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Analgesic Efficacy of Magnesium Sulphate versus Ketorolac when Added to Bupivacaine in Erector Spinae Plane Block for Acute and Chronic Postmastectomy Pain

Mai Abd Elmaguid[*1], Maha Younis Youssef[1], Mohammed A. Hegazy[1], Tarek Shams[1]
Department of Anesthesia, Surgical Intensive Care and Pain Management[1],
Faculty of Medicine, Mansoura University, Egypt
[*]**Corresponding Author:** Mai Abd Elmaguid, **Mobile:** 01066584947, **Email:** mai.abdelmaguid94@gmail.com

ABSTRACT

Background: Breast cancer surgeries are always proceeded by pain. The erector spinae plane block (ESPB) is a new inter-fascial block that has been recently used to control chronic pain in thoracoscopic surgery.

Aim: This study aimed to compare the analgesic effect of adding magnesium sulphate ($MgSO_4$) vs. ketorolac as an adjuvant to bupivacaine (BVC) in preoperative ESPB in females scheduled for modified radical mastectomy (MRM).

Methods: Seventy-five females were allocated into three groups (25 each). Group A received U/S guided ESPB with an injection of 20 ml of BVC plus 2 ml normal saline, group B received an injection of 20 ml of BVC plus 2 ml of 10% $MgSO_4$ (200 mg) and group C received an injection of 20 ml of BVC plus 2 ml (30 mg) ketorolac. The Visual Analogue Scale (VAS) score was utilized for evaluating the acute pain severity while brief pain inventory-short form (BPI-SF) was utilized to assess the chronic pain severity. **Results:** Magnesium and ketorolac didn't reduce the incidence of pain at 1, 2, 3 and 6 months. Magnesium group has lower BPI scores at 1 and 2 months than the ketorolac and control groups but not 3 and 6 months postoperatively. Magnesium & ketorolac groups had significantly lower acute pain postoperatively. Compared to the control group, magnesium and ketorolac groups showed significantly lower total morphine consumption and longer mean times to the first analgesic recall.

Conclusion: Adding magnesium sulfate or ketorolac to BVC in a preoperative single shot of ESPB didn't decrease the chronic post-surgical pain (CPSP) incidence 6 months after surgery. However, they provided superior early postoperative analgesia and reduced postoperative analgesic requirements.

Keyword: Magnesium sulphate, Ketorolac, ESPB, Postmastectomy pain.

INTRODUCTION

Breast cancer surgery (BCS) is a very common surgery in females [1]. About 30–50% of females with breast cancer report moderate-to-severe pain [2]. The acute post-operative pain, if not appropriately controlled, can result in an impairment of functional recovery, a delayed discharge from post-anesthesia care [5], and an increase in the length of hospital stay [3].

Approximately 50% of BC cases develop CPSP [4]. The latter is associated with many risk factors including younger age, invasive interventions during the surgery, and post-surgical adjuvant radiotherapy. Moreover, high pain scores in the early post-surgical period is also an important independent risk factor [5].

This CPSP after mastectomy is termed *"Post-Mastectomy Pain Syndrome (PMPS)"* which can be intense enough to affect sleep and personal activities. The patient may also suffer from an immobilized arm, a condition that can result in significant lymphoedema, frozen shoulder syndrome, as well as complex regional pain syndrome [6].

Many regional anesthesia procedures have been used to control pain post-mastectomy [7, 8]. These include paravertebral block, serratus anterior plane block, pectoral nerves block, and the ESPB. The relatively new ESPB was described by **Forero *et al.*** [9] and was applied to control pain in the thoracic region.

Magnesium sulphate has shown antinociceptive effects in animal and human models as it antagonizes the N methyl-D-aspartate (NMDA) receptors and Ca^{+2} channels [10]. Ketorolac is a non-steroidal anti-inflammatory drug (NSAID) that exerts its analgesic effect via inhibiting prostaglandins' production. Ketorolac, when added as an adjuvant to local anesthetic, produced superior analgesic efficacy and longer duration of pain control [11]. Therefore, our study aimed to compare the analgesic effect of adding $MgSO_4$ versus ketorolac as an adjuvant to BVC in preoperative ESPB in females undergoing MRM.

PATIENTS AND METHODS

This prospective randomized double-blinded controlled study that was carried out at the Oncology Center of Mansoura University during the period from August 2023 to August 2024. This study included BC females aged 18-70 years prepared for MRM and were classified as class II regarding American Society of Anesthesiologists (ASA).

Exclusion criteria: ASA greater than II, any patient having a coagulation disorder, those with infections at the needle entry site, those having psychiatric diseases interfering with cooperation, patients with deformities in their chest walls and previous surgeries, any patient with a history of adverse reactions to local anaesthetics, $MgSO_4$ or ketorolac, with body mass index (BMI) > 35 kg/m^2, with coexisting malignancy, with history of other chronic pain conditions, with asthmatic disorders, and with impairment of renal function.

Randomization: Seventy-Five patients underwent randomization into 3 equal groups (25 each) according to the computer-generated number codes that were

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placed in closed envelopes. For achieving the blinding, the ESPB was applied according to the randomized group and an investigator who was blinded to the group (to which the patient was assigned) collected the study variables. Also, the patient was blinded to the group. Sealed envelopes that contained the group allocation were only opened after obtaining written consents. One investigator assessed the eligibility of each patient, obtained written consents, and opened envelopes.

Group A included patients received US-guided ESPB with an injection of 20 ml of BVC (0.25%) and 2 ml normal saline. Group B included patients received US-guided ESPB with an injection of 20 ml of BVC (0.25%) and 2 ml of 10% $MgSO_4$ (200 mg). Group C included patients received US-guided ESPB with an injection of 20 ml of BVC (0.25%) and 2 ml (30 mg) ketorolac.

Methods: The study protocol was illustrated to all patients. The day before the MRM, the investigator took history, performed examination and ordered laboratory tests (CBC, coagulation panel, blood glucose and liver and renal function tests). Prior to surgery, the VAS score to describe pain was explained to each patient (0 = no pain while 10 = maximum pain) and baseline pain scores were documented. In the operating theatre, each patient was monitored with electrocardiography, blood pressure monitoring and oxygen saturation (SpO_2), and the baseline (0 min) data were recorded. In a peripheral line, an intravenous cannula (20 G) was inserted to infuse crystalloids and administer sedation. A midazolam 0.05 mg/kg was administered in the intravenous cannula before the technique. Hydration was maintained by ringer acetate infusion and prophylactic antibiotics were administered after performing of a sensitivity tes

Technique: In a seated patient, a scout US scan by a high frequency (7-15 MHz) linear transducer probe of Mindray DC 45 US was performed for identifying and marking the targeted thoracic spine level (T4) after counting ribs from above. Patient's skin underwent sterilization and the transducer was transversely placed to identify the transverse process (TP). The TP's tip was centered on the US screen, then the transducer was longitudinally rotated 90^o for obtaining a parasagittal view. After identifying the TP of T4 and overlying trapezius, rhomboid major and erector spinae muscles, the targeted site was anesthetized with 2% lidocaine (3–4 ml).

Needle tip location was confirmed by observing saline solution separating erector spinae muscle off the bony shadow of the TP on US. After that, the pre-prepared local anesthetic mixture was slowly injected with adequate visualization of the spread of the injectate by ultrasound.

Anesthesia: Induction was achieved by intravenous propofol (2-3 mg/kg), fentanyl (1 μ/kg) and atracurium besylate (0.5 mg/kg) then the patient was intubated. For $ETCO_2$ stabilization at 30-35 mmHg, the patient underwent mechanical ventilation in a volume control mode by TV (6-8 ml/kg), RR (12-18 /minute), and an I:E ratio of 1:2. Anaesthesia was maintained by 1-2% isoflurane minimal alveolar concentration (MAC) and 60% air through O_2 mixture, along with periodic atracurium doses (0.1 mg/kg). Intra-operative IV fluids were infused with the intra-operative loss was considered. The patient was monitored and vital signs were recorded by another anesthesiologist who was blinded to the group.

Data collection: The following data were recorded; demographics (age, BMI, and ASA classification), postoperative acute pain within 24 hours at rest using the VAS at 0, 2, 4, 6, 12, 18, & 24 h, postoperative acute pain within 24 hours during mobilization using the VAS at 0, 2, 4, 6, 12, 18, & 24 h, time of the first postoperative analgesic request, total amount of opioid administration in 24h, hemodynamics [Mean blood pressure (MBP)], pulse, SpO_2, incidence of side effects (pneumothorax, nausea & emesis), pain incidence at 1, 2 and 3 months postoperative and CPSP incidence at 6 months post-operatively using the BPI-SF (chronic pain was defined as persistent pain for 6 months at the surgical site with ≥ 3 out of 10 on item 5 of the BPI), and severity & interference of pain using BPI-SF at 1, 2, 3 and 6 months after the surgery. Pain severity was evaluated by BPI-SF in the previous 7 days as worst, least, and average, while current pain level is evaluated from 0 (no pain) to 10 (the worst pain.

Ethical consideration: Study informed consent was obtained from patients before the study. The study protocol was submitted for approval from IRB of Faculty of Medicine, Mansoura University (code number: MS.23.05.2429) before initiation of the study. All data were kept confidential. The Helsinki Declaration was followed throughout the course of the investigation. Written consents were taken from all participants before the procedure after describing all study aspects and possible complications of the approach.

Statistical analysis

The IBM SPSS software version 26 was utilized to analyze data. Frequencies and percent were used to describe qualitative data. After testing normality by Kolmogorov-Smirnov test, quantitative data were expressed as medians and as means ± SDs for non-parametric data and parametric data respectively. Significance of a result was set at $p < 0.05$. Chi-Square test was utilized to compare between ≥ 2 groups. Monte-Carlo test was utilized after Chi-square test when > 25% of cells have counted > 5 in 2x2 tables. One-way ANOVA test was used for continuous data testing to detect significant difference between > 2 normally distributed groups. Kruskal-Wallis test was utilized when ANOVA assumptions were violated to compare > 2 groups of skewed data. $P \leq 0.05$ was deemed significant.

RESULTS

In table **(1),** no significant difference existed between all groups as regards age (p= 0.285), BMI (p= 0.710) and ASA classification (p= 0.355). Also, no significant differences were reported between all groups as regards the presence of persistent or chronic postoperative pain at 1 month, two months, three months and 6 months. However, group B showed the least incidence of persistent and chronic postoperative pain, however the difference was not significant.

Table (1): Analysis of demographic, clinical data, persistent and chronic postoperative pain at follow up in studied groups

Variables		**Group A**	**Group B**	**Group C**	**P value**
Age (years)		51 ± 9.50	54.24 ± 8.05	54.68 ± 9.07	0.285
Body mass index (Kg/m^2)		31.62 ± 3.54	32.34 ± 2.98	31.75 ± 3.26	0.710
(ASA) classification	**ASA I**	13 (52%)	11 (44%)	8 (32%)	0.355
	ASA II	12 (48%)	14 (56%)	17 (68%)	
Persistent pain at 1 month		16 (64%)	11 (44%)	15 (60%)	0.321
Persistent pain at 2 months		13 (52%)	10 (40%)	12 (48%)	0.687
Persistent pain at 3 months		12 (48%)	9 (36%)	11 (44%)	0.683
Chronic pain at 6 months		11 (44%)	9 (36%)	10 (40%)	0.846

Quantitative data are represented in means ± SDs, Categorical data are represented in numbers (percent)
*: Statistically significant ($p < 0.05$), Group A: Control group, Group B: MgSO4 group, Group C: Ketorolac group.

As shown in table **(2),** a significant difference was recorded among all groups as regards PSS at one month, PIS at one month, PSS at two months and PIS at 2 months. These parameters showed a significant decrease in group B when compared to groups A and C. No significant difference existed between groups A and C. Regarding the PSS and PIS at three months and 6 months, no significant differences existed between all groups.

Table (2): Analysis of BPI-SF in studied groups

Time of follow up	Group A	Group B	Group C	P value
Brief pain inventory at one month				
Pain severity score at one month	14 (2-29)	9 (2- 19) A	13 (2- 29) B	0.016*
Pain interference score at one month	27 (6 -47)	14 (4 - 34) A	36 (9- 47) B	0.002*
Brief pain inventory at 2 months				
Pain severity score at 2 months	11 (4-25)	8 (3 - 14) A	11 (4 - 24) B	0.011*
Pain interference score at 2 months	21 (5-43)	10 (6 - 26) A	31 (7 - 37) B	0.001*
Brief pain inventory at 3 months				
Pain severity score at 3 months	9 (2 -24)	7 (2- 15)	9 (2- 22)	0.608
Pain interference score at 3 months	19 (3- 37)	12 (5- 33)	22 (4 - 31)	0.168
Brief pain inventory at 6 months				
Pain severity score at 6 months	7 (0 - 21)	2 (0- 16)	6 (0 - 18)	0.075
Pain interference score at 6 months	16 (0 - 32)	4 (0 - 27)	15 (0 - 28)	0.117

Quantitative data are expressed as medians (Ranges), *: Statistically significant ($p < 0.05$), A: Significance vs. group A, B: Significance vs. group B, Group A: Control group, Group B: MgSO4 group, Group C: Ketorolac group.

In table **(3),** a non-significant difference was found among all groups as regards the basal VAS score at rest, VAS score at rest at 2 h, VAS score at rest at 4 h and VAS score at rest at 24 h. However, a significant difference was found among groups A, B and C as regards the VAS score at rest at 6 h, 12 h and 18 h. The VAS score at rest was significantly lower in groups B and C than in group A. As compared to the baseline, there were significant increases in VAS score at rest in the three groups along the duration of follow up. No significant differences existed among all groups as regards the basal VAS score at movement, VAS score at movement at 2 h, VAS score at movement at 4 h and VAS score at movement at 24 h. However, a significant difference existed between all groups as regards the VAS score at movement at 6 h, 12 h and 18 h. The VAS score at movement was significantly decreased in groups B and C than in group A. As compared to the baseline, VAS scores were significantly increased at movement along the duration of follow up in all groups.

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Table (3): Analysis of VAS scores at rest and at movement in studied groups

Time of follow up		Group A	Group B	Group C	P value
Visual analogue scale at Rest	**Basal (0 hour)**	0 (0 – 1)	0 (0 – 1)	0	0.133
	2 hours	1 (1- 3)	1 (1- 3)	1 (1- 3)	0.181
	P1	< 0.001*	< 0.001*	< 0.001*	
	4 hours	3 (2 - 4)	2 (1 – 3)	2 (2 -4)	0.133
	P1	< 0.001*	< 0.001*	< 0.001*	
	6 hours	4 (2-5)	3 (1 – 5) A	3 (2-4) A	< 0.001*
	P1	< 0.001*	< 0.001*	< 0.001*	
	12 hours	5 (2 -6)	4 (3- 5) A	4 (3- 5) A	< 0.001*
	P1	< 0.001*	< 0.001*	< 0.001*	
	18 hours	5 (2 -6)	4 (2- 5) A	4 (3 - 5) A	< 0.001*
	P1	< 0.001*	< 0.001*	< 0.001*	
	24 hours	5 (2 -6)	5 (3 - 6)	5 (4 - 6)	0.335
	P1	< 0.001*	< 0.001*	< 0.001*	
Visual analogue scale at Movement	**Basal (0 hour)**	0 (0 – 1)	0 (0 – 1)	0 (0 – 1)	0.068
	2 hours	2 (1 - 3)	2 (1- 3)	2 (1- 3)	0.163
	P1	< 0.001*	< 0.001*	< 0.001*	
	4 hours	3 (2 - 5)	3 (2 – 4)	3 (2 – 4)	0.736
	P1	< 0.001*	< 0.001*	< 0.001*	
	6 hours	5 (2 - 6)	4 (2 – 6) A	4 (3-5) A	< 0.001*
	P1	< 0.001*	< 0.001*	< 0.001*	
	12 hours	6 (2 - 7)	5 (4- 6) A	5 (3 - 5) A	< 0.001*
	P1	< 0.001*	< 0.001*	< 0.001*	
	18 hours	6 (3 -7)	5 (3- 6) A	5 (4 - 6) A	0.004*
	P1	< 0.001*	< 0.001*	< 0.001*	
	24 hours	6 (3 -7)	6 (3 - 6)	6 (4 - 6)	0.528
	P1	< 0.001*	< 0.001*	< 0.001*	

Quantitative data are represented as median (Range), *: Statistically significant ($p < 0.05$), A: Significance vs. group A, P1: Significance vs. the baseline, Group A: Control group, Group B: MgSO4 group, Group C: Ketorolac group.

Figures 1, 2, & 3 showed a non-significant difference among all groups regarding the mean pulse, MBP and the mean oxygen saturation along the follow up duration.

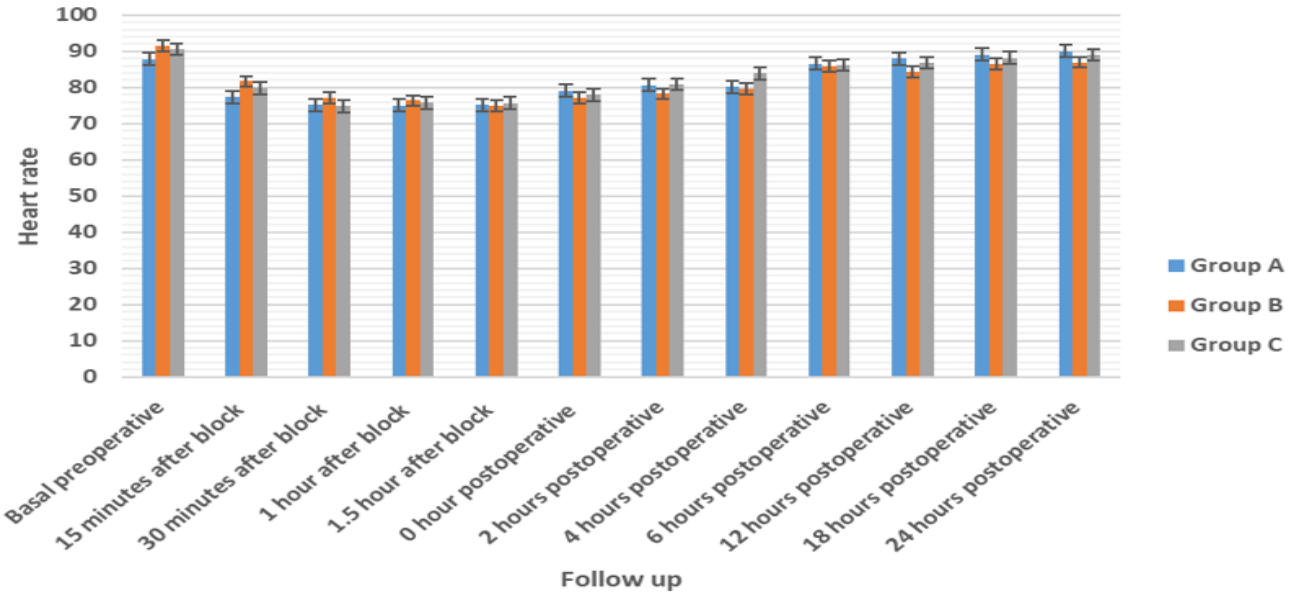

Figure (1): Follow up of the pulse (beats/min) of studied groups throughout the study.

Quantitative data are represented in means± SDs, *: Statistically significant ($p < 0.05$), Group A: Control group, Group B: Magnesium group, Group C: Ketorolac group.

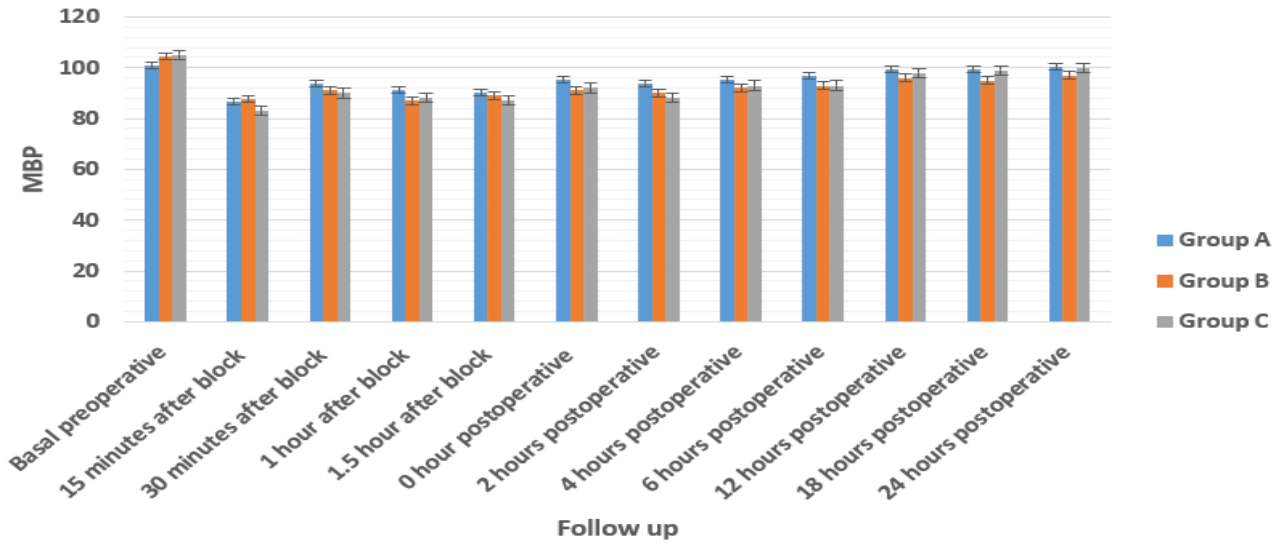

Figure (2): Follow up of the MBP (mmHg) of studied groups throughout the study.

Quantitative data are represented in means ± SDs, *: Statistically significant ($p < 0.05$), Group A: Control group, Group B: Magnesium group, Group C: Ketorolac group.

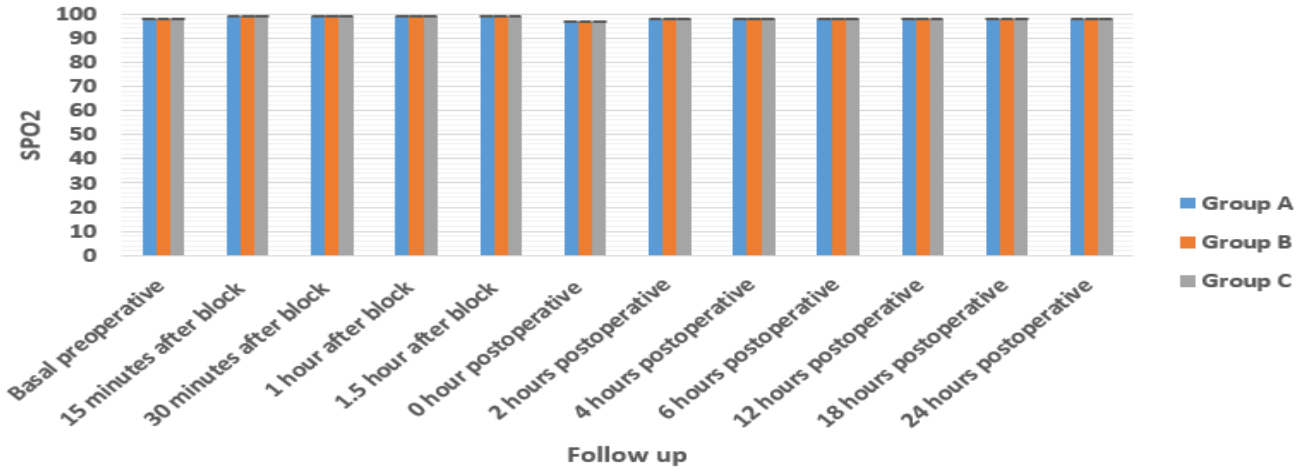

Figure (3): Follow up the peripheral oxygen saturation (SPO2) (%) of study groups throughout the study.

Quantitative data are represented in means ± SDs, *: Statistically significant ($p < 0.05$), Group A: Control group, Group B: Magnesium group, Group C: Ketorolac group.

Table **(4)** showed that the time of first analgesic recall was statistically significantly longer in groups B and C than in group A. The total opioid consumption was 20 ± 2.31 mg, 9.92 ± 1.78 mg and 10.32 ± 2.21 mg in groups A, B and C respectively. Total opioid consumption was statistically significantly lower in groups B and C than in group A. No significant difference was found among all study groups regarding the associated complications. Nausea was reported in 12%, 8% and 12% in groups A, B and C respectively. Vomiting was reported in 1 case (4%) only in all groups.

Table (4): Time to first analgesic recall, the total opioid consumption and complications in study groups

	Group A	Group B	Group C	P value
Time of first analgesic recall (min)	303.20 ± 71.63	604.80 ± 93.15 A	578.40 ± 117.32 A	< 0.001*
Total opioid consumption (24 hours) (mg)	20 ± 2.31	9.92 ± 1.78 A	10.32 ± 2.21 A	< 0.001*
Complications				
Nausea	3 (12%)	2 (8%)	3 (12%)	0.893
Vomiting	1 (4%)	1 (4%)	1 (4%)	1
Pneumothorax	0 (0%)	0 (0%)	0 (0%)	_____

Quantitative data are represented in means ± SDs, Categorical data are represented in numbers (percent), *: Statistically significant ($p < 0.05$), A: Statistical Significance versus group A, Group A: control group, Group B: magnesium group, Group C: ketorolac group.

DISCUSSION

Our study compared the effect of adding $MgSO_4$ versus ketorolac to BVC in US-guided ESPB on acute & chronic postmastectomy pain. To our knowledge, there are no previous trials evaluated the effects of magnesium sulfate or ketorolac on developing chronic postmastectomy pain by adding them as adjuvants to LA in ESPB in cases undergoing MRM.

In this study, adding magnesium or ketorolac didn't decrease the incidence of CPMP at six months and they didn't also decrease the pain incidence at 1, 2 and 3 months. However, magnesium group showed the least incidence of chronic pain, but the difference was non-significant, which may be because of our small sample size. Our results showed that magnesium and ketorolac provided better early post-operative analgesic efficacy as measured by VAS score, total opioid consumption within the post-operative 24 h and time of first analgesic recall when compared to control group without serious adverse effects.

Our study revealed that magnesium group had significantly lower BPI score (lower PSS and PIS) at 1 and 2 months than the ketorolac and control groups. However, at 3 and 6 months postoperatively, no difference was observed among all groups regarding BPI score (PSS and PIS), which may mean that the magnesium group needed another injection or higher dose to show lower chronic pain incidence and lower BPI score at 3 and 6 months postoperatively. According to estimates of GLOBOCAN 2020, new BC cases are expected to be 2.3 million worldwide. This makes BC one of the commonest tumours and the 5th major cause of malignancy-related mortalities. For patients undergoing BCS, PMPS can cause long-term impairment [12]. The incidence of CPSP after BCS varied between 25 and 78% in earlier reports [13].

$MgSO_4$ has been utilized as an adjuvant for peri-operative pain control and it reduced the intra-operative and post-operative consumption of analgesics [14]. NSAIDs, like ketorolac, can be perineurally injected in combination with LA to prolong the pain relief duration after the effect of the block ends [15] & influence peripheral inflammation and release of cytokines [16]. Ketorolac was utilized as an adjuvant to LA in Bier block [17], brachial plexus block (BPB), and popliteal nerve block [18, 19]. But ketorolac has not been yet utilized in ESPB. Similar to the present results, **Xin *et al.*** [20] showed no relationship between pre-operative ESPB and a lower CPSP incidence at 12 months following BCS. **Albi-Feldzer *et al.*** [21] found that PVB did not reduce CPSP incidence following BCS. PVB was associated with less immediate post-surgical pain, but not with significant differences in other post-operative outcomes. In a meta-analysis, single-shot PVB has protected against CPSP at 6 months after BCS [22]. **Wiech *et al.*** [23] found that bilateral ESPB decreased the severity and incidence of CPSP at 1-, 3-, and 6-months following coronary artery bypass grafting. **Amr *et al.*** [24] demonstrated that TPVB and ESPB decreased the CPMP incidence compared to control group during the 6-month follow up period after MRM.

We showed that magnesium & ketorolac groups achieved significantly lower VAS scores at 6, 12 &18 h post-operatively either at rest or activity and longer mean times for the first analgesic recall compared to control group. Furthermore, total opioid consumption was significantly lower in magnesium and ketorolac groups compared to controls.

Our results agree with **Elsherif and co-workers** [25] who revealed that adding $MgSO_4$ to BVC in bilevel ESPB in MRM surgeries was associated with lower mean total opioid consumption postoperatively (7.00 ± 0.61 mg) compared to the control group (14.40 ± 3.47 mg; $p < 0.001$) and longer time to the first analgesic recall (30.67 ± 10.58 hours) than in control group (7.50 ± 1.82 hours; $p < 0.001$) without serious side effects or complications. It also found that VAS scores at rest and activity were not different between $MgSO_4$ and control groups at all time points except only at 36 h postoperatively. In addition, **Yangtse *et al.*** [26] showed that adding 2 mL of 10% $MgSO_4$ to LA increased the analgesia duration after peripheral nerve block. Also, **Akhondzade *et al.*** [27] studied the effect of $MgSO_4$ for post-operative pain relief after upper limb surgery using US-guided BPB and showed that post-surgical VAS scores showed a significant decrease in $MgSO_4$ group compared to controls. On contrary, **Choi *et al.*** [28] did not report a difference in the post-surgical VAS scores or morphine consumption between $MgSO_4$ group and the control group. He evaluated the effect of $MgSO_4$ (200mg) addition to 0.2% ropivacaine (20 ml) in BPB in patients having upper extremity surgery. The block was done just before extubation. This discrepancy in results might be related to different methodologies, for example the lower conc. and volume (0.2% and 20 mL respectively) of ropivacaine as well as the site (brachial) and the block timing (post-operative). **Al-Touny *et al.*** [29] assessed the effects of adding ketorolac to BVC in PECS for patients undergoing MRM and showed that the time to the first analgesia recall was significantly longer in ketorolac group (14 h post-operatively) than in control group (9 h post-operatively). Furthermore, total 24 h meperidine consumption was significantly lower in ketorolac group than in control group (12 mg versus 19 mg), however post-operative VAS scores were not significantly different among both groups at all-time intervals. Contrary to our results, **Sayed *et al.*** [30] revealed that adding 50 mg ketorolac to lidocaine and BVC in interscalene BPB in shoulder arthroscopy wasn't associated with longer duration of analgesia (10.95 ± 1.05 h with ketorolac versus 11.7 ± 3.53 h in controls) or lower VAS score. However, the ketorolac group showed lower total dose of acetaminophen as rescue analgesia than in control group.

In our study, no significant difference existed among all studied groups as regards adverse effects (nausea, emesis & pneumothorax). The explanation of PONV after BCS under general anaesthesia is complex.

It is influenced by several factors including age, obesity, vehicle motion sickness, surgical techniques, post-operative pain, history of PONV, the anesthetic procedures, menstruation cycle phase and psychological factors [31]. In **Elsherif *et al.*** [25] study, no significant difference was reported in numbers of cases that had nausea and emesis between the $MgSO_4$ and the control groups. No other serious adverse effects were reported in all groups. **Xin *et al.*** [20] also showed no evidence of pneumothorax, haematoma, or other adverse effects related to ESPB.

LIMITATIONS

The sample size was relatively small. The study assessed only a single injection, rather than multiple injections, which may increase the quality of post-operative analgesic effects and decrease the chronic pain incidence. The sensory block and the radiologic spread of the LAs were not studied in our study, as the variation in the spread of LAs can be associated with different intensity and duration of block. Our study was single-center & this is another limitation. Serum drug levels were not quantified. Therefore, we couldn't conclude whether the effects of studied drugs were because of systemic absorption or a local mechanism. Single-level injection may also be a factor, which affects the results. We recommend that future research should include multicenter studies to validate our findings. More studies with larger sample sizes are therefore needed.

CONCLUSION

Addition of magnesium sulfate or ketorolac to BVC in a pre-operative single shot of ESPB didn't decrease the chronic pain incidence at 6 months following MRM. However, they provided superior early postoperative analgesia and reduced postoperative analgesic requirements without hemodynamic instability. Magnesium showed slightly better postoperative analgesia than ketorolac.

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