Samir *et al.*
Ain-Shams Journal of Anesthesiology (2023) 15:24
https://doi.org/10.1186/s42077-023-00323-9

Ain-Shams Journal of Anesthesiology

ORIGINAL ARTICLE

Open Access

The effect of addition of magnesium sulfate or dexamethasone to bupivacaine on the post-operative analgesic duration of ultrasound-guided quadratus lumborum block in open abdominal surgeries: a comparative study

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Abstract

Background The aim of this study was to assess the effect of addition of 500-mg magnesium sulfate ($MgSo_4$) or 8-mg dexamethasone to bupivacaine in bilateral ultrasound-guided quadratus lumborum block (QLB), on the duration of post-operative analgesia, the patient's hemodynamic parameters, the severity of post-operative pain, number of patients who required rescue analgesia, the total dose of pethidine given, the number of patients who maintained post-operative analgesia for 36 h, and the time to first ambulation. Sixty-six patients, 18 to 65 years old, with body weight 60–90 kg, scheduled to undergo elective open abdominal surgeries under general anesthesia, were randomly divided into three equal groups: the Bupivacaine-Magnesium QLB group (BM) patients, the Bupivacaine-Dexamethasone QLB group (BD) patients, and the Bupivacaine-Saline QLB group (BS) patients.

Results The post-operative visual analogue scale (VAS) at rest and with movement was comparable between patients in the three groups: upon arrival to the post-operative care unit (PACU), in the PACU, and in the post-operative 2, 4, 6, 8, 12, 24, and 36 h. At 30 post-operative hours, the VAS at rest and with movement was statistically significantly lower in group BD 2 (0–4) and 2.75 (2–4.5) than in group BM 2.25 (0–4) and 3 (0–4.5), than in group BS 3.25 (3–4) and 4 (3.5–5), respectively, with *P*-value $<$ 0.001. Although 100% of patients in group BS received pethidine, versus 68.2% of patients in group BM and 63.6% of patients in group BD, with *P*-value 0.007, the cumulative total pethidine doses given, the duration of post-operative analgesia, and the number of patients who maintained post-operative analgesia for 36 h were comparable between the three groups with *P*-value 0.170, 0.239, and 0.231, respectively.

Conclusions In bilateral ultrasound-guided QLB in open abdominal surgeries, the addition of dexamethasone or $MgSo_4$ to bupivacaine reduced the VAS scores and the number of patients experiencing moderate pain at 30 post-operative hours, with fewer patients receiving pethidine and less cumulative total pethidine doses given, with dexamethasone showing better results.

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Keywords Magnesium sulfate, Dexamethasone, Quadratus lumborum block, Abdominal surgery, Post-operative analgesia

Background

Ultrasound-guided posterior quadratus lumborum block (QLB) is a fascial plane block, with local anesthetic (LA) injected between the quadratus lumborum and the erector spinae muscles, with resultant anesthesia of the thoracolumbar nerves (Elsharkawy et al. 2019). The thoracolumbar fascia (TLF) encircling the quadratus lumborum (QL) muscle has numerous A- and C-fiber nociceptors, mechanoreceptors, and sympathetic nerve fibers which accompany the abdominal branches of the lumbar arteries (Benetazzo et al. 2011).

Adjuvants added to LAs in nerve blocks aim to prolong the duration of analgesia. Perineural $MgSo_4$ was postulated by Akutagawa, Luke, Hachiro, and Collins (Akutagawa et al. 1984) to enhance LA nerve block. Gunduz, Bilir, and Gulec (Gunduz et al. 2006) found that $MgSO_4$ offered dose–response analgesic effect, and Lee, Yi, Chung, and Ko (Lee et al. 2012) found that $MgSO_4$ ensured better post-operative analgesia with an opioid-sparing effect. Dexamethasone is a potent, highly selective glucocorticoid, also, used as an adjuvant to LAs in nerve blocks. It has an analgesic and anti-inflammatory effects (Wahal et al. 2018).

The aim of the current study was to assess the effect of addition of $MgSo_4$ or dexamethasone to bupivacaine in ultrasound-guided QLB, on the severity of post-operative pain at rest and with movement, the number of patients who required rescue analgesia and the total dose of pethidine given, the duration of post-operative analgesia, the patient's hemodynamic changes, and the time to first ambulation in comparison with bupivacaine use without adjuvants.

Methods

After obtaining the approval of our faculty ethical committee (FMASU MS 256/2021), informed consent was taken from 66 patients, ASA physical status 1 or 2, aged 18 to 65 years, body weight ≥ 60 kg and ≤ 90 kg, and scheduled for elective open abdominal surgeries with midline skin incision under general anesthesia, in this randomized study at Ain Shams University Hospitals. After completion of surgery, patients were randomized using computer-generated random number tables, and group allocation was done with closed envelopes technique.

Exclusion criteria

These are patients' refusal, history of allergy to any of the study medications, hepatic or renal disease, known neurologic disorders, psychiatric disorder, chronic pain, chronic treatment with calcium or calcium channel blockers, hypermagnesemia, contraindications to regional anesthesia, coagulopathy, anatomical abnormalities, hemodynamic instability, local infection, and suspected intra-abdominal sepsis.

In the preoperative visit, a detailed checkup was carried out to all patients including history taking, clinical examination and investigations, complete blood picture, liver and kidney functions tests, serum magnesium level, the coagulation profile, electrocardiography (ECG), and echocardiography (echo) for cardiac patients. All patients were informed about the study design, the analgesic regimen, and how to express pain intensity with the use of the VAS. The VAS is a 10-cm line corresponding to their pain level, with 0 at one end representing no pain at all and 10 at the other end representing the worst imaginable pain (Delgado et al. 2018).

The anesthetic technique

On arrival to the operating theater, patients had an 18-G intravenous (IV) cannula inserted in dorsum of the hand, and IV Ringer's solution was started according to the fluid chart of each patient. Noninvasive blood pressure, pulse oximeter, and electrocardiography were applied to the patients. Capnography was attached with induction of general anesthesia.

General anesthesia with endotracheal intubation was induced with 0.05 mg/kg midazolam, 1 μg/kg fentanyl, 2 mg/kg propofol, and 0.5 mg/kg atracurium. Anesthesia was maintained with 1.2% isoflurane in 50% O_2 in air mixture; additional boluses of 0.5–1 μg/kg fentanyl and 0.1 mg/kg atracurium were given every 30 min until the end of the operation.

At the end of surgery (Akerman et al. 2018), patients were laterally positioned to perform bilateral posterior QLB. Under complete aseptic conditions, with ultrasound guidance, a low-frequency (3–5 MHz) curvilinear probe covered with a sterile sheath, and a sterile 100-mm 22-G insulated needle was used to perform the block.

Preparation of the study drugs

Under complete aseptic conditions, 5 ml of 10% (500 mg) magnesium sulfate ($MgSo_4$) (Jebali et al. 2018) (10%

magnesium sulfate injection, Egypt, Otsuka Pharmaceutical Co., S.A.E.) or 2 ml of 8-mg dexamethasone (Akerman et al. 2018) (dexamethasone MUP, 8 mg/2-ml ampoule) was added to 20 ml of 0.5% (100 mg) bupivacaine (bupivacaine hydrochloride 0.5%, Sunny Pharmaceutical, Egypt, under license of Hamelin Pharmaceuticals, Germany), and then, 0.9% normal saline (NS) was added to the mixture, to have a total volume of 40 ml of 0.25% bupivacaine (Singariya et al. 2020), with considering the maximum dose of bupivacaine for each patient as 2.5 mg/kg (Akerman et al. 2018).

Performing the block

The ultrasound probe was placed between the lower costal margin and the iliac crest in the midaxillary line and in a transverse plane to view the three abdominal wall muscles: external oblique, internal oblique, and transversus abdominis muscles. The probe was moved towards the posterior axillary line, until the transversus abdominis muscle forms its aponeurosis. The aponeurosis was then followed posteriorly until the QL muscle was seen with its attachment to the transverse process of the L_4 vertebral body. Using the in-plane approach, the needle was inserted 1 cm anterior to the probe at 90° angle to the skin. The needle was then redirected and advanced until reaching the lumbar interfascial triangle, at the posterior surface of the QL muscle, anterior to the middle TLF. The penetration of the middle TLF provided a characteristic loss of resistance. After negative aspiration, the correct needle position was proved by hydrodissection with 2 mL of NS injection with a hypo-echoic image.

Patients were then randomly divided into 3 equal groups of 22 patients each:

- Group BM: Patients received bilateral QLB with 40 ml (20 ml on each side) of 0.25% bupivacaine and with 5 ml of 10% MgSO4.
- Group BD: Patients received bilateral QLB with 40 ml (20 ml on each side) of 0.25% bupivacaine and with 2 ml of 8 mg dexamethasone.
- Group BS: Patients received bilateral QLB with 40 ml (20 ml on each side) of 0.25% bupivacaine.

The study drug was injected in 5-ml increments with intermittent aspiration and with hypoechoic LA spread between the QL and the erector spinae muscles (Elsharkawy et al. 2019).

After completion of bilateral QLB, the residual neuromuscular blockade was then antagonized with a mixture of IV 0.05 mg/kg neostigmine and 0.02 mg/kg atropine. Tracheal extubation was done when the patient regained consciousness and the patients were transferred to the PACU. Patients were discharged after 60 min of observation in the PACU.

In the post-operative period, patients with *VAS* $>$ 3 at rest (Jebali et al. 2018) were prescribed rescue analgesia in the form of the following: IV 1-g paracetamol (Perfalgan vial, 100 ml of 10 mg/ml) over 10–20 min, with maximum dose of 15 mg/kg per administration and IV 25-mg incremental doses of pethidine.

Primary outcome

Duration of post-operative analgesia: Time from completion of the block to the first request of rescue analgesia.

Secondary outcomes

1. Mean arterial blood pressure: Measured before induction of anesthesia (base line), upon arrival to the PACU, after 30 and 60 min in the PACU. If hypotension (decrease in the *MBP* $>$ 20% of the base line value) occurred (11), 3-mg increments of ephedrine were given IV and repeated every 5 min if required. MBP was then recorded at 2, 6, 12, 24, 30, and 36 post-operative hours.
2. Heart rate: Recorded before induction of anesthesia (baseline), upon arrival to the PACU, and after 30 and 60 min in the PACU. If bradycardia (*HR* $<$ 50 bpm) occurred (Sun et al. 2017), 0.5-mg atropine was given IV. HR was then recorded at 2, 6, 12, 24, 30, and 36 post-operative hours.
3. The severity of post-operative pain at rest: Assessed using the VAS upon arrival to the PACU, after 30 and 60 min. The VAS was then recorded at 2, 4, 6, 8, 12, 24, 30, and 36 post-operative hours. Pain severity was categorized as mild (*VAS* $\leq$ 3), moderate (3 $<$ VAS $<$ 7), and severe (*VAS* $\geq$ 7) (Kelly 2001).
4. The severity of post-operative pain with movement (bilateral knee flexion): Assessed using the VAS upon arrival to the PACU, after 30 and 60 min. The VAS was then recorded at 2, 4, 6, 8, 12, 24, 30, and 36 post-operative hours.
5. Number of patients with *VAS* $>$ 3 at rest and with movement: Recorded at 30 and 36 post-operative hours
6. Number of patients requiring post-operative rescue analgesia: Number of patients requiring pethidine in the 36-h post-operative period
7. Total dose of pethidine given: The cumulative total IV pethidine doses given to each patient in the 36-h post-operative period
8. Number of patients who maintained post-operative analgesia for 36 h

9. Time to first ambulation: The time to the start of movement by each patient in the 24-h post-operative period

Statistical analysis

Using PASS11 program for sample size calculation, setting alpha error at 5% and power at 80%, and reviewing results from previous study (Singariya et al. 2020) showed a large effect size ($d > 0.6$) in the difference of mean duration of analgesia (4.95 h). Based on these results, a sample size of 66 patients (22 patients per group) was needed.

Data were analyzed using Statistical Package for Social Science (SPSS) version 21.0. Chicago, IL, USA. Qualitative variables were presented as number and percentages and compared between groups using chi-square test, while quantitative data were presented as mean and standard deviations and compared between the three groups using one-way ANOVA. Tukey post hoc analysis was conducted in case one-way ANOVA was statistically significant ($P<0.05$), to determine where exactly the differences lie. Nonparametric data were presented as median and range and compared between the three groups using Kruskal-Wallis test. $P<0.05$ was considered statistically significant.

Results

Sixty-six patients (22 patients in each group) with comparable age, sex, ASA physical status, and weight, with *P*-value 0.854, 0.822, 0.503, and 0.115, respectively (Table 1), were enrolled in the study. The patients were scheduled to undergo open abdominal surgeries under general anesthesia: hemicolectomy, ureteric implantation, ureterolithotomy, partial or radical nephrectomy, partial or radical gastrectomy and laparotomy with no significant difference between the three groups (*P*-value = 0.363) (Fig. 1), and comparable mean operative duration with *P*-value 0.933 (Table 1).

Regarding the mean values of the MBP, there was no statistically significant difference between the three groups with respect to the following: the mean values recorded before induction of anesthesia, after 30 min and 1 h from arrival to the PACU, and at 2, 6, and 30 post-operative hours, with *P*-value 0.157, 0.093, 0.056, 0.136, 0.055, and 0.058, respectively. Upon arrival to the PACU, the mean values of the MBP showed statistically significant higher values in group BM than in group BD than in group BS with *P*-value 0.008; the pairwise analysis revealed that the MBP difference between group BM and group BS was statistically significant, with *P*-value 0.005. At 12 post-operative hours, the mean values of the MBP showed statistically significant higher values in group BD than in group BS than in group BM with *P*-value < 0.001; the pairwise analysis revealed that the MBP difference between group BS and group BM and between group BD and group BM was statistically significant, with *P*-value 0.043 and 0.005, respectively. At 24 post-operative hours, the mean values of the MBP showed statistically significant higher values in group BD than in group BM than in group BS with *P*-value 0.048; the pairwise analysis revealed that the MBP difference between group BD and group BS was statistically significant with *P*-value 0.038. At 36 post-operative hours, the mean values of the MBP showed statistically significant higher values in group BS than in group BM than in group BD with *P*-value 0.014; the pairwise analysis revealed that the MBP difference between group BS and group BD was statistically significant, with *P*-value 0.015 (Fig. 2, Table 2).

Regarding the mean values of the HR, they were comparable between the three groups: before induction of anesthesia, upon arrival to the PACU, after 1 h in the PACU, and after 12, 24, 30, and 36 post-operative hours, with *P*-value 0.244, 0.808, 0.064, 0.351, 0.056, 0.091, and 0.403, respectively. After 30 min of arrival to the PACU and at 2 post-operative hours, the mean values of the HR showed statistically significant higher values in group BD than in group BM than in group BS, with *P*-value 0.010 and 0.013; the pairwise analysis revealed that the HR difference between group BD and group BS was statistically significant, with *P*-value 0.007 and 0.011, respectively. At 6 post-operative hours, the mean values of the HR showed statistically significant higher values in group BD than in group BS than in group BM, with *P*-value < 0.001;

Table 1 Patients' demographic data and duration of surgery

Variables	Group BS (*N* = 22)	Group BM (*N* = 22)	Group BD (*N* = 22)	*p*-value
Age (years)	49.68 ± 4.7	48.55 ± 6.1	48.68 ± 9.5	0.845
Sex (M/F)	14/8	15/7	13/9	0.822
ASA (I/II)	17/5	17/5	14/8	0.503
Weight (kg)	83.82 ± 4.4	80.86 ± 6.7	84.27 ± 6.1	0.115
Duration of surgery (min)	151.82 ± 38.7	148.18 ± 42.6	147.27 ± 47.1	0.933

Data are presented as number of patients or mean ± SD. *BS* Bupivacaine-Saline group, *BM* Bupivacaine-Magnesium group, *BD* Bupivacaine-Dexamethasone group, *M* male, *F* female, *ASA* American Society of Anesthesiologists

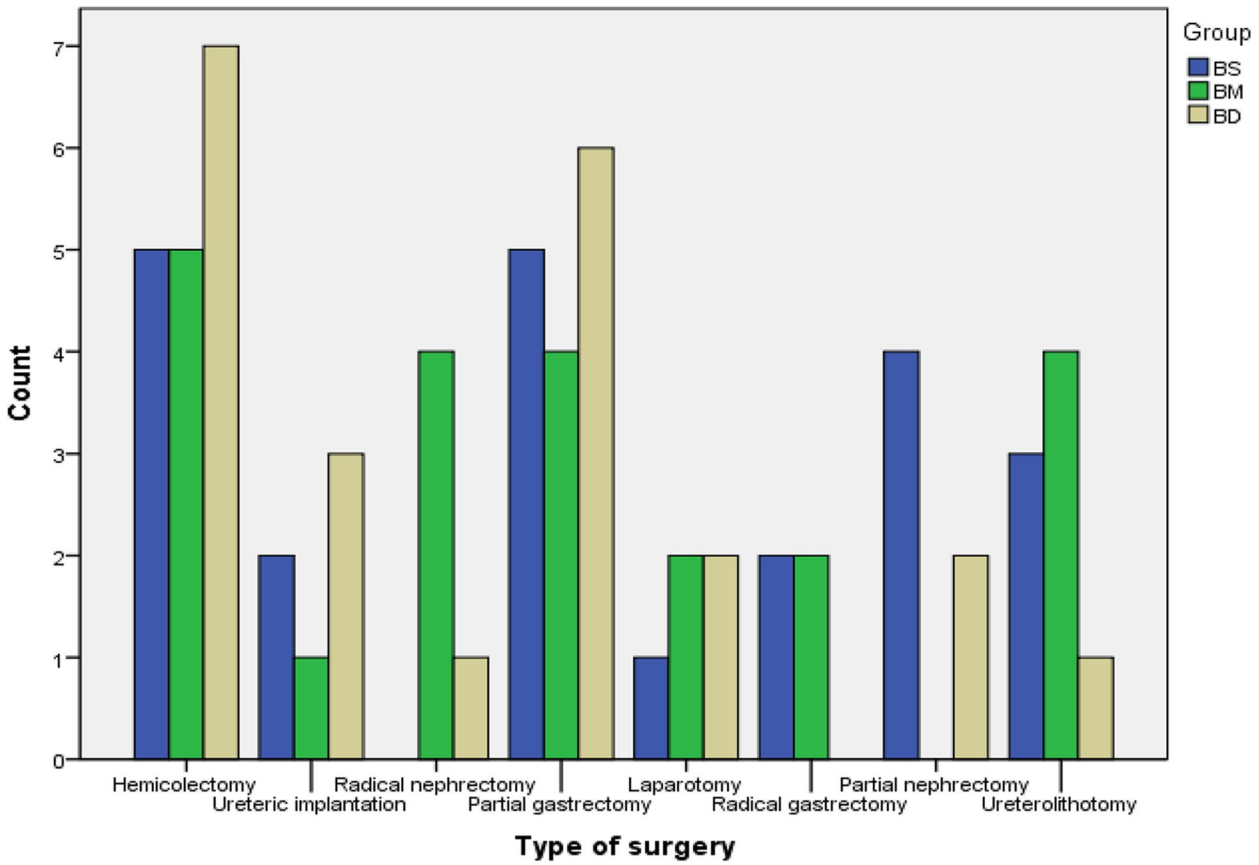

Fig. 1 Frequency distribution of the different types of surgeries. Data are presented as number of patients. *P*-value = 0.363. BS, Bupivacaine-Saline group; BM, Bupivacaine-Magnesium group; BD, Bupivacaine-Dexamethasone group

the pairwise analysis revealed that the HR difference between group BS and group BM and between group BD and group BM was statistically significant, with *P*-value 0.017 and 0.005, respectively (Fig. 3, Table 2).

Regarding the post-operative pain score at rest, the VAS was comparable between the three groups upon arrival to the PACU; the median (range) VAS was 0 (0–1.5) in groups BS and BM and 0 (0–0.5) in group BM with *P*-value 0.995. After 30 min and 1 h from arrival to the PACU, at 2, 4, 6, 8, and 12 post-operative hours, patients of the three groups reported VAS of 0. At 24 post-operative hours, the VAS was comparable between the three groups; the median (range) VAS was 0 (0–1) with *P*-value 0.634. At 30 post-operative hours, the VAS showed statistically significantly lower median (range) values in group BD 2 (0–4) than in group BM 2.25 (0–4) than in group BS 3.25 (3–4), with *P*-value $^{<}$ 0.001. Also, the number of patients with *VAS* $^{>}$ 3 was statistically significantly higher in group BS (50% of patients), than in group BM (18.2% of patients) than in group BD (13.6% of patients), with *P*-value 0.013. At 36 post-operative hours, the VAS showed statistically non-significant lower median (range) values in group BS 3.5 (2–5) than in group BD 3.5 (2.5–5) than in group BM 4 (2.5–5), with *P*-value 0.518. Also, the number of patients with *VAS* $^{>}$ 3 was statistically non-significant higher in group BM (68.2% of patients), than in groups BS and BD (59.1% of patients in each group), with *P*-value 0.773 (Table 3, Fig. 4).

Regarding the post-operative pain score with movement, the VAS showed statistically non-significant lower median (range) values in group BM and BD 0 (0–2) than in group BS 0.75 (0–2.5) upon arrival to the PACU, with *P*-value 0.291. After 30 min and 1 h from arrival to the PACU, at 2, 4, 6, 8, 12, and 24 post-operative hours, the VAS was comparable between the three groups, with *P*-value 0.462, 0.816, 0.999, 0.999, 0.565, 0.830, 0.562, and 0.674, respectively. At 30 post-operative hours, the VAS showed statistically significant lower median (range) values in group BD 2.75 (2–4.5) than in group BM 3 (0–4.5) than in group BS 4 (3.5–5), with *P*-value $^{<}$ 0.001. Also, the number of patients with *VAS* $^{>}$ 3 was statistically significant higher in group BS (100% of patients), than in group BM (27.3% of patients) than in group BD (13.6% of patients), with *P*-value < 0.001. At 36 post-operative

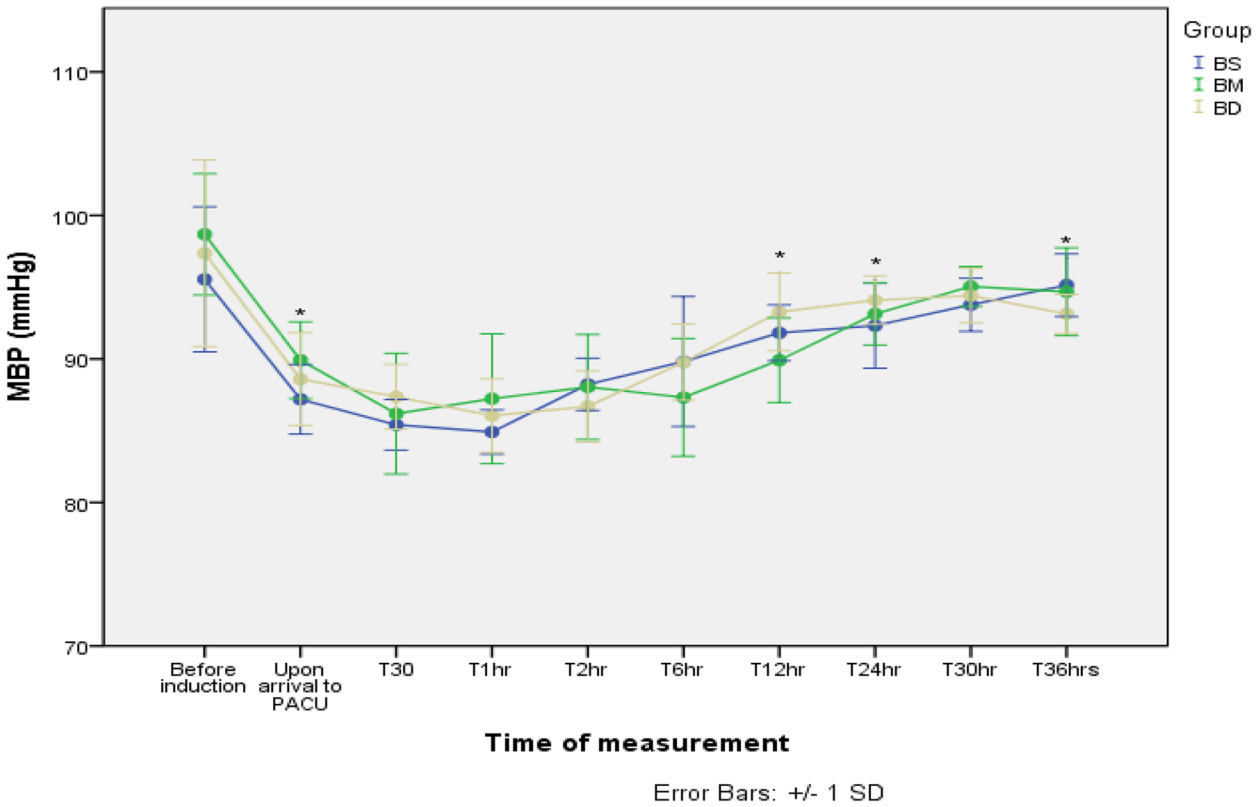

Fig. 2 The mean blood pressure (MBP) at different times of measurement. Data are presented as mean values; error bars represent the SD. *Significant difference between the three groups (*P*-value < 0.05). BS, Bupivacaine-Saline group; BM, Bupivacaine-Magnesium group; BD, Bupivacaine-Dexamethasone group; MBP, mean blood pressure; PACU, postanesthesia care unit

hours, the VAS showed statistically non-significant lower median (range) values in group BD 4 (3–5.5) than in group BS 4 (3–6) than in group BM 4.5 (3–5.5), with *P*-value 0.265. Also, the number of patients with *VAS* > 3 was statistically non-significant higher in group BM (95.5% of patients), than in groups BS and BD (81.8% of patients in each group), with *P*-value 0.314 (Table 4, Fig. 4).

Regarding the number of patients who required post-operative rescue analgesia in the 36 post-operative hours, 100% of patients in group BS required pethidine, versus 68.2% of patients in group BM and 63.6% of patients in group BD, with *P*-value 0.007; the pairwise analysis revealed statistically significant more number of patients who required pethidine, in group BS than in group BM than in group BD after Bonferroni correction with *P*-value 0.0018 (Fig. 5, Table 5). In spite of this, the cumulative total pethidine doses given were comparable between the three groups with *P*-value 0.170 (Fig. 6).

Regarding the duration of post-operative analgesia, it was comparable between the three groups with *P*-value 0.239 (Fig. 6). Regarding the number of patients who maintained post-operative analgesia for 36 h, it was comparable between the three groups with *P*-value 0.231 (Fig. 7). Regarding the time to first ambulation, it was comparable between the three groups with *P*-value 0.933 (Fig. 8).

Discussion

In the present study, the posterior approach to the QLB was used for post-operative analgesia after open abdominal surgeries. Also, Chakraborty, Khemka, and Datta (Chakraborty et al. 2016) illustrated the successful use of QLB in lower abdominal surgeries and open nephrectomy. In our study, the QLB was performed under general anesthesia, as the LA is not injected close to a large nerve with no risk of neurological injury (Chin et al. 2017).

In the current study, patients of the three groups showed comparable VAS at rest and with movement, upon arrival to the PACU until the 24 post-operative hours. This is explained by the somatic and visceral analgesic effect of the posterior QLB due to the cranial spread of bupivacaine along the middle TLF to the paravertebral space (Elsharkawy et al. 2017), reaching the fifth thoracic (T_5) segment (Chin et al. 2017) or even the fourth thoracic (T_4) segment (Elsharkawy and Bendtsen 2017).

Table 2 Pairwise comparison between the three groups regarding the mean blood pressure (MBP) and the heart rate (HR)

Variables	Group 1	Group 2	Mean difference	*p*-value
MBP upon arrival to the PACU (mmHg)	BM	BS	2.727	0.005
	BM	BD	1.318	0.269
	BD	BS	1.409	0.224
MBP after 12 h (mmHg)	BS	BM	1.909	0.043
	BD	BS	1.455	0.153
	BD	BM	3.364	0.005
MBP after 24 h (mmHg)	BM	BS	0.818	0.418
	BD	BS	1.773	0.038
	BD	BM	0.955	0.370
MBP after 36 h (mmHg)	BS	BM	0.455	0.791
	BS	BD	2.000	0.015
	BM	BD	1.545	0.076
HR after 30 min in the PACU (bpm)	BM	BS	1.273	0.169
	BD	BS	2.182	0.007
	BD	BM	0.909	0.397
HR after 2 h (bpm)	BM	BS	2.000	0.123
	BD	BS	3.000	0.011
	BD	BM	1.000	0.583
HR after 6 h (bpm)	BS	BM	2.682	0.017
	BD	BS	1.364	0.326
	BD	BM	4.045	0.005

Data are presented as mean difference in mmHg for the MBP and beat per minute (bpm) for the HR. *BS* Bupivacaine-Saline group, *BM* Bupivacaine-Magnesium group, *BD* Bupivacaine-Dexamethasone group, *HR* heart rate, *MBP* mean blood pressure, *PACU* postanesthesia care unit

Bupivacaine blocks the anterior and the lateral cutaneous branches of the mechanoreceptors and the A and C nociceptive fibers in the TLF (Elsharkawy et al. 2019). Our results go with those by Kumar, Gnanasekar, and Kurhekar (Kumar et al. 2018), who recorded adequate analgesic effect of bilateral QLB with 20-ml ropivacaine (0.25%) on each side, with decreased VAS scores to 1 or 2, both at rest and with movement, together with an opioid-sparing effect for more than 24 post-operative hours, compared to bilateral transversus abdominis plane block in seventy patients undergoing lower abdominal surgeries.

In the present study, at 30 post-operative hours, patients of the BD and the BM groups experienced mild pain at rest and with movement, with clinically non-significant lower median VAS in patients of the BD group than in patients of the BM group, whereas 50% of patients in the BS group experienced moderate pain at rest (median VAS = 3.25), and 100% of patients experienced moderate pain with movement (median VAS = 4), with mean total pethidine dose of 52.27 mg needed by patients in the BS group. At 36 post-operative hours, patients of the BD and the BS groups experienced moderate pain at rest and with movement, with lower median VAS (3.5 and 4, respectively) than patients in the BM group (4 and 4.5, respectively). Our results are explained in the meta-analyses of randomized controlled trials (RCTs), which showed that peri-neurally administered dexamethasone potentiated the duration of analgesia offered by nerve blocks compared to IV dexamethasone, due to its local and systemic anti-inflammatory effects by phospholipase A2 inhibition and the inhibition of the inflammatory mediator's production (Chong et al. 2017). Also, the analgesic effect of $MgSO_4$ as an adjuvant to bupivacaine was explained by different theories. First, $MgSO_4$ is a noncompetitive N-methyl-D-aspartate (NMDA) receptor antagonist; it prevents central sensitization from peripheral nociceptive surgical stimulus (Sun et al. 2017). Second, as a divalent ion, it decreases the negative charges on the outer surface of myelinated and unmyelinated nerve membranes, thus increasing the resting transmembrane potential with resultant hyperpolarization and increasing the action potential threshold with resultant conduction block (Akutagawa et al. 1984). Third, it blocks the release of the inflammatory mediators by direct action on the peripheral nerves and prevents the release of excitatory neurotransmitters at the synaptic junction (Sun et al. 2017). Fourth, $MgSO_4$ is a physiologic calcium antagonist; as calcium channel blockers potentiate the analgesic effect of LAs (Jebali et al. 2018; Michael

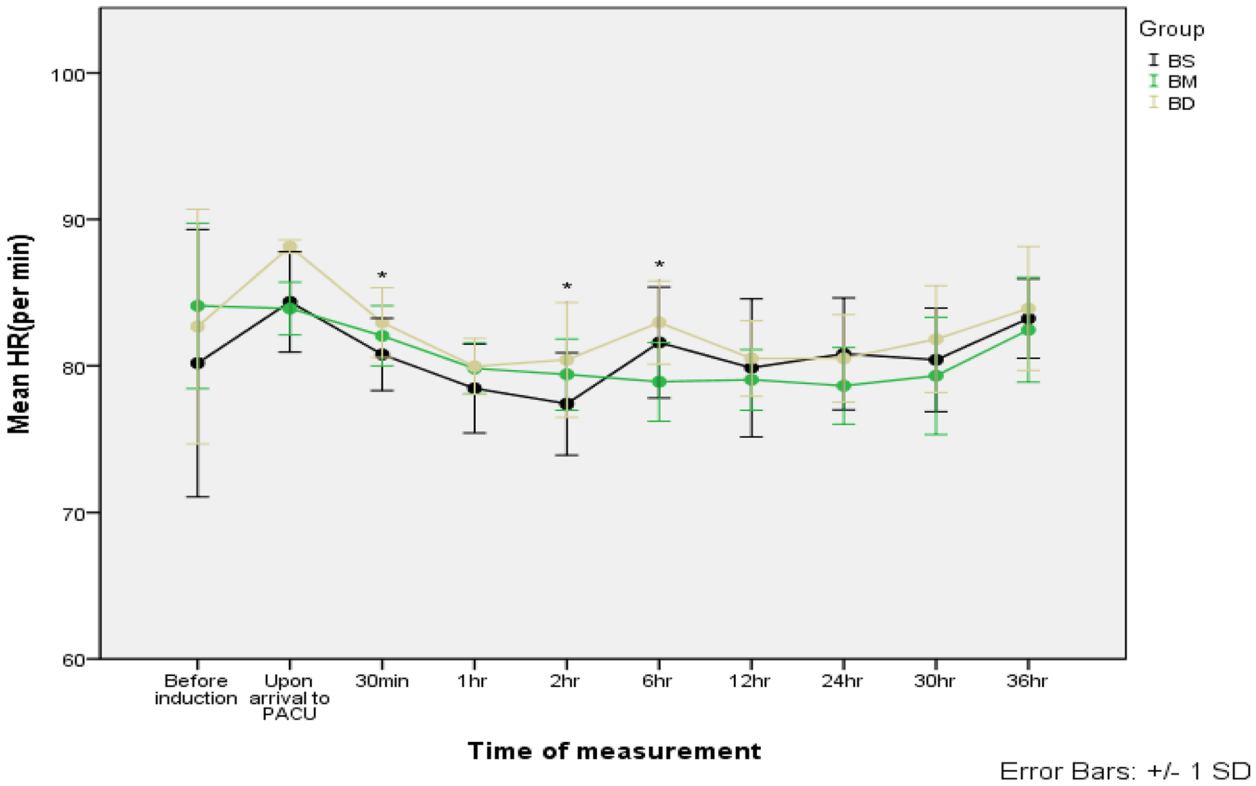

Fig. 3 The heart rate (HR) at different times of measurement. Data are presented as mean values; error bars represent the SD. *Significant difference between the three groups (*P*-value < 0.05). BS, Bupivacaine-Saline group; BM, Bupivacaine-Magnesium group; BD, Bupivacaine-Dexamethasone group; HR, heart rate; PACU, postanesthesia care unit

Table 3 The VAS values at rest

VAS at rest	Group BS (*N* = 22)	Group BM (*N* = 22)	Group BD (*N* = 22)	*p*-value
Upon arrival to the PACU	0 (0–1.5)	0 (0–1.5)	0 (0–0.5)	0.995
After 24 h	0 (0–1)	0 (0–1)	0 (0–1)	0.634
After 30 h	3.25 (3–4)	2.25 (0–4)	2 (0–4)	< 0.001
After 36 h	3.5 (2–5)	4 (2.5–5)	3.5 (2.5–5)	0.518

Data are presented as median (range). *BS* Bupivacaine-Saline group, *BM* Bupivacaine-Magnesium group, *BD* Bupivacaine-Dexamethasone group, *VAS* visual analogue scale, *PACU* postanesthesia care unit

et al. 2021). Fifth, its presence in high concentration slows the closure of the sodium channels and enhances the number of inactivated sodium channels; thus, more bupivacaine could reach the binding site and blocks more channels (Sun et al. 2017).

In the current study, patients of the BM and the BD groups showed clinically non-significant longer duration of post-operative analgesia than patients of the BS group. This finding goes with the review on newer regional anesthetic techniques, long-acting LAs and adjuvants to LAs, which stated that in spite of bupivacaine being a long-acting LA, it did not provide adequate post-operative analgesic duration; thus, adjuvants were added, or rescue analgesics were used for breakthrough pain (Wahal et al. 2018). Our results for perineural dexamethasone match those of the meta-analyses of RCTs, comparing the effectiveness of IV versus perineural dexamethasone in peripheral nerve blocks (Zorrilla-Vaca and Li 2018). These results were explained by the local action of dexamethasone on the inhibitory potassium channels and the intracellular glucocorticoid receptors in the C-fiber neurons (Parveen et al. 2017). Also, Albrecht, Kern, and Kirkham (Albrecht et al. 2015) stated that the local vasoconstrictive effect of dexamethasone decreased bupivacaine absorption. Our results for $MgSO_4$ match

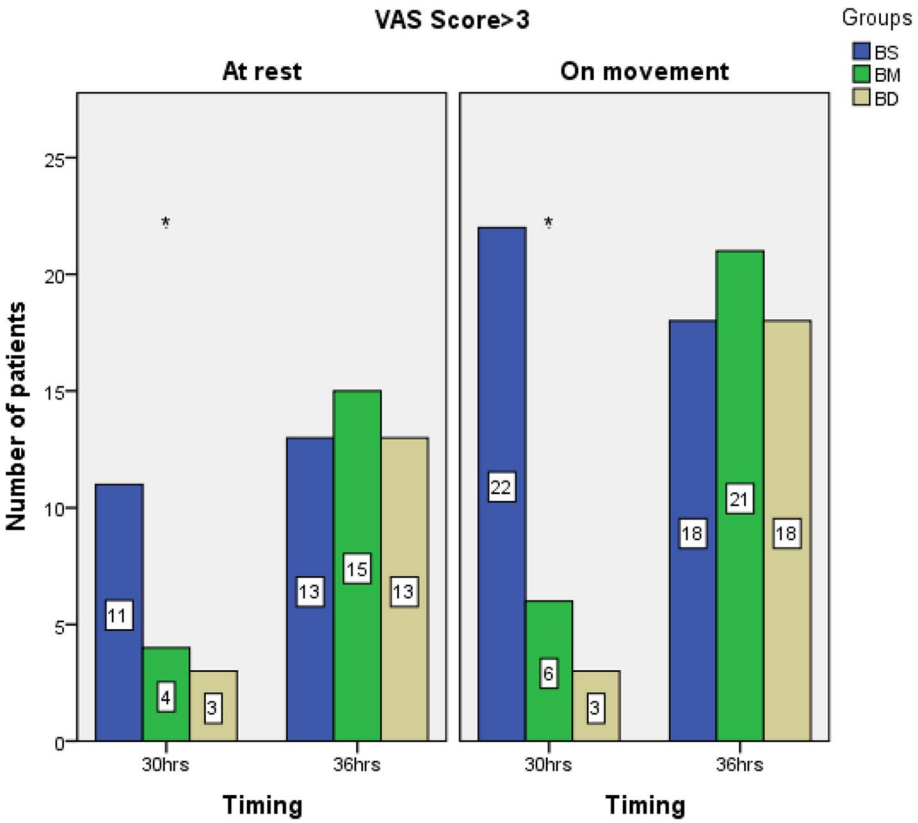

Fig. 4 Number of patients with VAS score > 3 at rest and on movement at 30 and 36 post-operative hours. Data are presented as number of patients. BS, Bupivacaine-Saline group; BM, Bupivacaine-Magnesium group; BD, Bupivacaine-Dexamethasone group; VAS, visual analogue scale

Table 4 The VAS values with movement

VAS with movement	Group BS ($N=22$)	Group BM ($N=22$)	Group BD ($N=22$)	*p*-value
Upon arrival to the PACU	0.75 (0–2.5)	0 (0–2)	0 (0–2)	0.291
After 30 min in the PACU	0 (0–1)	0 (0–1)	0 (0–1)	0.462
After 1 h in the PACU	0 (0–1.5)	0 (0–1)	0 (0–0.5)	0.816
After 2 h	0 (0–1.5)	0 (0–1.5)	0 (0–1)	0.999
After 4 h	0 (0–2)	0 (0–1)	0 (0–1)	0.999
After 6 h	0 (0–1)	0 (0–1.5)	0 (0–1)	0.565
After 8 h	0 (0–1.5)	0 (0–1)	0 (0–1)	0.830
After 12 h	0 (0–2)	0 (0–0.5)	0 (0–1)	0.562
After 24 h	0 (0–3)	0 (0–2)	0 (0–2)	0.674
After 30 h	4 (3.5–5)	3 (0–4.5)	2.75 (2–4.5)	< 0.001
After 36 h	4 (3–6)	4.5 (3–5.5)	4 (3–5.5)	0.265

Data are presented as median (range). *BS* Bupivacaine-Saline group, *BM* Bupivacaine-Magnesium group, *BD* Bupivacaine-Dexamethasone group, *VAS* visual analogue scale, *PACU* postanesthesia care unit

those by Mieszkowski, Mayzner-Zawadzka, Tuyakov, and Mieszkowska (Mieszkowski et al. 2018), who showed that QLB prolonged the post-operative analgesic duration and decreased the analgesic consumption and pain scores up to 48 post-operative hours, in sixty parturients undergoing cesarean section.

In the current study, upon arrival to the PACU, the mean values of the MBP were not clinically significant and higher in the BM group than the BD group

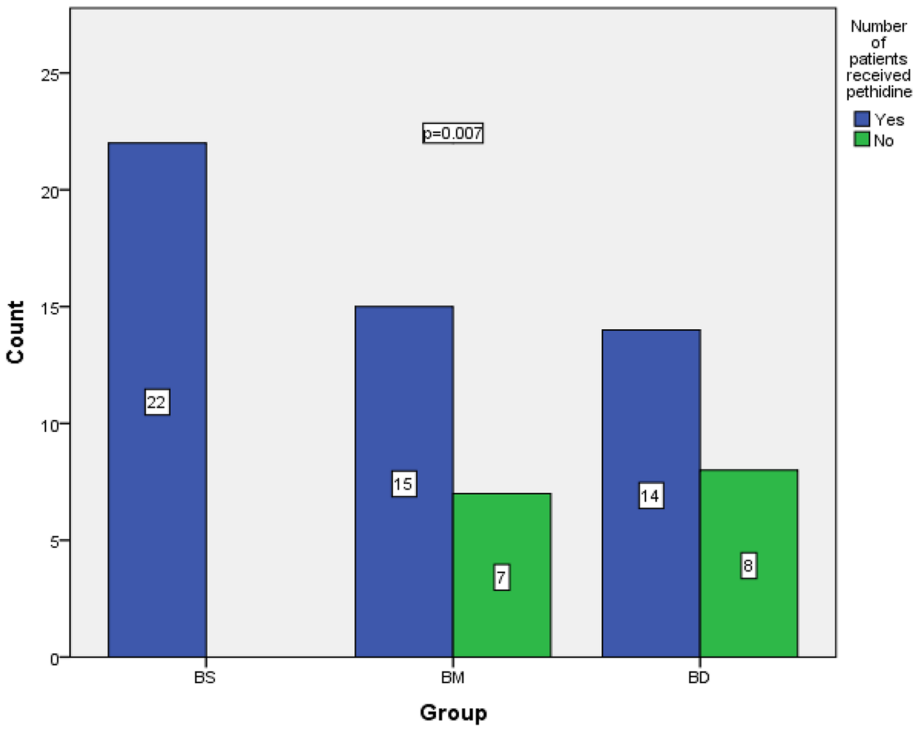

Fig. 5 Number of patients who received pethidine. Data are presented as number of patients. BS, Bupivacaine-Saline group; BM, Bupivacaine-Magnesium group; BD, Bupivacaine-Dexamethasone group

Table 5 Pairwise comparison between the three groups regarding the number of patients who received pethidine

Number of patients who received pethidine	Group			Total
	BS	BM	BD	
Count (%)	22 (43.14)	15 (29.41)	14 (27.45)	51 (100)
Adjusted residual (*P*-value)	3.12 (0.0018)	− 1.25 (0.2113)	− 1.87 (0.0615)	

Data are presented as number of patients (percentage). *BS* Bupivacaine-Saline group, *BM* Bupivacaine-Magnesium group, *BD* Bupivacaine-Dexamethasone group. The null hypothesis is that there is no difference between the 3 groups; this means that the expected number of patients who needed pethidine will be equal in the 3 groups. The *P*-value indicates if there is a significant difference between the actual number of patients who needed pethidine and the expected number in each group. The level of significance here is corrected. Bonferroni correction was made with statistical significance accepted at a *P*-value < 0.0167

and the BS group (mean difference range from 2.727 to 1.318 mmHg), with comparable HR in patients of the three groups, indicating the hemodynamic stability offered by the QLB which was potentiated by the addition of $MgSO_4$ or dexamethasone to bupivacaine, in spite of blocking the high-density thoracolumbar sympathetic fibers up to the fourth thoracic segment (T_4), which have a strong vasomotor effect, with fear of causing changes to the systemic autonomic tone (Elsharkawy et al. 2019). This hemodynamic stability continued for 30 min in the PACU and after 2 post-operative hours, with patients in the BD group showing clinically non-significant higher mean HR values than patients in the BM group and patients in the BS group (mean difference range from 2.182 to 0.909 bpm and from 3 to 1 bpm), respectively. After 6 post-operative hours, patients in the BD group showed clinically non-significant higher mean HR values than patients in the BS group than patients in the BM group (mean difference range from 4.045 to 1.364 bpm). After 12 post-operative hours, patients in the BD group showed clinically non-significant higher MBP values than patients in the BS group than patients in the BM group (mean difference range from 3.364 to 1.455 mmHg). After 24 post-operative hours, patients in the BD group showed clinically non-significant higher mean values of the MBP than patients in the BM group and patients in

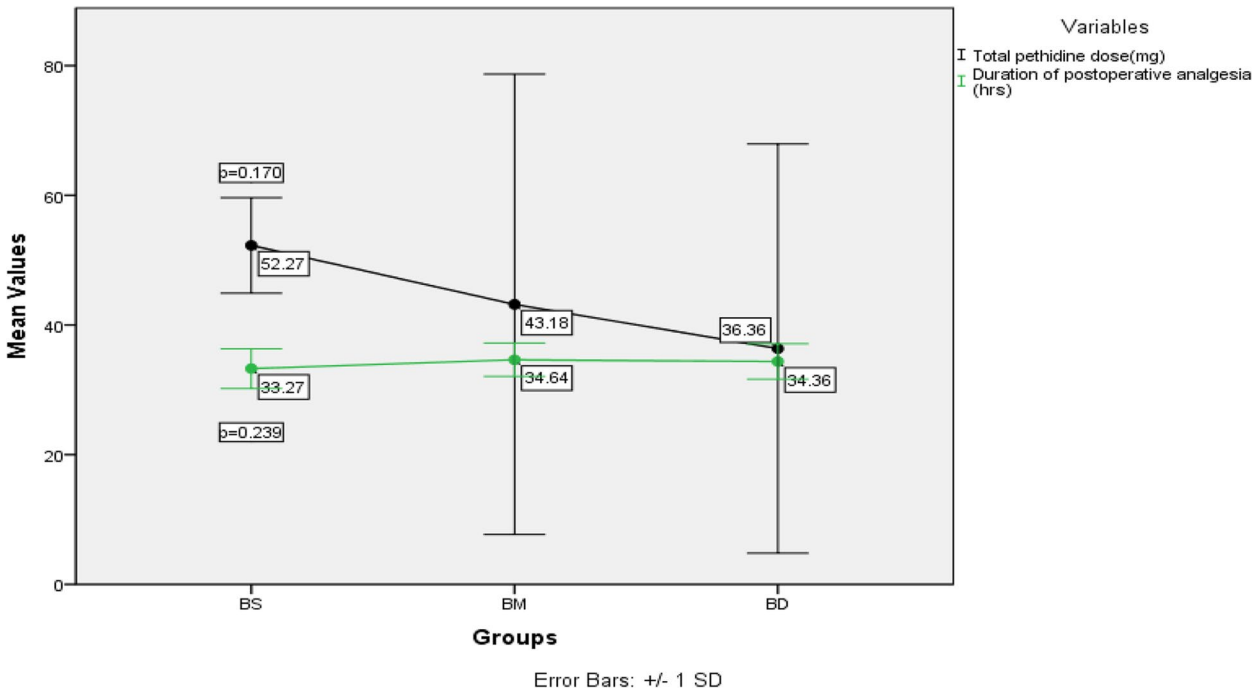

Fig. 6 The cumulative total pethidine dose (mg) and the mean duration of post-operative analgesia (h). Data are presented as mean ± SD. BS, Bupivacaine-Saline group; BM, Bupivacaine-Magnesium group; BD, Bupivacaine-Dexamethasone group

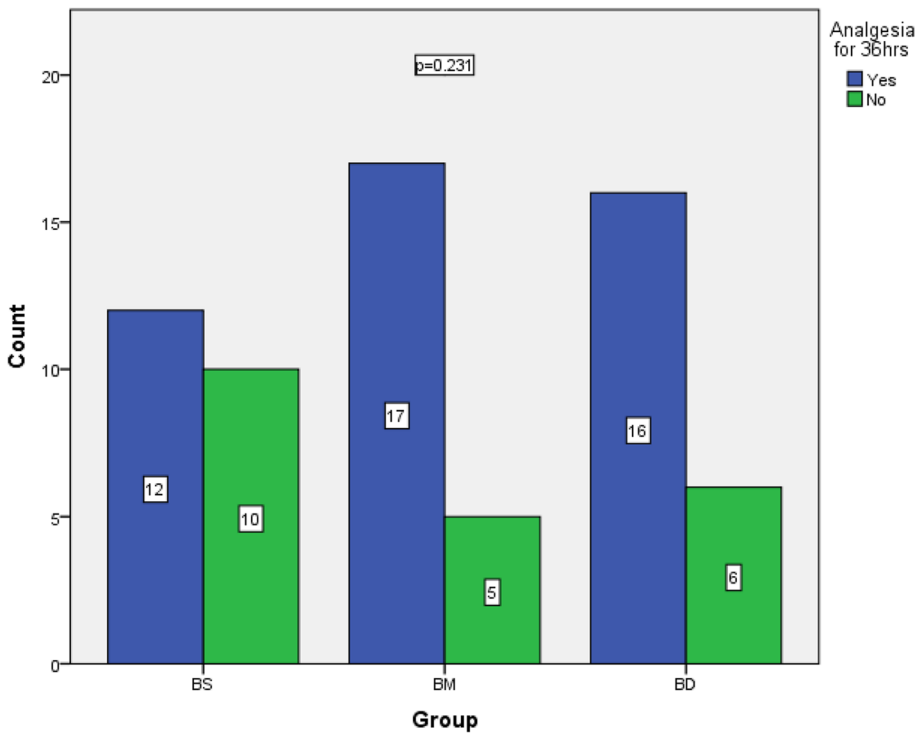

Fig. 7 Number of patients who maintained analgesia for 36 post-operative hours. Data are presented as number of patients. BS, Bupivacaine-Saline group; BM, Bupivacaine-Magnesium group; BD, Bupivacaine-Dexamethasone group

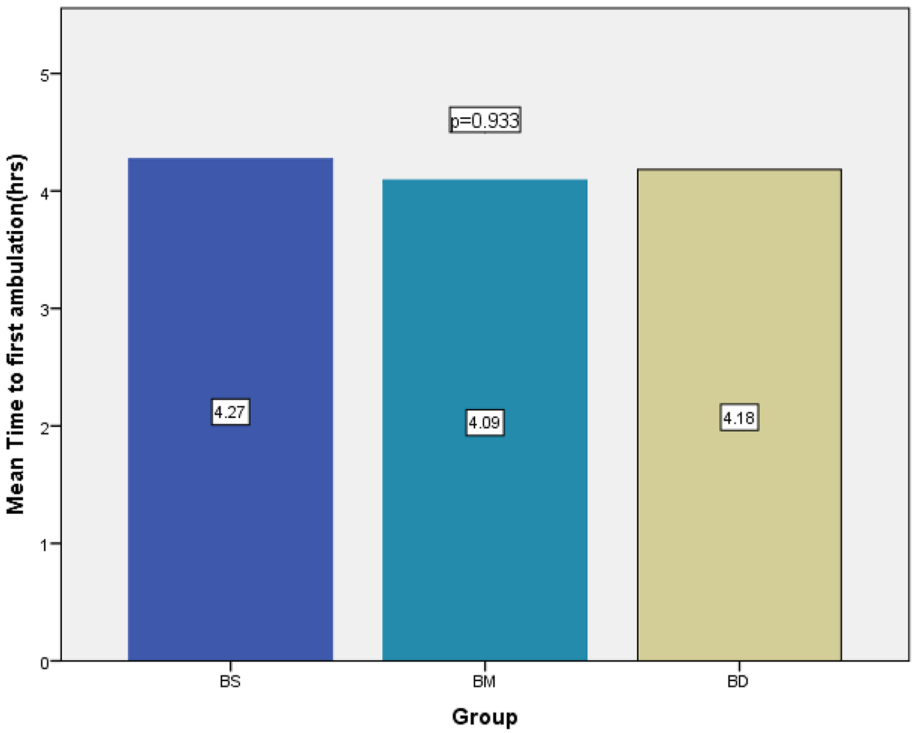

Fig. 8 Time to first ambulation. Data are presented as mean ± SD. BS, Bupivacaine-Saline group; BM, Bupivacaine-Magnesium group; BD, Bupivacaine-Dexamethasone group

the BS group (the mean difference range from 1.773 to 0.818 mmHg), and at 36 post-operative hours, patients in the BS group showed clinically non-significant higher mean values of the MBP than patients in the BM group and patients in the BD group (mean difference range from 2.0 to 0.454 mmHg).

In the present study, the post-operative analgesic profile with these types of surgeries affected the post-operative time to first ambulation, which was comparable between the three groups (mean duration from 4.09 to 4.27 h). This is one of the most important measures for the prevention of deep vein thrombosis and thromboembolic complications. Our results match those by Ishio, Komasawa, Kido, and Minami (Ishio et al. 2017), as ultrasound-guided posterior QLB aided in early mobilization of thirty-five female patients undergoing laparoscopic gynecologic surgery.

Conclusions

The addition of 8-mg dexamethasone or 5 ml of 10% $MgSo_4$ offered better post-operative VAS scores both at rest and with movement at 30 post-operative hours, with less number of patients receiving pethidine and more number of patients maintaining post-operative analgesia for 36 h, however, without significant prolongation of the post-operative analgesic duration compared to bupivacaine alone.

Abbreviations

ASA	American Society of Anesthesiologists
BD	Bupivacaine-Dexamethasone
BM	Bupivacaine-Magnesium
BS	Bupivacaine-Saline
Echo	Echocardiography
ECG	Electrocardiography
HR	Heart rate
IV	Intravenous
LA	Local anesthetic
MBP	Mean blood pressure
MgSo4	Magnesium sulfate
NS	Normal saline
PACU	Post-operative care unit
QL	Quadratus lumborum
QLB	Quadratus lumborum block
RCT	Randomized controlled trial
TLF	Thoracolumbar fascia
VAS	Visual analogue scale

Acknowledgements

Not applicable

Authors' contributions

SA designed the study and reviewed the manuscript. GS, design of the work, revised literature, performed the analysis, revised the statistical analysis, and wrote the manuscript. MS, design of the work, revised literature, and collected the data. ME followed the patients and collected the data. All authors approved the final version of the manuscript. All authors have contributed intellectually to the manuscript, and the manuscript has been read and

approved by all the authors. The manuscript has not been published, simultaneously submitted, or accepted for publication elsewhere.

Funding
We did not receive any financial support.

Availability of data and materials
The datasets generated and/or analyzed during the current study are not publicly available due to [publishing the clinical data about any study conducted in our hospitals and approved by the institutional ethical committee is against the policy of the Faculty of medicine, Ain Shams university unless there is a reasonable request] but are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
Approval of the research ethical committee of Faculty of Medicine, Ain-Shams University, was obtained (FMASU MS 256/2021) on 27th April 2021. Written informed consent was obtained from the patients after description of the procedure. The study was registered with Clinical Trials Registry (NCT05397236) on 23 May 2022.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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Received: 23 September 2022 Accepted: 28 April 2023
Published online: 09 May 2023

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