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Effect of addition of different additives: Magnesium sulfate and dexamethasone versus plain bupivacaine in ultrasound-guided erector spinae plane block in pediatrics undergoing repair of inguinal hernia

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ABSTRACT

Background: Erector spinae plane (ESP) block has been evaluated in many studies in pediatric surgeries by the use of postoperative rescue analgesia which is the objective parameter assessing the efficacy of the technique in controlling postoperative pain. Adjuvants were used with ESP block to densify its postoperative analgesia. Magnesium sulfate was used for suppressing somatic, endocrine and autonomic reflexes induced by noxious stimuli during surgery. Dexamethasone is a highly potent glucocorticoid that has been used in different regional anesthesia to prolong the anesthetic effect of the local anesthesia by inducing local vasoconstriction.

Methodology: Sixty pediatric patients underwent inguinal hernia repair under general anesthesia, and then they were assigned randomly into three groups that received ESP block either with local anesthetic alone or with magnesium sulfate or dexamethasone.

Results: Our study revealed no statistical significance among the three groups as regards demographic and vital data. Children's Hospital Eastern Ontario Pain Scale score for postoperative assessment of magnesium sulfate and dexamethasone which were added to bupivacaine in ESP block had a better score than bupivacaine alone with high statistical significance. Also, magnesium sulfate and dexamethasone had a delayed first-dose postoperative rescue analgesia with significant statistical value (P value = 0.002) and total postoperative doses of postoperative rescue analgesia were lesser in magnesium sulfate and dexamethasone groups with marked statistical significance (P value < 0.001). As regards complications, there were minor ones in the form of mild bruising and mild pain at injection site with no statistical significance between the three groups (P value = 0.108).

Conclusion: In our study, magnesium sulfate and dexamethasone added to bupivacaine in ESP block prolonged the duration of postoperative pain control and decreased the consumption of postoperative analgesia than bupivacaine alone. No major complications were recorded in our study in the three groups which solidify the safety of the technique.

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Erector spinae plane block; inguinal hernia repair; magnesium sulfate; dexamethasone

1. Background

Erector spinae plane (ESP) block is a new paraspinal interfascial technique that aims to deposit local anesthetics in the zone between the thoracic transverse process and the paraspinal erector spinae muscle. It was first performed by Forero et al. on four adult patients: two of them were undergoing video-assisted thoracoscopy and two patients had chronic thoracic neuropathic pain. In their study, they described two techniques for injection of local anesthetics for this block: one in the plane separating rhomboid and erector spinae muscles and the other one beneath the erector spinae [1].

The ESP block since then is used in a wide range of surgeries of thoracic, upper and lower abdominal, and it was introduced in challenging chronic pain conditions, such as complex regional pain syndromes and failed back surgery pain [2].

The ESP which is performed at the level of T5 is used for thoracic surgery, while ESP at the level of T7 can be used for abdominal surgery in which ESP was found to be effective in blocking visceral pain as well as somatic pain in laparoscopic abdominal surgery [3].

Many cadaveric, contrast-mediated imaging studies had shown the spread of injected dye cephalocaudal extending to nine dermatomal levels and anteriorly into the paravertebral region covering both the ventral and dorsal spinal rami [4].

A large number of case reports, which were pooled in a comprehensive review, have shown that patients who received ESP block had a reduction in

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postoperative opioid use and a low prevalence of complications with the erector spinae block [5].

The use of ESP block was evaluated in many studies in pediatric surgeries where the pain score was difficult to assess, and the use of postoperative rescue analgesia was the objective parameter for assessing the efficacy of the technique in controlling postoperative pain [6].

Additive adjuvant drugs were used with ESP block to densify and endure its postoperative analgesic function assessed by the quality of sensory block and time to first analgesia dose requested [2].

Magnesium is a calcium antagonist that physiologically blocks the N-methyl-D-aspartate receptor which is a glutamate receptor that mediates the process of pain signaling and release of nociceptive mediators. Magnesium sulfate had been used in perioperative pain management and in suppressing somatic, endocrine and autonomic reflexes induced by noxious stimuli [7].

Dexamethasone is a long-acting highly potent anti-inflammatory glucocorticoid that had been used in different regional anesthesia techniques to improve the anesthetic and the analgesic effect of the local anesthesia and prolong its effect by inducing local vasoconstrictive effect that decrease absorption of local anesthetic to systemic circulation [8].

2. Aim of the study

The aim of our work is to compare between the analgesic effect of adding magnesium sulfate and dexamethasone versus plain bupivacaine in sonographic-guided ESP block in pediatrics planned for the repair of inguinal hernia.

3. Methods

This clinical study was performed on 60 pediatric participants who underwent inguinal hernia repair under general anesthesia and then received ESP block either with local anesthetic alone or with magnesium sulfate or dexamethasone as adjuvants to local anesthetic. After ethical approval and obtaining informed written consents from the participants' parents, the participants from both sexes of ages from 1 to 7 years and those within normal weight for age percentiles were recruited.

3.1. Exclusion criteria

- Refusal of parents to participate.
- Pediatrics with coagulation disorders.
- Hypersensitivity to study medications.
- Developmental or mental delay.
- Skin lesions or infection at the planned site of needle insertion.
- Any patient with major comorbid diseases, e.g., cardiac or renal diseases.

Participants were assigned randomly into three study groups by computerized randomization as group A, group B and group C.

- Group A (20 patients) control group: plain bupivacaine 0.25%.
- Group B (20 patients): magnesium sulfate added to 0.25% bupivacaine.
- Group C (20 patients): dexamethasone added to 0.25% bupivacaine.

4. Pre-operative settings

History, clinical examination and routine investigations, including complete blood count, prothrombin time and activated partial thromboplastin time, kidney function test, liver function test, were performed in all participants.

5. Monitoring

The patients were monitored during the procedure using pulse oximetry, non-invasive blood pressure, electrocardiogram and end-tidal carbon dioxide.

6. Anesthetic technique

All the pediatric patients who underwent a standardized protocol of general anesthesia using inhalational induction with sevoflurane and then intravenous cannula were introduced after obtaining adequate depth of anesthesia, where 1 μ/kg fentanyl and 0.5 mg/kg atracurium were given intravenous and then endotracheal intubation and ventilation were done. Maintenance of anesthesia was applied with the introduction of mixture of oxygen and air (50:50) and sevoflurane at 2–3 MAC, while maintenance of muscle relaxation was done with increment of 0.1 mg/kg atracurium if needed according to the time of surgery.

7. Study procedures

After general anesthesia induction, the participant was positioned in the lateral position with the injection side in the upper orientation according to the side of inguinal hernia. Following skin disinfection, identification of seventh cervical vertebrae was followed by the use of the ultrasound straight probe of 2–5 megahertz (sonosite) placed in the parasagittal line and moving down in a longitudinal plane to visualize the transverse process of the tenth thoracic vertebra (T10) over lied by the erector spinae muscle where a 22 gauge, 2-inch needle was introduced in plane until the tip of the needle reached the plane separating the erector spinae muscle and the T10 transverse process were 0.5–1 ml of normal saline was injected to confirm the plane of injection, then:

- Group A (20 patients) recieved 0.5 ml/kg bupivacaine 0.25% (for each 1 ml bupivacaine 0.5% diluted by 1 ml normal saline).
- Group B (20 patients) recieved 0.5 ml/kg mixture of 0.25% bupivacaine and 10% magnesium sulfate in ratio 1:1.
- Group C (20 patients) recieved 0.5 ml/kg mixture of 0.25% bupivacaine and dexamethasone 0.2 mg/kg diluted in normal saline.

Skin incision was done 20 min after giving the block.

Assessment of the block and study interventions:

- The efficacy of the block was assessed intraoperative by changes in arterial blood pressure and heart rate (HR). If there was an increase by more than 20% of one of them or both at any time after the start of surgery, an incremental dose of 1 μ/kg fentanyl intravenous was to be given.
- Postoperative evaluation by Children's Hospital Eastern Ontario Pain Scale (CHEOPS) which assesses patients according to the following parameters: cry from 1 to 3, facial from 0 to 2, child verbal from 0 to 2, torso from 1 to 2, touch from 1 to 2 and legs from 1 to 2 (Zielinski et al., 2020). If the scale was equal to or more than 5 at 1-, 2-, 4-, 6-, 8-, 16- and 24-h intervals postoperative, a dose of 10 mg/kg of paracetamol per oral was given as a rescue analgesia.

8. Data collection and recording

(1) Demographic data for each patient were recorded preoperatively.
(2) Hemodynamic data, such as arterial blood pressure and HR, were recorded before induction of anesthesia and ESP block and every 5 min thereafter till the end of procedure.
(3) Peripheral oxygen saturation (SpO_2) was recorded before induction of anesthesia and every 5 min immediately after the block till the end of procedure.
(4) CHEOPS was recorded at 1-, 2-, 4-, 6-, 8-, 16- and 24-h intervals for each patient postoperatively.
(5) Time to first-dose paracetamol as a postoperative rescue analgesia for each group was recorded.
(6) The total doses of fentanyl that were used as a rescue intraoperative analgesia was recorded for each group.
(7) The total number of doses of paracetamol that was given postoperatively as rescue analgesia was recorded.
(8) Duration of procedure for every participant in each group was recorded in minutes.
(9) Any perioperative complications, e.g., postoperative nausea and vomiting, pain experienced at the site of injection, and bleeding or hematoma at the injection site, were recorded for each group.

9. Results

9.1. Demographic data

The three groups were compared regarding patients' age, sex, weight and duration of procedure, with no statistical difference (Table 1).

9.2. Vital data

(a) Systolic blood pressure:

The three groups were compared regarding patients' systolic blood pressure, with no statistical difference (Table 2).

(b) Diastolic blood pressure:

The three study groups were compared regarding patients' diastolic blood pressure, with no statistical difference (Table 3).

(c) Heart rate:

The three groups were compared regarding patients' HR, with no statistical difference (Table 4).

(d) Oxygen saturation:

The three groups were compared regarding oxygen saturation, and there was no statistical significance.

9.3. CHEOPS score :

The three study groups were compared regarding CHEOPS score that revealed a marked statistical difference which is shown in Table 5.

Table 1. Patients' characteristics and duration of surgery.

	Group A ($n = 20$)	Group B ($n = 20$)	Group C ($n = 20$)	*P*-value
Age (yrs.)	4.1 ± 1.68	3.74 ± 1.6	3.97 ± 1.8	0.793
Sex (M/F)	19/1	19/1	20/0	0.597
Weight (kg)	15.8 ± 3.2	15.5 ± 3.1	15.58 ± 3.6	0.951
Duration of surgery in minutes	35.25 ± 11.6	36.5 ± 10.9	40.5 ± 12.96	0.35

Data are represented as mean ± SD. Number of patients: Group A (20 patients) control group: plain Bupivacaine 0.25%; Group B (20 patients): magnesium sulfate added to 0.25% bupivacaine; Group C (20 patients): dexamethasone added to 0.25% bupivacaine. *P*-value > 0.05 is considered statistically non-significant.

Table 2. Comparison between group A, B and C as regard systolic blood pressure in millimeter mercury.

	Group A ($n = 20$)	Group B ($n = 20$)	Group C ($n = 20$)	*P*-value
Preoperative	101.75 ± 9 .6	99 ± 7.2	98.3 ± 6.87	0.347
5 minutes	97.75 ± 12.05	93.75 ± 6.5	95.2 ± 4.6	0.315
10 minutes	97 ± 10.18	91.75 ± 7.5	96.7 ± 5	0.066
15 minutes	93.5 ± 10.2	89.4 ± 5.6	93.1 ± 4.4	0.145
20 minutes	92.5 ± 8.9	88.6 ± 4.4	92 ± 4.09	0.092
25 minutes	92.25 ± 6.3	90.3 ± 5	92.2 ± 4	0.49
30 minutes	90 ± 5.38	86.65 ± 3.7	87 ± 5.7	0.075
35 minutes	91 ± 5.76	88.65 ± 4.53	88.75 ± 6.26	0.327

Data are represented as mean ± SD. P-value > 0.05 is considered statistically non-significant.

Table 3. Comparison between group A, B and C as regard diastolic blood pressure millimeter mercury.

	Group A ($n = 20$)	Group B ($n = 20$)	Group C ($n = 20$)	*P*-value
Preoperative	55.25 ± 5.37	55 ± 4.56	53.5 ± 7.3	0.607
5 minutes	54.7 ± 5.7	51.4 ± 4.6	52.4 ± 6.4	0.164
10 minutes	51.25 ± 11.8	52 ± 4.44	50.9 ± 5.42	0.901
15 minutes	51 ± 4.47	49.2 ± 4.5	50.6 ± 3.72	0.711
20 minutes	52.5 ± 4.6	49.15 ± 4.5	52.3 ± 4.54	0.34
25 minutes	52.6 ± 4.4	50 ± 4.87	51.9 ± 3.72	0.351
30 minutes	53 ± 4.7	50.2 ± 3.8	51.6 ± 3.48	0.095
35 minutes	52.5 ± 4.44	51.45 ± 4.41	49.5 ± 4.26	0.84

Data are represented as mean ± SD. P-value > 0.05 is considered statistically non-significant.

Table 4. Comparison between groups A, B and C as regard heart rate in beats per minute.

	Group A ($n = 20$)	Group B ($n = 20$)	Group C ($n = 20$)	*P*-value
Preoperative	103.3 ± 9.49	101.5 ± 9.2	100.5 ± 9.2	0.64
5 minutes	96.75 ± 10.2	95 ± 7.8	93.25 ± 7.6	0.443
10 minutes	93.25 ± 11.04	91.7 ± 5.4	91.25 ± 5.1	0.695
15 minutes	89.5 ± 8.1	89.25 ± 6	88.2 ± 6.2	0.827
20 minutes	87.5 ± 7.5	87.7 ± 6.6	86.3 ± 58	0.75
25 minutes	85.5 ± 6.63	86.3 ± 6.5	84 ± 6.2	0.52
30 minutes	84.2 ± 5.2	84.7 ± 5.5	82.75 ± 6.78	0.536
35 minutes	86 ± 4.5	85 ± 5.85	82.7 ± 6.8	0.194

Data are represented as mean ± SD. P-value > 0.05 is considered statistically non-significant.

Table 5. Comparison between groups A, B and C as regard CHEOPS score.

	Group A ($n = 20$)	Group B ($n = 20$)	Group C ($n = 20$)	*P*-value
1 hour	4(4–4)	4(4–4)	4(4–4)	1
2 hour	4(4–4)	4(4–4)	4(4–4)	0.131
4 hour	5(4–6)	4(4–4)	4(4–4)	<0.001*
6 hour	4(4–6)	4(4–6)	4(4–4)	0.088
8 hour	4(4–7)	5(4–6)	4(4–5)	0.506
16 hour	6(6–7)	5(4–5)	4(4–5)	<0.001*
24 hour	4(4–5)	4(4–5)	4(4–4)	0.099

Data are presented as median (IQR). *P-value < 0.05 is considered statistically significant.

9.4. Time to postoperative first-dose rescue analgesia and number of doses:

The three study groups were compared regarding time to postoperative first-dose rescue analgesia in hours and number of postoperative rescue analgesia doses, which showed a marked statistical difference which is presented in Table 6.

9.5. Complications

The three groups were compared regarding complications related to the technique, and there were no major complications recorded in the three groups of the study. However, there were only three cases in the control group (group A) and two cases in the magnesium sulfate group with mild bruising at the site of

Table 6. Comparison between groups A, B and C as regard time to postoperative first-dose rescue analgesia in hours and number of doses.

	Group A ($n = 20$)	Group B ($n = 20$)	Group C ($n = 20$)	*P*-value
Time to 1st dose of paracetamol (in hours)	4.5 ± 1.27	8.6 ± 3.3 <0.007†‡	8.6 ± 5.8	0.002*
Total number of doses of paracetamol	3 ± 0.79	1.7 ± 0.66 <0.001†‡	1.2 ± 0.84	<0.001*

Data are presented as mean and standard deviation. P > 0.05 was considered statistically non-significant between the three groups.*P < 0.05 was considered statistically significant between the three groups. †P < 0.05 was considered statistically significant between group A and group C. ‡P < 0.05 was considered statistically significant between group A and group B.

injection which spontaneously resolved and other two cases in the control group had mild pain at the site of injection which also resolved spontaneously.

10. Discussion

In our study, we found that the addition of magnesium sulfate or dexamethasone to bupivacaine in ESP block efficiently prolonged the postoperative analgesia than bupivacaine alone with high statistical significance assessed by the first-dose rescue analgesia in the form of oral paracetamol and its total number of postoperative doses, although there was no difference in intraoperative analgesia as the patients of the three study groups did not need rescue analgesia intraoperatively. These results match with those of Zeng et al. in which the use of magnesium sulfate in adjunct with peripheral and truncal nerve blocks in adults was proven to be efficient in reducing postoperative pain and prolonging the duration of sensory block in comparison to local anesthetics alone [9]; however, there are few data on the use of magnesium sulfate in erector spinae in pediatric patients. As regard to dexamethasone as an adjuvant in perineural nerve blocks, it also had a prolonged effect of sensory block in multiple trials [10].

Like some studies, our study found that both magnesium sulfate and dexamethasone increased the time of analgesia and reduced the total number of doses of postoperative rescue analgesia with no statistical significance as in the study of Fahmy et al. [11] in which magnesium sulfate and dexamethasone were found to prolong the time preceding the first-dose rescue analgesia and reduce the number of total doses of rescue analgesia when added to bupivacaine in interscalene nerve block in shoulder arthroscopy operations. And also in the study of Mahgoub et al. [12], there was no statistical significance between magnesium sulfate and dexamethasone in prolonging the duration of analgesia when added to levobupivacaine in supraclavicular nerve block in upper limb surgeries.

In other studies, both magnesium sulfate and dexamethasone were found to prolong analgesic duration than the local anesthetic alone, and dexamethasone was superior to magnesium sulfate with significant statistical difference as in Yousef et al. [13] in which dexamethasone was better in prolonging the duration of postoperative analgesia when added to ropivacaine than ropivacaine alone or ropivacaine with magnesium sulfate when used in caudal block in inguinal hernia surgeries in pediatric patients. This was also found in the study of Sharma et al. [14] in which dexamethasone had an advantage over magnesium sulfate as regard the duration of postoperative analgesia and the total doses of postoperative rescue analgesia when added to bupivacaine in pectoral nerve block for modified radical mastectomy.

On the contrary, Gad et al. found that magnesium sulfate was better in prolonging the postoperative analgesia and there was reduction in the total dose of rescue analgesia than dexamethasone when it was added to bupivacaine in transversus abdominis plane block in hysterectomy surgeries (Gad et al. 2019).

In our study, there were no recorded major complications in the three study groups; only there were three cases in the control group (group A) and two cases in the magnesium sulfate group with mild bruising at the site of injection which spontaneously resolved and other two cases in the control group had mild pain at site of injection which also resolved spontaneously. There was no statistical significant value between the three study groups as regard these minor complications. These findings go with the reported data pointing that ESP block is relatively simple as it is a superficial block performed under the guidance of ultrasound which makes it also a safe block in relation to other blocks such as paravertebral block as the plane of injection is away from blood vessels, nerves and pleura [15].

11. Conclusion

In our study, magnesium sulfate and dexamethasone added to bupivacaine in ESP block prolonged the duration of postoperative pain control and decreased the consumption of postoperative analgesia than the bupivacaine alone.

There were no major complications recorded in our study in the three groups which solidify the safety of the technique [16,17].

Disclosure statement

No potential conflict of interest was reported by the author(s).

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