

Comparison of forced expiratory spirometric flow changes following intrathecal bupivacaine and bupivacaine with fentanyl

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ABSTRACT

Background: Higher dermatomal block following spinal anaesthesia impairs inspiratory capacity and decreases forced expiratory flow rates. This decrease in forced expiratory flows can in turn decrease the effectiveness of cough. Intrathecal opioids are important adjuncts to intrathecal local anaesthetics. The objective of our study was to compare the decrease in forced expiratory flows from the baseline values after subarachnoid block with bupivacaine and bupivacaine with fentanyl.

Methods: Institutional ethics committee approval was obtained. Forty ASA I and II adult males, scheduled for elective surgery were included in the study. Informed written consent was obtained from all patients who were randomly allocated into two groups. Group B received intrathecal anaesthesia 15 mgs of bupivacaine with 0.5 ml of normal saline and Group BF received 15 mgs of bupivacaine with 0.5 ml of fentanyl (25 µg) intrathecally. The patients were instructed about the performance of the spirometry on the previous evening of the surgery. Forced vital capacity, forced expiratory volume in one second, peak expiratory flow rate and maximum expiratory pressure (Forced expiratory flows) were measured in supine position before intrathecal block and at 10, 60 and 120 minutes, following the establishment of the block. Highest dermatomal level of sensory blockade was noted.

Results: There was no statistically significant difference in the baseline values of FVC (Group B: 4.188 ± 0.821 , Group BF: 4.186 ± 0.575 , $p = 0.127$), FEV₁ (Group B: 3.301 ± 0.846 , Group BF: 3.276 ± 0.825 , $p = 0.240$), PEFR (Group B: 458.6 ± 43.024 , Group BF: 452.6 ± 41.036 , $p = 0.091$) and P_Emax (Group B: 52.64 ± 4.029 , Group BF: 53 ± 3.162 , $p = 0.119$) between the two groups. There was highly significant reduction in the values of FVC, PEFR and P_Emax when compared to the baseline in both the groups at all three study periods. There was an acute reduction in the values of FVC, FEV₁, PEFR and P_Emax at 10 minutes. The graphs then achieve a plateau from 10 minutes to 60 minutes. From 60 to 120 minutes there was a gradual upslope in the graph. With regards to FEV₁, though at 10 and 60 minutes there were statistically significant reductions when compared to the baseline values in both the groups, at 120 minutes the reductions were not significant. At all three time periods there was no difference in the reductions in FVC, FEV₁, PEFR and P_Emax values among the two groups. None of the patients in both the groups had PEFR and P_Emax values below the critical value.

Conclusion: The addition of 25 µg of fentanyl to intrathecal bupivacaine did not have any adverse effect on forced expiratory flows. There was a decrease in forced expiratory flows in both groups, but the decrease in PEFR and P_Emax were never below the critical values. It is unlikely that a combination of intrathecal local anaesthetic and opioids will impair the normal patient's ability to cough effectively.

Introduction

The addition of fentanyl to intrathecally administered bupivacaine improves intraoperative and early postoperative quality of analgesia.¹ But respiratory depression, both early and late, is an undesirable side effect of intrathecal opioids.² Also, previous studies have shown that spinal blockade with local anaesthetics reduced expiratory flow rates.^{3,4} Fentanyl administered intrathecally with bupivacaine may have a synergistic effect on forced expiratory flow rates. In this prospective randomised study, the researchers compared forced expiratory spirometric flow rate changes following intrathecal hyperbaric bupivacaine with a combination of intrathecal hyperbaric bupivacaine and fentanyl.

Methods

Approval for the study was obtained from the ethics committee of the Department of Anaesthesia and Intensive Care, Kasturba

Medical College, Manipal Academy of Higher Education. Written, informed consent was obtained from all patients. Forty ASA I and II adult males, aged 27–70 years scheduled for elective lower abdominal surgery and endoscopic urologic surgery of 40 to 60 minutes duration were selected. The exclusion criteria included patients on concurrent systemic opioids, known history of drug abuse, abnormal prothrombin time (International Normalised Ratio > 1.5), clinically significant valvular heart disease, a history of cardiovascular or respiratory disease, a raised intracranial pressure, allergy to opioids or local anaesthetics and peripheral/autonomic neuropathy.⁵ All patients were evaluated preoperatively and relevant investigations were obtained. All patients were trained to perform forced expiratory manoeuvres in the supine position. Patients were fasted overnight, received oral diazepam 0.2 mg kg⁻¹ both on the night prior to surgery and two hours preceding the intrathecal block. All patients were

preloaded with 10–15 ml/kg of lactated Ringer's solution before administration of the intrathecal block. Monitoring consisted of peripheral saturation, intermittent automated non-invasive blood pressure and electrocardiogram lead II and V₅. Baseline forced expiratory flows were measured in the supine position. The highest of the three measurements was recorded.6 Forced vital capacity (FVC), Forced expiratory volume in one second (FEV₁) (Vitalograph), Peak expiratory flow rate (PEFR) (modified Wright's Peak Flow meter) and maximum expiratory pressure (P_E max) (mercury sphygmomanometer) were measured. Patients were randomised, on the basis of pre-sealed envelopes, to receive either 3.0 ml (15 mgs) of bupivacaine 0.5% with 0.5 ml of normal saline (n = 20, Group-B) or 3.0 ml (15 mgs) of bupivacaine 0.5% with 0.5 ml of fentanyl (25 µg) (n = 20, Group-BF) intrathecally. The intrathecal solutions were prepared by a separate anaesthesiologist who had no further involvement with the study. With aseptic precautions, the skin and the interspinous ligament were infiltrated with 1% lignocaine, and dural puncture was performed in left lateral decubitus position at L₃–L₄ intervertebral space through midline approach using a 23 gauge Quinke needle. After a free flow of CSF was established, one of the solutions was injected by an anaesthesiologist who was blinded to the actual solution used. The solutions were injected at a standardised rate of 0.2 ml per second, without barbotage. The patients were returned to the supine position. Blood pressure, heart rate, and respiratory rate were monitored every two minutes for the first 10 minutes and then every 10 minutes during surgery. Hypotension, defined as a decrease in systolic pressure more than 20% below the baseline values, was treated by administering intravenous crystalloids and ephedrine. Respiratory depression, defined as respiratory rate less than ten breaths per minute, was noted. The level of sensory blockade was assessed by cold sensation at 10, 60 and 120 minutes. The highest dermatomal level of sensory blockade was noted. The forced expiratory flows were measured in the supine position at 10, 60 and 120

Table I: Demographic profile

	B	BF
Number	24	23
Age (years)*	49.05 ± 14.188	42.95 ± 13.264
Weight (kg)*	62.75 ± 7.047	58.4 ± 8.048
Height (cm)*	167.2 ± 5.643	165.5 ± 6.770
ASA class I	19	18
ASA class II	5	5
Surgeries		
Ureterocystoscopy	20	20
Indirect hernia repair	4	2
Umbilical hernia repair	-	1

* – non significant

Table II: Sensory levels at 10, 60 and 120 minutes after the intrathecal block*

Time		T ₄	T ₅	T ₆	T ₇	T ₈	T ₉	T ₁₀
10 min	Group B	9	9	6				
	Group BF	9	7	7				
60 min	Group B	6	8	10				
	Group BF	4	7	8	4			
120 min	Group B			5	5	8	3	3
	Group BF			10	5	8		

* – number of patients

minutes following the blockade. Side effects, including nausea, vomiting, pruritus, apnoea, headache and dizziness, if any, were noted. Urinary retention was not evaluated as most of the patients had indwelling urinary catheters. No systemic narcotics were administered during the study period.

Data was statistically analysed using Student's t test and Chi-Square test, with p < 0.05 being considered statistically significant.

Results

Twenty-five consecutive patients were enrolled in each group. One patient in Group B and two patients in group BF were excluded from the study, as they received general anaesthesia. There were no statistically significant differences between the two groups with respect to age, weight and height (Table I). The levels of sensory block at 10, 60 and 120 minutes after intrathecal administration of drugs are shown in Table II.

In both groups, the highest sensory blockade was T₄. There was no statistically significant difference in the height of sensory blockade achieved in both groups at 10 minutes (p = 0.659) and 60 minutes (p = 0.202). However, at 120 minutes the height of sensory blockade in Group BF was significantly greater (p = 0.021) than in Group B. Fifteen patients in Group BF had sensory blockade of T₆–T₇ at 120 minutes whereas in Group B only six patients had sensory blockade of T₆–T₇. Regression of anaesthesia to the T₆ dermatome took a longer time in Group BF.

Tables III and IV show the mean values of FVC, FEV₁, PEFR and P_Emax at baseline, 10 minutes, 60 minutes and 120 minutes and the difference from baseline at the three time periods in Group B and Group BF respectively.

There was no statistically significant difference in the baseline values of FVC (Group B: 4.188 ± 0.821, Group BF: 4.186 ± 0.575, p = 0.127), FEV₁ (Group B: 3.301 ± 0.846, Group BF: 3.276 ± 0.825, p = 0.240), PEFR (Group B: 458.6 ± 43.024, Group BF: 452.6 ± 41.036, p = 0.091) and P_Emax (Group B: 52.64 ± 4.029, Group BF: 53 ± 3.162, p = 0.119) between the two groups. There was a highly significant reduction in the values of FVC, PEFR and P_Emax when compared to the baseline in both groups at all three study periods. With regard to FEV₁, though at 10 and 60 minutes there were statistically significant reductions when compared to the baseline values in both groups, at 120 minutes the reductions were not significant.

Tables V, VI and VII compare the mean reduction and mean percentage reduction in forced expiratory flows between group B and group BF at 10 minutes, 60 minutes and 120 minutes respectively. At all three time periods there was no difference in the reductions in FVC, FEV₁, PEFR and P_Emax values between the two groups.

Table III: Mean values of FVC, FEV₁, PEFR and P_Emax at baseline, 10 minutes, 60 minutes and 120 minutes and the difference from baseline in Group B

	Baseline	10 minutes			60 minutes			120 minutes		
		Mean ± S D	D ± S D	p value	Mean ± S D	D ± S D	p value	Mean ± S D	D ± S D	p value
FVC (litres)	4.188 ± 0.821	3.474 ± 0.740	0.714 ± 0.354	0.001*	3.710 ± 0.751	0.677 ± 0.344	0.001*	4.031 ± 0.819	0.256 ± 0.316	0.001*
FEV ₁ (litres)	3.301 ± 0.846	3.012 ± 0.764	0.569 ± 0.567	0.001*	2.863 ± 0.721	0.418 ± 0.398	0.001*	3.348 ± 0.848	0.233 ± 0.512	0.062†
PEFR (L/min)	458.6 ± 43.024	378.4 ± 38.722	80.2 ± 16.613	0.0001*	370.2 ± 37.872	78.4 ± 30.981	0.0001*	428.4 ± 37.630	30.2 ± 16.232	0.0001*
P _E max (mm Hg)	52.64 ± 4.029	37.84 ± 4.102	14.8 ± 4.434	0.001*	37.22 ± 4.102	14.7 ± 4.962	0.001*	47.00 ± 3.547	5.64 ± 2.447	0.001*

* – significant, † – not significant, D – Difference from baseline

Table IV: Mean values of FVC, FEV₁, PEFR and P_Emax at baseline, 10 minutes, 60 minutes and 120 minutes and the difference from baseline in Group BF

	Baseline	10 minutes			60 minutes			120 minutes		
		Mean ± S D	D ± S D	p value	Mean ± S D	D ± S D	p value	Mean ± S D	D ± S D	p value
FVC (litres)	4.186 ± 0.575	3.516 ± 0.577	0.669 ± 0.304	0.001*	3.569 ± 0.596	0.616 ± 0.348	0.001*	3.932 ± 0.578	0.254 ± 0.251	0.001*
FEV ₁ (litres)	3.276 ± 0.825	2.755 ± 0.704	0.421 ± 0.465	0.001*	2.587 ± 0.713	0.319 ± 0.438	0.001*	3.437 ± 0.759	0.138 ± 0.346	0.057†
PEFR (L/min)	452.6 ± 41.036	381.6 ± 38.479	74 ± 13.844	0.0001*	358.2 ± 38.591	67.4 ± 18.092	0.0002*	431.4 ± 43.72	24.2 ± 14.838	0.0001*
P _E max (mm Hg)	53 ± 3.162	37.56 ± 2.346	12.44 ± 3.215	0.001*	37.6 ± 2.886	12.4 ± 3.316	0.001*	45.2 ± 2.943	4.80 ± 2.516	0.001*

* – significant, † – not significant, D – Difference from baseline

Table V: Comparison of mean reduction and mean percentage reduction in forced expiratory flows between Group B and Group BF at 10 minutes

		Mean reduction ±S.D)	p value	Mean % reduction ±S.D)	p value
FVC (litres)	Group B	0.6675 ±0.3770	0.863*	15.062 ± 7.94	0.574*
	Group BF	0.6875 ±0.349		16.481 ± 7.890	
FEV ₁ (litres)	Group B	0.5305 ±0.629	0.422*	14.453 ± 17.316	0.549*
	Group BF	0.483 ±0.512		12.234 ± 16.29	
PEFR (L/min)	Group B	79.25 ±17.492	0.178*	16.952 ± 3.241	0.712*
	Group BF	72.5 ±13.32		17.344 ± 3.41	
P _E max (mm Hg)	Group B	13.60 ±2.722	0.21*	26.621 ± 4.911	0.303*
	Group BF	12.45 ±2.981		24.917 ± 5.423	

* – non significant

Table VI: Comparison of mean reduction and mean percentage reduction in forced expiratory flows between Group B and Group BF at 60 minutes

		Mean reduction ±S.D	p value	Mean % reduction ±S.D)	p value
FVC (litres)	Group B	0.6360 ± 0.3656	0.818*	14.37 ± 7.791	0.563*
	Group BF	0.6625 ± 0.3569		15.845 ± 8.126	
FEV ₁ (litres)	Group B	0.3215 ± 0.579	0.506*	12.861 ± 22.62	0.283*
	Group BF	0.3620 ± 0.7335		14.87 ± 34.36	
PEFR (L/min)	Group B	79.25 ± 34.192	0.205*	16.790 ± 6.652	0.756*
	Group BF	73.80 ± 18.73		16.229 ± 4.50	
P _E max (mmHg)	Group B	13.50 ± 3.425	0.288*	26.458 ± 6.645	0.418*
	Group BF	12.40 ± 3.015		24.859 ± 5.656	

* – non significant

Table VII: Comparison of mean reduction and mean % reduction in forced expiratory flows between Group B and Group BF at 120 minutes

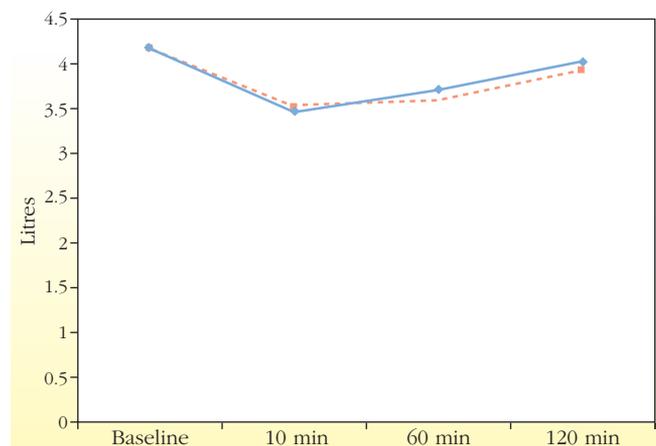
		Mean reduction ± S.D	p value	Mean % reduction ± S.D	p value
FVC (litres)	Group B	0.2600 ± 0.3508	0.877*	5.775 ± 7.610	0.96*
	Group BF	0.2445 ± 0.2717		5.88 ± 6.507	
FEV ₁ (litres)	Group B	0.258 ± 0.5668	0.351*	6.566 ± 14.697	0.374*
	Group BF	0.213 ± 0.3869		5.688 ± 12.455	
PEFR (L/min)	Group B	27.90 ± 17.814	0.128*	6.542 ± 3.55	0.372*
	Group BF	22.75 ± 15.59		5.491 ± 3.794	
P _E max (mmHg)	Group B	4.20 ± 3.019	0.833*	8.110 ± 5.902	0.718*
	Group BF	4.40 ± 2.945		8.796 ± 5.797	

* – non significant

Figures 1, 2, 3 and 4 graphically represent the forced expiratory flows at baseline, 10, 60 and 120 minutes. There was an acute reduction in the values of FVC, FEV₁, PEFR and P_Emax at 10

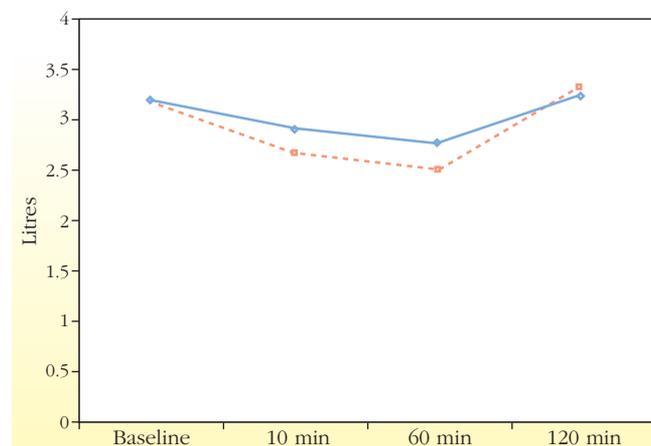
minutes. The graphs then achieve a plateau from 10 minutes to 60 minutes. From 60 to 120 minutes there was a gradual upslope in the graph.

Figure 1: Comparison of FVC at baseline, 10, 60 and 120 minutes in group B and group BF



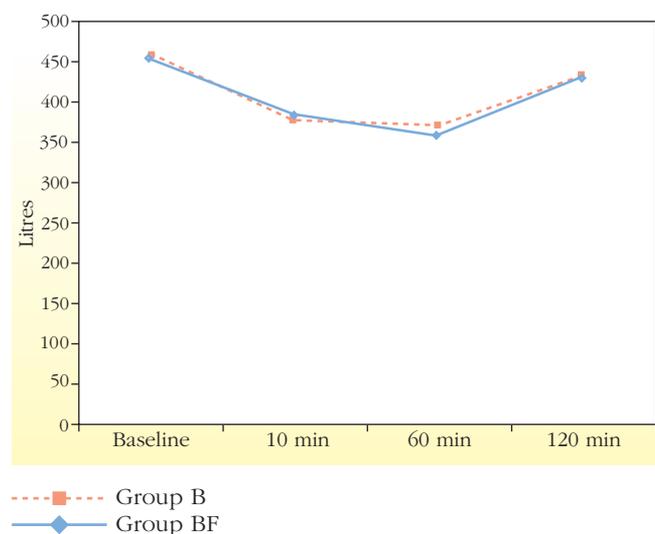
◆ Group B
- - ■ Group BF

Figure 2: Comparison of FEV₁ at baseline, 10, 60 and 120 minutes in group B and group BF



◆ Group B
- - ■ Group BF

Figure 3: Comparison of PEFR at baseline, 10, 60 and 120 minutes in group B and group BF



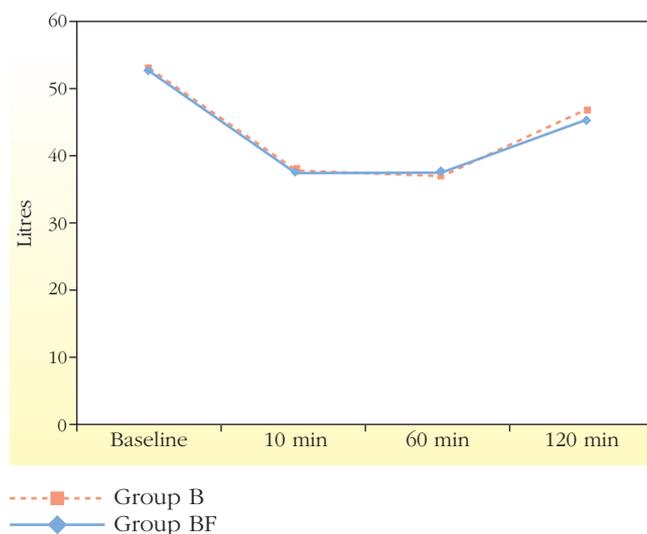
Discussion

Spinal blockade with sensory levels at or above the level of T₁₀ impair forced expiratory flow rates and jeopardise patients with excessive sputum production.^{3,4} The researchers could demonstrate a significant reduction in forced expiratory flow rates in both groups even after 120 minutes of blockade. The abdominal muscles are the most important muscles of forced expiration and coughing.^{6,7} Paralysis of abdominal musculature would reduce the ability to exhale forcibly, thus impairing forced expiratory manoeuvres like FVC, FEV₁, PEFR and P_E max.⁷ The study demonstrates the important fact that there is no significant difference in the forced expiratory flows after addition of fentanyl intrathecally, which has not been shown until now. This is despite the fact that in the fentanyl group sensory levels were higher at 120 minutes. This shows that intrathecal fentanyl, as an adjuvant, does not affect expiratory muscle function.

The performance of forced expiratory flow measurements requires initial inspiration to total lung capacity (TLC). The high levels of spinal blockade up to T₄ can cause paralysis of fifth to ninth intercostal muscles and affect the inspiratory capacity. Electromyographic techniques have demonstrated that the diaphragm and the fifth to ninth external intercostal muscles are the principal muscles of inspiration.^{8,9} The lack of initial forced inspiration is an important factor in the reduction of forced expiratory flows observed in the study. The reduction in forced expiratory flows is concordant with the findings of Von Ungern and Sternberg and others.¹⁰ Among the forced expiratory flows, FEV₁ approached pre-block values in 120 minutes in our study (Group B – p 0.062, Group BF – p 0.057), in contrast to a previous study.¹¹ FEV₁ is a sensitive indicator of the expiratory capacity when compared to FVC. This could be the reason for the return of the FEV₁ values close to the baseline earlier than the FVC values.

P_E max is one of the sensitive indicators of the power of expiratory muscles. This reduction could be due to the blockade produced by the spinal anaesthesia, confirming the fact that there is significant reduction in the power of the muscles that aid coughing. Very highly significant decreases (p value = 0.001) were seen in P_E max compared to pre-block values, in both groups. Again the magnitude of the decrease was similar in both groups and was not statistically significant at any of the measured times. The percentage reduction in P_E max was greater when compared to other forced expiratory flows, with a maximum reduction of 24.917% (p = 0.001) and 26.621% (p = 0.001) at 10 minutes, in Group BF and Group B respectively. This is consistent with the study of Harrop-Griffiths and others.⁶ The decrease in both PEFR and P_E max was never below the critical values of 200 L/min and 30 mmHg

Figure 4: Comparison of P_E max at baseline, 10, 60 and 120 minutes in group B and group BF



respectively. These critical values have been described to be essential for effective cough.^{12,13} These findings are consistent with findings of earlier studies of Walsh and others.⁵

The addition of neuraxial opioids augments the analgesia produced by local anaesthetics through direct binding with the specific spinal receptors¹⁴ and improves the intraoperative and early postoperative quality of subarachnoid block.¹⁵ In this study, the highest sensory blockade achieved in both groups was T₄. However at 120 minutes, the sensory blockade in Group B had receded to lower dermatomal levels, faster than in Group BF, showing that fentanyl had prolonged the sensory blockade.

Conclusion

The addition of 25 µg of fentanyl to intrathecal bupivacaine did not have any adverse effect on forced expiratory flows. There was a decrease in forced expiratory flows in both groups, but the decrease in PEFR and P_E max was never below previously described critical values. It is unlikely that the combination of intrathecal local anaesthetic and opioids will impair a normal patient's ability to cough effectively, despite sensory segmental levels up to T₄–T₅. An amount of 25 µg fentanyl can safely be added to intrathecal bupivacaine to improve the quality of analgesia in ASA I and II patients.

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