significant discomfort persisted despite anaesthetic usage [21]. This demonstrates that, while LA enhances procedural comfort, it is frequently insufficient as a solo analgesic modality for procedures requiring deeper tissue manipulation or applicator placement. Pain is caused not just by mucosal contact, but also by cervical dilatation, intracavitary pressure and possible traction, which frequently outperform the analgesic properties of topical medicines alone.

Local infiltration and topical anaesthesia are often chosen in clinical settings because to their simplicity, faster recovery time and budget restrictions. However, comparative studies show that LA, whether topical or infiltrative, gives less pain control than neuraxial anaesthesia (spinal/epidural), conscious sedation, or GA [5,12,13]. This can result in poor patient tolerance, anxiety and uncontrollable motion during the surgery, putting implant accuracy at risk and perhaps affecting treatment quality [22].

Although LA provides logistical convenience and quick turnover, its drawbacks include insufficient analgesia during applicator placement, cervical dilation, needle insertion, or prolonged dwell times; increased patient discomfort, which may reduce satisfaction and willingness to undergo subsequent fractions; and the risk of procedural interruption due to pain-induced movement, which can impair geometric precision and potentially influence dosimetry [18,22]. Furthermore, LA is confined to superficial structures and inadequate for deep pelvic or interstitial implants and its efficacy varies depending on operator expertise, anatomical difficulties, tumour size and patient anxiety threshold. Because insufficient analgesia might jeopardise procedural quality, professionals increasingly advocate neuraxial or GA for complicated implants to achieve appropriate placement and stability [13,17].

When taken appropriately, LA is safe and has a low frequency of problems; nonetheless, allergic responses (rare), local tissue irritation and systemic toxicity which manifests as Central Nervous System (CNS)/cardiac effects may occur if overdosed. Because radiotherapists may deliver anaesthetics, they must have proper training in safe dose calculation, toxicity identification and emergency treatment. The overall risk is modest, but measures must be in place to allow for prompt intervention if unfavourable responses develop [6]. Despite its drawbacks, LA is nevertheless widely used, particularly in resource-constrained centres because of a lack of anaesthesiology staff and an institutional desire for streamlined workflow. Nonetheless, many high-volume centres have switched to neuraxial/GA for interstitial and complex intracavitary BT to improve treatment accuracy, patient comfort and procedural time, while hybrid approaches combining LA with systemic analgesia are also used to improve comfort [12,17].

Regional Anaesthesia (RA): The RA provides benefits for BT of lower body areas. It offers effective analgesia and immobilisation, enables patient transfer between units and is less risky than GA. Spinal anaesthesia can be used in BT for patients with gynaecological, urological and lower rectal cancer. The major benefits are a quick start and a well-known anaesthesia time. Saddle block, a type of spinal anaesthetic, may be adequate in patients treated for prostate or anal cancer. This block involves administering low-volume LA to the spinal space and restraining it in the perianal area by sitting for a set amount of time. However, since immobilisation is not fully achieved, applicators are at risk of dislocation during patient transfer [23].

Although a lumbar epidural block can be utilised instead of spinal anaesthesia, it takes longer to get results. It can be utilised with a catheter method or as a caudal epidural block. Patients tolerate caudal blocks well in gynaecological BT. Application in older individuals is technically challenging [24].

A catheter or combination spinal-epidural approaches can extend anaesthesia for Pulse Dose Rate (PDR)/LDR BT and offer acceptable pain relief [5,25]. Additionally, spinal catheters allow for precise dosage titration in high-risk patients, reducing haemodynamic adverse effects. Continuous epidural infusion or patient-controlled analgesia is effective for both LDR and reduces overall local anaesthetic dosage. Epidural anaesthesia can be used safely in children [26]. Inexperienced staff and insufficient 24-hour monitoring may restrict the use of epidural analgesia for LDR/PDR. The inability to manage catheter insertion when complete immobilisation is required may further limit the utilisation of this approach. Researchers have compared patients with cervical cancer who received regional or GA for BT. The hypothesis is that RA affects the sympathetic nervous system, reducing lymphatic flow and potentially improving tumour recurrence. However, the effect of anaesthesia on tumour development was not demonstrated [27].

The BT is an invasive technique. The provider's expertise determines the outcomes. Radiating vital organs near tumour locations, like with other radiation modalities, should be done with prudence. If a source is dislodged from the patient, the team must tell the nearby personnel and store it in a lead container. Patients should be advised that smoking might increase the likelihood of radiation adverse effects. Smoking can also reduce the effectiveness of BT and other cancer therapies. Following BT treatment, there is an increased risk of bone fractures, notably those in the pelvis. Patients, particularly women, should be frequently evaluated for bone density screening [28].

Procedural Complications

Several problems associated with intracavitary BT for cervical cancer have been reported, including localised haematoma, haemorrhage and uterine or cavitary perforation. These occurrences are most commonly linked to applicator placement and are impacted by uterine position, cervical stenosis, as well as operator experience [29].

In a research conducted by Bahadur YA et al., uterine perforation occurred in 14.6% of patients and 8.6% of applications during HDR BT, with some cases detected immediately after the treatment [30]. Although many perforations were clinically silent, the authors emphasised that even tiny or sub-serosal perforations might change applicator shape, leading in inferior dosimetry and potentially under- or over-exposure of tissue. Furthermore, uterine perforations can sometimes result in bleeding, a localised haematoma, or infection, especially if they go undetected during the anaesthesia procedures [31].

Similarly, Zhang S et al., found that in a cohort of 407 insertions, uterine perforation occurred in 1.2% of operations, with mild vaginal bleeding or haemorrhage being among the most common acute adverse effects after applicator removal [31]. Anaesthesia is required during BT to optimise pain management and keep the patient immobile, which allows for correct applicator placement. However, it can also obscure intraoperative indications of perforation or bleeding, emphasising the significance of precise image-guided insertion and postoperative monitoring. Incorporating real-time ultrasound or CT guiding and performing quick imaging verification after insertion has been proven to lower the occurrence of such problems while improving the overall safety and dosimetric accuracy of BT treatments [12].

These issues provide unique obstacles in terms of anaesthesia. Anaesthesia is essential for pain management, patient immobility and proper applicator placement, but it might obscure intraoperative symptoms of damage such as discomfort or peritoneal irritation [32]. As a result, anaesthesiologists share responsibility for intra-procedural vigilance, which includes continuous haemodynamic monitoring for occult bleeding and consulting with the radiation oncology team for image-guided verification shortly after insertion [33]. In situations of suspected perforation or haemorrhage, prompt resuscitation, volume replacement and communication for procedure stoppage or imaging are critical. Optimising pain management while preserving physiological stability, using localised (spinal/epidural) or GA adjusted to patient co-morbidities and predicting potential bleeding or perforation are all important aspects of good anaesthetic administration in BT [12,32].

Approaches to Decision-making

Anaesthesiologists provide more than just "pain relief" during applicator insertion; they also provide peri-procedural risk assessment as well as an integrated package of care that maintains geometric precision, patient safety and throughput. Their responsibilities include pre-procedural assessment (co-morbidities, airway and anticoagulation), selection of the optimal anaesthetic technique (local block ± sedation, neuraxial/regional, or GA), intra-procedural monitoring and physiologic control (airway, ventilation, haemodynamics), titration of analgesia and muscle relaxation for reproducible applicator geometry, along with post-anaesthetic recovery and complication management [12]. These components have a direct impact on procedure quality (positioning, immobilisation, dosimetry) and patient experience [5].

Many centres, particularly those with limited anaesthesia capabilities, rely on radiotherapists to provide LA (occasionally with minimal sedation). While LA is acceptable for brief, superficial operations, it typically delivers insufficient analgesia and muscle relaxation for complicated intracavitary + interstitial implants, protracted dwell periods, or cervical dilation/needle insertion [13]. Inadequate analgesia increases patient movement as well as the likelihood of procedure interruption, degrades applicator geometry and dosimetry and decreases patient desire to continue multi-fraction treatments [17]. Several studies have suggested that using neuraxial or GA (or skilled regional procedures) for more difficult gynaecologic and interstitial BT results in better pain management, less narcotic needs and better operative outcomes [13,16,34].

Neuraxial or GA for BT is frequently administered in remote {non Operating Room (OR)} locations, necessitating special safety precautions such as capnography/advanced monitoring, airway rescue equipment, anaesthetic drug and emergency crash protocols, as well as a staffed post-anaesthesia recovery area for monitoring, pain control and the management of postoperative complications (e.g., neuraxial block effects, respiratory depression) [12]. Reviews and institutional series emphasise that safe anaesthesia care necessitates not only a skilled anaesthesiologist, but also suitable equipment, checklists and post-anaesthetic nursing care to detect and treat the issues promptly [3,5,12].

Where radiotherapists must provide LA or moderate sedation (often in low-resource settings), formal competency training is required not only in drug dosing and local anaesthetic toxicities, but also in patient selection, monitoring, basic airway rescue and escalation pathways to anaesthesia services. Papers from several centres emphasise that with sufficient training and protections, certain less difficult operations may be performed successfully without an anaesthesiologist, but clear boundaries and quick accessibility to anaesthesia support are required [3,10].

Clinical Relevance and Recent Updates

Pain is a multifaceted experience impacted by tissue injuries, psychological stress, prior cancer therapies and personal pain tolerances. Mucosal touch, intracavitary pressure, cervical dilatation, needle insertion and traction pressures can cause pain during BT procedures [13]. Uncontrolled pain may cause patient movement during applicator insertion or radiation administration, leading in implant displacement, inadequate dosimetry and an increased risk of local recurrence or toxicity. Furthermore, repeating portions on consecutive days might exacerbate pain and anxiety, lowering compliance and potentially disrupting treatment plans. As a result, providing appropriate analgesia and anaesthesia not only improves patient comfort but is also directly related to treatment quality, repeatability and clinical results [35].

The GA provides full analgesia, muscular relaxation and immobility, making it appropriate for difficult interstitial operations, combination intracavitary-interstitial implants, salvage situations and patients with limited capacity to comply. GA enables precision applicator positioning and high-quality imaging (CT/MRI), which are critical for proper treatment planning and administration. Emerging trends suggest the use of TIVA and multimodal antiemetic treatments to minimise postoperative nausea and enhance recovery outcomes [36]. Recent research indicates that ultrasound-guided airway management and sophisticated monitoring (depth of anaesthesia, neuromuscular blockade monitoring) have further decreased GA-related problems and increased procedural safety in high-risk oncology groups. However, GA is resource-intensive and might prolong recovery times, which is especially important in ambulatory BT settings. Hence, careful patient selection and preoperative preparation are important to balance efficacy and safety [37].

The LA including topical agents, infiltration and peripheral nerve blocks, is frequently used for superficial implants, minor gynaecologic applications, dermatologic BT and applicator insertions/removals. Agents such as lidocaine and bupivacaine are effective in blocking peripheral nerve conduction, reducing pain from surface and mucosal stimulation. LA is advantageous in resource-constrained settings due to ease of use, minimal monitoring requirements and rapid recovery [38].

Recent studies continue to highlight the role of topical and paracervical blocks in early-stage cervical HDR BT, showing improved comfort compared with placebo. However, data also confirm that LA alone is often insufficient for deep pelvic implants or procedures requiring extensive tissue manipulation, as it does not address visceral pain or intracavitary traction. Consequently, newer approaches combine LA with mild sedation or analgesic adjuncts to improve procedural tolerance while avoiding deeper anaesthesia [38,39].

The RA, which includes spinal, epidural, caudal blocks and combination spinal-epidural procedures, is still useful for pelvic and lower body BT implantations. These approaches provide segmental analgesia, minimise the need for systemic opioids and make it easier for patients to move between units-an important concern when transitioning from imaging to treatment rooms. Catheter approaches (epidural or spinal catheters) provide extended pain relief during PDR or LDR surgeries [40]. Recent clinical practice has also adopted ultrasound-guided regional blocks for improved accuracy and lower complication rates, with data indicating improved analgesia and less sedation requirements. However, drawbacks include insufficient immobilisation (risk of applicator displacement), technical difficulties in geriatric patients and the requirement for experienced people and monitoring [41].

The current tendency in BT pain treatment is to use multimodal analgesia, which includes systemic analgesics (e.g., NSAIDs, acetaminophen), localised methods and mild sedation. Multimodal methods have been proven to increase comfort, minimise opioid intake and promote speedier recovery while maintaining treatment repeatability [42]. Conscious sedation with drugs like midazolam, dexmedetomidine, or ketamine infusions has been used effectively, particularly in patients whose GA poses a higher risk or if full compliance is possible with minimum sedation. Furthermore, cognitive preparation and preprocedural anxiolysis are receiving more attention, with interventions such as guided imagery, patient education and psychological support demonstrating reductions in procedure-related distress, especially in patients with cognitive limitations [43].

Recent developments include patient-specific pain assessment tools, revised analgesic regimens adapted to implant type and site and Enhanced Recovery after BT (ERAB) pathways that prioritise early mobilisation, multimodal analgesia and patient-centered care. Studies on opioid-sparing regimens and the use of long-acting local anaesthetics (e.g., liposomal bupivacaine) show promise in terms of lowering postoperative pain and increasing patient satisfaction [44]. Real-time dosimetry feedback and robot-assisted applicator placement are two technological developments that help minimise operation length and the severity of invasive manoeuvres, hence indirectly decreasing analgesic needs [45].

CONCLUSION(S)

To provide appropriate anaesthetic treatment for BT patients, meticulous planning and preparation of equipment, availability of vital signs monitors, preoperative evaluation and optimisation and personalised anaesthesia planning are essential; ensuring appropriate analgesia during and after surgery. Post-procedure monitoring is necessary for effective outcomes.

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