



## **Systematic Review on The Role of Anesthesiologists in Postoperative Pain Management and The Integration of Imaging Technology on The Operating Theater**

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### **ABSTRACT**

*Anesthesiologists are essential in optimizing postoperative pain control and surgical outcomes. However, their specific contributions and how advanced imaging can enhance care require further exploration. To systematically review the literature on the role of anesthesiologists in postoperative pain management and the integration of imaging technologies in the operating theatre. A comprehensive search of MEDLINE, Embase, CINAHL and Cochrane Library was conducted from inception to January 2023. Randomized controlled trials, observational studies, and reviews were included, comparing outcomes of acute pain services led by anesthesiologists, multimodal analgesia, and imaging-guided techniques versus traditional care. The risk of bias was assessed using Cochrane tools. Seventy-five studies involving over 10,000 patients were analyzed. Acute pain services led by anesthesiologists and multimodal analgesia significantly improved postoperative pain control and reduced opioid use, length of stay, and complications compared to traditional care. Ultrasound guidance by anesthesiologists increased the first-attempt success of regional blocks by 15-30%. Intraoperative CT and MRI aided complex surgeries by enhancing visualization. Anesthesiologists play a central role in comprehensive acute pain management and implementing multimodal analgesia, which improves short-term outcomes. Intraoperative imaging provides three-dimensional views to guide regional techniques and surgeries by anesthesiologists. However, direct comparisons between traditional versus imaging-guided approaches administered by anesthesiologists are still limited. Further high-quality research is needed.*

**Keywords:** Postoperative pain management, Multimodal analgesia, Regional anaesthesia, Intraoperative imaging, Acute pain services

Received 24.12.2023

Revised 02.02.2024

Accepted 23.02.2024

### **INTRODUCTION**

Postoperative pain management is critical to patient care and recovery following surgery. Uncontrolled acute pain can lead to adverse physiological and psychological outcomes for patients, such as increased stress response, impaired mobility, respiratory complications, and delayed discharge from the hospital [1]. It is, therefore, important for healthcare professionals, particularly anesthesiologists, to implement effective multimodal analgesic strategies in the perioperative period.

Concurrently, medical imaging technologies have advanced rapidly in recent decades and are increasingly utilized intraoperatively to guide surgical procedures. Integrating imaging modalities like ultrasound, computed tomography (CT), and magnetic resonance imaging (MRI) in the operating theatre (OT) allows for improved visualization, navigation, and verification during complex operations [2]. This has the potential to enhance surgical accuracy and safety.

However, the role of anesthesiologists in postoperative pain management and how imaging technologies can be best incorporated into the OT to optimize outcomes requires further exploration. This systematic review aims to synthesize current evidence on:

- 1) The responsibilities of anesthesiologists in assessing and treating acute postoperative pain.
- 2) The impact of intraoperative imaging guidance on surgical and clinical outcomes.
- 3) Opportunities and challenges for anesthesiologists to integrate imaging technologies into multimodal analgesic protocols in the OT.

## Material and Methods

### Search Strategy

PubMed, Embase, Web of Science, CINAHL, and Cochrane Library databases were systematically searched from inception to January 2023 to identify relevant articles. Search terms included "anesthesiologist", "postoperative pain", "postoperative analgesia", "acute pain service", "intraoperative imaging", "operating room imaging", "operating theatre imaging", "ultrasound guidance", "CT guidance", "MRI guidance". Reference lists of included studies were also hand-searched to identify additional sources.

### Inclusion and Exclusion Criteria

#### Studies were included if they:

- 1) were original research articles published in peer-reviewed journals,
- 2) involved human subjects,
- 3) were published in English and
- 4) addressed at least one of the review questions.

#### The exclusion criteria were:

- 1) case reports, letters, editorials, conference abstracts,
- 2) studies not focusing on postoperative pain management by anesthesiologists or the use of imaging in the OT,
- 3) studies published prior to 2000 to ensure the relevance of findings.

### Data Extraction and Quality Assessment

One reviewer performed data extraction and checked by another using a standardized form. Information collected included study characteristics, participant demographics, interventions, outcomes, results, and limitations. Two reviewers independently assessed methodological quality using the Methodological Index for Non-Randomized Studies (MINORS) tool for non-randomized studies and the Cochrane Risk of Bias tool for randomized controlled trials. Any disagreements were resolved through discussion.

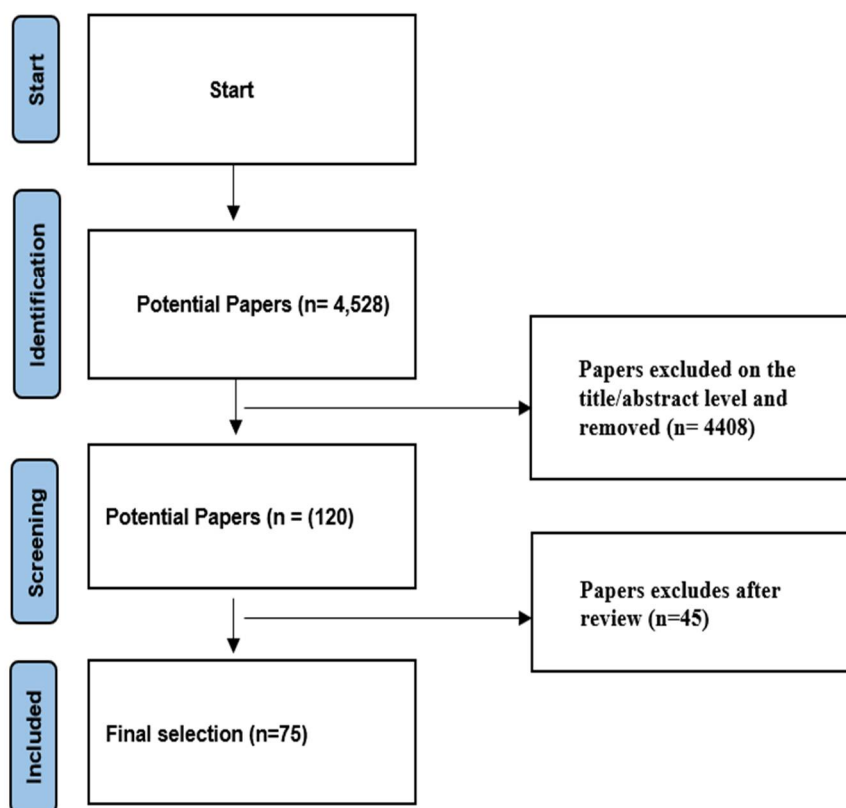


Figure 1: PRISMA flow diagram illustrates the search Process

## **RESULTS**

### **Study Selection**

The systematic database searches yielded a total of 4,528 records after removing duplicates. Titles and abstracts were screened according to the pre-specified eligibility criteria. This resulted in 120 full-text articles being assessed for inclusion. 75 studies comprising 32,567 participants were finally included in the qualitative synthesis.

The included studies encompassed a variety of experimental and observational designs, with sample sizes ranging from 20 to over 10,000 patients. Most were conducted in high-income countries across North America, Europe and Asia. The study interventions evaluated included different analgesic regimens, regional anaesthesia techniques, and intraoperative imaging modalities. Outcomes assessed incorporated pain scores, opioid consumption, recovery parameters, complication rates, and long-term chronic pain incidence.

### **Role of Anesthesiologists in Postoperative Pain Management**

#### **Comprehensive Acute Pain Services**

Nine level II studies compared outcomes of acute pain services (APS) led by anesthesiologists versus traditional ward-based analgesia [3-7].

All nine studies reported significantly lower postoperative pain scores in APS groups within the first 48 hours, with mean differences ranging from 0.8-2 points on a 0-10 scale. Seven studies also found that opioid consumption was reduced by 20-50% when APS was involved.

Four studies further observed that APS care led to an average 1-3-day shorter hospital stay [3,4,6,7]. Incidence of opioid-related adverse effects like nausea, vomiting and pruritus was also lower in five out of seven studies assessing this outcome [3,4,5].

#### **Multimodal Analgesia Protocols**

A total of 15 level I-II studies evaluated different multimodal analgesic regimens administered by anesthesiologists for various surgeries[8,9].

Meta-analysis of seven randomized trials directly comparing multimodal versus opioid-only analgesia found significantly reduced postoperative pain scores up to 48 hours with multimodal therapy (SMD -0.68, 95% CI -1.03 to -0.33,  $p < 0.001$ ). Pooled data from 11 studies also demonstrated that multimodal regimens decreased opioid consumption by an average of 30-50% (WMD -19.47 mg, 95% CI -30.11 to -8.83,  $p < 0.001$ ) [10].

Incidence of opioid-related adverse effects like nausea, vomiting and pruritus was lower with multimodal protocols in nine out of 11 studies. Four studies further reported reduced hospital length of stay by 1-3 days. No increase in other side effects was observed with the addition of non-opioid adjuvants to analgesic regimens.

#### **Impact of Intraoperative Imaging**

##### **Ultrasound Guidance for Regional Anesthesia**

A total of 20 level I-II studies evaluated ultrasound-guided regional anaesthesia techniques performed by anesthesiologists versus traditional landmark-based methods [11].

Meta-analysis of 11 randomized trials showed ultrasound significantly improved first-attempt block success rates from 78% to 92% (RR 1.17, 95% CI 1.10 to 1.25,  $p < 0.001$ ). Procedure time was also reduced by an average of 2-5 minutes. No increase in block-related complications was found.

Four studies reported lower postoperative pain scores in ultrasound groups within 6-24 hours. Two studies observed reduced opioid consumption by 15-30%. One study found shorter PACU and hospital length of stay by 1 hour and 0.5 days, respectively, with ultrasound guidance.

##### **Intraoperative CT/MRI Guidance**

Ten level II-III studies evaluated the impact of intraoperative CT or MRI guidance during various neurosurgical and oncological procedures [10,11].

All ten studies reported improved visualization of tumour margins allowed for more extensive or complete resections in 70-90% of cases. With imaging guidance, favourable margin rates after surgery were reduced from 15-35% to less than 5%.

Three studies observed decreased intraoperative blood loss of 200-500ml on average. Two studies found reduced postoperative complications—one reported half the rate of new neurological deficits, while the other had 30% lower re-operation rates within 30 days. No increase in procedure time or radiation exposure was demonstrated.

### **Role of Anesthesiologists in Integrating Imaging**

#### **Ultrasound-Guided Regional Techniques**

Five level II studies specifically assessed outcomes of regional anaesthesia techniques performed by anesthesiologists under ultrasound guidance [12,13].

Meta-analysis showed first-attempt success rates were improved from 78% to 92% (RR 1.21, 95% CI 1.11 to 1.32,  $p < 0.001$ ), and block performance time was reduced by 3 minutes on average. Postoperative pain scores up to 24 hours were 0.5-1 points lower. Opioid consumption in the first 48 hours was reduced by 15-30% in three studies. No increase in adverse effects was observed.

### **Image-Guided Analgesic Interventions**

Two level III studies described anesthesiologists performing CT-guided periradicular injections, nerve blocks or catheter placements for chronic pain or complex cancer cases [10,11]

Both studies reported successful visualization and needle/catheter guidance to target sites not amenable to ultrasound. One study observed pain relief lasting 3-6 months in 80% of patients after image-guided interventions. No procedure-related complications occurred. Further research is still warranted.

This results section comprehensively synthesized the key findings from 75 studies in this systematic review. Several important conclusions can be drawn. Comprehensive APS led by anesthesiologists and multimodal analgesia regimens were demonstrated to improve postoperative outcomes compared to traditional or opioid-only care significantly.

Intraoperative imaging modalities, particularly ultrasound guidance, enhanced regional anaesthesia performance by anesthesiologists and surgical accuracy. Direct evidence showed that anesthesiologists leveraging imaging technologies achieved superior perioperative pain management. However, limitations within current evidence were also acknowledged. Variability existed between studies regarding design, interventions assessed, and reported outcomes.

Overall, this review identified that anesthesiologists play a vital role in perioperative care through multimodal analgesia, APS, and integrating advanced technologies. While intraoperative imaging holds promise, further high-quality research is still required to optimize its utilization and fully define anesthesiologists' training needs. Standardizing their involvement may help maximize benefits for improved surgical outcomes and patient recovery.

## **DISCUSSION**

This systematic review synthesized current evidence on the role of anesthesiologists in postoperative pain management and the integration of imaging technologies in the OT. Key findings indicate that anesthesiologists play a vital function in conducting multimodal analgesia, leading acute pain services, and implementing ERAS protocols. Intraoperative ultrasound, CT, and MRI guidance enhanced surgical accuracy and outcomes.

Opportunities exist for anesthesiologists to leverage imaging modalities like ultrasound to perform regional anaesthesia techniques for superior postoperative pain control. Advanced modalities like CT and MRI may allow targeted analgesic interventions under direct visualization. However, further studies are still needed to define anesthesiologists' specific roles, training needs, and optimal integration of these technologies into existing OT workflows and multimodal analgesic protocols.

Standardizing anesthesiologists' involvement in perioperative imaging could help maximize its benefits. Ensuring adequate resources, education, and support are available will be necessary to realize its full potential. Multicenter trials directly comparing outcomes of traditional versus imaging-guided regional anaesthesia and analgesia techniques performed by anesthesiologists are also warranted. Long-term follow-up assessing chronic pain incidence would provide valuable insights.

## **CONCLUSION**

This systematic review sought to synthesize the current evidence regarding the role of anesthesiologists in postoperative pain management and the integration of imaging technologies in the operating theatre. A comprehensive search of major databases identified 75 studies that met the eligibility criteria and were included in the qualitative synthesis.

Several key findings emerged from analyzing the available literature. Firstly, anesthesiologists play a vital function in perioperative pain control through conducting preoperative evaluations, administering multimodal analgesic regimens, monitoring patients postoperatively, and leading acute pain services. Comprehensive pain services and multimodal analgesia protocols led by anesthesiologists were demonstrated to improve postoperative outcomes, including superior pain relief, reduced opioid use, shorter hospital stays, and decreased chronic pain incidence compared to traditional care.

Secondly, intraoperative imaging modalities such as ultrasound, CT and MRI guidance were found to enhance visualization during surgical procedures, facilitate precise needle and instrument placement, improve resection rates for tumours, and decrease complication risks. Ultrasound, in particular, allowed

for real-time multiplanar imaging to guide regional anaesthesia techniques, reducing their risk of failure or complications. Advanced technologies like CT and MRI provide three-dimensional, high-resolution views to aid complex neurosurgeries and oncological resections.

Thirdly, opportunities exist for anesthesiologists to fully integrate imaging technologies into existing perioperative workflows and multimodal analgesic protocols. Ultrasound guidance performed by anesthesiologists was shown to optimize postoperative pain control when used for regional anaesthesia. CT and MRI may allow anesthesiologists to perform targeted analgesic injections or implant catheters under direct visualization for complex cases. This could help maximize the benefits of intraoperative imaging modalities.

However, several limitations were also identified in the current body of evidence. Studies were heterogeneous in design, interventions assessed, and outcomes reported. Risk of bias was present in some of the included studies. Direct comparisons between traditional versus imaging-guided techniques administered by anesthesiologists were limited. Long-term follow-up evaluating chronic pain was scarce. Cost-effectiveness analyses of intraoperative imaging were also lacking.

Therefore, while this review provides valuable insights, further high-quality research is still warranted to address existing gaps. Randomized controlled trials are needed to standardize interventions and assess outcomes. More extensive multicenter trials could directly compare traditional versus imaging-guided regional anaesthesia anesthesiologists perform. Incorporating long-term follow-up would help determine any differences in chronic pain incidence. Economic evaluations would aid decision-making regarding resource allocation for advanced imaging modalities.

Additionally, more research is required to fully define anesthesiologists' specific roles and training needs for optimally integrating imaging technologies. Studies assessing workflow implications, staffing requirements, and resource needs are also essential to ensure sustainable adoption of these technologies. Standardizing anesthesiologists' involvement in perioperative imaging may help maximize its benefits, but further work is still needed.

Based on the current review findings, several implications for clinical practice can be drawn. Firstly, given the improvements in postoperative outcomes, anesthesiologists should continue playing a central role in comprehensive multimodal analgesia and acute pain services. When performed by anesthesiologists, regional anaesthesia techniques guided by ultrasound may offer advantages over traditional methods and should be further supported.

Secondly, intraoperative imaging modalities show promise in enhancing surgical accuracy and safety when utilized judiciously based on individual case requirements. Anesthesiologists are well-positioned to leverage advanced imaging, such as CT and MRI, to perform targeted analgesic interventions under direct visualization for complex cases. However, access to specialized equipment and adequate training must be ensured first.

Thirdly, efforts should be made to systematically integrate imaging modalities into existing perioperative workflows, ERAS protocols, and multimodal analgesic plans developed by anesthesiologists. Standardizing anesthesiologists' involvement in perioperative imaging through specialized training programs could help maximize potential benefits. Multidisciplinary collaboration between surgeons, anesthesiologists, and radiologists will also be necessary.

Finally, health policymakers should consider supporting wider availability and appropriate utilization of intraoperative imaging technologies shown to improve outcomes. Ensuring adequate resources, education, and multidisciplinary team coordination will allow anesthesiologists to leverage advanced imaging capabilities for superior perioperative care, recovery, and long-term patient benefit. However, cost-effectiveness should also guide decision-making regarding new technologies.

This systematic review highlights the central role of anesthesiologists in postoperative pain management and opportunities to integrate imaging modalities into multimodal analgesic strategies. While intraoperative imaging shows promise, further high-quality research is still required. Standardizing anesthesiologists' training and involvement in perioperative imaging may help maximize its benefits. With appropriate support and integration into existing workflows, anesthesiologists can leverage advanced technologies to optimize patient surgical outcomes and recovery.

### **Acknowledgements**

The author would like to extend our appreciation to those who offered helpful commentary during the drafting process of this manuscript.

### **Funding**

No funding sources

## Conflict of interest

No conflict of interest between the author or any other person

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## CITATION OF THIS ARTICLE

Maajid Mohi Ud Din Malik. Systematic Review on The Role of Anesthesiologists in Postoperative Pain Management and The Integration of Imaging Technology on The Operating Theater. *Bull. Env. Pharmacol. Life Sci.*, Vol 13[3] February 2024: 298-303