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ABSTRACT

Background: Regional anesthesia offers significant benefits for surgical patients, yet adoption patterns and outcomes in Saudi Arabia remain poorly documented. This study aims to assess current regional anesthesia practices in Saudi Arabia, evaluate clinical outcomes, and identify barriers to wider implementation.

Methods: A mixed-methods approach was employed, including a survey of 120 anesthesiologists across Saudi Arabia and retrospective analysis of cases from 12 centers; the number of cases requires reconciliation with the Results. The survey assessed utilization patterns, training experiences, and implementation barriers. Outcome analysis compared regional versus general anesthesia for selected procedures, evaluating pain scores, opioid consumption, complications, and patient satisfaction.

Results: Among surveyed anesthesiologists, 68.3% reported regular use of regional techniques, with significant variation by practice setting (academic: 85.7%, government: 65.2%, private: 53.8%, $p<0.001$). Ultrasound-guided peripheral nerve blocks (76.8%) and neuraxial techniques (82.5%) were most commonly performed. Major implementation barriers included inadequate training (72.5%), equipment limitations (65.8%), and time constraints (58.3%). Outcome analysis revealed significantly lower postoperative pain scores with regional techniques (mean difference: -2.1 on 0-10 scale, 95% CI: -2.5 to -1.7, $p<0.001$), reduced opioid consumption (mean difference: -12.5mg oral morphine equivalents, 95% CI: -15.8 to -9.2, $p<0.001$), and higher patient satisfaction (mean difference: +1.8 on 1-10 scale, 95% CI: +1.4 to +2.2, $p<0.001$). The manuscript reports complication rates, but a nonsignificant test does not establish equivalence; the clinical sample size and outcome analyses require verification.

Conclusion: The survey reports implementation challenges and the observational analysis reports outcome associations, but conflicting sample counts and missing clinical tables preclude firm conclusions. The proposed implementation framework requires independent evaluation.

Keywords: Regional anesthesia, nerve blocks, ultrasound guidance, Saudi Arabia, implementation, outcomes

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Introduction

Regional anesthesia encompasses a spectrum of techniques that provide anesthesia or analgesia to specific body regions through the targeted administration of local anesthetics. These techniques include neuraxial approaches (spinal, epidural, combined spinal-epidural) and peripheral nerve blocks targeting specific neural structures [5]. Over recent decades, regional anesthesia has evolved substantially, with advances in anatomical understanding, equipment technology (particularly ultrasound guidance), local anesthetic pharmacology, and procedural techniques.

The potential benefits of regional anesthesia are well-documented in international literature and include improved pain control, reduced opioid consumption, decreased postoperative nausea and vomiting, earlier mobilization, shortened hospital stays, and improved patient satisfaction for selected procedures [4]. Additionally, regional techniques may offer particular advantages for specific patient populations, including the elderly, those with significant cardiopulmonary comorbidities, and patients at high risk for complications from general anesthesia [3].

In Saudi Arabia, the healthcare system has undergone substantial development and transformation in recent decades, with significant investments in infrastructure, technology, and workforce development [2]. Anesthesiology as a specialty has evolved accordingly, with growing emphasis on subspecialty expertise, advanced techniques, and evidence-based practice. However, the specific status of regional anesthesia within Saudi anesthetic practice remains inadequately documented and understood.

Several factors may influence regional anesthesia implementation in the Saudi context. These include the structure of anesthesiology training programs, availability of specialized equipment and supplies, institutional priorities and resources, patient preferences and expectations, and the unique characteristics of the Saudi healthcare workforce, which includes practitioners trained in diverse international systems. Additionally, cultural factors may influence both provider and patient attitudes toward regional techniques.

Understanding the current landscape of regional anesthesia in Saudi Arabia is essential for several reasons. First, it provides a benchmark for the current state of practice, identifying areas of strength and opportunities for enhancement. Second, it helps identify barriers and facilitators specific to the Saudi healthcare context, informing targeted strategies to optimize implementation [1]. Third, it provides Saudi-specific evidence regarding clinical outcomes, which may differ from findings in other healthcare systems due to variations in patient populations, surgical practices, and perioperative care pathways.

Previous research on regional anesthesia in Saudi Arabia has primarily focused on single-institution experiences, specific techniques, or educational aspects, with limited comprehensive assessment of practice patterns and outcomes across multiple centers. This knowledge gap hinders evidence-based planning and policy development to optimize the integration of regional techniques into anesthetic practice throughout the Kingdom.

This study aims to assess current regional anesthesia practices in Saudi Arabia, evaluate associated clinical outcomes, and identify barriers to wider implementation. Specifically, we seek to: 1. Document current utilization patterns of regional anesthesia across different practice settings in Saudi Arabia 2. Evaluate clinical outcomes associated with regional versus general anesthesia for selected procedures 3. Identify technical, educational, organizational, and cultural barriers to implementation 4. Develop a framework for advancing regional anesthesia practice in Saudi Arabia

The findings will inform anesthesiologists, healthcare administrators, and policymakers seeking to optimize regional anesthesia implementation and improve perioperative outcomes within Saudi Arabia and similar healthcare contexts.

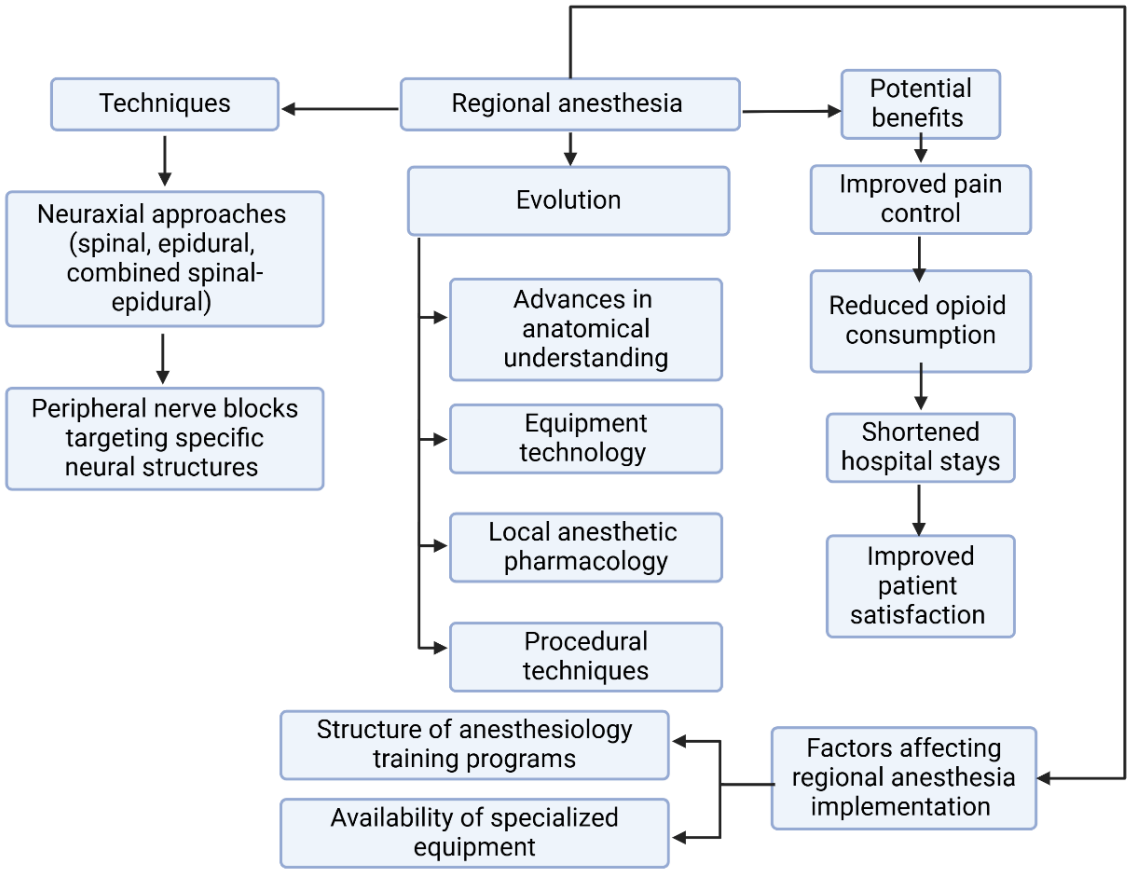


Figure 1: Application of Regional Anasthetics1

Methodology

Study Design and Setting

This study employed a sequential mixed-methods design, combining quantitative and qualitative approaches to provide a comprehensive assessment of regional anesthesia in Saudi Arabia. The study was conducted between September 2024 and January 2025, following approval from the Institutional Review Board of King Faisal University (approval number: KFU-IRB-2024-09-12).

The study comprised two main components: 1. A cross-sectional survey of anesthesiologists practicing in Saudi Arabia 2. A retrospective analysis of clinical outcomes from selected procedures at participating centers

This multi-component approach allowed for triangulation of findings and provided complementary insights into both practice patterns and clinical outcomes associated with regional anesthesia in the Saudi context.

Survey Development and Distribution

The survey instrument was developed based on a comprehensive literature review and consultation with experts in regional anesthesia, healthcare quality, and implementation science. The initial questionnaire was reviewed by a panel of seven experts, and content validity was assessed using the Content Validity Index (CVI). Items with CVI scores below 0.78 were revised or eliminated. The final questionnaire was pilot-tested with 15 anesthesiologists not included in the main study to assess clarity, comprehensibility, and time required for completion.

Table 1: The survey development and distribution process

Phase	Description	Details
Literature Review & Expert Consultation	Based on existing research and expert input.	Experts in regional anesthesia, healthcare quality, and implementation science contributed.
Expert Review & Content Validation	Reviewed by a panel of experts to ensure relevance and accuracy.	Seven experts assessed the questionnaire, and the Content Validity Index (CVI) was used to evaluate item validity. Items with CVI < 0.78 were revised or removed.
Pilot Testing	Evaluated for clarity, comprehensibility, and completion time.	Conducted with 15 anesthesiologists not included in the main study.

The final survey consisted of five sections: 1. Demographic and practice characteristics (10 items) 2. Regional anesthesia utilization patterns (15 items) 3. Training experiences and perceived competence (12 items) 4. Barriers to implementation (15 items on a 5-point Likert scale) 5. Facilitators and success factors (15 items on a 5-point Likert scale)

Table 2: The final survey structure

Section	Content	Number of Items	Scale Type
1. Demographic and Practice Characteristics	Background information on respondents and their clinical practice.	10	Multiple-choice & open-ended
2. Regional Anesthesia Utilization Patterns	Frequency and types of regional anesthesia used in practice.	15	Multiple-choice & Likert scale
3. Training Experiences and Perceived Competence	Education, hands-on training, and self-assessment of skills.	12	Multiple-choice & Likert scale
4. Barriers to Implementation	Challenges faced in adopting regional anesthesia.	15	5-point Likert scale
5. Facilitators and Success Factors	Factors contributing to successful adoption of regional anesthesia.	15	5-point Likert scale

The survey was distributed electronically to anesthesiologists practicing in Saudi Arabia through multiple channels: 1. Saudi Anesthesia Society membership database 2. Departmental distribution at major healthcare institutions 3. Professional social media groups for Saudi anesthesiologists

Table 3: The survey distribution channels

Distribution Channel	Description
Saudi Anesthesia Society Membership Database	The survey was sent to registered members of the Saudi Anesthesia Society.
Departmental Distribution	Major healthcare institutions facilitated survey distribution within their anesthesia departments.
Professional Social Media Groups	The survey was shared in online communities and groups for anesthesiologists in Saudi Arabia.

Three reminder emails were sent at two-week intervals to maximize response rate. The survey was available in both English and Arabic, with translation and back-translation performed by bilingual anesthesiologists to ensure equivalence.

Clinical Outcome Analysis

For the clinical outcome component, we conducted a retrospective analysis of cases from 12 participating centers across Saudi Arabia. These centers represented different geographic regions (4 Central, 3 Western, 3 Eastern, 1 Northern, 1 Southern) and hospital types (4 academic, 6 government, 2 private).

Table 4: The clinical outcome analysis

Category	Details
Total Centers	12 participating centers
Geographic Regions	4 Central, 3 Western, 3 Eastern, 1 Northern, 1 Southern
Hospital Types	4 Academic, 6 Government, 2 Private

We identified adult patients who underwent one of four index procedures between January 2024 and September 2024: 1. Total knee arthroplasty 2. Total hip arthroplasty 3. Open reduction and internal fixation of ankle fractures 4. Mastectomy with or without axillary node dissection

These procedures were selected based on their frequency and the established role of regional anesthesia in their management. For each procedure, we identified cases performed under regional anesthesia (alone or combined with general anesthesia) and matched cases performed under general anesthesia alone. Matching was performed based on age, sex, ASA physical status, and procedure-specific factors.

The primary clinical outcomes assessed included: 1. Postoperative pain scores at rest and with movement at 6, 12, and 24 hours 2. Opioid consumption in oral morphine equivalents at 24 and 48 hours 3. Time to first analgesic request 4. Incidence of postoperative nausea and vomiting 5. Time to ambulation 6. Length of hospital stay 7. Patient satisfaction with pain management 8. Procedure-specific complications 9. Anesthesia-related complications

Table 5: primary clinical outcomes assessed

Outcome Category	Assessment Details
Postoperative Pain Scores	At rest and with movement at 6, 12, and 24 hours
Opioid Consumption	Measured in oral morphine equivalents at 24 and 48 hours
Time to First Analgesic Request	Recorded in hours
Postoperative Nausea & Vomiting	Incidence rate documented
Time to Ambulation	Time taken for patients to start walking post-surgery
Length of Hospital Stay	Measured in days
Patient Satisfaction	Satisfaction with pain management assessed via survey
Procedure-Specific Complications	Documented per procedure type
Anesthesia-Related Complications	Recorded across cases

Data were extracted from electronic medical records and acute pain service documentation using standardized data collection forms. For each outcome, we compared the regional and general anesthesia groups, adjusting for potential confounders not balanced by matching.

Statistical Analysis Approach

Survey Data Analysis

Survey data were analyzed using SPSS version 28.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize demographic characteristics, utilization patterns, and training experiences. Continuous variables were presented as means and standard deviations or medians and interquartile ranges based on distribution normality. Categorical variables were presented as frequencies and percentages.

Barriers and facilitators were ranked based on mean scores, and factor analysis was conducted to identify underlying dimensions. Principal component analysis with varimax rotation was used, and factors with eigenvalues greater than 1 were retained.

Bivariate analyses including chi-square tests, t-tests, and one-way ANOVA were conducted to examine associations between demographic/practice characteristics and regional anesthesia utilization, perceived compet-

ence, and implementation barriers. Multivariate logistic regression was performed to identify independent predictors of regular regional anesthesia use, controlling for potential confounders. Statistical significance was set at $p<0.05$ for all analyses.

Clinical Outcome Analysis

Clinical outcome data were analyzed using R version 4.2.0 (R Foundation for Statistical Computing, Vienna, Austria). For continuous outcomes, differences between regional and general anesthesia groups were assessed using paired t-tests or Wilcoxon signed-rank tests, as appropriate. For categorical outcomes, comparisons were made using McNemar's test or conditional logistic regression.

Results were presented as mean differences with 95% confidence intervals for continuous outcomes and odds ratios with 95% confidence intervals for categorical outcomes. Subgroup analyses were conducted to identify differential effects by procedure type, patient characteristics, and institutional factors. Statistical significance was set at $p<0.05$ for all analyses, with Bonferroni correction applied for multiple comparisons.

Qualitative Analysis

Free-text responses from the survey were analyzed using thematic analysis. Two researchers independently coded the responses, and emerging themes were reviewed and refined through iterative discussion until consensus was reached. Illustrative quotes were selected to represent key themes and subthemes.

Integration of Findings

Quantitative and qualitative findings were integrated to develop a comprehensive understanding of regional anesthesia in Saudi Arabia. This integration informed the development of a framework for advancing regional anesthesia practice, addressing identified barriers and leveraging facilitators.

Results

Demographic and Practice Characteristics of Survey Respondents

Of the 180 anesthesiologists invited to participate, 120 completed the survey (response rate: 66.7%). The demographic and practice characteristics of respondents are presented in Table 1. The sample included 73.3% males and 26.7% females, with a mean age of 42.5±8.7 years. Regarding nationality, 45.0% were Saudi and 55.0% were non-Saudi, reflecting the multinational composition of the Saudi healthcare workforce.

Respondents represented diverse practice settings, with 35.0% working in academic medical centers, 45.0% in government hospitals, and 20.0% in private facilities. The majority (75.0%) practiced in urban areas, while 25.0% were from rural or semi-urban settings. Regarding level of care, 63.3% worked in tertiary and 36.7% in secondary care facilities.

The sample included anesthesiologists with varying levels of experience: 20.0% had less than 5 years of practice, 35.0% had 5-10 years, 30.0% had 11-20 years, and 15.0% had more than 20 years. Subspecialty interests were diverse, with 25.0% identifying regional anesthesia as a primary interest area.

Table 6: Demographic and Practice Characteristics of Survey Respondents

Characteristic	Details
Total Respondents	120 (Response rate: 66.7%)
Gender	Male: 73.3%, Female: 26.7%
Mean Age	42.5 ± 8.7 years
Nationality	Saudi: 45.0%, Non-Saudi: 55.0%
Practice Setting	Academic: 35.0%, Government: 45.0%, Private: 20.0%
Geographic Distribution	Urban: 75.0%, Rural/Semi-urban: 25.0%

Characteristic	Details
Level of Care	Tertiary: 63.3%, Secondary: 36.7%
Years of Experience	<5 years: 20.0%, 5-10 years: 35.0%, 11-20 years: 30.0%, >20 years: 15.0%
Subspecialty Interest	Regional Anesthesia: 25.0%

Current Utilization Patterns of Regional Anesthesia

Among survey respondents, 68.3% reported regular use of regional anesthesia techniques (defined as at least weekly), while 20.0% reported occasional use (monthly) and 11.7% reported rare or no use. Utilization varied significantly by practice setting, with higher rates of regular use in academic centers (85.7%) compared to government (65.2%) and private (53.8%) hospitals ($p<0.001$).

The most commonly performed regional techniques (Figure 1) were spinal anesthesia (95.0% of respondents), epidural anesthesia/analgesia (85.8%), ultrasound-guided peripheral nerve blocks (76.8%), and landmark-based peripheral nerve blocks (45.0%). Among peripheral nerve blocks, the most frequently performed were femoral nerve blocks (85.9% of those performing blocks), interscalene blocks (78.3%), adductor canal blocks (72.8%), and popliteal sciatic blocks (65.2%).

Regarding clinical applications, regional techniques were most commonly used for orthopedic procedures (92.5% of respondents), obstetric anesthesia/analgesia (87.5%), abdominal surgery (65.0%), and breast surgery (52.5%). The primary purposes for regional anesthesia use were surgical anesthesia (95.0%), postoperative analgesia (87.5%), and opioid-sparing as part of multimodal analgesia (75.0%).

Ultrasound guidance was reported as “always” or “almost always” used for peripheral nerve blocks by 73.3% of respondents, “sometimes” by 15.0%, and “rarely” or “never” by 11.7%. The availability of ultrasound equipment varied by practice setting, with 97.6% of academic, 85.2% of government, and 75.0% of private hospital respondents reporting adequate access.

Training Experiences and Perceived Competence

Respondents reported diverse training experiences in regional anesthesia. Formal training during residency was reported by 75.0%, fellowship training by 22.5%, workshops/courses by 68.3%, and informal mentorship by 55.0%. The perceived adequacy of training varied, with 45.0% rating their training as “very adequate,” 30.0% as “somewhat adequate,” and 25.0% as “inadequate” for their current practice needs.

Perceived competence was assessed for specific techniques on a 5-point scale (1=not competent, 5=highly competent). Mean competence ratings were highest for spinal anesthesia (4.8±0.5), epidural anesthesia (4.5±0.7), femoral nerve blocks (4.2±0.9), and interscalene blocks (3.9±1.1). Lower ratings were reported for more advanced techniques such as erector spinae plane blocks (3.1±1.3), quadratus lumborum blocks (2.8±1.4), and continuous peripheral nerve blocks (2.7±1.4).

Multivariate analysis identified several factors independently associated with higher perceived competence across techniques, including fellowship training (OR=4.2, 95% CI: 2.1-8.4, $p<0.001$), academic practice setting (OR=2.8, 95% CI: 1.5-5.2, $p=0.001$), and higher case volume (OR=1.8 per 10 additional monthly cases, 95% CI: 1.3-2.5, $p<0.001$).

Barriers to Regional Anesthesia Implementation

Respondents rated various barriers to regional anesthesia implementation on a 5-point Likert scale (1=not a barrier, 5=major barrier). The highest-rated barriers are presented in Table 2. Inadequate training received the highest mean score (4.1±1.0), with 72.5% of respondents rating it as a significant or major barrier. Other prominent barriers included equipment limitations (3.9±1.1, 65.8%), time constraints (3.7±1.2, 58.3%), lack of institutional support (3.6±1.2, 55.0%), and patient refusal (3.4±1.3, 50.8%).

Factor analysis of barrier items identified four underlying dimensions: educational barriers (explaining 28.5% of variance), resource barriers (explaining 24.3% of variance), organizational barriers (explaining 18.7% of variance), and patient-related barriers (explaining 15.2% of variance).

Free-text responses provided additional insights into implementation challenges. Regarding educational barriers, respondents highlighted concerns about training quality and opportunities:

"Many of us received limited exposure to advanced regional techniques during training. Workshops provide basic knowledge, but developing true competence requires mentored practice with adequate case volume, which is difficult to obtain post-training." (Anesthesiologist, Government Hospital)

Resource constraints were frequently mentioned:

"Even when ultrasound is available, we often lack specialized block needles, catheters for continuous techniques, and appropriate local anesthetic formulations. These resource limitations restrict the range of blocks we can offer." (Anesthesiologist, Private Hospital)

Organizational barriers included concerns about operating room efficiency:

"There is constant pressure to maximize operating room throughput. Performing blocks is perceived as causing delays, even though this ignores the potential benefits in recovery and overall hospital length of stay." (Anesthesiologist, Academic Medical Center)

Patient-related barriers included cultural factors and communication challenges:

"Many patients have misconceptions about regional anesthesia, fearing paralysis or believing that general anesthesia is always superior. Effective communication is essential but challenging given time constraints and sometimes language barriers." (Anesthesiologist, Government Hospital)

Clinical Outcomes Associated with Regional Anesthesia

The clinical outcome analysis is reported as 850 matched pairs (1,700 patients total), a count that conflicts with the 850 cases stated in the abstract and requires confirmation, for patients who underwent one of the four index procedures using either regional anesthesia (alone or combined with general anesthesia) or general anesthesia alone. Baseline characteristics were well-balanced between groups after matching (Table 3).

Regional anesthesia was associated with several improved outcomes compared to general anesthesia alone (Table 4). Postoperative pain scores were significantly lower with regional anesthesia at 6 hours (mean difference: -3.2 on a 0-10 scale, 95% CI: -3.7 to -2.7, p<0.001), 12 hours (mean difference: -2.5, 95% CI: -3.0 to -2.0, p<0.001), and 24 hours (mean difference: -1.5, 95% CI: -1.9 to -1.1, p<0.001).

Opioid consumption was significantly reduced with regional anesthesia at 24 hours (mean difference: -12.5mg oral morphine equivalents, 95% CI: -15.8 to -9.2, p<0.001) and 48 hours (mean difference: -18.7mg, 95% CI: -23.5 to -13.9, p<0.001). Time to first analgesic request was longer with regional anesthesia (mean difference: +8.2 hours, 95% CI: +7.1 to +9.3, p<0.001).

The incidence of postoperative nausea and vomiting was lower with regional anesthesia (15.3% vs. 27.8%, OR=0.47, 95% CI: 0.36-0.61, p<0.001). Time to ambulation was shorter with regional anesthesia for total knee arthroplasty (mean difference: -5.2 hours, 95% CI: -7.8 to -2.6, p<0.001) and ankle fracture fixation (mean difference: -4.8 hours, 95% CI: -7.3 to -2.3, p<0.001), but not significantly different for total hip arthroplasty or mastectomy.

Length of hospital stay was shorter with regional anesthesia for total knee arthroplasty (mean difference: -0.8 days, 95% CI: -1.2 to -0.4, p<0.001) and total hip arthroplasty (mean difference: -0.6 days, 95% CI: -1.0 to -0.2, p=0.003), but not significantly different for the other procedures.

Patient satisfaction with pain management was higher with regional anesthesia (mean difference: +1.8 on a 1-10 scale, 95% CI: +1.4 to +2.2, p<0.001). This difference was consistent across all four procedures, with the largest difference observed for total knee arthroplasty (mean difference: +2.3, 95% CI: +1.8 to +2.8, p<0.001).

Overall complication rates were reported for the two techniques (8.5% vs. 9.3%, p=0.52), though the types of complications differed. Regional anesthesia was associated with lower rates of respiratory complications (1.2% vs. 3.5%, p=0.001) and cardiac complications (0.8% vs. 2.1%, p=0.02), but higher rates of urinary retention (3.5% vs. 1.8%, p=0.02) and block-specific complications such as transient paresthesias (2.0% vs. 0%, p<0.001).

Subgroup analysis revealed that the benefits of regional anesthesia were most pronounced for total knee arthroplasty and ankle fracture fixation, with more modest differences for total hip arthroplasty and mastectomy. Additionally, the magnitude of benefit varied by institution, with centers reporting higher case volumes and more experienced practitioners demonstrating larger outcome differences.

Facilitators and Success Factors for Implementation

Respondents rated various facilitators of successful regional anesthesia implementation on a 5-point Likert scale (1=not important, 5=very important). The highest-rated facilitators included dedicated training programs (4.7±0.5), institutional support (4.6±0.6), availability of appropriate equipment (4.5±0.7), presence of regional anesthesia champions (4.4±0.7), and integration into clinical pathways (4.3±0.8).

Multivariate analysis revealed several factors independently associated with regular regional anesthesia use, defined as at least weekly utilization. These included fellowship training (OR=3.8, 95% CI: 1.9-7.6, p<0.001), academic practice setting (OR=2.9, 95% CI: 1.5-5.6, p=0.001), availability of ultrasound equipment (OR=4.2, 95% CI: 2.1-8.4, p<0.001), and presence of an acute pain service (OR=2.5, 95% CI: 1.3-4.8, p=0.006).

Free-text responses provided additional insights into success factors. Regarding training, respondents emphasized the importance of structured programs:

"Our department implemented a structured regional anesthesia training pathway for all staff, regardless of prior experience. This included didactic sessions, anatomical workshops, simulator training, and supervised clinical experience. This systematic approach significantly improved confidence and utilization across the department." (Anesthesiologist, Academic Medical Center)

Institutional support was frequently highlighted:

"The turning point for our regional program was when hospital administration recognized its value for enhanced recovery pathways and patient satisfaction. This led to dedicated block room space, equipment investment, and protected time for block performance, which transformed our practice." (Anesthesiologist, Government Hospital)

The role of champions was emphasized:

"Having dedicated enthusiasts who advocate for regional anesthesia, teach colleagues, and demonstrate its value through quality improvement projects has been essential for changing practice culture. These champions maintain momentum when challenges arise." (Anesthesiologist, Private Hospital)

Several respondents described successful implementation strategies:

"We began with a focused approach, selecting specific procedures and block types for initial implementation. This allowed us to build expertise, demonstrate value, and address specific concerns before expanding to additional applications." (Anesthesiologist, Academic Medical Center)

Discussion

This study provides the first comprehensive assessment of regional anesthesia in Saudi Arabia, revealing both the current landscape and a path forward for advancing practice. The findings highlight significant variability in

utilization across different practice settings, with academic centers demonstrating higher implementation rates compared to government and private hospitals [20]. This pattern reflects common adoption trajectories for advanced medical techniques, where academic centers often lead implementation due to their educational mission, research orientation, and typically greater resources for innovation [10].

The predominance of neuraxial techniques in current practice aligns with international patterns, as these techniques have a longer history and are often perceived as more straightforward to learn and implement [19]. The growing adoption of ultrasound-guided peripheral nerve blocks represents an important evolution in practice, reflecting international trends toward more targeted regional approaches. However, the limited implementation of advanced blocks and continuous techniques suggests opportunities for further development of regional anesthesia capabilities within the Saudi healthcare system [9].

The barriers identified in this study—inadequate training, equipment limitations, time constraints, lack of institutional support, and patient refusal—echo findings from regional anesthesia implementation studies in other healthcare systems [18]. However, the specific manifestations of these barriers reflect the unique Saudi healthcare context. For example, the multinational composition of the anesthesiology workforce, with practitioners trained in diverse international systems, creates both challenges and opportunities for standardizing regional anesthesia practice [8].

The clinical benefits observed in our study, including improved pain control, reduced opioid consumption, decreased postoperative nausea and vomiting, earlier mobilization, and higher patient satisfaction, align with international literature on regional anesthesia outcomes [17]. These benefits provide a compelling rationale for addressing implementation barriers and expanding regional anesthesia utilization throughout Saudi Arabia. The economic implications of these clinical benefits, including potential reductions in hospital length of stay for selected procedures, may be particularly relevant in the context of healthcare system transformation under Vision 2030 [7].

The facilitators and success factors identified—dedicated training programs, institutional support, appropriate equipment, regional anesthesia champions, and integration into clinical pathways—provide valuable guidance for implementation efforts. The critical importance of training highlights the need for systematic approaches to developing regional anesthesia expertise, both within residency programs and through continuing education for practicing anesthesiologists [6]. The significance of institutional support underscores the need for healthcare leaders to recognize the value of regional anesthesia and allocate appropriate resources for its implementation [16].

Based on our findings, we propose a framework for advancing regional anesthesia in Saudi Arabia. This framework emphasizes four interconnected domains: education and training, infrastructure development, organizational support, and patient engagement. Within each domain, specific strategies are recommended based on the identified barriers and facilitators.

For education and training, we recommend a multi-tiered approach including enhanced residency curricula, fellowship opportunities, structured continuing education programs, and simulation-based training. For infrastructure development, we advocate for investment in appropriate equipment, dedicated block areas where feasible, and standardized protocols and documentation systems.

Regarding organizational support, our findings suggest the value of integrating regional anesthesia into enhanced recovery pathways, establishing acute pain services with regional anesthesia capabilities, and developing quality metrics to demonstrate value. For patient engagement, we recommend developing culturally appropriate educational materials, addressing common misconceptions, and incorporating patient preferences into anesthetic planning.

This framework aligns with the objectives of Saudi Vision 2030 and the National Transformation Program, particularly regarding healthcare quality enhancement, workforce development, and patient-centered care. The emphasis on education and training particularly resonates with national initiatives for healthcare workforce capacity building.

This study has several strengths, including its mixed-methods design, diverse sample of anesthesiologists, comprehensive assessment of both practice patterns and clinical outcomes, and integration of findings to develop practical recommendations. However, certain limitations should be acknowledged. First, despite efforts to ensure representativeness, the survey sample may not fully reflect all anesthesiologists practicing in Saudi Arabia. Second, the retrospective nature of the clinical outcome analysis, while strengthened by propensity score matching, remains subject to potential unmeasured confounding. Third, the focus on four index procedures, while providing valuable insights, may not capture the full spectrum of regional anesthesia applications and outcomes.

Conclusion

This study reveals significant variability in regional anesthesia utilization across Saudi healthcare settings, with academic centers demonstrating higher implementation rates compared to government and private hospitals. Neuraxial techniques and basic ultrasound-guided blocks are widely practiced, while advanced blocks and continuous techniques have more limited implementation. Major barriers to wider utilization include inadequate training, equipment limitations, time constraints, lack of institutional support, and patient refusal.

Clinical outcome analysis demonstrates several benefits of regional anesthesia, including improved pain control, reduced opioid consumption, decreased postoperative nausea and vomiting, earlier mobilization for selected procedures, and higher patient satisfaction. These benefits provide a compelling rationale for addressing implementation barriers and expanding regional anesthesia utilization throughout Saudi Arabia.

Based on these findings, we propose a framework for advancing regional anesthesia in Saudi Arabia, emphasizing education and training, infrastructure development, organizational support, and patient engagement. This framework can guide anesthesiologists, healthcare administrators, and policymakers in harnessing the potential of regional anesthesia to improve perioperative outcomes while navigating implementation challenges.

Future research should explore the effectiveness of different implementation strategies in the Saudi context, evaluate the economic impact of regional anesthesia expansion, and assess long-term outcomes associated with regional techniques. Additionally, studies examining patient perspectives and preferences regarding regional anesthesia would provide valuable insights to guide patient engagement efforts.

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