RESEARCH
www.commprac.com
ISSN 1462 2815

PROSPECTIVE STUDY ON THE EFFECTIVENESS OF PAIN MANAGEMENT IN MULTIPLE RIB FRACTURE WITH USG GUIDED SERRATUS ANTERIOR PLANE BLOCK FOR PATIENTS PRESENTING IN EMERGENCY ROOM

T. Pooja Rani [1], Kandasamy Ganeshsankar [2], Melvin Dominic [3] Manickam Senthil Kumar [4] and R Srinivasan [5]*

[1] Postgraduate, Department of Emergency Medicine,
Vinayaka Missions Kirupanandha Variyar Medical College and Hospital,
Vinayaka Missions Research Foundation (Deemed to be University) Salem, Tamilnadu, India.
[2,3] Associate Professor, Department of Emergency Medicine,
Vinayaka Missions Kirupanandha Variyar Medical College and Hospital,
Vinayaka Missions Research Foundation (Deemed to be University) Salem, Tamilnadu, India.
[4] HOD & Professor, Department of Emergency Medicine,
Vinayaka Missions Kirupanandha Variyar Medical College and Hospital,
Vinayaka Missions Research Foundation (Deemed to be University) Salem, Tamilnadu, India.
[5] Assistant professor, Department of Emergency Medicine, Government Medical College, Namakkal, Tamilnadu, India. *Corresponding Author Email: drsrinivasan3@gmail.com

Abstract

Background: Rib fractures, resulting from traumatic events, frequently induce severe pain, which can precipitate impaired pulmonary function and subsequent complications. The imperative for efficacious analgesia in the emergency department is paramount; however, traditional opioid-centric regimens carry substantial risk profiles. This investigation explores the practicality and therapeutic potential of employing ultrasound-guided Serratus Anterior Plane Block (SAPB) as a novel analgesic technique for rib fracture discomfort within the emergency care context of India. **Methods:** In this prospective inquiry, we evaluated 53 adults with multiple rib fractures at Vinayaka Mission's Kirupananda Variyar Medical College and Hospital, Salem,Tamilnadu India. Each subject received SAPB under ultrasound navigation. We meticulously recorded the analgesic duration, pain relief quality, and hemodynamic parameters post-intervention. Pain intensity was quantified via a rigorously vetted scale, and the resultant data underwent statistical scrutiny utilizing both repeated measures ANOVA and the Friedman test. **Results:** Our findings indicate a statistically significant diminution in pain scores post-SAPB administration ($p < 0.001$), with over 64% of participants reporting extended analgesic benefit spanning 10-12 hours. Hemodynamic parameters remained stable throughout the observation period, with no adverse incidents documented. These results are congruent with extant literature, endorsing the consistent analgesic efficacy of SAPB in the context of rib fracture management. **Conclusion**: The ultrasound-facilitated SAPB emerges as a compelling and viable opioid alternative for the alleviation of pain associated with multiple rib fractures in the emergency department milieu. It ensures prolonged analgesia whilst preserving hemodynamic integrity. Prospective studies are advocated to corroborate the long-standing benefits and facilitate the seamless incorporation of SAPB into comprehensive pain management regimens for traumatic rib injuries.

Keywords: Ultrasound-guided Serratus Anterior Plane Block, SAPB, Rib Fracture Pain Management, Non-opioid Analgesia in Trauma Care, Hemodynamic Stability, Multimodal Pain Management for Rib Fractures

INTRODUCTION

Thoracic injuries represent a critical and perilous dimension within the spectrum of traumatic incidents, accounting for approximately 10–15% of all trauma cases and significantly contributing to trauma-related deaths by a substantial 25%. Set against the backdrop of India's healthcare framework, where a trauma-induced fatality occurs every 1.9 minutes, the urgent necessity for effective pain management solutions becomes strikingly apparent [1-4]. The origins of thoracic traumas are multifaceted, including blunt chest trauma from falls, vehicular collisions, occupational accidents, or

acts of violence, frequently leading to rib fractures that significantly impact patient outcomes. Traditionally, opioids have been pivotal in managing the pain associated with these injuries. Nonetheless, the significant adverse effects associated with opioids have spurred a noticeable shift towards multimodal analgesia strategies. In this evolving context, regional anesthesia techniques, particularly the serratus anterior plane block (SAPB), have risen in prominence as a viable alternative [5, 6], especially valued for its suitability in patients with multiple traumas, including those facing hemodynamic instability or coagulopathy, as it can be administered in a supine position [7-9].

Despite the potential of SAPB in thoracic trauma pain management, its efficacy and applicability within the dynamic and urgent milieu of emergency departments remain to be fully elucidated [10, 11]. This study seeks to address this gap by thoroughly investigating the analgesic efficacy and safety of ultrasound-guided SAPB in patients sustaining multiple rib fractures, even those necessitating the insertion of intercostal drains [12, 13].

The study is designed with several key objectives, including a comprehensive evaluation of analgesic effectiveness using visual numerical rating scales (NRS) for both static and dynamic pain contexts specific to SAPB. Moreover, it aims to determine the analgesia duration, assess the need for parenteral analgesics, and investigate potential complications associated with SAPB—vital for managing patients with multiple rib fractures and those requiring intercostal drainage insertion. Beyond these core goals, the study will also examine variations in hemodynamic parameters, like heart rate and mean arterial pressure, pre and post-SAPB administration [14, 15]. By extending its analysis to include rib fracture scores and thoracic trauma severity scores, the study aspires to offer a holistic view of SAPB's impact on patients with complex rib fractures, including those necessitating intercostal drainage [16, 17].

This rigorously designed investigation is poised to provide pivotal insights that could significantly refine pain management protocols for patients encountering thoracic injuries in emergency settings. By pursuing these comprehensive objectives, the study aims to elevate the collective understanding of SAPB's role in emergency care, thereby contributing to enhanced clinical outcomes in this critically important area.

MATERIALS AND METHODS

A prospective study was carried out at the Department of Emergency Medicine, Vinayaka Mission's Kirupananda Variyar Medical College and Hospital, Salem, Tamilnadu India. This study primarily targeted patients sustaining multiple rib fractures that necessitated intercostal drainage within the same hospital's Emergency Department. To ascertain the Sample Size, the investigation required 52 individuals for each group, a figure derived from previous research and accounting for potential non-participation. A convenience sampling strategy was employed to reach the target sample size.

The Study Period extended across one year, from January 2023 to December 2023. The Inclusion Criteria included individuals aged between 18 and 60, encompassing all genders, with a Body Mass Index (BMI) below 35 Kg/m^2. The Exclusion Criteria ruled out individuals not meeting the inclusion standards, those who declined participation, had allergies to local anesthetics, were diagnosed with coagulopathy, sepsis, were pregnant, had psychiatric conditions, significant cardiovascular, respiratory, renal, or

hepatic disorders, a history of seizures or neurological impairments, and vertebral anomalies.

Ethical Considerations and Participant Consent were meticulously observed, with the study receiving endorsement from the institutional ethics committee. Participants provided informed written consent, which outlined the voluntary basis of their involvement and detailed the potential risks and benefits associated with the study.

Data was meticulously gathered using a structured study proforma. Comprehensive investigations including Arterial Blood Gas (ABG) analysis, Chest X-Rays (CXR), and CT scans of the chest were conducted for all participants.

The SAPB necessitated specific Requirements: an ultrasound device, bupivacaine, a regional block needle, an intravenous cannula, monitoring apparatus, betadine, sterile gloves, surgical drapes, and chlorhexidine. During the Procedure, patients were positioned either supine or laterally, with the ultrasound guiding the parasagittal placement below the clavicle. The needling technique was carefully executed to identify the pleural space, with the needle's position verified through hydrodissection.

Post-Procedure Monitoring involved evaluating static and dynamic Numerical Rating Scale (NRS) scores, Heart Rate (HR), and Mean Arterial Pressure (MAP) before and after administering the block (at intervals of 2, 4, and 8 hours). Rescue analgesia was provided if the Visual Analog Scale (VAS) score surpassed 4. Potential Complications were diligently monitored, and rib fracture along with thoracic trauma scores were assessed using diagnostic investigations (CXR/CT chest, ABG) [18, 19].

STATISTICAL ANALYSIS

In the study, the statistical analysis was intricately designed to handle different types of data through appropriate statistical methods, ensuring a comprehensive understanding of the results. Categorical variables were analyzed by calculating their frequencies and proportions to understand the distribution of discrete data points such as demographics or binary outcomes. For continuous variables, such as physiological measurements, the analysis involved computing the mean and standard deviation, offering insights into the central tendency and variability within the data. Ordinal variables, representing ordered categories, were assessed using the median and interquartile range, which is crucial for data that does not fit a normal distribution or contains outliers. To explore the differences across multiple measurements or conditions, the study employed Repeated Measures ANOVA for normally distributed data and the Friedman test for ordinal or non-normal continuous data, focusing on whether changes over time or between groups were statistically significant. A p-value threshold of less than 0.05 was set to determine significance, indicating that observed differences were unlikely due to chance. These complex statistical procedures were carried out using RStudio Desktop Version 2022.07.0+492, a robust platform for statistical analysis and visualization, enabling the researchers to meticulously process and interpret the data, ensuring the reliability and validity of their findings. Through this rigorous statistical framework, the study aimed to provide clear, evidence-based conclusions drawn from a detailed and methodologically sound analysis.

RESULTS

Table 1 reveals a relatively balanced age distribution among the study participants, spanning across four distinct age brackets. Predominantly, the highest proportion of participants, accounting for 41.5%, falls within the 31 to 40 years age range. This is closely followed by those above 50 years, making up 26.4% of the population. The 41 to 50 years age bracket encompasses 20.8% of the subjects, while the youngest group, those at or below 30 years, constitutes 11.3%. However, it is crucial to acknowledge the modest sample size of this study, which comprises 53 individuals. This limitation suggests that the findings might not be extrapolatable to a broader demographic. Furthermore, the relatively wide intervals defining each age group complicate the process of identifying precise age-related patterns or trends within these categories.

Table 1: Age distribution in the study population (N=53)

Age group	Frequency	Percentage
30 years	6	11.30%
s31 to 40 years	22	41.50%
41 to 50 years	11	20.80%
>50 years	14	26.40%

The composition of the study's cohort was overwhelmingly male, accounting for 98.1% of participants, while females represented a mere 1.9%. This distribution might indicate a higher prevalence of rib fractures or the necessity for intercostal drainage among males compared to females. Nonetheless, it's critical to emphasize that these observations stem from a single study with a limited sample size, underscoring the need for further research to substantiate these preliminary findings. Additionally, the pronounced gender disparity observed within the study population could be attributed to various other factors, including differences in referral patterns or the distinct approaches adopted by men and women in seeking medical assistance (Table 2).

Table 2: Gender distribution in the study population (N=53)

Gender	Frequency	Percentage
Male	52	98.1
Female	01	1.9

In this study, road traffic accident (RTA) emerged as the predominant diagnosis, with an overwhelming 92.5% (49 out of 53) of participants identified with this condition (Table 3). This observation intimates that RTA could play a significant role as an underlying factor in cases of rib fractures and the requirement for intercostal drainage within the emergency department context. Nonetheless, it's crucial to recognize that these findings are derived from a singular study characterized by a relatively small cohort, highlighting the necessity for further investigation to corroborate this association.

The absence of a control group within the study design further complicates the ability to definitively assert the prevalence of RTA among patients experiencing rib fractures and necessitating intercostal drainage, in comparison to the general populace. While the data hints at a potential correlation between RTA and these specific medical interventions, conclusive evidence necessitates additional, more comprehensive research to establish a firm conclusion.

Table 3: Diagnosis in the study population (N=53)

Diagnosis	Frequency	Percentage
RTA	49	92.5
Accidental fall	01	1.9
Assault with chest trauma	01	1.9
Self-fall	01	1.9
Self-fall with chest trauma	01	1.9

The Numerical Rating Scale (NRS) score, utilized to quantify pain intensity, exhibited a marked decrease following the administration of the SAPB, evident at all evaluated intervals (2, 4, and 8 hours post-procedure). This indicates the block's efficacy in alleviating pain for patients suffering from rib fractures and requiring intercostal drainage.

Specifically, the median NRS score observed prior to the block application was 7, which significantly dropped to a median score of 3 post-block across the aforementioned time frames, equating to a 57% reduction in pain intensity. The statistical analysis underscored this outcome, with a p-value of less than 0.001 for the NRS score comparisons pre and post-block at all measured points, affirming the significance of the pain relief achieved as not merely coincidental.

Notably, the analysis also revealed no substantial variance in NRS scores at the different post-block time points (2, 4, and 8 hours), suggesting that the analgesic effect of the block was maintained throughout the 8-hour observation period.

Table 4 elucidates the potent analgesic impact of ultrasound-guided SAPB on pain mitigation for patients with rib fractures and intercostal drainage in the emergency setting, highlighting sustained pain relief over the evaluated duration. However, it's imperative to consider the study's constraints, such as the limited participant number, which calls for further exploration to reinforce these preliminary results. Additionally, the lack of a control group restricts the ability to make absolute comparisons to alternative pain management approaches. Despite these considerations, the encouraging outcomes position SAPB as a potentially invaluable resource for emergency care practitioners aiming to enhance pain control for affected patients.

Table 4: Comparison of NRS score static at different time period of SAP block

Time	NRS score static (Median IQR)	P-Value (Friedman test)	P-Value (Bonferroni post-hoc test)		
			Before block Vs. After 2 hrs of Block	Before block Vs. After 4 hrs of Block	Before block Vs. After 8 hrs of Block
Before block	7 (6, 7)	<0.001	<0.001	<0.001	<0.001
After 2 hours of block	3 (3, 4)				
After 4 hours of block	3 (3, 4)				
After 8 hours of block	3 (3, 4)				

Table 5 reveals that there was a statistically significant variance in the dynamic NRS scores over different time intervals following the administration of the SAP block, with a p-value of less than 0.05. This indicates that the median dynamic NRS scores observed at various time points post-SAP block administration varied significantly. Utilizing the Bonferroni post-hoc analysis, it was determined that the dynamic NRS scores prior to the SAP block were significantly higher compared to those recorded at 2 hours, 4 hours, and 8 hours following the SAP block, all with p-values less than 0.05. This demonstrates the effectiveness of the SAP block in consistently reducing the

dynamic NRS scores across all measured time points subsequent to its application. Essentially, the SAP block has proven its efficacy in diminishing the intensity of pain as measured by dynamic NRS scores at various intervals post-administration, underscoring its potential as a reliable method for pain management in relevant clinical scenarios.

Table 5: Comparison of NRS score dynamic at different time period of SAP block

Time	NRS score static (Median IQR)	P-Value (Friedman test)	P-Value (Bonferroni post-hoc test)		
			Before block Vs. After 2 hrs of Block	Before block Vs. After 4 hrs of Block	Before block Vs. After 8 hrs of Block
Before block	7 (6, 8)	<0.001	<0.001	<0.001	<0.001
After 2 hours of block	4 (3, 4)				
After 4 hours of block	3 (3, 4)				
After 8 hours of block	4 (3, 4)				

The SAP block proved to be a potent modality for diminishing heart rate. A marked and statistically significant reduction was observed, with the average heart rate falling from 102.87 (±9.22) beats per minute pre-SAP block to 91.00 (±7.34) beats per minute after 8 hours post-application of the SAP block ($p<0.05$). This decline in heart rate was consistently significant across all measured intervals following the SAP block application, showcasing the most notable effect after the initial 2 hours, yet maintaining its efficacy through the 8-hour mark (Table 6).

These findings position the SAP block as a potentially impactful strategy for heart rate management in individuals experiencing chronic pain, potentially contributing to enhanced cardiovascular health within this demographic. Nonetheless, given that the SAP block represents a comparatively novel approach, further investigations are imperative to ascertain its long-term safety and effectiveness.

It's critical to recognize that the SAP block serves as a palliative, rather than curative, treatment for chronic pain. Its primary function is to alleviate discomfort and augment the quality of life, rather than provide a definitive cure for chronic pain conditions.

Table 6: Comparison of heart rate at different time period of block

Time	Heart rate (Beats/min) Mean±SD	P-Value (Repeated measures of ANOVA)	P-Value (Bonferroni post-hoc test)		
			Before block Vs. After 2 hrs of Block	Before block Vs. After 4 hrs of Block	Before block Vs. After 8 hrs of Block
Before block	102.87±9.22	<0.001	<0.001	<0.001	<0.001
After 2 hours of block	94.91±7.06				
After 4 hours of block	92.06±6.29				
After 8 hours of block	91.00±7.34				

Table 7 presents a comparison of Mean Arterial Pressure (MAP) before and after the administration of the Serratus Anterior Plane (SAP) block at various intervals. The data indicates a significant reduction in the mean MAP at all measured points following the SAP block when compared to its levels prior to the intervention. Notably, the mean MAP experienced a substantial decrease from 100.40 (±8.41) mmHg before the SAP block to 91.53 (±8.61) mmHg eight hours post-administration ($p<0.05$). This significant

reduction in MAP was consistent across all subsequent time points after the SAP block was applied.

The observed decrease in MAP can be attributed to the vasodilatory effects of the SAP block. By inhibiting the sympathetic nerves that innervate the blood vessels, the SAP block induces relaxation and dilation of these vessels. Such vasodilation lowers the resistance against blood flow, thereby reducing blood pressure.

The reduction in MAP is generally viewed as a positive outcome of the SAP block, facilitating improved blood flow and enhanced oxygen delivery to the tissues. However, it is crucial to meticulously monitor patients for potential hypotension, particularly following the initiation of the SAP block.

Given that the SAP block is a relatively recent therapeutic approach, additional research is necessary to fully establish its long-term safety and effectiveness. It's important to emphasize that the SAP block does not serve as a cure for chronic pain but rather as a palliative measure that can significantly alleviate pain and enrich the quality of life for those affected.

Table 7: Comparison of MAP at different time period of SAP block

Time	MAP (mm Hg) Mean±SD	P-Value (Repeated measures of ANOVA)	P-Value (Bonferroni post-hoc test)		
			Before block Vs. After 2 hrs of Block	Before block Vs. After 4 hrs of Block	Before block Vs. After 8 hrs of Block
Before block	100.40±8.41	<0.001	<0.001	<0.001	<0.001
After 2 hours of block	95.77±7.83				
After 4 hours of block	93.35±8.03				
After 8 hours of block	91.530±8.61				

The efficacy of the SAP block in providing analgesia within this study's cohort was observed to span between 5 to 12 hours. A significant proportion of the participants (64.2%) reported experiencing relief from pain for a duration ranging from 10 to 12 hours, whereas 35.8% of the patients benefited from pain alleviation for 5 to 9 hours (Table 8). These results highlight the SAP block as an enduring analgesic technique, which harbors the capability to diminish the need for opioids and enhance patient outcomes across diverse medical environments.

The outcomes of this research align with the findings from other investigations into the analgesic duration afforded by the SAP block. For instance, a notable study identified that the SAP block extended pain relief for an average of 10 hours among patients undergoing knee arthroscopy.

Although the SAP block emerges as a relatively recent therapeutic approach, further studies are imperative to validate its sustained safety and effectiveness across varied patient demographics. Nevertheless, the insights gained from this study underscore the SAP block's potential as an instrumental strategy for pain management in numerous clinical scenarios.

Table 8: Duration of analgesia in SAP block among the study population

Duration of analgesia	Frequency	Percentage
5 to 9 hours	19	35.8
10 to 12 hours	34	64.2

The Table 9 presents the distribution of rib fracture scores within the study cohort. A majority of the participants (49.1%) exhibited a rib fracture score ranging from 1 to 3, denoting relatively minor injuries. Nonetheless, a considerable segment of the cohort experienced more severe rib fractures, with scores of 4 or higher, accounting for 37.7% of the population (22.6% + 15.1%).

These findings align with prior research, which indicates that a significant number of individuals with rib fractures sustain moderate to severe injuries. Patients with elevated rib fracture scores are at an augmented risk of encountering complications such as pneumonia, acute respiratory distress syndrome, and flail chest.

Hence, it is imperative to meticulously evaluate all patients with rib fractures, irrespective of their initial rib fracture score. Those with higher scores should be vigilantly monitored for complications and provided with appropriate supportive care.

The rib fracture score serves as a valuable instrument for gauging the severity of rib fractures and forecasting the likelihood of complications. However, it is crucial to acknowledge that the rib fracture score is not an infallible predictor of outcomes. Some patients with low rib fracture scores may still develop serious complications, whereas others with high rib fracture scores may only suffer mild injuries. The management of rib fractures is contingent upon the injury's severity and the presence of any concomitant complications. Patients with minor rib fractures may be treated conservatively with analgesics and rest. Those with more severe rib fractures or accompanying complications may necessitate hospitalization and more intensive therapy.

Table 9: Rib fracture score among the study population

Rib fracture score	Frequency	Percentage
0	07	13.2
1 to 3	26	49.1
4 to 6	12	22.6
7 to 10	08	15.1

The Thoracic Trauma Severity Score (TTSS) serves as an instrument to evaluate the severity of thoracic injuries. The TTSS spans from 1 to 25, where higher scores denote more severe injuries. According to the table, a majority of the participants in the study cohort had a TTSS ranging from 4 to 6 (54.72%), indicating moderate injuries. Additionally, a significant portion of patients had either minor injuries (22.64% with a TTSS of 1 to 3) or severe injuries (22.64% with a TTSS of 7 to 9) (Table 10).

These results are in line with other research, which suggests that a substantial number of individuals with thoracic injuries suffer from moderate to severe injuries. Patients with elevated TTSS scores are at a heightened risk of encountering complications such as pneumonia, acute respiratory distress syndrome, and flail chest. Consequently, it is crucial to thoroughly evaluate all patients with thoracic injuries, regardless of their initial TTSS score. Those with higher TTSS scores should be vigilantly monitored for complications and provided with appropriate supportive care.

The TTSS is a valuable tool for assessing the severity of thoracic injuries and forecasting the risk of complications. However, it is essential to recognize that the TTSS is not an infallible predictor of outcomes. Some patients with low TTSS scores may still develop serious complications, whereas others with high TTSS scores may only suffer mild injuries.

The management of thoracic injuries is contingent upon the injury's severity and the presence of any concomitant complications. Patients with minor thoracic injuries may be treated conservatively with analgesics and rest. Those with more severe thoracic injuries or accompanying complications may necessitate hospitalization and more intensive therapy.

Table 10: Thoracic trauma severity score among the study population

Thoracic Trauma Severity Score	Frequency	Percentage
1 to 3	12	22.64
4 to 6	29	54.72
7 to 09	12	22.64

DISCUSSION

The conducted research provides comprehensive insights into the efficacy of SAPB as a method for pain management in patients with rib fractures [21, 22]. The study reveals that SAPB yields adequate analgesia, with a significant reduction in pain intensity observed within 2 hours of administration. This reduction persists for up to 8 hours, as evidenced by both dynamic and static scores on the NRS. The duration of analgesia within the study population ranged from 5 to 12 hours, establishing the sustained efficacy of SAPB [23, 24].

Post-block, all patients exhibited sinus rhythm and normotension, indicating the hemodynamic stability achieved through SAPB administration. The ultrasound-guided SAPB technique emerges as a promising and relatively novel approach, providing almost complete analgesia of the hemithorax. Notably, the procedure poses minimal risk, lacking significant adverse effects or contraindications [25, 26). This feature positions SAPB as a safe and accessible alternative, particularly beneficial for polytrauma patients experiencing hemodynamic instability or coagulopathy, distinguishing it from procedures such as epidural and paravertebral blocks.

The study encompassed 53 individuals, with ages ranging from 16 to 59 years. The majority fell within the 31 to 40 years age group, and males constituted 98.1% of the population. The predominant cause of rib fractures was road traffic accidents (RTA), accounting for 92.5% of cases, followed by accidental falls, assault with chest trauma, self-fall, and self-fall with chest trauma [27, 28). These findings align with the broader context where rib fractures are most common in men and younger individuals, often resulting from direct impacts such as motor vehicle accidents and falls.

The study employed the NRS as a pain screening tool, with scores ranging from 0 to 10, where 0 represents no pain and 10 signifies the worst pain. Statistical analysis revealed a significant reduction in both NRS static and dynamic scores post-SAPB administration at various time intervals, highlighting the effectiveness of the intervention in alleviating pain [29, 30]. Hemodynamic stability was assessed through heart rate and mean arterial pressure measurements. Despite a slightly elevated heart rate before the block, patients-maintained sinus rhythm throughout the 2-hour, 4-hour, and 8-hour post-block periods. Mean arterial pressure remained within the normotensive range after the block, further indicating the positive impact of SAPB on hemodynamic stability.

The study emphasizes the crucial role of SAPB in pain management, with its analgesic effect extending up to 12 hours. The calculated rib fracture score and thoracic trauma

severity score further contribute to the overall understanding of the patient condition, revealing that the majority of patients experienced mild to moderate severity of rib fractures and thoracic trauma [31]. Comparative analysis with existing studies reinforces the reliability and consistency of SAPB as a pain management technique. The present study aligns with previous research in terms of pain reduction, absence of complications, and sustained analgesic effects. The detailed examination of related studies underscores the robustness of the findings and positions SAPB as a viable and effective intervention for managing pain associated with rib fractures. SAPB provided significant pain relief in all studies included in the table. The mean or median NRS score decreased after SAPB in all studies, ranging from a 1-point decrease to a 6-point decrease. The current study showed that SAPB provided a median pain reduction of 4 points after 2 hours. This is comparable to the pain reduction reported in other studies, such as the study by Kring et al.(2022) which showed a median pain reduction of 5 points after 60 minutes. The duration of analgesia also varied across studies, ranging from 5 to 12 hours. However, the majority of studies reported a duration of analgesia of at least 8 hours. The evidence suggests that SAPB is an effective and safe intervention for managing pain in patients with rib fractures. It provides significant pain relief with a favourable duration of analgesia [41].

Table 11: Comparison of pain scores before and after SAPB in different studies

STUDY	NRS SCORE (MEAN OR MEDIAN) BEFORE SAPB	NRS SCORE (MEAN OR MEDIAN) AFTER SAPB
Current study	7 (median)	3 (median)
Kring et al (2022)	8-9	0-4
Schnekenburger et al (2021)	6.5 (mean)	3 (mean)
Diwan et al (2021)	1-3 (mean)	NA
Durant et al (2021)	8.5	1
Martinez et al (2020)	7.3	4
Paul et al (2020)	9	2.1

CONCLUSION

In this study, the effectiveness and safety of ultrasound-guided SAPB for managing pain in individuals with rib fractures were systematically investigated. The study encompassed 53 patients, predominantly male (98.1%) with an average age of 41

57 years, providing a comprehensive assessment of SAPB's impact on pain relief, duration of analgesia, hemodynamic stability, and overall safety. A significant finding was the substantial pain relief achieved through SAPB, evidenced by a median Numeric Rating Scale (NRS) score reduction of 4 points after 2 hours, which persisted up to 8 hours post-administration. The duration of analgesia varied between 5 to 12 hours, with a noteworthy proportion of patients experiencing 10 to 12 hours of sustained pain relief.

Importantly, SAPB ensured hemodynamic stability, maintaining patients in sinus rhythm with normal heart rates and mean arterial pressure after the block. The absence of adverse effects or complications further emphasized the safety profile of SAPB. This study underscores the importance of SAPB as a secure and effective intervention for managing pain in rib fracture patients. Its capacity to deliver substantial pain relief, along with a commendable duration of analgesia and an excellent safety

profile, positions SAPB as a valuable tool for enhancing patient comfort and overall outcomes in this specific population.

Highlighted demographic characteristics, including the predominance of males and the common occurrence of rib fractures due to road traffic accidents, provide additional context to the study's findings. The rib fracture score distribution, ranging from 0 to 10, elucidates that the majority of patients experienced mild to moderate severity, with scores falling within the 1 to 3 range.

Looking ahead, further research endeavors are warranted to validate the long-term efficacy and safety of SAPB for rib fracture pain management. Exploring potential synergies between SAPB and other pain management modalities could yield valuable insights into comprehensive treatment approaches. Additionally, investigating the cost-effectiveness of SAPB relative to alternative pain management interventions holds the potential to inform healthcare providers in optimizing patient care strategies. In essence, while this study establishes a robust foundation, ongoing research efforts are imperative to enhance our understanding and optimize the integration of SAPB into the broader spectrum of rib fracture pain management.

Acknowledgments:

The authors would like to thank all of the study participants and the administration of Department of Emergency Medicine, Vinayaka Mission's Kirupananda Variyar Medical College and Hospital, Salem, Tamilnadu India for granting permission to carry out the research work.

Ethical statement:

Institutional ethical committee accepted this study. The study was approved by the institutional human ethics committee, Vinayaka Mission's Kirupananda Variyar Medical College and Hospital, Salem, Tamilnadu India (VMKVMC&H/IEC/22/176 Dated: 08-06-2022). Informed written consent was obtained from all the study participants and only those participants willing to sign the informed consent were included in the study. The risks and benefits involved in the study and the voluntary nature of participation were explained to the participants before obtaining consent. The confidentiality of the study participants was maintained.

Authors' contributions:

T. Pooja rani and R Srinivasan - conceptualization, data curation, investigation, methodology, project administration, visualization, writing—original draft, writing—review and editing; ***Kandasamy ganeshsankar*** -conceptualization, methodology, writing—original draft, writing—review and editing; ***Melvin Dominic*** - conceptualization, visualization, supervision, writing—original draft; ***Manickam senthilkumar*** - methodology, writing—original draft, writing, review and editing. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work. All authors have read and agreed to the published version of the manuscript***.***

Data Avaılabılıty:

All datasets generated or analyzed during this study are included in the manuscript.

Informed Consent:

Written informed consent was obtained from the participants before enrolling in the study

Funding sources: None

Conflict of Interest: None

Reference

1) Ziegler, D. W., & Agarwal, N. N. (1994). The morbidity and mortality of rib fractures. Journal of Trauma, 37(6), 975-979.

2) Kant, K. C., Kant, K. S., & Noman, M. (2020). A study to evaluate the clinico-etiologic profile and management of patients with trauma to the chest in a tertiary care Hospital. European Journal of Molecular and Clinical Medicine, 7(08), 2020.

3) Witt, C. E., & Bulger, E. M. (2017). Comprehensive approach to the management of the patient with multiple rib fractures: a review and introduction of a bundled rib fracture management protocol. Trauma Surgery & Acute Care Open, 2(1), e000064.

4) Ekpe, E. E., & Eyo, C. (2016). Overview of blunt chest injury with multiple rib fractures. British Journal of Medical and Medical Research, 12, 1-15.

5) El-Boghdadly, K., Pawa, A., & Chin, K. J. (2018). Local anesthetic systemic toxicity: current perspectives. Local and Regional Anesthesia, 11, 35-44.

6) Graeber, G. M., & Nazim, M. (2007). The anatomy of the ribs and the sternum and their relationship to chest wall structure and function. Thoracic Surgery Clinics, 17(4), 473-489.

7) Bulger, E. M., Arneson, M. A., Mock, C. N., & Jurkovich, G. J. (2000). Rib fractures in the elderly. Journal of Trauma, 48(6), 1040-1047.

8) Sajjan, S. G., Barrett-Connor, E., McHorney, C. A., Miller, P. D., Sen, S. S., & Siris, E. (2012). Rib fracture as a predictor of future fractures in young and older postmenopausal women: National Osteoporosis Risk Assessment (NORA). Osteoporosis International, 23(3), 821-828.

9) Hernlund, E., Svedbom, A., Ivergård, M., Compston, J., Cooper, C., Stenmark, J., et al. (2013). Osteoporosis in the European Union: medical management, epidemiology and economic burden. A report prepared in collaboration with the International Osteoporosis Foundation (IOF) and the European Federation of Pharmaceutical Industry Associations (EFPIA). Archives of Osteoporosis, 8(1), 136.

10) Henry, T. S., Donnelly, E. F., Boiselle, P. M., Crabtree, T. D., Iannettoni, M. D., Johnson, G. B., et al. (2019). ACR Appropriateness Criteria(®) Rib Fractures. Journal of the American College of Radiology, 16(5S), S227-S234.

11) Boele van Hensbroek, P., Mulder, S., Luitse, J. S. K., van Ooijen, M. R., & Goslings, J. C. (2009). Staircase falls: high-risk groups and injury characteristics in 464 patients. Injury, 40(8), 884-889.

12) Sirmali, M., Türüt, H., Topçu, S., Gülhan, E., Yazici, Ü., Kaya, S., et al. (2003). A comprehensive analysis of traumatic rib fractures: morbidity, mortality and management. European Journal of Cardio-Thoracic Surgery, 24(1), 133-138.

13) Peek, J., Beks, R. B., Hietbrink, F., De Jong, M. B., Heng, M., Beeres, F. J. P., et al. (2022). Epidemiology and outcome of rib fractures: a nationwide study in the Netherlands. European Journal of Trauma and Emergency Surgery, 48(1), 265-271.

14) Park, K. (2002). Accidents. Textbook of Social and Preventive Medicine, 17, 304-305.

15) Dalal, S., Nityasha, V. M., & Dahiya, R. (2008). Prevalence of chest trauma at an apex institute of North India: a retrospective study. Internet Journal of Surgery, 18(1), 1-5.

16) Cogbill, T. H., Moore, E. E., Millikan, J. S., & Cleveland, H. C. (1983). Rationale for selective application of Emergency Department thoracotomy in trauma. Journal of Trauma, 23(6), 453-460.

17) Pettiford, B. L., Luketich, J. D., & Landreneau, R. J. (2007). The management of flail chest. Thoracic Surgery Clinics, 17(1), 25-33.

18) Assi, A.-A. N., & Nazal, Y. (2012). Rib fracture: Different radiographic projections. Polish Journal of Radiology, 77(4), 13-16.

19) Hwang, E. G., & Lee, Y. (2014). Effectiveness of intercostal nerve block for management of pain in rib fracture patients. Journal of Exercise Rehabilitation, 10(4), 241-244.

20) Doben, A. R., Eriksson, E. A., Denlinger, C. E., Leon, S. M., Couillard, D. J., Fakhry, S. M., et al. (2014). Surgical rib fixation for flail chest deformity improves liberation from mechanical ventilation. Journal of Critical Care, 29(1), 139-143.

21) Pieracci, F. M., Coleman, J., Ali-Osman, F., Mangram, A., Majercik, S., White, T. W., et al. (2018). A multicenter evaluation of the optimal timing of surgical stabilization of rib fractures. Journal of Trauma and Acute Care Surgery, 84(1), 1-10.

22) Rostas, J. W., Lively, T. B., Brevard, S. B., Simmons, J. D., Frotan, M. A., & Gonzalez, R. P. (2017). Rib fractures and their association With solid organ injury: higher rib fractures have greater significance for solid organ injury screening. American Journal of Surgery, 213(4), 791-797.

23) He, Z., Zhang, D., Xiao, H., Zhu, Q., Xuan, Y., Su, K., et al. (2019). The ideal methods for the management of rib fractures. Journal of Thoracic Disease, 11(Suppl 8), S1078-S1089.

24) May, L., Hillermann, C., & Patil, S. (2016). Rib fracture management. BJA Education, 16(1), 26-32.

25) Peek, J., Smeeing, D. P. J., Hietbrink, F., Houwert, R. M., Marsman, M., & de Jong, M. B. (2019). Comparison of analgesic interventions for traumatic rib fractures: a systematic review and meta-analysis. European Journal of Trauma and Emergency Surgery, 45(4), 597-622.

26) Yeh, D. D., Kutcher, M. E., Knudson, M. M., & Tang, J. F. (2012). Epidural analgesia for blunt thoracic injury--which patients benefit most? Injury, 43(10), 1667-1671.

27) Haefeli, M., & Elfering, A. (2006). Pain assessment. European Spine Journal, 15(Suppl 1), S17-S24.

28) Truitt, M. S., Mooty, R. C., Amos, J., Lorenzo, M., Mangram, A., & Dunn, E. (2010). Out with the old, in with the new: a novel approach to treating pain associated with rib fractures. World Journal of Surgery, 34(10), 2359-2362.

29) Kumar, G., Kumar Bhoi, S., Sinha, T. P., & Paul, S. (2020). Erector spinae plane block for multiple rib fracture done by an Emergency Physician: A case series. Australasian Journal of Ultrasound in Medicine, 24(1), 58-62.

30) Elwen, F., Desai, N., Parras, T., Blanco, R., & Duran, J. (2020). Serratus Plane Block. Regional Anaesthesia, 45(June), 1-8.

31) Smith, R. J., Nyquist-Battie, C., Clark, M., & Rains, J. (2003). Anatomical characteristics of the upper serratus anterior: cadaver dissection. Journal of Orthopaedic & Sports Physical Therapy, 33(8), 449-454.

32) Mayes, J., Davison, E., Panahi, P., Patten, D., Eljelani, F., Womack, J., et al. (2016). An anatomical evaluation of the serratus anterior plane block. Anaesthesia, 71(9), 1064-1069.

33) Southgate, S. J., & Herbst, M. K. (2021). Ultrasound Guided Serratus Anterior Blocks. In StatPearls. Retrieved from https://www.ncbi.nlm.nih.gov/books/NBK538476/

34) Saad, F. S., El Baradie, S. Y., Abdel Aliem, M. A. W., Ali, M. M., & Kotb, T. A. M. (2018). Ultrasound-guided serratus anterior plane block versus thoracic paravertebral block for perioperative analgesia in thoracotomy. Saudi Journal of Anaesthesia, 12(4), 565-570.

35) Blanco, R., Parras, T., McDonnell, J. G., & Prats-Galino, A. (2013). Serratus plane block: a novel ultrasound-guided thoracic wall nerve block. Anaesthesia, 68(11), 1107-1113.

36) Wildgaard, K., Petersen, R. H., Hansen, H. J., Møller-Sørensen, H., Ringsted, T. K., & Kehlet, H. (2012). Multimodal analgesic treatment in video-assisted thoracic surgery lobectomy using an intraoperative intercostal catheter. European Journal of Cardio-Thoracic Surgery, 41(5), 1072-1077.

37) Xie, C., Ran, G., Chen, D., & Lu, Y. (2021). A narrative review of ultrasound-guided serratus anterior plane block. Annals of Palliative Medicine, 10(1), 700-706.

38) Gupta, A., Ahmed, A., & Malviya, A. K. (2022). Bilateral continuous serratus anterior plane block: An effective alternative for bilateral multiple rib fracture analgesia. Turkish Journal of Emergency Medicine, 22(1), 51-53.

39) Camacho, F. C. de O., & Segura-Grau, E. (2019). Continuous serratus anterior plane block provides analgesia in multiple rib fractures: a case report. Brazilian Journal of Anesthesiology, 69(1), 87-90.

40) Nair, A., & Diwan, S. (2022). Efficacy of Ultrasound-Guided Serratus Anterior Plane Block for Managing Pain Due to Multiple Rib Fractures: A Scoping, Cureus. 2022;14(1):e21322.

41) Kring, R. M., Mackenzie, D. C., Wilson, C. N., Rappold, J. F., Strout, T. D., & Croft, P. E. (2022). Ultrasound-Guided Serratus Anterior Plane Block (SAPB) Improves Pain Control in Patients With Rib Fractures. Journal of Ultrasound in Medicine.

42) El Malla, D. A., Helal, R. A. E. F., Zidan, T. A. M., & El Mourad, M. B. (2022). The Effect of Erector Spinae Block versus Serratus Plane Block on Pain Scores and Diaphragmatic Excursion in Multiple Rib Fractures: A Prospective Randomized Trial. Pain Medicine, 23(3), 448-455.

43) Schnekenburger, M., Mathew, J., Fitzgerald, M., Hendel, S., Sekandarzad, M. W., & Mitra, B. (2021). Regional Anaesthesia for Rib Fractures: A Pilot Study of Serratus Anterior Plane Block. Emergency Medicine Australasia, 33(5), 788-793.

44) D'Errico, C., Sellini, M., Cafiero, T., Romano, G. M., & Frangiosa, A. (2022). Successful Weaning from Mechanical Ventilation after Serratus Anterior Plane Block in a Chest Trauma Patient. Scandinavian Journal of Pain, 22(2), 417-420.

45) Bhalla, P. I., Solomon, S., Zhang, R., Witt, C. E., Dagal, A., & Joffe, A. M. (2021). Comparison of Serratus Anterior Plane Block with Epidural and Paravertebral Block in Critically Ill Trauma Patients with Multiple Rib Fractures. Trauma Surgery & Acute Care Open, 6(1), e000621.

46) Paul, S., Bhoi, S. K., Sinha, T. P., & Kumar, G. (2020). Ultrasound-Guided Serratus Anterior Plane Block for Rib Fracture-Associated Pain Management in Emergency Department. Journal of Emergency Trauma and Shock, 13(3), 208-212.

47) Lin, J., Hoffman, T., Badashova, K., Motov, S., & Haines, L. (2020). Serratus Anterior Plane Block in the Emergency Department: A Case Series. Clinical Practice Cases in Emergency Medicine, 4(1), 21-25.

48) Tekşen, Ş., Öksüz, G., Öksüz, H., Sayan, M., Arslan, M., & Urfalıoğlu, A., et al. (2021). Analgesic Efficacy of the Serratus Anterior Plane Block in Rib Fractures Pain: A Randomized Controlled Trial. The American Journal of Emergency Medicine, 41, 16-20.

49) Eid, M., Nassr, M., & Aziz, A. (2014). Serratus Anterior Plane Block for Flail Chest Injury. Anaesthesia Cases, 2(1), 140-143.

50) Diwan, S., & Nair, A. (2021). A Retrospective Study Comparing Analgesic Efficacy of Ultrasound-Guided Serratus Anterior Plane Block versus Intravenous Fentanyl Infusion in Patients with Multiple Rib Fractures. Journal of Anaesthesiology Clinical Pharmacology, 37(3), 411-415.

51) Durant, E., Dixon, B., Luftig, J., Mantuani, D., & Herring, A. (2017). Ultrasound-Guided Serratus Plane Block for ED Rib Fracture Pain Control. The American Journal of Emergency Medicine, 35(1), 197.e3-197.e6.

52) Martinez, T., Belveyre, T., Lopez, A., Dunyach, C., Bouzit, Z., & Dubreuil, G., et al. (2020). Serratus Plane Block is Effective for Pain Control in Patients with Blunt Chest Trauma: A Case Series. Pain Practice, 20(2), 197-203.

53) Rose, P., Ramlogan, R., Madden, S., & Lui, A. (2019). Serratus Anterior Plane Block Home Catheter for Posterior Rib Fractures and Flail Chest. Canadian Journal of Anesthesia, 66(8), 997-998.