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The effect of adding epinephrine on the duration of spinal anaesthesia for patients undergoing total knee replacement

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Abstract
Background: Spinal anesthesia is popular for lower abdominal and extremity operations. The sympathomimetic catecholamine epinephrine can constrict blood vessels with local anesthetics. Its pharmacologic activities include alpha and β-adrenergic receptors. The study compared the effects of adding epinephrine to spinal anesthesia on sensory and motor nerve block, haemodynamic condition, and complications in total knee replacement patients.
Method: A convenient sample of 80 patients who underwent total knee replacement under spinal anaesthesia were enrolled and divided into two groups: the intervention group received 40 patients who received a four-ml solution containing 3.5 ml (17.5 mg) of bupivacaine 0.5% and 0.5 ml of epinephrine (100 micrograms), and the control group received 40 patients who received a standard saline solution. Blood pressure, pulse rate, nerve block duration, and postoperative nausea and vomiting were recorded.
Results: Before and during the first, fifth, tenth, and fifteenth minutes following the surgery, the study groups had similar blood pressure and heart rates. Sensory and motor nerve block duration was substantially longer in the intervention group than the control group. In the intervention group, nausea and vomiting were not substantially lower than in the control group.
Conclusion: The addition of epinephrine to spinal anaesthesia significantly prolonged the duration of sensory and motor nerve block. There were no significant effects of epinephrine on the haemodynamic state and the incidence of nausea and vomiting.

Keywords: Epinephrine, spinal, nerve block, hemodynamic, complications

Introduction
The central nervous system (CNS), comprising the brain and spinal cord, is protected by meninges, which are three tissue membranes: dura mater, arachnoid, and pia mater. These meninges contain cerebrospinal fluid (CSF), which cushions the brain and circulates within the brain's ventricular system [1, 2]. The vertebral column, consisting of 33 vertebrae connected by ligaments and intervertebral discs, provides structural support and mobility. Typical vertebrae feature a vertebral body, arch, and seven processes [3, 4]. The vertebral body, made of trabecular bone with red marrow and an outer compact bone layer, forms the vertebral canal along with the arch. This canal houses the spinal cord, spinal nerves, and epidural space [3]. The intervertebral discs, composed of the nucleus pulposus, annulus fibrosus, and vertebral end-plates, facilitate mobility and stability. These avascular discs receive nutrition through diffusion [3]. The spinal cord, extending from the brainstem to the lower lumbar vertebrae, is surrounded by CSF and three meningeal layers, ending at L1 or L2 in adults and lower in infants [5, 6]. The epidural space contains unevenly distributed fat, which protects the dural sac but can also compress structures and affect epidural catheter placement in certain pathologies [7]. Spinal anesthesia, a neuraxial technique involving the delivery of local anesthetic into the subarachnoid space, provides numerous advantages, especially for patients with respiratory conditions or difficult airway management, by avoiding general anesthesia risks [8, 9]. However, it can lead to hemodynamic complications such as hypotension and bradycardia due to sympathovagal imbalance. Hypotension, with an incidence of 16% to 33%, results from sympathetic inhibition and decreased venous return, while bradycardia can occur if the vagus nerve is stimulated [10, 11]. Several measures, including fluid loading, limb compression, optimal anesthetic dosing, and vasopressor administration, are employed to prevent and treat these complications.

Prophylactic vasopressor infusion is recommended to manage hypotension [12, 13]. Other potential complications include headaches from CSF leakage, transient neurological symptoms, and rare cases of sensorineural hearing loss [10, 13]. Direct needle trauma, vertebral canal hematoma, infection, spinal cord ischemia, and nerve injury are additional risks [14]. Epinephrine, a sympathomimetic catecholamine, acts on both alpha and beta-adrenergic receptors to produce various physiological effects, including increased blood pressure and coronary blood flow, as well as bronchodilation [15]. It is metabolized primarily in the liver and kidneys, with its metabolites excreted in urine [16]. Clinically, epinephrine is used as a vasoconstrictor with local anesthetics, for severe allergic reactions, and as a mydriatic agent [17]. However, it poses risks of ventricular arrhythmia, myocardial ischemia, and other adverse effects, particularly when administered in large doses or in certain conditions like myocarditis or hypercapnia [18]. This study aimed to compare the effect of adding epinephrine to spinal anesthesia on the duration of sensory and motor nerve block, hemodynamic state, and incidence of complications in patients undergoing total knee replacement.

Method

A double-blind randomized clinical trial was conducted at Duhok Emergency Teaching Hospital from February 1 to December 1, 2023, to evaluate the effects of bupivacaine with epinephrine versus bupivacaine with distilled water in patients undergoing total knee replacement under spinal anesthesia.

Scientific Considerations

Approval was granted by the Scientific Council of Anesthesia and Intensive Care of the Iraqi Board of Medical Specializations. Verbal consent was obtained from all patients, and data confidentiality was maintained.

Study Population

A total of 80 patients, aged 50-80 years and classified as I, II, or III by the American Society of Anesthesiologists, were included. Patients were divided into two groups:

- **Intervention Group:** 40 patients received 3.5 ml of bupivacaine 0.5% with 0.5 ml (100 µg) of epinephrine.
- **Control Group:** 40 patients received 3.5 ml of bupivacaine 0.5% with 0.5 ml of distilled water.

Data Collection

Preoperative information was collected, including age, gender, weight, height, and medical history. In the operating room, patients were preloaded with 7 ml/kg of normal saline, and vital signs were continuously monitored. Spinal anesthesia was administered using a 25 G pencil-point needle at the L3-L4 or L4-L5 intervertebral space. The researcher and supervisor were blinded to the group allocation. Sensory and motor blocks were assessed, and surgery commenced when patients achieved a Modified Bromage scale grade >2 at or above T12.

Data Recorded

- Blood pressure and pulse rate were recorded before the procedure and at 1, 5, 10, and 15 minutes after.
- Duration of nerve block (time to first analgesia request).
- Incidence of postoperative nausea and vomiting.

Statistical Analysis

Data were analyzed using SPSS version 22. Descriptive statistics were presented as frequencies, percentages, and means ±SD. Comparisons between groups were conducted using t-tests and Chi-Square tests, with a significance level set at $p<0.05$.

Results

A total of 80 patients were enrolled in the current study, there were no significant differences between the study groups regarding age (P-value=0.185), BMI (P-value=0.147), and gender (P-value=0.501). As shown in table 1.

Table 1: Distribution of the age according to the study groups

Patients characteristics		Intervention group Mean ±SD	Control group Mean ±SD	P-value
Age (years)		57.24 ±4.6	58.43 ±3.2	0.183
BMI (kg/m^2)		25.3 ±1.7	24.6 ±2.5	0.147
		Intervention group N (%)	**Control group N (%)**	
Gender	Male	24 (60.0)	21 (52.5)	0.501
	Female	16 (40.0)	19 (47.5)	

There was no significant difference between the study groups regarding the systolic blood pressure before the procedure and at the first, fifth, tenth, and fifteenth minutes after the beginning of the procedure, as shown in table 2.

Table 2: Differences in the systolic blood pressure between the study groups before and after administration of spinal anaesthesia

Time	Systolic blood pressure (mmHg)		P-value
	Intervention group Mean ±SD	**Control group Mean ±SD**	
Before procedure	124.3 ±3.1	123.7 ±4.6	0.495
At first minutes	105.3 ±4.2	105.6 ±38	0.738
At fifth minutes	104.9 ±5.1	106.3 ±4.9	0.214
At tenth minutes	108.9 ±3.2	107.8 ±3.7	0.159
At fifteenth minutes	113.2 ±5.6	114.2 ±2.7	0.312

No significant difference was obtained between the study groups regarding the diastolic blood pressure before the procedure and at the first, fifth, tenth, and fifteenth minutes after the beginning of the procedure, as shown in table 3.

Table 3: Differences in the diastolic blood pressure between the study groups before and after administration of spinal anaesthesia

Time	Diastolic blood pressure (mmHg)		P-value
	Intervention group Mean ±SD	Control group Mean ±SD	
Before procedure	74.2 ±5.6	73.6 ±2.4	0.535
At first minutes	67.4 ±3.8	66.9 ±2.7	0.499
At fifth minutes	70.1 ±1.9	66.7 ±3.8	0.553
At tenth minutes	71.5 ±1.4	70.8 ±3.3	0.220
At fifteenth minutes	73.8 ±2.1	74.6 ±4.7	0.328

There was no significant difference between the study groups regarding the heart rate before the procedure and at the first, fifth, tenth, and fifteenth minutes after the beginning of the procedure, as shown in table 4.

Table 4: Differences in the heart rate between the study groups after induction of anaesthesia

Time	Heart rate (beat/minutes)		P-value
	Intervention group Mean ±SD	Control group Mean ±SD	
Before procedure	77.6 ±2.1	78.5 ±4.8	0.280
At first minutes	80.1 ±2.2	79.0 ±4.1	0.146
At fifth minutes	77.1 ±5.8	77.7 ±1.8	0.533
At tenth minutes	78.3 ±6.1	78.4 ±1.4	0.919
At fifteenth minutes	80.4 ±4.7	79.3 ±1.8	0.170

The duration of the sensory and motor nerve block was significantly longer in the intervention group compared to the control group (P-values were 0.001 for both), as shown in table 5.

Table 5: Duration of the nerve block

Nerve block (minutes)	Intervention group Mean ±SD	Control group Mean ±SD	P-value
Sensory nerve block	147.2 ±7.1	131.6 ±4.2	0.001
Motor nerve block	161.4 ±3.2	138.8 ±6.7	0.001

The incidence of nausea and vomiting was insignificantly lower in the intervention group compared to the control group (P-values were 0.448 and 0.558, respectively). As shown in table 6.

Table 6: Incidence of complications in the study groups

Complications	Intervention group N (%)	Control group N (%)	P-value
Nausea	9 (22.5)	12 (30.0)	0.448
Vomiting	6 (15.0)	8 (20.0)	0.558

Discussion

Spinal anesthesia is widely used in various surgeries due to its effectiveness, but it can have complications. To mitigate these side effects and enhance the quality and duration of analgesia, various adjuvants are employed. However, the efficacy of these additives remains debated [19]. This study aimed to evaluate the effects of adding epinephrine to spinal anesthesia on nerve block duration and complications. In this study, conducted at Duhok Emergency Teaching Hospital, 80 patients undergoing total knee replacement under spinal anesthesia were divided into two groups: one receiving bupivacaine 0.5% with epinephrine and the other receiving bupivacaine 0.5% with distilled water. The addition of epinephrine did not significantly affect the patients' hemodynamic parameters, such as systolic and diastolic blood pressure and heart rate. Similar findings were reported in studies by Ainur *et al*. in Indonesia, Ebru *et al*. in Turkey, and Won Ho Kim *et al*. in Korea, which all indicated that epinephrine did not significantly alter the hemodynamic state of patients undergoing various surgeries under spinal anesthesia [20-22]. Mohamed Fouad's study in Egypt, involving pregnant women undergoing cesarean sections, also supported these findings, showing no significant differences in hemodynamic parameters between the epinephrine and control groups [23]. The current study found that adding epinephrine significantly prolonged the duration of sensory and motor blocks. Won Ho Kim *et al*.'s study in Korea similarly concluded that epinephrine prolongs analgesia duration and reduces the bupivacaine dose needed to block tourniquet pain in total knee replacement patients [22]. Mohamed Fouad's study in Egypt and Gurbet *et al*.'s study in Turkey, involving cesarean section patients, also reported that epinephrine significantly extends analgesia duration, likely due to the suppression of noxiously evoked activity in wide-dynamic-range neurons [23, 24]. A meta-analysis by Clément *et al*. further supported these findings, indicating that epinephrine addition to spinal anesthesia extends sensory and motor block by 30–60 minutes [25]. Regarding complications, there were no significant differences between the study groups in terms of nausea and vomiting incidence. This was consistent with Mohamed Fouad's findings in Egypt, showing similar complication rates between epinephrine and control groups in cesarean section patients [23]. Ebru *et al*. in Turkey also found no significant difference in nausea and vomiting incidence between the groups, though it was slightly lower in the epinephrine group [21]. Studies by Won Ho Kim *et al*. in Korea and Gurbet *et al*. in Turkey further corroborated these results, showing no significant differences in complication rates between patients receiving epinephrine and those in the control group [22, 24].

Conclusion

The addition of epinephrine to spinal anesthesia significantly increased the duration of sensory and motor blockade. Epinephrine had no significant effect on the patient's hemodynamic status or the occurrence of nausea and vomiting.

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Conflict of Interest: Nil

References

1. Ousman SS, Kubes P. Immune surveillance in the central nervous system. Nature neuroscience. 2012;15(8):1096-1101.
2. Hayakawa K, Snyder EY, Lo EH. Meningeal Multi-potent Cells: A Hidden Target for CNS Repair? Neuro Molecular Medicine. 2021;23(3):339-343.
3. Waxenbaum JA, Reddy V, Williams C, Futterman B. Anatomy, Back, Lumbar Vertebrae: StatPearls Publishing, Treasure Island (FL); c2022.
4. Bijendra D, Wu X, Jiang Z, Zhu L, Maharjan P, Singh R. Adjacent Level Vertebral Fractures in Patients Operated with Percutaneous Vertebroplasty. Open Journal of Orthopedics. 2018;08:116-126.
5. Bican O, Minagar A, Pruitt AA. The spinal cord: a review of functional neuroanatomy. Neurol Clin. 2013;31(1):1-18.
6. Gerheuser F, Roth A. [Epidural anesthesia]. Anaesthesist. 2007;56(5):499-523; quiz 4-6.
7. Reina M, Franco C, López A, Dé Andrés J, Van Zundert A. Clinical implications of epidural fat in the spinal canal. A scanning electron microscopic study. Acta anaesthesiologica belgica. 2009;60(1):7.
8. Stock LA, Dennis K, MacDonald JH, Goins AJ, Turcotte JJ, King PJ. Postoperative outcomes of mepivacaine vs. bupivacaine in patients undergoing total joint arthroplasty with spinal anesthesia. Arthroplasty. 2022;4(1):32.
9. Khan ZH, Eftekhar N, Barrak RS. General versus spinal anesthesia during caesarean section: A narrative review. Archives of Anesthesiology and Critical Care. 2019;5(1):18-21.
10. Herbosa GAB, Tho NN, Gapay AA, Lorsomradee S, Thang CQ. Consensus on the Southeast Asian management of hypotension using vasopressors and adjunct modalities during cesarean section under spinal anesthesia. Journal of Anesthesia, Analgesia and Critical Care. 2022;2(1):56.
11. Hofhuizen C, Lemson J, Snoeck M, Scheffer GJ. Spinal anesthesia-induced hypotension is caused by a decrease in stroke volume in elderly patients. Local Reg Anesth. 2019;12:19-26.
12. Šklebar I, Bujas T, Habek D. Spinal anaesthesia-induced hypotension in obstetrics: Prevention and therapy. Acta Clin Croat. 2019;58(1):90-95.
13. Helander EM, Kaye AJ, Eng MR, Emelife PI, Motejunas MW, Bonneval LA, *et al*. Regional Nerve Blocks - Best Practice Strategies for Reduction in Complications and Comprehensive Review. Current Pain and Headache Reports. 2019;23(6):43.
14. Neal JM, Kopp SL, Pasternak JJ, Lanier WL, Rathmell JP. Anatomy and pathophysiology of spinal cord injury associated with regional anesthesia and pain medicine: 2015 update. Regional Anesthesia & Pain Medicine. 2015;40(5):506-525.
15. Bylund DB. Epinephrine. Reference Module in Biomedical Sciences: Elsevier; c2015.
16. Thumpangat S. Catecholamines. In: Wexler P, editor. Encyclopedia of Toxicology (Third Edition). Oxford: Academic Press; c2014. p. 748-50.
17. O'Shaughnessy KM. Adrenergic mechanisms and drugs. In: Bennett PN, Brown MJ, Sharma P, editors. Clinical Pharmacology (Eleventh Edition). Oxford: Churchill Livingstone; c2012. p. 382-92.
18. Procaccini DE, Sawyer JE, Watt KM. 19 - Pharmacology of Cardiovascular Drugs. In: Ungerleider RM, Meliones JN, Nelson McMillan K, Cooper DS, Jacobs JP, editors. Critical Heart Disease in Infants and Children (Third Edition). Philadelphia: Elsevier; c2019. p. 192-212.e6.
19. Derakhshan P, Imani F, Koleini ZS, Barati A. Comparison of adding sufentanil and low-dose epinephrine to bupivacaine in spinal anesthesia: A randomized, double-blind, clinical trial. Anesthesiology and Pain Medicine, 2018, 8(5).
20. Rahmah A, Arie Utariani A, Basori A. Profile Hemodynamic (Blood Pressure and Heart Rate) Changes in the use of Adrenaline in Cesarean Section with Spinal Anesthesia at Dr. Sortomo Surabaya Hospital. Indonesia Journal of Anesthesiology and Reanimation (IJAR), 2(1), 33-37.
21. Biricik E, Karacaer F, Ünal İ, Sucu M, Ünlügenç H. The effect of epinephrine for the treatment of spinal-hypotension: comparison with norepinephrine and phenylephrine, clinical trial. Revista Brasileira de Anestesiologia. 2020;70:500-507.
22. Kim WH, Ko JS, Ahn HJ, Choi SJ, Shin BS, Gwak MS, *et al*. Epinephrine decreases the dose of hyperbaric bupivacaine necessary for tourniquet pain blockade during spinal anesthesia for total knee replacement arthroplasty. Journal of anesthesia. 2013;27:72-79.
23. Elmeleigy MFM. Comparative Study Following Addition of Epinephrine (0.2 mg) to Spinal Hyperbaric Bupivacine (0.5%) in Normotensive and Pre-Eclamptic Parturients Undergoing Elective Cesarean Section: A Pilot Study.
24. Gurbet A, Turker G, Kose D, Uckunkaya N. Intrathecal epinephrine in combined spinal-epidural analgesia for labor: dose-response relationship for epinephrine added to a local anesthetic-opioid combination. International journal of obstetric anesthesia. 2005;14(2):121-125.
25. Tschopp C, Tramèr MR, Schneider A, Zaarour M, Elia N. Benefit and harm of adding epinephrine to a local anesthetic for neuraxial and locoregional anesthesia: A meta-analysis of randomized controlled trials with trial sequential analyses. Anesthesia & Analgesia. 2018;127(1):228-239.

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