Original Article

Comparative Study between the Effects of Dexmedetomidine and Lidocaine Infusion on Intraoperative Hemodynamic and Requirement of Nalbuphine for Postoperative Analgesia in Upper Limb Orthopaedic Surgeries

Komal Mumtaz, Liaqat Ali, Saima Zia, Ramisa Afzal, Soman Nadim Iqbal, Malaika Nasir

Abstract

Objectives: To compare the intraoperative and postoperative hemodynamics and requirement of nalbuphine for postoperative analgesia in upper limb orthopedic surgeries between dexmedetomidine and lidocaine.

Study Design: Comparative analytical study

Place and duration of study: Department of Anesthesia, Fauji Foundation Hospital, Rawalpindi, Pakistan from 17th Oct 22 to 15th July 23.

Methodology: Patients undergoing upper limb orthopedic surgeries in our tertiary care setup. Ninety patients undergoing upper limb orthopaedic surgeries were divided into two equal groups of forty-five patients each. Group A received Dexmedetomidine infusion, while Group B received Lidocaine infusion. Data collection involved gathering information related to upper limb orthopaedic procedures, including both intraoperative and postoperative parameters.

Results: Ninety patients undergoing upper limb surgeries were randomized into two groups (Dexmedetomidine: Group A, Lidocaine: Group B). Group A experienced statistically significant reductions in intraoperative mean arterial pressure (MAP) by 20% ($p<0.05$) and heart rate (HR) by 15% ($p<0.01$) compared to Group B at all time points (10-120 minutes). Postoperative pain scores were significantly higher in Group B (mean difference: 1.5 points, $p<0.001$) across all time points (2-24 hours). Group A also exhibited significantly higher sedation scores (mean difference: 2 points, $p<0.001$) and required significantly less postoperative analgesia (one dose vs. multiple doses, $p<0.001$) than Group B.

Conclusion*:* The findings affirm dexmedetomidine infusion's advantages in achieving optimal outcomes: improved hemodynamics, reduced pain, and lowered postoperative analgesic demands, reinforcing its role in effective pain management.

Keywords: Dexmedetomidine, Heart rate, Lidocaine, Mean Arterial Pressure, Numeric rating scale,

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INTRODUCTION

Surgical procedures, vital for treating diverse medical issues, often lead to postoperative pain and related complications like nausea, vomiting, blood clots, and cognitive impairment. The management of postoperative analgesia and intraoperative analgesics is an essential concern in surgical procedures and anaesthetic agents play a crucial role in this. In recent years, practicing anesthesiologists utilized various non-opioid analgesic adjuncts such as dexmedetomidine and lidocaine in the perioperative periods to curtail the use of opioids as a part of enhanced recovery after surgery protocol and to minimize opioid-related adverse events. [1] These two commonly used agents include dexmedetomidine and lidocaine that have exhibited promising results in improving hemodynamic parameters and alleviating requirement for postoperative pain. There is limited data available for upper limb surgeries that directly compares the effectiveness of these agents in this particular context.[2]

Dexmedetomidine is an alpha-2 adrenergic agonist and is wellknown for its sedative and analgesic properties. Its capacity to attenuate the stress response during surgery procedures and maintain hemodynamic stability makes it a valuable solution. [3] Dexmedetomidine has also been found to reduce the opioid requirement in the postoperative period, potentially mitigating opioid-related side effects.[4] It can also be used for procedural sedation such as during colonoscopy.[5] It can be used as an adjunct with other sedatives like benzodiazepines, opioids, and propofol to enhance sedation and help maintain hemodynamic stability by decreasing the requirement of other sedatives.[6,7] Intravenous dexmedetomidine shows the linear pharmacokinetics with a rapid distribution half-life of approximately 6 minutes in healthy volunteers and a longer and more variable distribution half-life in ICU patients. Dexmedetomidine is also used for procedural sedation in children.[8]

It can be used for sedation required for awake fibreoptic nasal intubation in patients with a difficult airway.[9] On the other hand, lidocaine, which is a well-known local anaesthetic and antiarrhythmic, is increasingly being used as for systemic analgesia and anti-inflammatory effects.[10]This is one approach which is also known as opioid-free anaesthesia (OFA), which avoids narcotics by combining drugs like dexmedetomidine, ketamine, and lidocaine with conventional anaesthetics. These agents help reduce the noxious stimulation and improve efficacy while capitalizing on the analgesic potential of dexmedetomidine and ketamine. [11]

One of the key challenges in postoperative care is the management of pain at times done through opioid analgesics like Nalbuphine. [12] Opioids are very effective but they come with a plethora of adverse effects such as nausea, vomiting, and potential dependency. However the risk of dependency is not high in limited postoperative administration.[13] The consequences of opioid use extend beyond initial pain relief, they are well-known to cause neuroadaptation and provoking 'opioid-induced hyperalgesia,' which undermines its capacity for sustained analgesia.[14] Maintaining the postoperative hemodynamics stability is another important concern, as variability in blood pressure and heart rate may persist due to unresolved pain, residual anaesthetic effects, or autonomic stress responses.[15]

Despite these potential benefits, there remains a significant gap in comparative research assessing dexmedetomidine and lidocaine particularly in the context of upper limb orthopaedic procedures. These surgeries pose distinct challenges due to tourniquet use, prolonged operative times, and varying degrees of nociceptive stimulation. Additionally, investigating their impact on postoperative opioid consumption, particularly nalbuphine ,a commonly used analgesic in many perioperative settings, can provide important insights into optimizing pain management strategies while minimizing opioid exposure.

This study's aim is to seek a comprehensive comparison of the efficacy of dexmedetomidine and lidocaine infusion during a variety of orthopaedic surgeries. By evaluating the following parameters: hemodynamic, nalbuphine requirements, and postoperative analgesia, the aim is to uncover insights that can further refine perioperative protocols and overall improve patient outcomes. The aim is to establish a foundation for more tailored and effective pain management strategies by delving into the potential synergies between these adjuvant techniques and conventional anaesthesia.

METHODOLOGY:

A comparative analytical study was conducted at Fauji Foundation Hospital, Rawalpindi from 7th Oct 2022 to 15th July 2023. The ethical review board of Fauji Foundation Hospital granted ethical approval (reference number 556/RC/FFH/RWP dated 17th October 2022) for this project and informed consent was obtained from all participants. Proper measures were used to ensure patient confidentiality and compliance with associated ethical guidelines. Sample size was estimated by WHO Calculator using formula ($n= 2ó^2[z_{1-á} + z_{1-â}]^2 /[\mu_{1-} \mu_2]^2$) after thorough study of literature with 95% confidence interval.Reported heart rate with dexmedetomidine(73) and lidocaine infusion (83)Variance 235.469, so estimated sample size was 45 per group. The sample included patients presenting for upper limb orthpaedic surgeries in a 10 month period, this included 90 patients with them being divided into two groups.

Included patients receiving dexmedetomidine 1mcg/kg over 10min and lidocaine infusion 0.3 to 0.5 mg/kg/hr after the induction of anesthesia till the end of upper limb surgeries in our setup. Those patients with ASA 3-4, pregnant females, patients who are allergic to dexmedetomidine and lidocaine infusion, and patients with any cardiac, renal, neurological, respiratory or hepatic dysfunction were excluded from the study. Patients were equally divided into two groups A and B, with one receiving dexmedetomidine and the other lidocaine infusion.

Receiving Loading dose: Dexmedetomidine infusion 1mcg/kg over 10min. Maintenance dose Dexmedetomidine infusion 0.3 to 0.5 ug/kg/hr after induction of anaesthesia (Group A). Receiving Lidocaine infusion 0.3 to 0.5 mg/kg/hr after induction of anaesthesia(Group B)

Data collection included both intraoperative and postoperative parameters relevant to upper limb orthopaedic procedures. Intraoperative parameters included the mean heart rate and mean arterial pressure, recordings of which were made at intervals prior to surgery, 10 mins, 15 mins, 30 mins, 60 mins, 90 mins and 120 mins after induction throughout the procedure. Postoperative factors included the numerical rating pain scale (NRS) for pain assessment, opioid dose requirements, and the Ramsey sedation score.

Statistical analyses were carried out using appropriate methods usingusing statistical package for social sciences (SPSS) version 22. The quantitative data was expressed in mean and standard deviation (SD) and qualitative data was expressed by using Frequency and percentages.Discrete variables such as NRS scores, and opioid dose requirements, were analysed using the Mann-Whitney U test with a significance level of< 0.05.Because data was not normally distributed.

RESULTS

Ninety patients undergoing upper limb orthopaedic surgeries was meticulously assigned to two distinct groups, each consisting of forty-five individuals. Comparison between group A and group B according to demographic data has been shown (Table I). In our research, a greater proportion of the cases pertained to males. 34 (75.6%) in group A, and 31(68.9%) in group. The normality of data was assessed through the Shapiro Wilk test and it was not normally distributed, because of which the Mann-Whitney U test(Non-Parametric Test) was applied. Notably, the dynamic interplay between the two groups showcased intriguing trends. In Group A, which received Dexmedetomidine infusion, a notable reduction in both intraoperative mean arterial pressure (MAP) and heart rate (HR) was observed. This contrasted distinctly with Group B, where such a reduction was not as

Table 3: Comparison between group A and group B according to Ramsay Sedation Score

Ramsay Sedation Scores	Group A (n=45) Median(IQR)	Group B (n=45) Median(IQR)	P value
After surgery	34.34	56.66	<0.00
After 2hrs	36.16	54.84	<0.00
After 4hrs	38.66	52.34	<0.011
After 6hrs	50.94	40.06	<0.040
After 9hrs	51.00	40.00	<0.042
After 12hrs	49.40	41.60	<0.151
After 24hrs	39.03	51.97	<0.016

Table-4 Comparison between group A and group B according to post-operative analgesic requirement

Doses	Study Groups		p-value
	Group A (n=45)	**Group B (n=45)**	
1st dose	25 (55.56%)	4 (8.89%)	**0.00<0.05**
2nd dose	6 (13.33%)	19 (42.22%)	
3rd dose	14 (31.11%)	22 (48.89%)	

Figure-1: Comparison between group A and group B according to Intra operative parameter to be assessed numeric rating scale

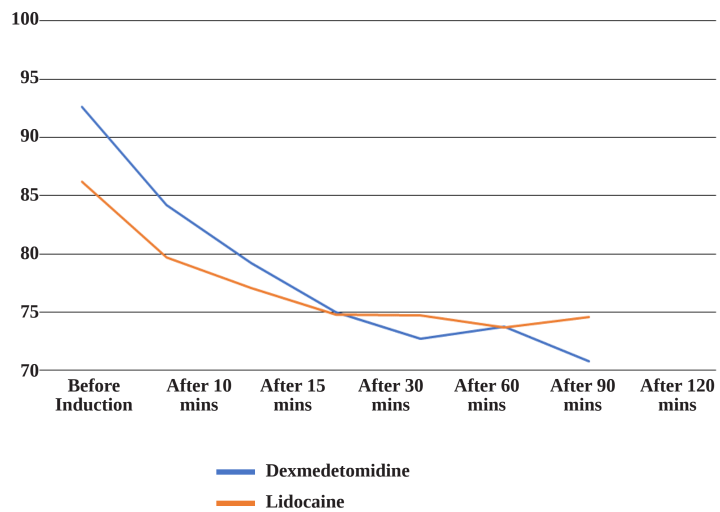

Table-1: Demographic Characteristics of both groups (n=90)

PARAMETERS	GROUP A (n=45)	GROUP B (n=45)
Gender		
Male	34 (75.6%)	31 (68.9%)
Female	11 (24.4%)	14 (31.1%)
Age		
Median(IQR)	42.00(34.50)	37.00(21.00)
Range	15-73	16-70
ASA		
ASA 1	28 (62.2%)	31 (68.9%)
ASA 2	17 (37.8%)	14 (31.1%)

Table-2: Distribution of various parameters in group A and group B

Parameter	GROUP A		GROUP B	
	Shaipiro-wilk Test	**Distribution***	**Shaipiro-wilk Test**	**Distribution***
After surgery	0.00	Skewed	0.00	Skewed
After 2hrs	0.00	Skewed	0.00	Skewed
After 4hrs	0.00	Skewed	0.00	Skewed
After 6hrs	0.00	Skewed	0.00	Skewed
After 9hrs	0.03	Skewed	0.00	Skewed
After 12hrs	0.029	Skewed	0.009	Skewed
After 24hrs	0.00	Skewed	0.006	Skewed

Value generated according to Shapiro-wilk Test. Data normal if p-value >0.05

pronounced. Furthermore, a key dimension of patient experience, post-operative pain intensity, was explored using the numeric rating scale. The results unveiled a statistically significant trend – patients in Group B reported higher mean post-operative pain values compared to those in Group A. This distinction persisted immediately after surgery and extended to subsequent time intervals of 2, 4, 6, 9, 12, and 24 hours. Expanding the scope of assessment, the Ramsay Sedation Score was employed to gauge patient sedation levels. Impressively, Group A showcased consistently higher sedation scores across various time points post-surgery – at intervals of 2, 4, 6, 9, 12, and 24 hours – in comparison to Group B. This finding emphasizes the efficacy of Dexmedetomidine in inducing and sustaining higher levels of sedation in the postoperative period. (table 4) The investigation also delved into the realm of post-operative analgesic requirements, a cornerstone of postoperative care. Strikingly, Group A exhibited a notably reduced demand for postoperative analgesia, necessitating only one dose, in stark contrast to Group B, which required multiple doses to achieve adequate pain relief. This stark divergence substantiates the effectiveness of Dexmedetomidine in minimizing the need for postoperative pain management. (Table 5)

DISCUSSION

Dexmedetomidine stands out as a remarkably precise and potent activator targeting central alpha-2 adrenergic receptors. When introduced via neuraxial pathways, dexmedetomidine influences both somatic and visceral pain sensations effectively. Additionally, it displays the ability to alleviate postoperative pain and extend the duration of pain relief. Intravenous lidocaine infusion, on the other hand, hampers nerve transmission at injury sites and boasts substantial anti-inflammatory attributes by curbing cytokine release. This, in turn, minimizes cytokine-triggered cell damage through ATP-gated potassium channels, stemming fromneutrophil suppression. [15,16] In our study, patients receiving intraoperative dexmedetomidine infusion exhibit considerable drops in mean arterial blood pressure and heart rate, along with reduced numeric rating scale scores post-surgery, leading to decreased postoperative analgesic needs, unlike their counterparts on lidocaine infusion.

In a study conducted in CMH Malir, the mean Ramsay Sedation Scale was found to be significantly higher in group-1 compared to group-2, indicating a deeper level of sedation in the dexmedetomidine group during septoplasty under monitored anesthesia care. Additionally, a significantly lower number of patients in dexmedetomidine group required analgesia compared to group 2, suggesting better pain control with dexmedetomidine. Thesefindings support the conclusion that dexmedetomidine is superior to group 2 (midazolam) for providing both sedation and analgesia during septoplasty, highlighting its potential as a preferred option for anesthesia management in this context. [17]

The study at Liaquat National Hospital found that Group D had significantly lower heart rates and mean arterial pressures compared to Group P, indicating superior hemodynamic stability. This highlights the clinical relevance of Group D's treatment for maintaining cardiovascular stability. Also, the study at Sindh Institute of Urology & Transplantation Karachi, highlighted dexmedetomidine's role in improving anesthesia by enhancing safety, comfort, and reducing anesthesia requirements during laryngoscopy-induced hemodynamic changes.[12]

Our study echoes Vishwadeep Singh's research on laparoscopic surgery patients, affirming that dexmedetomidine usage leads to sustained lower heart rate and mean arterial pressure during procedures compared to controls. Dexmedetomidine significantly prolongs early functional recovery discharge, with consistently lower pain levels indicated by visual analogue scale scores, underscoring its superior pain management efficacy versus lignocaine in the control group.[18]Confirming our findings, there exists a strong and statistically significant decrease in heart rate (HR) due to dexmedetomidine, a contrast that differed from the effects of lidocaine (L) in laparoscopic gynaecologic surgery. Importantly, the largest increase in average HR values within the lidocaine group remained below 20% of the starting value. Moreover, this change did not result in a significant rise in the average mean arterial pressure (MAP). These differences could be attributed to variations in the surgical procedures employed in their study. [19]

Similarly, another study revealed marked reductions in heart rate (HR) and mean arterial pressure (MAP) during laryngoscopy and intubation, notably more significant in the dexmedetomidine group compared to lignocaine, highlighting its pronounced impact on hemodynamics.[20]

Corroborating our own findings, a Randomized Clinical Trial conducted among individuals afflicted with failed back surgery syndrome unveiled noteworthy results on the Visual Analog Scale (VAS). This outcome showcased a considerable divergence in pain levels between the cohort administered with dexmedetomidine and the control group during the post-test period. Consequently, we are firmly positioned to affirm that the application of dexmedetomidine injections distinctly facilitated a significant alleviation of pain within the experimental group.[21]

In contrast to our own research, Ebru Tarýkçý Kýlýç and Gaye Aydýn's study found that using Dexmedetomidine during spinal anesthesia did not prolong postoperative effects or reduce the need for pain relief. They also discovered notable insights regarding the Ramsay Sedation Score, revealing a significant and distinct divergence in sedation levels based on the timing of dexmedetomidine administration during spinal anesthesia. This underlines the significant influence of dexmedetomidine on sedation, suggesting that its timing during the procedure can significantly impact patient sedation experiences. These insights enhance our understanding of how dexmedetomidine can modulate sedation levels during medical procedures.[22]

In a study examining the efficacy of multimodal and conventional approaches for mitigating postoperative pain among oral cancer patients, a noteworthy finding came to light concerning the need for postoperative analgesia. Specifically, the time at which the initial need for analgesia arose was markedly extended (with a p-value of 0.001) in Group C, which received dexmedetomidine, in comparison to both Group B and Group A. This finding suggests that patients in Group C experienced a delayed requirement for pain-relieving measures, indicating a potentially enhanced pain management effect associated with the administration of dexamethasone.[23]

The utilization of epidural dexmedetomidine infusion holds potential for abdominal cancer-related surgeries, possibly leading to a broader impact on clinical approaches. The gentle calming influence of dexmedetomidine might contribute to a reduction in postoperative restlessness, extended period before the initial analgesic administration, and diminished pain severity during the initial 48 hours following surgery, all without adverse effects on hemodynamic stability.[24]Choosing opioid-free anesthesia helps alleviate postoperative pain and minimize analgesic consumption, reducing typical opioid-related complications such as postoperative nausea and vomiting (PONV), with potential benefits extending into long-term outcomes.[25]Our study presents significant findings regarding the potential benefits of dexmedetomidine and lidocaine infusion in upper limb surgeries, but it is essential to acknowledge its limitations as well. The sample size determined at 90 patients undergoing upper limb procedures may introduce some limitations in the extent of our results to broader patient populations. While we did provide some demographic information; a more detailed exploration considering variables like medical history and surgical background could offer a deeper understanding of how these factors influence treatment responses in the population. An exciting avenue for development would be to investigate the combined use of dexmedetomidine and lidocaine, this approach could lead to better understanding of distinct impacts and potential synergies. More than that while our focus centred around upper limb surgeries other procedures involving general anaesthetics could be used in comparison to upgrade guidelines.

Limitations: This study was conducted in a single tertiary care hospital, that may limit the generalizability of the findings to the other institutions with different population of patients, surgical protocols, or anaesthesia practices. Also, it has relatively small sample size, as the inclusion of only 90 patients may not reflects the full variability of responses, particularly among the subgroups with the different surgical complexities. The exclusion of ASA III-IV patients, pregnant females, and the patients with significant organ dysfunction would not apply to high-risk or medically complex patients. This study assessed postoperative pain and analgesic requirements up to 24 hours only. The longer postoperative duration could provide more authentic and valuable information related to rebound pain, late analgesic needs or delayed adverse effects. The only individual drugs were compared. The synergistic impacts of combining dexmedetomidine and lidocaine, which is a relevant emerging trend in opoid-sparing anaesthesia, were not explored. The lack of blinding also considered one of the limitations, as the study design does not specify blinding of anaesthetists or outcome assessors. Knowledge of the administered drug may introduce observer bias, particularly in subjective measures such as pain scores and sedation levels. Sedation scores were evaluated but the other known side effects such as hypotension, PONV, bradycardia, neurotoxicity or lidocaine toxicity were not officially analyzed.

CONCLUSION

This study evaluated dexmedetomidine and lidocaine infusion efficacy as opioid alternatives for post-upper limb surgery pain control, emphasizing dexmedetomidine's benefits like improved hemodynamics, reduced pain, and lower analgesic needs.The findings align with existing evidence, endorsing dexmedetomidine for optimized pain management and highlight the potential for synergistic effects with lidocaine, encouraging further research in opioid-sparing approaches to contribute to the evolving medical landscape aiming to combat the opioid crisis and enhance pain management guidelines.

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Authors Contribution:
Komal Mumtaz: Contribution to study design, acquisition of data, has given final approval of the version to be published
Liaqat Ali: Substantial contribution to analysis and interpretation of data, has given final approval of the version to be published
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Malaika Nasir: Contribution to study design, acquision of data, has given final approval of the version to be published

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