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Effect of Transversus Abdominis Plane Block for Postoperative Analgesia after Caesarean Section on the Recovery from General Anesthesia

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Abstract: Background: Anesthesiologists widely acknowledge that pain plays a critical role in recovery, albeit with a complex relationship to consciousness. While inadequate pain management may accelerate the recovery of consciousness, it can also provoke agitation in patients with impaired consciousness. Effective pain relief, such as through regional anesthetic techniques, can potentially lower the level of consciousness, particularly when long-acting analgesic medications are already in use. **Aim**: To evaluate the effect of pain relief by TAP block after caesarean section on the duration and quality of recovery from general anesthesia. **Patients and Methods:** This single-blinded clinical trial involved 60 pregnant women undergoing elective cesarean sections at the Diwaniyah Teaching Center from April to December 2024. Participants were randomly assigned to either the TAP block group (n = 30) or the control group (n = 30). Demographic data, extubation times, pain scores (using the Visual Analog Scale), rescue analgesia requirements, and hemodynamic parameters were recorded. The TAP block was administered bilaterally using 10 mL of plain Marcaine with dexamethasone and saline under ultrasound guidance. Data were analyzed using t-tests and chi-squared tests, with a significance threshold of $p < 0.05$. **Results:** The TAP block group exhibited significantly shorter extubation times (4.5 ± 1.8 minutes vs. 6.9 ± 1.8 minutes, $p < 0.001$) and consistently lower pain scores at 10, 20, and 30 minutes post-extubation ($p < 0.001$ for all intervals). Rescue analgesia was needed in only 13.3% of TAP patients, compared to 60% in the control group ($p < 0.001$). Hemodynamic parameters, including systolic blood pressure and respiratory rate, were more stable in the TAP group during recovery. However, the total recovery time from the last muscle relaxant to extubation was comparable between groups ($p = 0.4$). **Conclusion:** The TAP block significantly reduces postoperative pain and analgesic requirements while enhancing hemodynamic stability and recovery after cesarean sections under general anesthesia. These findings support its routine integration into multimodal analgesia strategies to improve maternal outcomes. Further studies are warranted to standardize protocols and evaluate long-term benefits.

Keywords: Transversus Abdominis Plane Block, Cesarean Section, Postoperative Analgesia, General anesthesia.

INTRODUCTION

Pain is a potent stimulus to the CNS, but its effect on level of consciousness is complex. In the presence of inadequate analgesia it has the potential to speed recovery of conscious level but can also increase agitation in patients with depressed consciousness. Successful treatment of pain, such as with an effective regional anesthetic technique, may cause a reduction in the conscious level if long-acting analgesic drugs have already been administered.(Thompson, J. *et al*., 2019)

Post-operative pain control is one of the most important duting because it enhances patients' comfort and it reduce potential for causing harmful effects since the beginning of practice. Caesarean section is one of the most commonly performed surgical procedures. It is estimated that 15% of the births worldwide and 21.1% of the births in the developed world occur by caesarean section.(Buluc, H. *et al*., 2019)

Postoperative pain following a CS can impede recovery, patient satisfaction, successful breastfeeding, and mother-child bonding. In the long term, it may lead to hyperalgesia and chronic postoperative pain. Neglecting pain management can have adverse effects on various systems, including the neuroendocrine, cardiovascular, respiratory, digestive, and central nervous systems.(Borges, N.C. *et al*., 2016)

Various treatments are available for post-CS pain management, but a standardized guideline remains elusive. These treatments include systemic and intrathecal opioid administration, patient-controlled analgesia, intramuscular injection of non-steroidal anti-inflammatories (NSAIDs), and regional nerve blocks. Often, these methods are part of multimodal analgesia, offering combined pain relief with potential side effects. (Gamez, B.H. *et al*., 2018)

Rafi first described the TAP block in 2001, He portrayed TAP block as a refined abdominal field block, with a targeted single shot anesthetic delivery into the TAP, a site which relevant nerve branches are located.

The TAP block can be used for postoperative analgesia management in open and laparoscopic abdominal surgeries and inpatient and outpatient surgical procedures. (Thompson, J. *et al*., 2019) Unilateral left- or right-sided blocks are used for

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unilateral surgical procedures, such as cholecystectomy, appendectomy, nephrectomy, or renal transplants. In contrast, bilateral TAP blocks are used for midline and transverse abdominal incisions, such as umbilical or ventral hernia repair, cesarean deliveries, hysterectomy, and prostatectomy. TAP blocks are part of multimodal pain management for abdominal surgeries, which adds analgesic benefit to patients, reducing postoperative opioid requirements. TAP blocks are typically placed intraoperatively, either before the surgical incision or at the end of the procedure before emergence from anesthesia. The TAP block's efficacy depends on the spread of LA across the interfacial plane. Newer tissue plane blocks, like the quadratus lumborum block, provide somatic and visceral analgesia.(Makmur, I.S. *et al*., 2022)

The TAP block has become one of the most common truncal blocks performed for postoperative analgesia after abdominal surgeries. This activity reviews the anatomy of the abdominal wall, the history of the TAP block, classification, approaches, techniques, and complications for this block. It also highlights the indications, contraindications, clinical significance, and materials to perform this block safely.(Bacal, V. *et al*., 2019)

OBJECTIVE OF THE STUDY

To evaluate the effect of pain relief by TAP block after caesarean section on the duration and quality of recovery from general anesthesia.

PATIENTS AND METHOD

This study is a single-blinded clinical trial involving a total of 60 pregnant women admitted for elective cesarean delivery under general anesthesia. Conducted at Diwaniyah Teaching Center-Women's and Children's Hospital from 1st April to 1st December 2024.

Ethical and scientific approval for the research was obtained from the Scientific Committee at the Department of Anesthesia and Intensive Care, Iraqi board for medical specialization. Verbal consent was obtained from all patients before starting data collection and after explaining the details of the study and assuring confidentiality.

The study included 60 pregnant women admitted for elective cesarean delivery under general anesthesia. Participants were randomly assigned to two groups: the TAP block group (n = 30) and the control group (n = 30), who did not receive a TAP block.

Inclusion Criteria

- Elective cesarean section.
- ASA Physical Status Classification 2 (ASA II).

Exclusion Criteria

- Emergency cesarean section.
- ASA Physical Status Classification 3 (ASA III).
- Patients on any type of medication.
- Complicated pregnancies, including placenta previa, placenta accreta, eclampsia, or gestational diabetes mellitus (DM).

Prior to induction, each patient was initially positioned in a left lateral tilt to improve venous return and then returned to a supine position for the transversus abdominis plane (TAP) block. Standard monitoring protocols were applied, including electrocardiogram (ECG), non-invasive blood pressure (NIBP), and pulse oximetry. For induction, rapid sequence induction (RSI) was employed to minimize the risk of aspiration and postoperative nausea and vomiting (PONV). Propofol was administered at a dose of 1.5-2 mg/kg, ketamine at 0.5 mg/kg, and rocuronium at 1 mg/kg to achieve neuromuscular blockade. Cricoid pressure was maintained for 60 seconds during induction to prevent regurgitation, and positive pressure ventilation was avoided prior to intubation.

Endotracheal intubation was then performed, followed by connection to a positive pressure ventilator in volume-controlled ventilation (VCV) mode.

Anesthesia maintenance was achieved using isoflurane at a concentration of 0.8%-1.2%, with additional boluses of rocuronium (0.1-0.2 mg/kg) administered as needed to sustain muscle relaxation. After delivery of the neonate, intraoperative analgesia was provided with 1 gram of paracetamol and 100 mg of tramadol to manage postoperative pain. This protocol aimed to ensure hemodynamic stability, effective analgesia, and smooth emergence from anesthesia.

For the transversus abdominis plane (TAP) block group, each patient was placed in a supine position under aseptic conditions. The procedure was guided by ultrasound to ensure accuracy and safety. A linear ultrasound probe was positioned between the costal margin and the iliac crest, specifically at the triangle of Petit, to obtain a clear view of the abdominal wall layers: the external

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oblique, internal oblique, and transversus abdominis muscles.

Using an in-plane technique, the needle was advanced under direct visualization. Proper needle placement was confirmed by observing the separation of the target muscle layers, and, following negative aspiration to avoid intravascular injection, a mixture of local anesthetic was administered.

This solution consisted of 10 ml of plain Marcaine, combined with 8 mg of dexamethasone and 8 ml of normal saline, injected on each side. The injection was delivered precisely into the fascial plane between the internal oblique and transversus abdominis muscles, providing effective regional anesthesia.

Demographic data, including age, number of previous cesarean sections, parity, height, and weight, were collected from all participants preoperatively. Body mass index (BMI) was calculated based on height and weight measurements.

Hemodynamic and respiratory parameters were monitored at various key time points throughout the procedure. The baseline, or "zero time," was defined as the moment when inhalation anesthesia was discontinued. At this point, blood pressure, pulse rate, and SpO_2 were recorded as initial measurements.

For patients who remained intubated, these hemodynamic parameters— blood pressure, SpO_2, and pulse rate were recorded again at 5 and 10 minutes after zero time to observe any changes. During extubation, additional measurements were taken, including blood pressure, SpO_2, pulse rate, and respiratory rate, to assess the patient's status as they transitioned off mechanical support.

Following extubation, these parameters were measured again at 10, 20, and 30 minutes to monitor the stability of hemodynamic and respiratory responses in the immediate postoperative period. The time between the discontinuation of inhalation anesthesia and extubation was documented.

Additionally, the timing of the last dose of muscle relaxant before zero time was recorded

Pain levels were assessed using the Visual Analog Scale (VAS) at 10, 20, and 30 minutes post-extubation. The need for rescue analgesia was also documented.

Continuous variables were expressed as means and standard deviations. Categorical variables were expressed as frequency and percentages. The Welch's t-test was performed. The difference between categorical variables was investigated using the $\chi 2$ test. A P-value less than 0.05 was considered statistically significant. R software packages (dplyr, gt_summery and ggplot) were used for data processing, visualization, and statistical analysis ("R version 4.2.2, R Foundation for Statistical Computing, Vienna, Austria").

RESULTS

The study compared the demographic and clinical characteristics of the study groups: those who received a TAP block (N = 30) and those who did not (N = 30). The mean age was slightly higher in the TAP block group (31.7 ± 5.7 years) compared to the non-TAP group (29.8 ± 5.9 years), but the difference was not statistically significant (p = 0.2). Similarly, the mean parity was higher in the TAP group (2.2 ± 1.1) versus the non-TAP group (1.8 ± 1.0), though this difference also did not reach significance (p = 0.14).

The mean number of cesarean sections was 2.3 ± 1.1 in the TAP group compared to 1.9 ± 1.3 in the non-TAP group, with a p-value of 0.3. The body mass index (BMI) was comparable between the groups, at 24.9 ± 2.3 kg/m² for the TAP group and 25.2 ± 2.9 kg/m² for the non-TAP group (p=0.6).

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Table 1: Description of the sociodemographic factors of the study groups

Characteristic	With TAP block, N = 30[1]	Without TAP block, N = 30[1]	p-value[2]
Age, years	31.7 ± 5.7	29.8 ± 5.9	0.2
Parity	2.2 ± 1.1	1.8 ± 1.0	0.14
Number of cesarean section	2.3 ± 1.1	1.9 ± 1.3	0.3
Body mass index Kg/m^2	24.9 ± 2.3	25.2 ± 2.9	0.6

[1]Mean ± SD
[2]Welch Two Sample t-test

Table 2 presents a comparison of outcomes and clinical parameters between the groups from the point of inhalation discontinuation ("zero time"). Patients with a TAP block had significantly shorter times to extubation (4.5±1.8 minutes) compared to those without the block (6.9±1.8 minutes, p<0.001). Pain scores were consistently lower in the TAP block group at 10 minutes (4.4±0.7 vs. 6.9±0.9, p<0.001), 20 minutes (3.5±0.7 vs. 6.1±0.9, p<0.001), and 30 minutes (3.1 ± 0.6 vs. 5.3 ± 0.9, p< 0.001). The need for rescue analgesia was markedly lower in the TAP block group, with 13.3% requiring it compared to 60.0% in the non-TAP group (p<0.001). The time from administration of the last muscle relaxant to zero time was longer in the TAP block group (24.7 ± 5.6 minutes) than in the non-TAP group (21.4 ± 5.5 minutes, p=0.012). However, the time from the last muscle relaxant to extubation did not significantly differ between the groups (29.2 ± 5.8 vs. 28.6 ± 4.6 minutes, p = 0.4).

Table 2: Comparison of time to extubation, pain scores, and analgesic requirements between groups

From zero time* /min	With TAP block, N = 30[1]	Without TAP block, N = 30[1]	p-value[2]
Time passed until extubation	4.5 ± 1.8	6.9 ± 1.8	**<0.001**
Pain score after 10 min	4.4 ± 0.7	6.9 ± 0.9	**<0.001**
Pain score after 20 min	3.5 ± 0.7	6.1 ± 0.9	**<0.001**
Pain score after 30 min	3.1 ± 0.6	5.3 ± 0.9	**<0.001**
Rescue analgesia need	4 (13.3%)	18 (60.0%)	**<0.001**
Time for last muscle relaxant before zero time	24.7 ± 5.6	21.4 ± 5.5	**0.012**
Time passed from last muscle relaxant until extubation	29.2 ± 5.8	28.6 ± 4.6	0.4

[1] Mean ± SD; n (%)
[2] Welch Two Sample t-test; Pearson's Chi-squared test
*Zero time = discontinuation of inhalation

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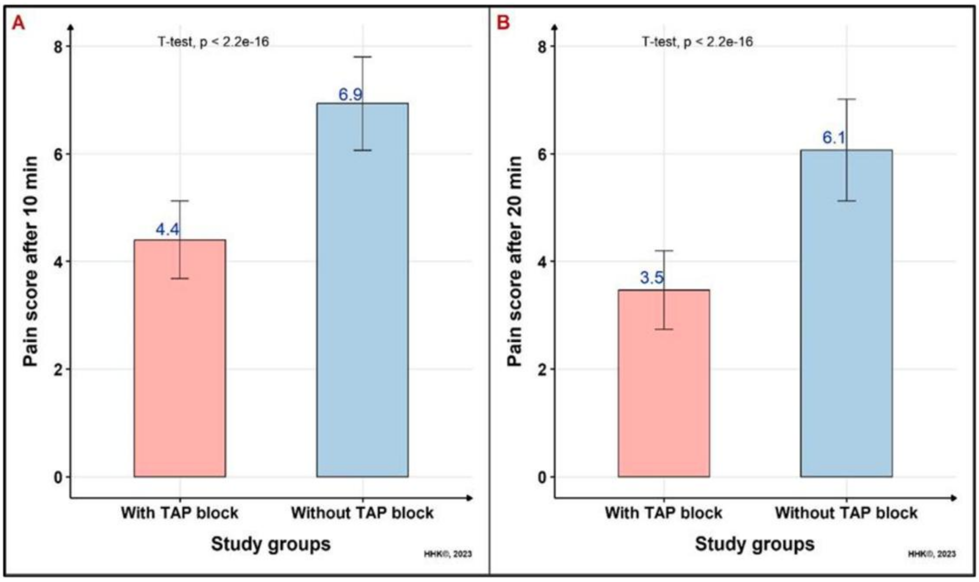

Figure 1: Error plot showing the difference in pain scores between the study groups after 10 and 20 minutes from zero time.

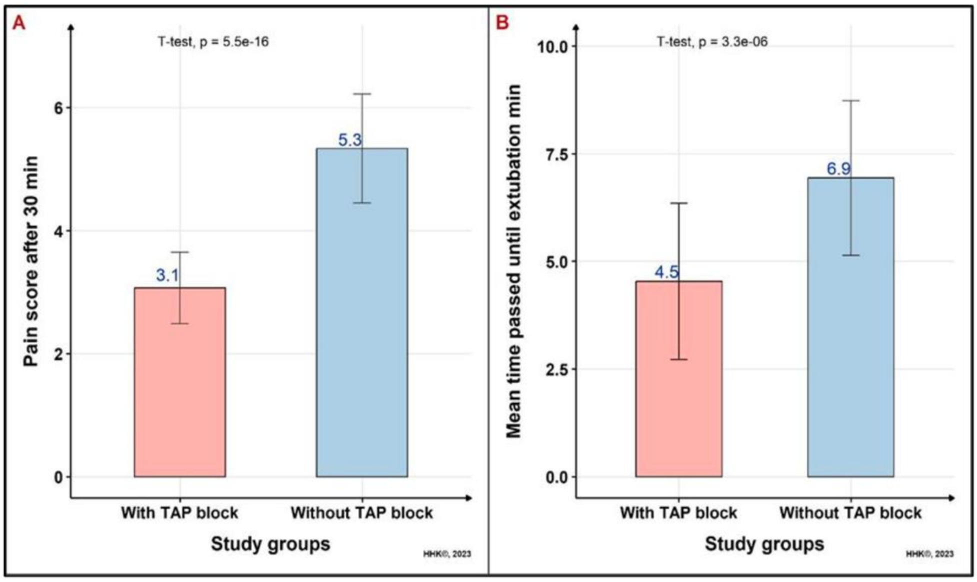

Figure 2: Error plot showing the difference in pain scores between the study groups after 30 minutes and time passed from zero time until extubation.

Table 3 presents a comparison of vital signs between the study groups during the period between the discontinuation of inhalation and extubation.

The mean pulse rate was slightly lower in the TAP group (99.1 ± 14.3 beats per minute) compared to the non-TAP group (101.7 ± 15.0 beats per minute), but the difference was not statistically significant ($p = 0.5$).

Similarly, oxygen saturation (SpO_2) was comparable between the two groups, with mean values of 98.9 ± 0.6% for the TAP group and 99.1 ± 0.3% for the non-TAP group ($p = 0.3$). Regarding blood pressure, systolic values were slightly lower in the TAP group (127.7 ± 13.5 mmHg) than in the non-TAP group (131.3 ± 10.3 mmHg), but this difference was not significant ($p = 0.2$). Diastolic blood pressure followed a similar trend, being lower in the TAP group (76.1 ± 11.9 mmHg) compared to the non-TAP group (80.3 ± 8.6 mmHg), with a p-value of 0.12. None of the observed differences reached statistical significance.

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Table 3: comparison of hemodynamic parameters between discontinuation of inhalation and extubation

Characteristic	With TAP block, N = 30[1]	Without TAP block, N = 30[1]	p-value[2]
Pulse rate /min	99.1 ± 14.3	101.7 ± 15.0	0.5
Sp02	98.9 ± 0.6	99.1 ± 0.3	0.3
Blood pressure mmHg			
Systolic	127.7 ± 13.5	131.3 ± 10.3	0.2
Diastolic	76.1 ± 11.9	80.3 ± 8.6	0.12

[1] Mean ± SD
[2] Welch Two Sample t-test

Table 4 provides a comparison of hemodynamic parameters at extubation and during the postoperative recovery period. Pulse rate at extubation was similar between the TAP group (107.1 ± 11.9/min) and the non-TAP group (109.7 ± 10.8/min, p = 0.4). Over time, the pulse rate decreased in both groups, with a significant difference observed at 30 minutes, favoring the TAP group (85.8 ± 7.2/min vs. 89.7 ± 6.9/min, p = 0.038). Respiratory rate at extubation was slightly lower in the TAP group (25.6 ± 5.0/min) compared to the non-TAP group (27.6 ± 3.7/min, p = 0.085). Significant differences in respiratory rate were noted at 10 minutes (p = 0.014), 20 minutes (p = 0.006), and 30 minutes (p < 0.001), with consistently lower values in the TAP group.

Systolic blood pressure at extubation was significantly lower in the TAP group (129.2 ± 9.4 mmHg) compared to the non-TAP group (136.5 ± 11.6 mmHg, p = 0.010), but subsequent measurements showed no significant differences between the groups. Diastolic blood pressure was also lower in the TAP group at extubation (78.3 ± 9.7 mmHg vs. 82.3 ± 7.9 mmHg, p = 0.090), but differences at later time points were not statistically significant.

Table 4: Comparison of hemodynamic parameters between the study groups at extubation and during postoperative recovery

Characteristic	With TAP block, N = 30[1]	Without TAP block, N = 30[1]	p-value[2]
Pulse rate /min			
At extubation	107.1 ± 11.9	109.7 ± 10.8	0.4
After 10 min	99.3 ± 8.3	103.5 ± 10.8	0.10
After 20 min	92.8 ± 6.9	94.5 ± 7.5	0.4
After 30 min	85.8 ± 7.2	89.7 ± 6.9	**0.038**
Respiratory rate /min			
At extubation	25.6 ± 5.0	27.6 ± 3.7	**0.085**
After 10 min	21.5 ± 2.8	23.5 ± 3.0	**0.014**
After 20 min	18.5 ± 2.3	20.3 ± 2.6	**0.006**
After 30 min	16.8 ± 1.7	18.7 ± 2.3	**<0.001**
Systolic blood pressure			
At extubation	129.2 ± 9.4	136.5 ± 11.6	**0.010**
After 10 min	126.9 ± 8.3	129.0 ± 8.1	0.3
After 20 min	121.8 ± 5.7	123.1 ± 8.5	0.5
After 30 min	122.0 ± 4.0	119.7 ± 8.1	0.2
Diastolic blood pressure			
At extubation	78.3 ± 9.7	82.3 ± 7.9	0.090
After 10 min	76.3 ± 10.1	78.7 ± 7.8	0.3
After 20 min	71.5 ± 8.6	74.1 ± 7.9	0.2
After 30 min	70.7 ± 8.8	74.1 ± 8.5	0.14

[1] Mean ± SD
[2] Welch Two Sample t-test

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DISCUSSION

Postoperative pain management remains a critical component of enhancing recovery and improving outcomes following surgical procedures. Among the various techniques employed, the transversus abdominis plane (TAP) block has emerged as a promising modality for achieving effective analgesia while minimizing the need for systemic opioids.[8] Given the increasing prevalence of cesarean sections worldwide and the unique postoperative challenges faced by mothers, optimizing pain control strategies is essential. This study aimed to evaluate the postoperative analgesic efficacy of the TAP block in patients undergoing cesarean section under general anesthesia.

The TAP group had a slightly higher mean age (31.7 ± 5.7 years vs. 29.8 ± 5.9 years, p = 0.2) and parity (2.2 ± 1.1 vs. 1.8 ± 1.0, p = 0.14), but these differences were not significant, suggesting that age and reproductive history were unlikely to skew the findings. Similarly, the mean BMI was comparable between groups (24.9 ± 2.3 kg/m² for the TAP group vs. 25.2 ± 2.9 kg/m² for the non-TAP group, p = 0.6), ruling out obesity as a factor affecting analgesia efficacy or recovery.

By confirming the similarity in baseline characteristics, this table strengthens the validity of the study's comparisons regarding analgesic outcomes and recovery times. It establishes that observed differences in postoperative parameters, such as pain scores and extubation times, are likely attributable to the intervention itself rather than pre-existing disparities between the groups.

The significantly shorter mean extubation time observed in the TAP block group compared to the non-TAP group highlights the potential role of TAP block in facilitating quicker emergence from general anesthesia. This outcome can be partially attributed to the enhanced analgesia provided by the TAP block, which reduces the reliance on high doses of inhalational anesthetics, thereby allowing for a smoother and faster anesthetic emergence. However, an alternative explanation must also be considered: the procedural differences between the groups. In the TAP block group, the inhalational anesthesia discontinuation typically occurs after the surgeon's completion, following sterilization for the TAP block application. This procedural sequence inherently introduces a time lag, which could contribute to the observed differences in extubation times. Such procedural nuances align with findings from studies like Manoharan, *et al*., 2023; which emphasize that TAP block enhances recovery profiles through superior analgesia. These findings underscore the importance of factoring in procedural timing differences when interpreting extubation outcomes in clinical trials.

This observation aligns with previous studies indicating that effective regional anesthesia techniques can expedite recovery times by minimizing the need for systemic opioids and their associated sedative effects.[10]

While the TAP block group showed a longer time from the last muscle relaxant administration to "zero time" (24.7 ± 5.6 minutes), extubation times were shorter. This suggests that TAP block allows more effective neuromuscular recovery through enhanced pain relief, consistent with findings by other studies on the benefits of lignocaine infusion for postoperative recovery.

The findings indicate that the "Time passed from the last muscle relaxant until extubation" was comparable between the TAP block group (29.2 ± 5.8 minutes) and the non-TAP group (28.6 ± 4.6 minutes), with no statistically significant difference (p = 0.4). This is an important observation as it highlights that the overall recovery duration, measured from the administration of the last muscle relaxant to extubation, remained consistent across both groups despite the procedural differences in other time intervals.

When analyzing this outcome, it is crucial to account for the two other significant findings: the "Time passed until extubation" and the "Time for the last muscle relaxant before zero time." In the TAP group, the time passed until extubation was significantly shorter, suggesting that enhanced analgesia facilitated faster readiness for extubation. Conversely, the time for the last muscle relaxant before zero time was significantly longer in the TAP group, as the procedure includes an additional step of sterilization and TAP block administration before discontinuing inhalational anesthesia. When these intervals are combined, their effects cancel each other out, resulting in a non-significant difference in the total recovery time between the two groups.

This conclusion aligns with findings from studies that emphasize the multifactorial nature of anesthetic recovery. For example, Manoharan, *et al*., 2023; reported that TAP blocks enhance

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recovery efficiency primarily by reducing pain and anesthetic requirements, which can accelerate patient readiness for extubation.

The non-significant difference in total recovery time observed in this study suggests that while the TAP block enhances certain aspects of the recovery process, procedural factors and other time-consuming steps inherent to its application can offset these benefits. Future studies should aim to control for such variables to provide a clearer understanding of the TAP block's impact on recovery dynamics. This observation also reinforces the importance of standardized procedural timelines and consistent protocols to ensure that the benefits of interventions like the TAP block are not obscured by process-related variances.

The significantly lower pain scores at 10 minutes (4.4 ± 0.7 vs. 6.9 ± 0.9), 20 minutes (3.5 ± 0.7 vs. 6.1 ± 0.9), and 30 minutes (3.1 ± 0.6 vs. 5.3 ± 0.9) in the TAP block group compared to the non-TAP group demonstrate the efficacy of TAP block in providing superior analgesia during the immediate postoperative period. These findings align with current evidence indicating that TAP blocks reduce nociceptive transmission from the abdominal wall by targeting the thoracolumbar nerves.

Comparable results have been reported by Pinarbaşi A, *et al*., 2024; who observed significantly reduced postoperative pain scores and a delay in the first analgesic request among patients receiving TAP blocks. Additionally, Matam, *et al*. found that TAP block not only reduced pain scores but also decreased the total 24-hour morphine consumption, supporting the broader analgesic benefits of this technique.

Interestingly, Salazar-Flórez, J.E, *et al*., 2024; concluded that, the TAP block proves advantageous in mitigating postoperative pain for women post-caesarean delivery, particularly in the initial 6 postpartum hours. This relief promotes early mother-infant bonding and facilitates breastfeeding.

Moreover, Chesov, *et al*., 2017; demonstrated that the TAP block resulted in better pain control at rest and during movement after ventral hernia repair, highlighting its versatility across various surgical procedures. These studies collectively reinforce the conclusion that TAP block provides superior analgesia compared to standard pain management approaches.

The observed reductions in pain scores can be attributed to the precise blockade of somatic nerve fibers achieved through the TAP block. This mechanism minimizes the pain signals reaching the central nervous system, thereby lowering the subjective experience of pain and reducing reliance on systemic analgesics. Furthermore, the superior analgesia provided by the TAP block is likely due to the sustained local anesthetic effect, as supported by findings from Shreyas, *et al*., 2019; which indicate that adding dexamethasone to the TAP block further prolongs its analgesic efficacy.

The reduction in pain scores has profound implications for patient recovery. Improved pain control enhances patient comfort, facilitates early mobilization, and reduces the risk of complications such as thromboembolism. Additionally, lower pain scores reduce the need for opioids, thereby minimizing opioid-related side effects like nausea, sedation, and respiratory depression.

Overall, the significant reduction in pain scores observed in this study underscores the efficacy of the TAP block in postoperative pain management and highlights its role in optimizing recovery outcomes in patients undergoing abdominal surgeries. Further studies with larger cohorts are warranted to generalize these findings across diverse surgical contexts.

The study's findings demonstrate a significantly lower need for rescue analgesia in the TAP block group (13.3%) compared to the non-TAP group (60.0%), with a highly significant p-value (<0.001). This stark difference underscores the efficacy of TAP block in controlling postoperative pain, leading to reduced reliance on additional analgesic interventions.

The results align with findings from Mankikar, M.G, *et al*., 2016; who reported that TAP block recipients experienced significantly reduced Time for rescue analgesia, as well as reduced requirement of opioid analgesic and decreased VAS compared to control group.

Furthermore, Pinarbaşi A, *et al*., 2024; reported that patients in the TAP block group required rescue analgesia significantly less frequently between 4 and 8 hours postoperatively [2.00 (5.00%) vs. 9.00 (23.08%), P = 0.02]. This finding aligns closely with the current study, which demonstrated a significantly lower need for rescue analgesia in the TAP block group (13.3%)

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compared to the non-TAP group (60.0%, P < 0.001). These results further validate the effectiveness of the TAP block in extending postoperative analgesia and reducing breakthrough pain during the critical early recovery period.

Moreover, O' Donnell, *et al*.'s 2006; study proved the efficacy of TAP block for postoperative analgesia and less postoperative rescue analgesics requirements in patients undergoing midline incision abdominal surgeries.

Also, Jadon, A, *et al*., 2018; concluded that TAP block reduces pain, prolongs the duration of analgesia and decreases supplemental opioid consumption when used for multimodal analgesia for pain relief after caesarean section.

The delayed and reduced need for rescue analgesia in TAP block recipients, as observed in both studies, highlights the block's ability to maintain consistent pain control during the hours following surgery when nociceptive stimuli are typically at their peak. The reduction in systemic analgesic requirements reflects the effectiveness of the TAP block in minimizing nociceptive input through somatic nerve blockade.

The reduced reliance on rescue analgesia has significant clinical benefits. It suggests better pain control with the TAP block, which contributes to enhanced patient comfort, reduced opioid-related complications, and shorter recovery times. Furthermore, minimizing systemic analgesic use aligns with current efforts to mitigate the risks of opioid dependence in postoperative care.

At the time of extubation, the mean pulse rate in the TAP block group was slightly lower (99.1 ± 14.3 beats per minute) compared to the non-TAP group (101.7 ± 15.0 beats per minute), though the difference was not statistically significant (p = 0.5). Similarly, at extubation, the pulse rates were comparable between the groups (107.1 ± 11.9 vs. 109.7 ± 10.8, p = 0.4). However, over time, the pulse rate in the TAP group demonstrated a significant decline, particularly at 30 minutes post-extubation (85.8 ± 7.2 vs.89.7 ± 6.9, p = 0.038). This reduction reflects effective pain control provided by the TAP block, minimizing pain-induced sympathetic activation, which often leads to tachycardia in the postoperative period. This was in line with Xue M, *et al*., 2022; study that showed similar results for heat rate.

The TAP block group exhibited a significantly lower systolic blood pressure at extubation (129.2 ± 9.4 mmHg) compared to the non-TAP group (136.5 ± 11.6 mmHg, p = 0.010). This difference did not persist during subsequent measurements at 10, 20, or 30 minutes post-extubation, suggesting that the TAP block's impact on systolic blood pressure stabilization is most pronounced during the immediate recovery period.

Effective pain relief provided by the TAP block reduces pain-induced sympathetic overactivity, which is known to elevate blood pressure. At extubation, the mean diastolic blood pressure was lower in the TAP block group (78.3 ± 9.7 mmHg) than in the non-TAP group (82.3 ± 7.9 mmHg, p =0.090). While this trend was evident immediately, the differences in diastolic blood pressure measurements over time (10, 20, and 30 minutes post-extubation) were not statistically significant. The initial reduction may reflect the superior analgesia provided by the TAP block, which reduces pain-related increases in vascular resistance mediated by sympathetic activation. As recovery progresses, other physiological mechanisms likely mitigate these differences, consistent with findings in studies evaluating analgesia and hemodynamics during recovery. These results align with Singla N, *et al*., 2021; study that showed no significant difference in post-operative hemodynamic parameters between the two groups. As well as of Xue M, *et al*., 2022; who noted no significant difference in SBP nor DBP between both groups onward overtime.

The respiratory rate at extubation was lower in the TAP block group (25.6 ± 5.0 breaths per minute) compared to the non-TAP group (27.6 ± 3.7, p = 0.085). Over the following 30 minutes, this trend became statistically significant, with the TAP group exhibiting consistently lower rates: at 10 minutes (21.5 ± 2.8 vs. 23.5 ± 3.0, p = 0.014), 20 minutes (18.5 ± 2.3 vs. 20.3 ± 2.6, p = 0.006), and 30 minutes (16.8 ± 1.7 vs. 18.7 ± 2.3, p < 0.001).

These findings suggest that the TAP block reduces hyperventilation typically associated with postoperative pain, likely due to its ability to mitigate abdominal discomfort.

Oxygen saturation levels remained high and comparable between the groups during the study period, with mean values of 98.9 ± 0.6% in the TAP group and 99.1 ± 0.3% in the non-TAP group (p = 0.3). This finding indicates that the TAP block does not impair respiratory function or oxygenation during extubation or the early recovery phase. The maintenance of high SpO_2

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levels reflects the absence of respiratory compromise, likely aided by the reduced opioid requirements in the TAP block group, as opioids are known to cause respiratory depression. These results echo the findings of Xue, M. *et al*., 2022; who noted no significant difference in SpO_2 between both groups at any giving time.

The study demonstrates that the Transversus Abdominis Plane (TAP) block provides significant benefits in postoperative analgesia and hemodynamic stability for patients undergoing cesarean sections. Notably, the TAP block group experienced reduced pain scores, decreased need for rescue analgesia, and enhanced recovery profiles compared to the non-TAP group. However, no significant differences were observed in overall recovery time, as measured by the time from the last muscle relaxant to extubation. These findings reinforce the TAP block's value as a critical component of multimodal analgesia strategies, with potential to improve patient comfort and reduce opioid-related complications.

Despite these positive outcomes, the study has limitations that should be acknowledged. First, the sample size was relatively small, which may limit the generalizability of the findings to larger populations. Second, procedural differences, such as the timing of inhalation discontinuation in the TAP and non-TAP groups, could introduce confounding variables that affect recovery metrics. Third, the study did not evaluate long-term outcomes, such as pain management beyond the immediate postoperative period or patient satisfaction. Finally, the reliance on subjective pain scores could introduce bias, underscoring the need for more objective measures of analgesic efficacy. Future research should address these limitations by incorporating larger, multicenter cohorts, standardizing procedural protocols, and assessing long-term recovery outcomes to validate and expand upon these findings.

CONCLUSION

1- The Transversus Abdominis Plane (TAP) block provides effective postoperative analgesia for patients undergoing cesarean section under general anesthesia. It exhibited significantly lower pain scores, reduced need for rescue analgesia, and shorter extubation times compared to the non-TAP group. With more stability in pulse rate and respiratory rate.

2- Despite procedural differences, the overall recovery time, from the last muscle relaxant to extubation, was similar between the TAP and non-TAP groups, indicating that TAP block does not delay recovery.

3- These findings validate the TAP block as a valuable component of multimodal analgesia strategies, enhancing recovery and minimizing opioid-related complications.

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