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A RANDOMIZED DOUBLE-BLINDED STUDY OF ULTRASOUND-GUIDED TRANSVERSE ABDOMINIS PLANE BLOCK FOR POSTOPERATIVE ANALGESIA FOR LOWER ABDOMINAL SURGERIES WITH BUPIVACAINE VS BUPIVACAINE WITH DEXAMETHASONE

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ABSTRACT

Background: Managing pain after lower abdominal surgeries is vital for quick patient recovery and early walking. The transversus abdominis plane (TAP) block provides good pain relief, but extending its duration without toxic side effects remains a goal. This study evaluated the effect of adding dexamethasone as a helper medication to bupivacaine in ultrasound-guided TAP blocks.
Methods: A prospective, randomized, double-blinded study was done with 120 patients split into two equal groups of 60. Group BS received 20 ml of 0.25% bupivacaine plus saline, while Group BD received 20 ml of 0.25% bupivacaine with 8 mg dexamethasone. Pain scores via the Visual Analogue Scale (VAS), total tramadol consumption, time to first rescue pain medication, and side effects were tracked over 24 hours post-surgery.
Results: The average duration of pain relief was significantly longer in Group BD compared to Group BS (1155.00 ± 370.96 minutes vs 501.00 ± 173.55 minutes, $p < 0.001$). The time to first rescue pain medication was also much longer in Group BD (857.25 ± 502.61 minutes vs 375.48 ± 131.42 minutes, $p < 0.001$). Total tramadol use was significantly lower in the dexamethasone group (38.33 ± 21.33 mg vs 70.83 ± 30.93 mg, $p < 0.001$). Pain scores on the VAS were much lower in Group BD at 2, 4, 8, and 24 hours.
Conclusion: Adding dexamethasone to bupivacaine in an ultrasound-guided TAP block safely doubles the time patients remain free of pain and heavily reduces the need for opioid painkillers.

Keywords*: TAP block, Bupivacaine, Dexamethasone, Adjuvant, Postoperative analgesia, and Ultrasound-guided.*

INTRODUCTION

Pain is a highly complicated phenomenon that involves physical, emotional, and psychological reactions within the human body. The International Association for the Study of Pain defines it as an unpleasant sensory and emotional experience tied to actual or potential tissue damage[1]. Dealing with post-surgical pain remains a primary task for medical practitioners worldwide. When patients undergo major operations in the lower abdomen, the resulting injury to the muscle layers and skin generates intense pain signals. If this discomfort is not managed properly, it can slow down recovery, cause lung or blood clot complications, and increase the time a patient spends in the hospital ward[2]. Modern medical practice emphasizes finding methods that minimize pain at the root source rather than using heavy full-body medications that cloud the patient's mind.

For many decades, traditional medical approaches relied heavily on systemic painkillers like opioids or strong non-steroidal anti-inflammatory drugs. While these medications help dull the pain pathway, they frequently cause unwanted side effects

such as nausea, severe vomiting, slow breathing, confusion, and delayed bowel movement function[3]. To overcome these limitations, regional numbing techniques have gained massive popularity. These techniques target the specific nerves supplying the surgical zone, allowing the patient to remain awake, fully interactive, and free from full-body drug side effects. Among these regional numbing methods, the field block has stood out as a simple and safe choice for abdominal operations.

The concept of blocking the nerves of the front abdominal wall was significantly advanced when Rafi introduced the transversus abdominis plane block in the year 2001. Initially, this was described as a landmark-guided method where the doctor felt for a specific physical space called the triangle of Petit. By inserting a needle through this anatomical zone, local numbing medicine could be deposited into the muscle layer to block the spinal nerve branches from T6 to L1. However, relying purely on touch and physical feel carried an inherent risk of missing the exact layer or accidentally injuring internal organs like the liver or bowel loops.[4]

To make this technique safer and much more reliable, Hebbard and colleagues introduced the use of ultrasound guidance for the TAP block in the year 2007.[5] Using sound wave imaging allows the practitioner to see the live needle tip path clearly as it travels through the skin, fat, external oblique muscle, and internal oblique muscle. The needle is safely stopped right above the transversus abdominis muscle sheet. Seeing the numbing liquid spread like a dark lens shape on the screen guarantees that the medicine is exactly where it needs to be to block the nerves effectively[6]. This high level of visual guidance has made the procedure standard practice in modern surgical units.

Bupivacaine is one of the most widely chosen local numbing agents for this procedure due to its powerful action and medium-to-long duration of effect. However, a major challenge is that the numbing block naturally wears off after several hours, leaving the patient exposed to returning surgical pain. Raising the volume or strength of bupivacaine is risky because high doses can damage the heart muscle, leading to severe drops in blood pressure, slow heart rates, and life-threatening heart rhythm failures. Therefore, researchers have focused on adding safe companion medicines, known as adjuvants, to prolong the block without increasing the risk of toxicity.

There are very few formal studies in the current medical literature that evaluate the helper role of dexamethasone when combined with bupivacaine for ultrasound-guided TAP blocks in South Indian clinical settings. Dexamethasone is a well-known, highly affordable steroid medication that reduces swelling and alters how nerves send pain text. This clinical study was planned to explicitly compare how long postoperative pain relief lasts when using bupivacaine alone versus using a combination of bupivacaine and dexamethasone in patients undergoing lower abdominal operations.

METHODOLOGY

Study Design and Setting

This clinical investigation was designed as a prospective, randomized, double-blinded, controlled trial. The study was conducted within the active operating theaters and post-surgical wards of Government Kilpauk Medical College Hospital and Government Royapettah Hospital located in Chennai, India. The full data collection period spanned six continuous months, beginning in April 2021 and concluding in September 2021.

Inclusion and Exclusion Criteria

Patients were thoroughly screened and chosen based on precise medical criteria. The study included adult individuals between the ages of 18 and 60 years who were scheduled to undergo elective lower abdominal procedures under routine spinal anesthesia. These individuals belonged to the American Society of Anesthesiologists (ASA) physical status classes I and II, meaning they were either completely healthy or possessed mild, well-controlled medical conditions. Both male and female patients were equally eligible. Every single participant provided formal, written informed consent prior to inclusion.

Patients were excluded from participation if they refused to participate or lacked the mental capacity to comprehend the pain rating scale. Additional exclusion grounds included known allergies to amide-type local numbing drugs, blood clotting disorders, active skin infections at the needle site, or severe underlying heart, lung, kidney, or liver illnesses. Patients categorized as ASA classes III or IV were strictly kept out of the study pool.

Sample Size Calculation

The required number of study subjects was calculated mathematically based on findings from a previous baseline study conducted by Ammar and colleagues[7]. In that research, the average pain rating score at 48 hours for the plain bupivacaine group was noted as 1.1 with a standard deviation of 0.2, whereas the group receiving bupivacaine combined with dexamethasone showed an average score of 1.0 with a standard deviation of 0.19. Using a 95% confidence level and an 80% statistical power tool, the standard sample size formula determined that approximately 60 patients were needed in each group. This brought the grand total for the entire study population to exactly 120 individuals, ensuring robust mathematical comparisons.

Randomization and Blinding

To avoid bias, a computer system generated a random assignment sequence that placed patients into one of two matching tracks. The 120 patients were divided equally: 60 were assigned to Group BS (Bupivacaine-Saline) and 60 to Group BD

(Bupivacaine-Dexamethasone). The allocation sequence was concealed in opaque, numbered envelopes. To achieve complete double-blinding, a separate technician prepared the identical-looking drug mixtures in unmarked syringes. The primary anesthesiologist performing the ultrasound block and the floor nurses recording the postoperative data had no knowledge of what specific medicine was inside the syringes.

Clinical and Block Procedure

On arriving at the preoperative room, all patients received standard preventive medications, including 4 mg of ondansetron to prevent nausea and an injection of ranitidine to protect the stomach. Standard monitoring tools, including a three-lead electrocardiogram (ECG), a non-invasive blood pressure cuff, and a pulse oximetry sensor, were securely attached. Under strict clean surgical habits, spinal anesthesia was given while the patient sat up, utilizing the L3-L4 spinal bone space. A standard dose of 0.5% heavy bupivacaine was injected into the spinal space using a fine 25-gauge Quincke needle.

The main surgery was then carried out. At the very end of the surgical closure, as the full spinal block naturally began to wear off and regressed to the T8 spinal nerve level, the ultrasound-guided TAP block was carefully performed. The patient was kept flat on their back, and a high-quality curvilinear ultrasound probe was positioned along the side line of the waist, right between the lower rib cage margin and the top edge of the hip bone. The three distinct muscle bands—external oblique, internal oblique, and transversus abdominis were identified clearly on the display monitor.

Using an in-plane approach, a regional block needle was guided steadily until its tip rested precisely in the clear tissue line between the internal oblique and transversus abdominis muscle sheets. After carefully drawing back the syringe plunger to make sure no blood vessels were pierced, the drug mixture was steadily injected, and the live spread was verified visually. The exact same step was then completed on the opposite side of the patient's abdomen.

The mixtures were prepared as follows:

- Group BD (Dexamethasone Track): Received 20 ml of 0.25% bupivacaine combined with 2 ml (8 mg) of active dexamethasone liquid and 2 ml of sterile distilled water (Total volume = 24 ml per side).
- Group BS (Saline Control Track): Received 20 ml of 0.25% bupivacaine combined with 2 ml of normal saline liquid and 2 ml of sterile distilled water (Total volume = 24 ml per side).

Once the block was fully set and the spinal effect moved down past the L2 level, the skin sensation was checked on both sides using a cold item. The block success was officially graded into three distinct levels: Grade 0 meant complete failure, where the patient felt the cold item normally on both sides at the L1 skin zone; Grade 1 meant a partial success, where the cold feel was lost on only one side; Grade 2 meant a complete success, where cold sensation was successfully blocked on both sides at the L1 skin zone.

Postoperative Monitoring and Data Analysis

Patients were continuously observed for 24 hours. The primary item tracked was the total duration of pain relief, measured as the exact time from finishing the block injection to the patient's very first request for additional pain medication. Pain levels were evaluated using the standard Visual Analogue Scale (VAS), which spans from 0 (no pain at all) to 100 (unbearable pain). These scores were recorded at the 2, 4, 8, 12, 18, and 24-hour marks. If a patient's pain score crossed equal to or above 40, or if they explicitly asked for pain relief earlier, a rescue painkiller tramadol at a dose of 1 mg per kilogram of body weight was given intramuscularly. The total amount of tramadol consumed over the 24-hour timeframe was tallied carefully. Any side effects, such as nausea, skin itching, slow heart rate, or accidental block injury, were documented.

All data fields were organized into an electronic spreadsheet and processed using SPSS software version 16.0. Flat counts and percentages described group variables like gender and side effects. Averages and standard deviations described numerical items like age, pain relief time, and drug amounts. The Student's t-test compared averages between the two groups, while the Chi-square test evaluated group count charts. A p-value below 0.05 was considered mathematically significant.

RESULTS

A total of 120 patients were successfully enrolled and followed through the complete 24-hour study period, with 60 individuals in Group BD and 60 individuals in Group BS. There were no dropouts or technical failures during the block applications.

Baseline Demographics and Block Characteristics

The two study groups were highly comparable regarding baseline physical characteristics, confirming that the randomization process worked flawlessly. As detailed in Table 1, the mean age of patients in Group BD was 25.97 ± 4.88 years, while the mean age in Group BS was 25.37 ± 4.23 years. This slight difference of 0.6 years was not statistically significant ($p = 0.473$). Looking at age categories, Group BD had 10% of patients aged 20 or younger, 41.66% between 21 and 25 years, 25% between 26 and 30 years, and 23.33% older than 30 years. Similarly, Group BS comprised 11.66% aged 20 or younger, 48.33% between 21 and 25 years, 25% between 26 and 30 years, and 15% older than 30 years. The overall group spread was highly balanced and showed no meaningful difference between the tracks (Chi-square $p = 0.691$).

Table 1: Age Category Distribution and Comparability Between Groups

Age Category	Group BD (n=60)	Group BS (n=60)	Statistical Value
<= 20 years	6 (10.00%)	7 (11.66%)	Grand Total: 13 (10.83%) Grand Total: 54 (45.00%) Chi-Square Value: 0.691 p-value > 0.05 (Insignificant)
21 - 25 years	25 (41.66%)	29 (48.33%)	
26 - 30 years	15 (25.00%)	15 (25.00%)	
> 30 years	14 (23.33%)	9 (15.00%)	
Mean Age ± SD	25.97 ± 4.88 years	25.37 ± 4.23 years	t-test p-value = 0.473

Interestingly, the time required for the initial spinal block level to drop down to the L2 nerve level showed significant variations. As documented in Table 2, patients in Group BD experienced a mean regression time of 76.75 ± 38.28 minutes, whereas Group BS showed a significantly higher mean time of 92.57 ± 29.87 minutes. This difference was statistically meaningful ($p = 0.013$), indicating a faster initial sensory return profile before the primary action of the local TAP block took over completely.

Table 2: Comparison of Time for Spinal Block Regression to L2 Segment

Parameter	Group BD (n=60)	Group BS (n=60)	Mean Difference	p-value
Time for Regression to L2 (min)	76.75 ± 38.28	92.57 ± 29.87	15.82 minutes	0.013*

Primary Analgesic Outcomes

The primary focus of this study was the total duration of effective post-surgical pain relief. The addition of dexamethasone resulted in a highly significant extension of pain-free time. As explicitly shown in Table 3, the average duration of analgesia in Group BD reached an outstanding 1155.00 ± 370.96 minutes. In sharp contrast, the control group (Group BS) recorded a mean pain relief duration of only 501.00 ± 173.55 minutes. This massive difference of 654 minutes was highly significant ($p < 0.001$), demonstrating that dexamethasone more than doubled the time patients remained comfortable after surgery.

Matching this pattern, the mean time to the first request for rescue pain medication was dramatically prolonged in the dexamethasone track. Group BD patients went an average of 857.25 ± 502.61 minutes before requiring additional painkillers, while Group BS patients requested rescue analgesia much sooner, at a mean of 375.48 ± 131.42 minutes. This clear gap of 481.77 minutes was statistically robust ($p < 0.001$).

Table 3: Primary Numbing Outcomes and Pain Relief Durations

Analgesic Marker	Group BD (n=60)	Group BS (n=60)	Absolute Difference	p-value
Total Duration of Analgesia (min)	1155.00 ± 370.96	501.00 ± 173.55	654.00 min	0.001*
Time for First Rescue Drug (min)	857.25 ± 502.61	375.48 ± 131.42	481.77 min	0.001*

Rescue Painkiller Consumption

Because the pain block lasted significantly longer in the dexamethasone track, the overall need for heavy opioid painkillers dropped heavily. The mean total tramadol consumption over the 24-hour post-surgical monitoring window was only 38.33 ± 21.33 mg for Group BD. Meanwhile, patients in the plain bupivacaine group (Group BS) required a significantly higher average dose of 70.83 ± 30.93 mg. This significant reduction in overall opioid use (mean difference of 32.5 mg, $p < 0.001$) is displayed clearly in Table 4 and highlights the profound clinical benefit of adding a steroid helper to the regional nerve block.

Table 4: Total Rescue Painkiller Consumption Over 24 Hours

Medication Metric	Group BD (n=60)	Group BS (n=60)	Net Reduction	p-value
Total Tramadol Consumption (mg)	38.33 ± 21.33	70.83 ± 30.93	32.50 mg	0.001*

Visual Analogue Scale (VAS) Pain Trends

Pain intensity profiles tracked via the VAS scale revealed that Group BD patients remained significantly more comfortable throughout the majority of the study timeline. The average pain scores across all specific recording marks are compiled in Table 5. At 2 hours post-surgery, Group BD showed a remarkably low mean pain score of 1.47 ± 0.60, whereas Group BS had a higher score of 2.20 ± 0.51 ($p < 0.001$). At 4 hours post-surgery, the mean pain score in Group BD rose slightly to 2.05 ± 0.29, while Group BS climbed significantly to 3.00 ± 0.37 ($p < 0.001$).

This gap reached its peak at the 8-hour mark, where Group BD maintained a stable mean pain score of 3.00 ± 0.45, while the plain bupivacaine block had completely worn off for the control patients, whose mean pain score spiked sharply to 5.47 ± 1.71 ($p < 0.001$). As the block began to fade in the dexamethasone track and rescue medications were given in the control track, the groups converged at 12 hours (4.15 ± 1.60 vs 4.40 ± 1.62, $p = 0.397$) and perfectly matched at 18 hours (4.18 ± 1.49 vs 4.18 ± 1.74, $p = 1.000$). By the final 24-hour evaluation, Group BD again recorded a significantly lower mean pain score of 3.55 ± 0.67 compared to 4.83 ± 1.91 in Group BS ($p < 0.001$), confirming superior long-term control.

Table 5: Visual Analogue Scale (VAS) Pain Score Distribution Timeline

Time Interval	Group BD (n=60)	Group BS (n=60)	Mean Difference	p-value
2 Hours Post-Surgery	1.47 ± 0.60	2.20 ± 0.51	0.73	0.001*
4 Hours Post-Surgery	2.05 ± 0.29	3.00 ± 0.37	0.95	0.001*
8 Hours Post-Surgery	3.00 ± 0.45	5.47 ± 1.71	2.47	0.001*
12 Hours Post-Surgery	4.15 ± 1.60	4.40 ± 1.62	0.25	0.397
18 Hours Post-Surgery	4.18 ± 1.49	4.18 ± 1.74	0.00	1.000
24 Hours Post-Surgery	3.55 ± 0.67	4.83 ± 1.91	1.28	0.001*

No significant local or full-body side effects, such as accidental bowel puncturing, local bleeding, severe slow heart rate, or nerve damage, were seen in either group.

DISCUSSION

The results of this prospective clinical trial clearly prove that adding dexamethasone as a helper medication to a bupivacaine ultrasound-guided TAP block is highly effective. It greatly extends the time patients remain free from pain after lower abdominal operations. In modern hospital settings, minimizing pain after surgery while avoiding the heavy use of opioid painkillers is a major goal. The data gathered in this trial shows that adding 8 mg of dexamethasone safe and cheap more than doubles the pain-free time for patients, keeping them comfortable for an average of 1155 minutes compared to only 501 minutes when using plain bupivacaine.

The exact way that dexamethasone works locally inside the nerve layer to block pain signals is not completely understood by medical science yet. However, experts believe it acts directly on the cell walls of pain fibers. It stimulates specialized glucocorticoid receptors, which increases the action of calming potassium channels while quieting down the electrical activity of the nerve membrane. Additionally, because it is a powerful anti-inflammatory medicine, it prevents the local release of swelling chemicals like interleukins and cytokines that normally make nerve endings highly sensitive to pain[8]. This combination of calming the nerve cells and reducing chemical swelling explains why the block lasts so much longer. Studies show this helper effect is most powerful when combined with long-acting numbing medicines like bupivacaine or ropivacaine.

Our practical findings match several international reports. In a similar trial, Ammar et al.[7] studied the effect of adding dexamethasone to bupivacaine for patients undergoing abdominal womb removal operations. They reported that the dexamethasone group had much lower pain scores, a significantly longer time before needing extra painkillers, and required far less morphine after surgery. Similarly, a comprehensive meta-analysis by Chen and colleagues[9] that looked at data from 9 separate clinical trials concluded that using dexamethasone in TAP blocks consistently lowers pain scores, extends the numbing action, and reduces post-surgical nausea and vomiting by lowering the need for heavy opioid medications.

Another study by Deshpande et al.[10] evaluated the clinical use of dexamethasone added to ropivacaine for abdominal hysterectomies done under spinal anesthesia. They observed a significant drop in post-surgical pain scale scores and a matching decrease in the amount of rescue tramadol required by patients. In pediatric care, Abdelwahab and colleagues[11] tested this mixture in children aged 1 to 6 years undergoing major abdominal operations, proving that the steroid helper safely lowers pain scales and reduces the need for paracetamol liquid.

Furthermore, a large systematic review by Zhang and coworkers[12] involving 575 surgical patients confirmed that perineural dexamethasone is a highly reliable and safe approach. It shortens recovery times, cuts down full-body opioid use, and keeps pain ratings low. In maternal health, Zemedkun et al.[13] reported that mothers delivering babies via Cesarean section experienced significantly longer periods of deep comfort at rest and while coughing when dexamethasone was used in the abdominal block layer.

When comparing different helper options, Singla and colleagues[14] noted that while alpha-2 agonists like dexmedetomidine also prolong pain relief effectively, they carry a slight risk of causing drops in blood pressure or slowing down the heart rate. Dexamethasone, on the other hand, provides excellent pain extension while keeping the patient's heart rate and blood

pressure remarkably stable. Additional studies by researchers like Sachdeva et al.[15] and Kiran et al.[16] confirm that this steroid helper provides clear clinical benefits across various regional blocks and surgical fields.

LIMITATIONS

This clinical study has a few limitations that should be noted. First, pain was measured using the Visual Analogue Scale, which relies entirely on the patient's personal description. Because the primary researcher was also the treating doctor on the floor, some patients might have reported higher scores to receive more clinical attention. Second, while the two groups were perfectly matched in terms of age, the potential influence of unknown hidden factors cannot be completely ruled out. Third, the sample size of 120 patients was mathematically sufficient to compare pain scores, but a much larger group would be needed to detect rare side effects. Finally, this trial was conducted in a well-equipped tertiary hospital, so these exact results might differ in smaller rural clinics with limited resources.

STRENGTHS

The main strength of this study is its robust design as a randomized controlled trial, which minimizes the risk of hidden biases affecting the results. The use of complete double-blinding ensured that neither the patients nor the evaluating nurses knew which medicine was given, keeping the data completely objective. Despite the challenges of the COVID-19 pandemic during the data collection phase, we successfully achieved our full target sample size without any patient dropouts. Furthermore, because a single primary investigator performed the ultrasound blocks and collected the core data, the risk of variation between different operators was kept to a absolute minimum.

RECOMMENDATIONS

Based on our clear findings, we highly recommend adding dexamethasone as a routine helper medication alongside bupivacaine for ultrasound-guided TAP blocks in patients undergoing lower abdominal operations. Since dexamethasone is an extremely cheap and widely available medicine, using it is a highly cost-effective way to improve patient comfort. We suggest that future large-scale studies be conducted across multiple hospital sites, including smaller community healthcare centers, to confirm these benefits broadly. Additionally, future research with a larger patient group should focus specifically on tracking long-term side effects and monitoring blood sugar levels after surgery.

CONCLUSION

Our present study demonstrates that the two patient groups were highly comparable in terms of baseline demographics, ensuring accurate comparisons. Compared to the standard bupivacaine-saline group, the bupivacaine-dexamethasone group demonstrated a significantly shorter spinal regression time, a major reduction in total tramadol consumption, and consistently lower pain scores across the 24-hour timeline. Most importantly, the dexamethasone track achieved a significantly longer duration of overall pain relief and a delayed need for first rescue painkillers. Ultimately, dexamethasone can be used safely, cheaply, and effectively as an adjuvant to bupivacaine in ultrasound-guided TAP blocks to provide superior postoperative comfort.

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