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Study on Addition of Dexmedetomidine Versus Fentanyl to Intrathecal Hyperbaric Bupivacaine for General and Orthopedic Surgeries

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ABSTRACT

Background: Spinal anaesthesia is extensively used for overall and orthopaedic surgeries due to its effective sensory and motor blockade. Hyperbaric oxygen therapy bupivacaine is a generally used local anaesthetic, and the addition of adjuvants like dexmedetomidine and fentanyl can improve its effects. This study compares these two adjuvants' efficacy in terms of analgesia duration, motor block, hemodynamic stability, and postoperative complications.

Methods: A randomized observational study was conducted on 104 patients experiencing lower abdominal and orthopaedic surgeries. Patients were separated into two groups: Group A (dexmedetomidine, five mcg) and Group B (fentanyl, 25 mcg), with 52 patients each. Both groups received intrathecal hyperbaric bupivacaine (0.5%). The duration of analgesia, motor block, hemodynamic parameters, and postoperative complications were recognized and analyzed significantly.

Results: The results of this study showed that Dexmedetomidine provided longer analgesia and motor block than fentanyl ($p<0.001$), though fentanyl showed lower pain scores postoperatively ($p<0.05$). Surgical durations were similar. Bradycardia was more common with dexmedetomidine; hypotension, itching, and dry mouth occurred more with fentanyl. Nausea and vomiting were slightly more frequent with dexmedetomidine; chills were comparable.

Conclusion: This study has concluded that the SCFP group has significantly higher coronary flow values compared to the Control group across the LAD (Left Anterior Descending artery), LCX (Left Circumflex artery), and RCA (Right Coronary Artery).

Key-words: Spinal anaesthesia, Hyperbaric bupivacaine, Dexmedetomidine, Fentanyl, Postoperative analgesia, Motor block, Hemodynamic stability

INTRODUCTION

Spinal anaesthesia is an extensively used anaesthetic method for various surgical and wide-ranging orthopaedic surgical procedures [1]. It provides effective sensory and motor blockade while maintaining hemodynamic stability, making it a favoured choice in many clinical surroundings [2]. The method involves the administration of local anaesthetic agents into the subarachnoid space, leading to the reversible reserve of nerve impulse communication [3]. Among the numerous local anaesthetic agents available, hyperbaric bupivacaine, a long-acting amide-type local anaesthetic, is the most regularly used due to its excellent analgesic properties, reliable blockade, and expected duration of action [4].

Despite its effectiveness, a significant encounter in spinal anaesthesia is the control of the duration of analgesia and motor blockade. The mission of extending the duration of analgesia, enhancing the quality of the block, and minimizing possible side effects has directed the incorporation of adjuvants such as opioids and alpha-2 agonists [5]. These adjuvants modify the pharma cokinetics and pharmacodynamics of local anaesthetic agents, improving the overall anaesthetic experience and patient consequences [6].

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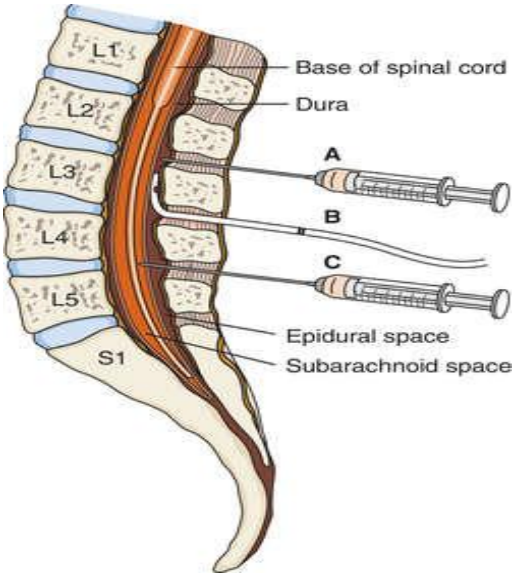

Fig. 1: Spinal anaesthesia

Among the regularly used adjuvants, fentanyl, a copied opioid, and dexmedetomidine, an extremely selective alpha-2 adrenergic receptor agonist, have gained significant attention. Fentanyl makes accessible potent analgesia with minimal hemodynamic effects, making it a popular choice for cultivating spinal anaesthesia [7]. On the other hand, dexmedetomidine has been recognised for its sedative, anxiolytic, and analgesic possessions, along with its ability to prolong the duration of sensory and motor block [8]. Assuming these distinct pharmacological properties, comparing their effectiveness and safety profiles is overbearing when used as adjuvants to hyperbaric bupivacaine in spinal anaesthesia for general and orthopaedic surgeries [9].

Rationale for the Study- Collecting a suitable adjuvant in spinal anaesthesia is fundamental in determining surgical outcomes, postoperative analgesia, and overall patient approval. Through counting with adjuvants, clinicians aim to accomplish continuous and improved analgesia while reducing the requirement for supplemental analgesics during the postoperative period [10].

Fentanyl, as an adjunct, is fentanyl is a lipophilic opioid that is performed by required opioid receptors in the spinal cord, moderating pain perception and reducing nociceptive transmission. The situation is known for its rapid onset of action and potent analgesic effect while exhibiting minimal neurotoxicity [11]. These possessions make it an extensively used assistant in spinal anaesthesia. However, fentanyl is related to specific side effects, as well as pruritus, nausea, vomiting, and, in some cases, respiratory despair. These adverse effects require careful dosing and monitoring to optimize their benefits while minimizing potential difficulties [12].

Table 1: Assessment of Fentanyl and Dexmedetomidine as Adjuvants in Spinal Anaesthesia [13]

Adjunct	Mode of Action	Compensations	Difficulties
Fentanyl	Quandaries to opioid receptors in the spinal cord, dropping nociceptive transmission.	Fast onset, potent analgesia, negligible neurotoxicity.	Pruritus, nausea, vomiting, respiratory depression.
Dexmedetomidine	Performances on alpha-2 adrenergic receptors, moderating pain pathways and extending block duration.	Continued sensory and motor block, sedation, and improved postoperative analgesia.	Bradycardia, hypotension.

Dexmedetomidine, as an adjunct dexmedetomidine, is an extremely selective alpha-2 agonist that modulates pain pathways by acting on both presynaptic and postsynaptic receptors in the central nervous system. It has been shown to prolong both sensory and motor block duration, offering a prolonged period of postoperative analgesia without causing important respiratory depression [14]. In addition, dexmedetomidine provides sedation and anxiolysis, contributing to better intraoperative conditions and improved postoperative comfort. Its use is related to potential apprehensions such as bradycardia and hypotension, which require careful hemodynamic monitoring during management [15].

Empathetic to the comparative efficacy of these adjuvants is critical for optimizing anaesthetic management in various surgical procedures. The assistances and possible disadvantages of both fentanyl and dexmedetomidine must be cautiously assessed to determine their appropriateness for specific patient populations and surgical situations [16]. This study evaluates and compares their effects on sensory and motor block appearances, hemodynamic constancy, postoperative analgesia, and adverse effects. Through doing so, this research will contribute to appreciating perceptions of the optimal use of adjuvants in spinal anaesthesia, eventually improving patient care and surgical outcomes.

MATERIALS AND METHODS

Research design- This randomized, observational, and comparative study was conducted at the Department of Anaesthesiology, ESI Hospital Inpatient Conveniences, Sanathnagar, Hyderabad, Telangana, India. The study aimed to assess the effectiveness of different anaesthetic agents in patients experiencing lower abdominal surgeries below the umbilicus. The Institutional Human Ethics Committee designed and accepted the study protocol before opening. A complete literature review was directed, and applicable information was collected from numerous certified sources and peer-reviewed articles, periodicals, and medical readers to establish the research background.

This study involved 104 patient roles confidential under the ASA Physical Status I-II group. These patients were arranged for elective lower abdominal and orthopaedic surgical procedures and were casually allocated into two assemblies, each containing 52 individuals. The main objective of this study was to assess and compare the effectiveness of intrathecal administration of bupivacaine (0.5 mics) in combination with dexmedetomidine (5 mcg) in group A and fentanyl (25 mcg) provided that optimal anaesthesia and postoperative analgesia in group B.

The randomization process was performed to confirm impartial results, thereby cultivating the reliability and rationality of the study. Patients were put in danger of standard ASA monitoring through the perioperative period. The study medications were selected based on their well-documented analgesic and anaesthetic possessions. Bupivacaine, a long-acting local anaesthetic, was chosen for its reflective physical and motor blockade, while dexmedetomidine and fentanyl were combined to improve analgesia and extend the period of anaesthesia.

The investigative procedure followed an organized method that complicated preoperative assessment, intraoperative monitoring, and postoperative evaluation. Before management anaesthesia, each patient experienced a complete preoperative assessment, a demographic data group, a medical history assessment, and a baseline vital sign video recording. Patients were informed about the study facts, and knowledgeable written permission was obtained in their preferred language to ensure understanding and voluntary contribution.

Throughout the intraoperative stage, patients established the given anaesthetic schedule under severe aseptic circumstances. The depth of anaesthesia, haemodynamic constancy, and adverse reactions were incessantly monitored and recognized. Postoperative pain evaluation was directed using the Visual Analogue Scale, with follow-ups arranged at two-hour intermissions to assess pain concentration. The Bromage scale was also second-hand to the amount of motor block retrieval, a subordinate consequence limit.

Inclusion criteria

- Patients off the record under ASA Grade I and II.
- Patient role of both genders (male and female).
- Affected patients aged between 18 and 65 years.
- Patients experiencing general surgeries below the level of the umbilicus.
- Patients experiencing orthopaedic surgeries.

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Exclusion criteria

- Patients disinclined to subsidise the study.
- Patients with a time past of dislikes to the study drugs (fentanyl and dexmedetomidine).
- Patients with any blood disorders and a platelet amount under 100,000.
- Gravid and breast-feeding women.

Statistical Analysis- Statistical analysis was focused on IBM SPSS software and Microsoft Excel. The T-test statistical tool was active to regulate the p-value for the collected data. A paired T-test was utilized to compare two population means, where both samples are subject to each other. This examination, also known as the repeated samples T-test or in need of samples T-test, required two variables, one defining a pair of observations and the other in place of dimension data. The null hypothesis was rejected if the $p<0.005$ instead of a significant difference between the groups. Statistical tools established an objective investigation of the efficacy of the anaesthetic agents, enabling accurate understanding and inference of the study consequences.

RESULTS

Fig. 2 shows age groups aged 21-30 to 81-90. The maximum number of subjects were in the 51-60 age group, where 13 males received dexmedetomidine, while eight males received fentanyl. The 41-50 age group also had a substantial number of patients, with 12 males receiving both dexmedetomidine and fentanyl and a considerable number of females in both groups. In the 21-30 age group, fentanyl male subjects 10 were >deemed male subjects 8, while female illustration remained lower across both drugs. As age increases, subjects decrease, with very few applicants in the 71-80 and 81-90 age groups. Mainly, only one fentanyl male was recorded in the 81-90 age group, with no other applicants.

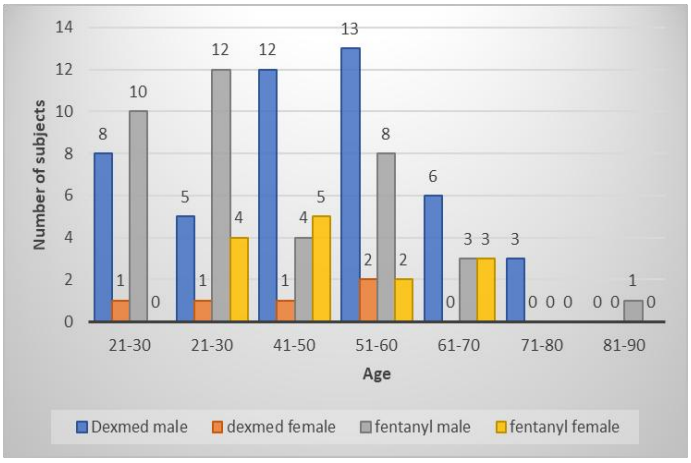

Fig 2: Dispersal of study residents based on age

Among the patients who received dexmedetomidine, 90% were male, while only 9.6% were female, representing a significant male prevalence in this group. The fentanyl group presented a comparatively more composed dispersal, with 73.07% males and 26.92% females (Fig. 3).

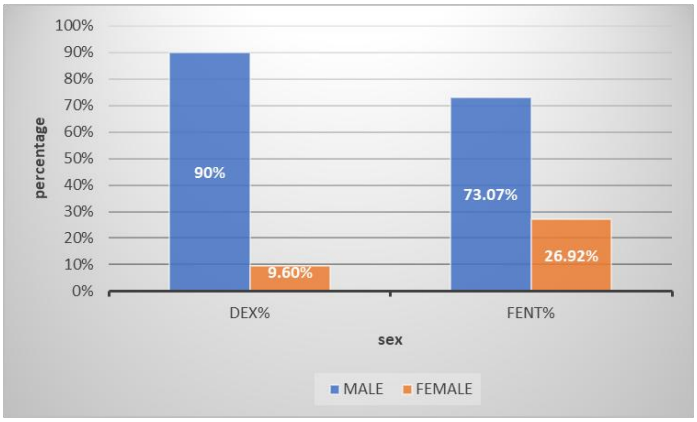

Fig 3: Dispersal of study residents based on gender

Most patients in both groups revealed sensory blockade at the L3-L4 level, with 41 subjects in the dexmedetomidine group and 35 in the fentanyl group, representing that this was the most common level of sensory blockade completed. At the T12 level, 10 subjects in the dexmedetomidine group and 13 in the fentanyl group were recorded, showing a to some extent higher number for fentanyl at this level. The L10 level was detected in very few cases, with only one dexmedetomidine and three fentanyl subjects. Remarkably, a sensory level as high as T6 was observed in only one subject receiving fentanyl, while none in the dexmedetomidine group stretched this level (Fig. 4).

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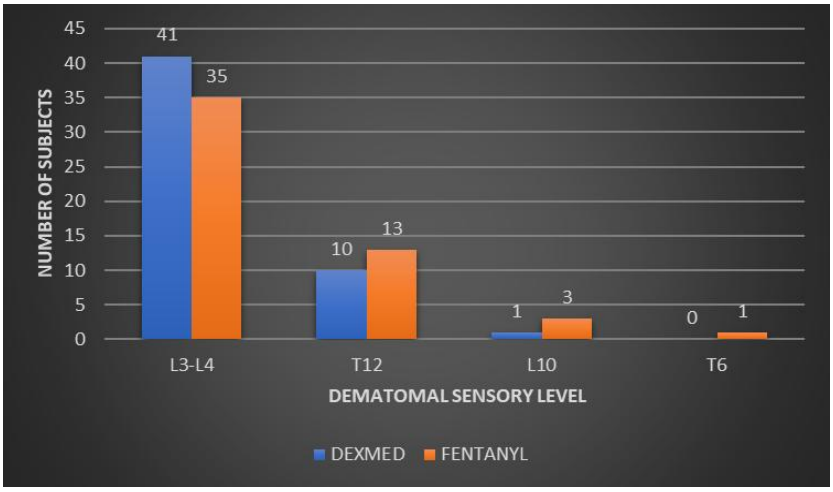

Fig. 4: Dispersal of study residents based on dermatomal sensory level

The haemodynamic parameters, including blood pressure, pulse rate, heart rate, and oxygen saturation, were monitored instantaneously for two groups of patients receiving different anaesthetic agents. The results indicate that blood pressure remained moderately stable in both groups, with minor variations observed throughout the time intervals. Pulse and heart rates showed insignificant differences, which may be attributed to the physiological responses to anaesthesia and surgical stimuli. However, these differences were within the satisfactory clinical range, suggesting adequate haemodynamic stability with both anaesthetic agents. SpO2 levels remained above 98% in both groups, representing adequate oxygenation and respiratory stability (Fig. 5).

Fig. 5: Comparative Analysis of Haemodynamic Parameters in Patients Suffering Lower Abdominal Surgeries: A Study of Dexmedetomidine vs. Fentanyl

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At 0 hours, both fentanyl and dexmedetomidine groups started with a Bromage score of 4, indicating a complete motor block. Over time, the recovery of motor function was faster in the fentanyl group compared to the dexmedetomidine group. At 4 hours, three patients in the dexmedetomidine group still had a motor block, while only two in the fentanyl group showed residual effects. By 6 hours, only one patient in the fentanyl group and two in the dexmedetomidine group continued to show signs of motor block.

The Visual Analogue Score results indicate postoperative pain observation at different time intervals. Both groups had no pain at 0 hours. Over time, the pain scores increased in both groups, but the fentanyl group exhibited lower pain scores compared to the dexmedetomidine group. At 2 hours, the VAS score for fentanyl was 0.288, whereas it was somewhat higher in the dexmedetomidine group (0.42). The tendency continued at 4 and 6 hours, with fentanyl demonstrating significantly lower pain scores (0.94 and 1.96) compared to dexmedetomidine (3.55 and 5.90) (Table 2).

Table 2: Study population based on the Bromage scale and visual analogue score

Bromage scale				
Drug	0HR	2HR	4HR	6HR
Fentanyl	4	300%	2	1
Dexmedetomidine	4	400%	3	2
Visual analogue score				
Dexmedetomidine	0	0.42	3.55	5.90
Fentanyl	0	0.28	0.94	1.96

Chills were observed in 52 patients in both groups, representing no difference in occurrence. Dry mouth was more prevalent in the fentanyl group (45 cases) compared to the dexmedetomidine group (32 cases), signifying that fentanyl may have a higher association with this side effect. Nausea and vomiting were, to some extent, more common in the dexmedetomidine group (4 cases) than in the fentanyl group (3 cases), but the overall occurrence was low in both groups. Itching was reported only in the fentanyl group (5 cases), which is a known side effect of opioid use. Hypotension was observed entirely in the fentanyl group (15 cases), whereas bradycardia was more frequent in the dexmedetomidine group (9 cases) compared to the fentanyl group (4 cases) (Table 3).

Table 3: The study population based on complications

Complications	**Chills**	**Dry mouth**	**Nausea vomiting**	**Itching**	**Hypotension**	**Bradycardia**
Dexmedetomidine	52	32	4	0	0	9
Fentanyl	52	45	3	5	15	4
Total	54	47	7	5	15	13

Group A verified a significantly longer duration of analgesia (343.846±78.918 minutes) compared to Group B (129.134±26.359 minutes), representing superior pain relief over time. The duration of surgery was comparable between the two groups, with Group A at 132.596±33.57 minutes and Group B at 133.461±22.1 minutes, signifying that the type of intervention did not influence surgical time. In addition, the duration of motor block was mainly longer in Group A (271.538±25.182 minutes) than in Group B (183.764±9.617 minutes), suggesting a more prolonged motor impairment in Group A (Table 4).

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Table 4: The study population based on Duration.

Parameter	Group A (n=52)	Group B (n=52)
Duration of analgesia	343.846±78.918	129.134±26.359
Duration of surgery	132.596±33.57	133.461±22.1
Duration of motor block	271.538±25.182	183.764±9.617

DISCUSSION

Vertebral anaesthesia using hyperbaric oxygen therapy, bupivacaine is an extensively accepted technique for general and orthopaedic surgical procedures due to its thoughtful sensory and motor blockade. Numerous adjuvants enhance efficacy and prolong the duration of anaesthesia while reducing adverse effects [17]. Between them, dexmedetomidine, an α2-adrenergic agonist, and fentanyl, an unreal opioid, have been studied expansively for their role in potentiating the effects of intrathecal hyperbaric bupivacaine.

Dexmedetomidine is a discriminating α2-adrenergic receptor agonist with sedative, analgesic, and sympatholytic properties. It provides prolonged analgesia with minimal respiratory depression. In contrast, fentanyl is a lipophilic opioid that improves the quality of spinal anaesthesia by binding to μ-opioid receptors. This leads to a faster onset and moderate duration of analgesia with possible side effects such as itching and respiratory depression [18].

Numerous studies have compared the effects of dexmedetomidine and fentanyl as adjuvants to intrathecal hyperbaric bupivacaine. The following features are generally estimated in the onset and duration of the sensory and motorized blockade, hemodynamic constancy, postoperative analgesia, and adverse effects [19].

The studies have shown that dexmedetomidine suggestively prolongs the duration of sensory and motor blockade. Verma *et al.* reported that dexmedetomidine prolonged sensory blockade duration by approximately 120-150 minutes more than fentanyl [20].

Fentanyl delivers a quicker onset of analgesia but a comparatively shorter duration compared to dexmedetomidine. Dhawale *et al.* well-known that while fentanyl accelerates sensory blockade onset, its duration is shorter by 60-90 minutes associated with dexmedetomidine [21].

It causes mild to moderate hypotension and bradycardia due to its sympatholytic effect. However, hemodynamic stability is well-maintained with appropriate fluid management and vasopressors in Dexmedetomidine. Exhibitions better hemodynamic stability compared to dexmedetomidine, with less incidence of bradycardia and hypotension. However, it may cause nausea and vomiting due to its opioid nature in Fentanyl [22].

This provides prolonged postoperative analgesia. Multiple studies, including research by Al-Mustafa *et al.,* have demonstrated significantly reduced analgesic consumption postoperatively due to the extended duration of action. It offers satisfactory analgesia but with a shorter duration. Rescue analgesia is often required earlier than in dexmedetomidine groups [23].

It is more commonly associated with bradycardia and hypotension. However, it has minimal effects on respiratory function, making it a safer option for patients at risk of respiratory compromise. Communal side effects include pruritus, nausea, and vomiting. It may cause mild respiratory depression, predominantly in susceptible individuals [24].

Table 5: Main findings of the similar studies [25]

Limitation	Dexmedetomidine	Fentanyl
Onset of Sensory Block	To some extent, delayed	Rapid
Period of Sensory Block	Prolonged (~120-150 min longer)	Shorter (~60-90 min)
Onset of Motor Block	Slightly delayed	Rapid
Duration of Motor Block	Prolonged (~120 min longer)	Shorter
Postoperative Analgesia	Prolonged (~6-8 hours)	Moderate (~3-4 hours)

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Hemodynamic Effects	Bradycardia, Hypotension (manageable)	Stable, less incidence of hypotension
Side Effects	Mild sedation, Bradycardia, Hypotension	Pruritus, Nausea, Vomiting, Mild Respiratory Depression
Respiratory Depression	Nominal	Possible, predominantly at higher doses
Overall Patient Approval	Higher due to prolonged analgesia	Good, but it may require early rescue analgesia

Clinical Inferences- Constructed on these results, the choice between dexmedetomidine and fentanyl as an adjuvant depends on the clinical scenario:

For prolonged surgeries and postoperative analgesia requirements, dexmedetomidine is preferred due to its extended duration of action. For more rapid procedures where rapid onset is desired, fentanyl provides adequate analgesia with better hemodynamic stability. In patients with cardiovascular risks, fentanyl may be safer due to fewer hypotensive and bradycardic effects [26].

CONCLUSIONS

This study has concluded that the SCFP group has significantly higher coronary flow values compared to the Control group across the LAD (Left Anterior Descending artery), LCX (Left Circumflex artery), and RCA (Right Coronary Artery). Specifically, the mean flow in the LAD, LCX, and RCA for the SCFP group was 35.5±2.5, 21.3±5.0, and 23.9±3.7, respectively, compared to 26.8±2.0, 17.2±3.3, and 16.1±2.1 in the Control group ($p<0.001$ for all). Additionally, the mean TFC (total flow coefficient) in the SCFP group was 27.3±3.7, significantly higher than the 19.5±1.9 observed in the Control group ($p<0.001$), indicating slower coronary blood flow in the SCFP group. The data also reveals that a higher proportion of patients in the SCFP group had multi-vessel coronary artery involvement, with 28% having single-vessel disease, 42% with two-vessel involvement, and 30% with three-vessel involvement. Specifically, 72% of SCFP patients had LAD involvement, 55% had LCX involvement, and 83% had RCA involvement, highlighting more widespread coronary artery disease in the SCFP group compared to controls.

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