

Intramuscular Neostigmine for Accelerating Bladder Emptying after Cesarean Section by Spinal Anesthesia

Original
Article

Aml Mohamed Aljaml¹, Mohamed Abdellatef Elnegery², Nermeen Mohamed Shams-Eldien², Khalid Samir² and Mohamed Sayed Abdelhafez²

¹Belqas Central Hospital, Belqas, Egypt

²Department of Obstetrics and Gynecology, Mansoura University, Mansoura, Egypt

ABSTRACT

Objective: To assess the efficacy of intramuscular (IM) neostigmine administration for acceleration of urinary bladder (UB) emptying and prevention of postoperative urine retention (POUR) following cesarean section (CS) performed under spinal anesthesia.

Patients and Methods: Randomized controlled trial conducted on pregnant women who were planned to undergo elective CS under spinal anesthesia. All participants were randomly allocated after surgery into 2 groups; neostigmine group who received 0.5 mg IM neostigmine, and placebo group who received IM NaCl 0.9%. The primary outcome measures were time to first voiding after treatment and time to first voiding after catheter removal, and the secondary outcome measures were volume of excreted urine, postvoid residual bladder volume (PVRBV) and catheterization rate.

Results: A total of 100 women (50 women in each group) were subjected to final analysis. Time to first voiding after treatment was significantly lower in neostigmine group than in placebo group (266.94 ± 77.53 vs 303.72 ± 64.07 min; $P = 0.027$). Also, time to first voiding after catheter removal was significantly lower in neostigmine group than in placebo group (214.90 ± 66.53 vs 241.60 ± 61.73 min; $P = 0.036$). However, there were no significant difference between both groups in volume of excreted urine, PVRBV and catheterization rate.

Conclusion: IM injection of neostigmine can effectively accelerate UB emptying following CS under spinal anesthesia but it does not appear to decrease PVRBV or catheterization rate.

Key Words: Cesarean section, neostigmine, spinal anesthesia, urinary retention.

Received: 13 June 2023, **Accepted:** 19 September 2023

Corresponding Author: Aml Mohamed Aljaml, Belqas Central Hospital, Belqas City, Dakahlia, Egypt, **Tel.:** +2 010 3034 3100, **E-mail:** amlzein91@gmail.com

ISSN: 2090-7265, November 2023, Vol.13, No. 4

INTRODUCTION

Cesarean section (CS) operation is one of the commonest surgeries performed and its prevalence is rising. Beside rising rates in developed nations, rates are rising in certain developing nations. The majority of CS operations go on smoothly and safely, however, CS represents a major, open abdominal surgery that is often carried out in an emergency settings. Postoperative complications can occur immediately after surgery or during or after the healing phase, and can cause significant suffering of the patient and major clinical issues. Postoperative urine retention (POUR) is one of the complications of CS^[1,2].

Urine retention could be defined as an inability to empty the urinary bladder (UB) or a postvoiding residual bladder volume (PVRBV) measurement of more than 300 ml. POUR is a reasonably common complication that is influenced by the type and the site of surgery, the anesthetic technique, the medications administered, and the underlying physiology and medical condition of the

patient^[3]. Nowadays, spinal anesthesia is the anesthetic technique of choice in healthy pregnant women undergoing elective CS^[4]. Micturition reflex is interrupted during spinal anesthesia and thus UB function may be affected. POUR is one of the most frequent voiding adverse effects of spinal anesthesia. The duration of voiding disorders is determined by the potency and the dose of the local anesthetics^[5].

Urinary catheterization is advised if the patient is unable to urinate at a UB volume greater than 600 ml detected on ultrasonographic scanning. Catheterization is an invasive maneuver, which is accompanied by urethral trauma, discomfort of the patient, and catheter-related infections^[6]. POUR can be treated with a variety of drugs, including anticholinesterase agents, cholinergic agents, alpha-blockers, prostaglandins, and sedatives^[7].

Acetylcholinesterase is an enzyme that hydrolyze the neurotransmitter acetylcholine at the neuromuscular junction and at synapses in the nervous system, and this stops the cholinergic signaling. Neostigmine is

an ionized water-soluble compound that reversibly inhibits acetylcholinesterase, and it allows acetylcholine to accumulate around the cholinergic nerve endings. Contraction of the UB is reliant on acetylcholine-induced activation of the contractile muscarinic receptors on the UB smooth muscle (detrusor)^[8]. In patients undergoing surgery under spinal anesthesia, the intramuscular (IM) administration of neostigmine was evaluated for its efficacy in preventing POUR, however, the results were inconclusive^[9]. Moreover, to the best of our knowledge, and based on intensive literature research, there are no studies handling the role of neostigmine in the prevention of this problem after CS. Therefore, we aimed in this study to assess the efficacy of IM neostigmine administration for acceleration of UB emptying and prevention of POUR following CS performed under spinal anesthesia.

PATIENTS AND METHODS

Study design

This was a prospective double-blind randomized controlled trial conducted in the Obstetrics and Gynecology department, Mansoura University Hospitals, Egypt during the period from August 2020 through October 2021. The study protocol was reviewed and approved by the Mansoura Faculty of Medicine Institutional Research Board (Code # MS.19.12.937.R1). The trial was registered with ClinicalTrials.gov, identifier NCT04364607. Before inclusion in the study, written informed consent was obtained from each participant after insuring confidentiality and outlining the method in a simple language. All participants had the option to withdraw from the study at any time that was convenient for them.

The main inclusion criterion was pregnant women who were planned to undergo elective CS under spinal anesthesia. Women with any of the following criteria were excluded from the study: 1) age < 20 or > 35 years; 2) height < 150 or > 180 cm or body mass index (BMI) > 35 kg/m²; 3) multifetal pregnancy; 4) active labor; 5) fetal distress; 6) vaginal bleeding or placental abruption; 7) placenta previa; 8) medical conditions co-existing with or complicating pregnancy such as cardiac disease, pulmonary disease, hepatic or renal impairment, thrombocytopenia, or HELLP syndrome; 9) urinary tract symptoms such as dysuria, frequency, hesitancy, urgency, incontinence, enuresis, nocturia, weak stream, and inability to empty the UB fully; 10) contraindication for spinal anesthesia; 11) refusal to undergo spinal anesthesia; 12) history of adverse reaction or contraindications to neostigmine; 13) intraoperative significant bleeding (> 10% of blood volume); 14) surgical duration more than one hour; 15) any postoperative complications such as eclampsia.

Intervention

Women were allowed to drink clear fluid up to 200 ml until 2 hours prior to induction of anesthesia. All women were asked to empty the UB before transfer to the operative theatre. On arrival of the patient to operative theatre,

intravenous (IV) cannula was inserted, and IV infusion of Ringer's lactate solution (20 ml/kg) was given as a fluid preload. All women were subjected to spinal anesthesia with hyperbaric bupivacaine 5 mg/ml. A size 16-18 Charriere (Ch) indwelling Foley catheter was inserted prior to CS and then removed after complete recovery of motor function. Hydration was maintained with Ringer's lactate solution (10 ml/kg/hour). The standard intraoperative care and monitoring were given to all participants.

Following surgery, in the postoperative care unit, all the study participants were randomly allocated into 2 groups: neostigmine group and placebo group. The randomization was simple and was conducted by a nurse using opaque, unlabeled, sealed envelopes containing computer-generated random numbers. The ratio of participant's assignment to each group was 1:1 (balanced randomization). The group assignment was concealed from the participants, investigators and caregivers. Participants in the neostigmine group received 0.5 mg IM neostigmine while participants in the placebo group received IM NaCl 0.9%.

Following removal of the urinary catheter, ultrasound scanning of the UB was performed every hour until spontaneous micturition occurs. PVRBV was assessed by a UB scan within 5 minutes of the first micturition. The UB volume was measured using the prolate ellipsoid method based on the formula: volume = length × width × height × 0.52 on a two-dimensional image. Urinary catheterization by closed envelope technique was performed if POUR occurred (inability to urinate at a UB volume greater than 600 ml detected on ultrasonographic scanning).

The following anesthesia related parameters were evaluated: 1) sensory block latency which was defined as the interval between the end of the spinal injection of the anesthetic medication and the absence of pain to pinprick stimulation at T10 level (evaluated very 0.5 minute); 2) maximal level of sensory block which was evaluated 20 minutes following the end of the spinal injection of the anesthetic medication; 3) time for complete motor recovery which was defined as the interval between the end of the spinal injection of the anesthetic medication and the free movement of lower limbs; 4) duration of analgesia which was defined as the interval between the end of the spinal injection of the anesthetic medication and the patient's spontaneous complaint of pain.

Outcome measures

The primary outcome measures of this study were time to first voiding after treatment (IM injection of the drug) and time to first voiding after catheter removal, while the secondary outcome measures of this study were volume of excreted urine, PVRBV and catheterization rate.

Sample size calculation

The sample size was calculated using the computer statistical software G*Power 3.1.9.2 (t test, tow-tailed significance, alpha error probability = 0.05, power = 95%,

allocation ratio for groups = 1). A sample size of at least 42 women (21 per group) was needed to detect difference of at least 85 minutes in the mean time to first voiding after treatment. The estimation of the sample size was based on the previously reported mean time to first voiding after spinal anesthesia of 280.8 ± 66.6 minutes with neostigmine and 364.2 ± 77.3 minutes with placebo^[9]. We planned to enroll 100 women (50 per group) in our study.

Statistical analysis

The IBM® SPSS® Statistics, version 20.0 for Windows was used for statistical analysis. Continuous variables were presented as mean \pm standard deviation (SD) or median (minimum - maximum) as appropriate. The Kolmogorov-Smirnov and Shapiro-Wilk tests were employed to determine the normality distribution of continuous variables. The Student t test was used to compare the normally distributed continuous variables while the Mann Whitney U test was used to compare continuous variables

without normal distribution. Categorical variables were presented as frequencies and percentages and they were compared by the Chi-Square test with Fischer's exact test as a correction for Chi-Square test when $> 25\%$ of cells have count less than 5. The *P values* were considered statistically significant at level ≤ 0.05 .

RESULTS

During the period of the study, 317 pregnant women who were scheduled to undergo elective CS under spinal anesthesia were evaluated for eligibility, and 100 of them were randomized. All randomized women received the assigned intervention, and no women from either group were lost to follow up. The 100 women's data on all pertinent outcomes were available, and data from 50 participants in the neostigmine group and 50 participants in the placebo group were analyzed (Figure 1). The demographic and clinical features of both groups are displayed in (Table 1).

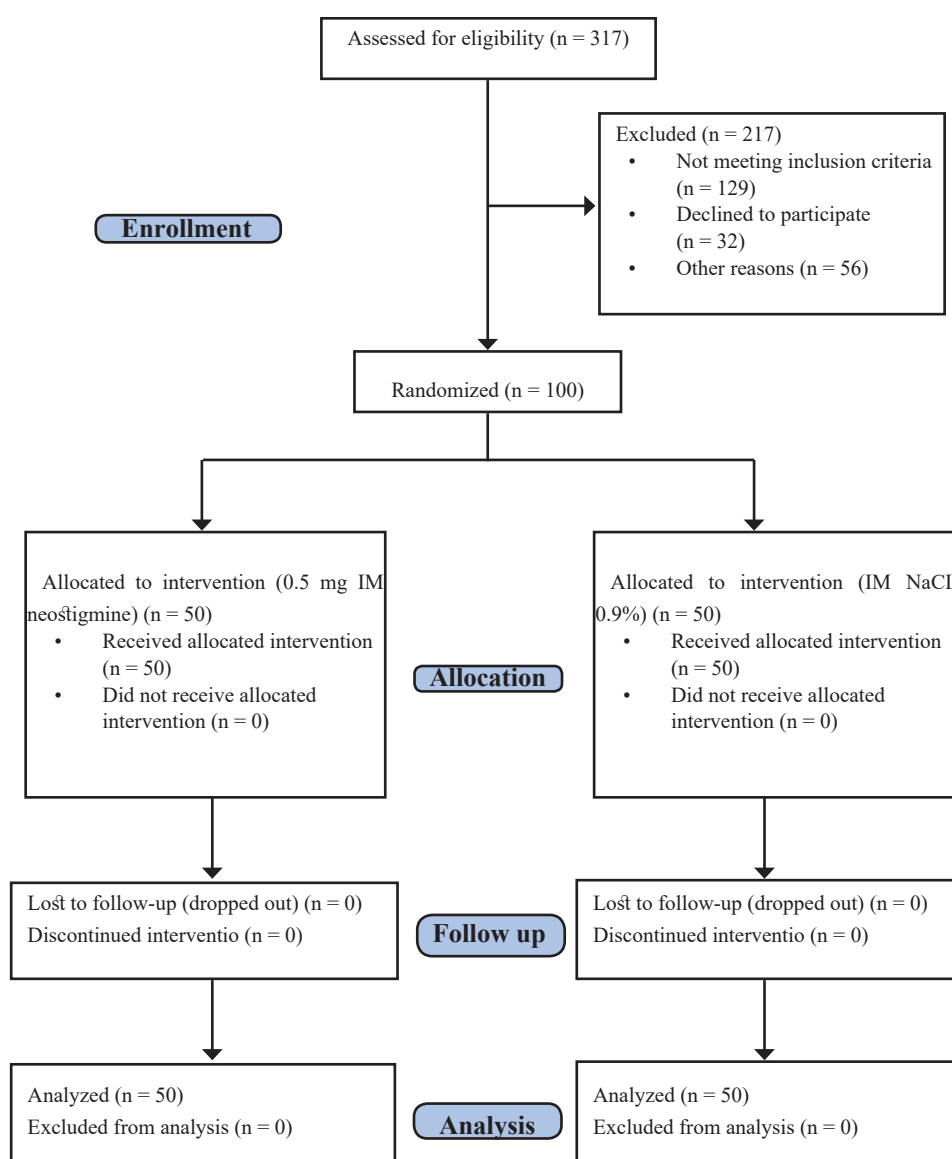


Fig. 1: Study flow diagram

Table 1: Demographic and clinical characteristics of both groups

	Neostigmine group (n = 50)	Placebo group (n = 50)	P value
Age (years)*	26.56 ± 4.28	26.72 ± 4.30	0.858
Gravidity†	3 (1-8)	3 (1-6)	0.900
Parity†	1.5 (0-3)	2 (0-4)	0.337
Prev CS‡	1 (0-3)	1.5 (0-3)	0.441
Weight (kg)*	85.82 ± 9.58	87.22 ± 8.83	0.473
Height (cm)*	167.60 ± 6.37	168.00 ± 5.95	0.697
BMI (kg/m ²)*	30.55 ± 2.96	30.91 ± 2.80	0.504
Indication of CS‡			
Previous CS	43 (86%)	48 (96%)	
Breech presentation	3 (6%)	1 (2%)	0.233
CPD	3 (6%)	0 (0%)	
Fetal anomaly	1 (2%)	1 (2%)	
Gestational age at delivery (weeks)*	38.66 ± 0.77	38.68 ± 0.88	0.697

* Expressed as mean ± SD and P value was calculated by the Mann-Whitney U-test.

† Expressed as median (minimum – maximum) and P value was calculated by the Mann-Whitney U-test.

‡ Expressed as frequency and percentage and P value was calculated by the Chi-Square test.

BMI, body mass index.

CPD, cephalopelvic disproportion.

CS, cesarean section.

No significant difference was found between both groups in the basal hemodynamics including basal heart rate (HR), basal systolic blood pressure (SBP) and basal diastolic blood pressure (DBP). The spinal block parameters were similar among both groups as shown by comparable local anesthetic dose, sensory block latency, maximal level of sensory block, time for complete motor recovery and duration of analgesia (Table 2).

Table 2: Basal hemodynamics and block characteristics of both groups

	Neostigmine group (n = 50)	Placebo group (n = 50)	P value
Baseline HR (bpm)*	81.64 ± 7.38	80.92 ± 6.57	0.792
Baseline SBP (mmHg)*	119.50 ± 7.09	118.30 ± 6.28	0.390
Baseline DBP (mmHg)*	74.00 ± 5.71	72.60 ± 4.97	0.158
Local anesthetic dose (ml)*	2.78 ± 0.25	2.83 ± 0.24	0.308
Sensory block latency (min)*	2.04 ± 0.43	2.02 ± 0.40	0.855
Maximal level of sensory block†	7 (6-8)	7 (6-8)	0.953
Time for complete motor recovery (min)*	131.20±27.56	134.10±25.73	0.523
Duration of analgesia (min)*	124.90±27.69	127.50±25.32	0.543

* Expressed as mean ± SD and P value was calculated by the Mann-Whitney U-test.

† Expressed as median (minimum – maximum) and P value was calculated by the Mann-Whitney U-test.

DBP, diastolic blood pressure.

HR, heart rate.

SBP, systolic blood pressure.

T, thoracic.

The duration of operation was similar in both groups and IV fluid volume and duration of administration were comparable between both groups. The time to first voiding after treatment was significantly lower in the neostigmine group than in the placebo group (266.94 ± 77.53 vs 303.72 ± 64.07 min; $P = 0.027$). Also, the time to first voiding after catheter removal was significantly lower in the neostigmine group than in the placebo group (214.90 ± 66.53 vs 241.60 ± 61.73 min; $P = 0.036$). However, there were no significant difference between both groups in the volume of excreted urine and the PVRBV. One patient (2%) needed catheterization in the neostigmine group and 3 patients (6%) needed catheterization in the placebo group with no significant difference between both groups in the catheterization rate ($P = 0.617$). No significant difference was found between both groups in the postoperative hospital stay period (Table 3).

Table 3: Operative and postoperative characteristics among both groups

	Neostigmine group (n = 50)	Placebo group (n = 50)	P value
Surgical duration (min)*	45.20 ± 6.54	45.30 ± 7.52	0.871
Volume of IV fluids (ml)*	3480 ± 440	3480 ± 484	0.878
Duration of IV fluids (hrs)*	7.80 ± 1.53	7.76 ± 1.65	0.860
Time to first voiding after treatment (min)*	266.94 ± 77.53	303.72 ± 64.07	0.027
Time to first voiding after catheter removal (min)*	214.90 ± 66.53	241.60 ± 61.73	0.036
Volume of excreted urine (ml)*	370.10 ± 69.74	364.30 ± 85.06	0.741
PVRBV (ml)*	128.59 ± 68.23	134.85 ± 81.92	0.767
Patients needed urinary catheterization†	1 (2%)	3 (6%)	0.617
Postoperative hospital stay (hrs)*	37.51 ± 8.49	39.74 ± 5.51	0.390

* Expressed as mean ± SD and P value was calculated by the Mann-Whitney U-test.

† Expressed as frequency and percentage and P value was calculated by the Chi-Square test with Fischer's exact test as a correction for Chi-Square test when > 25% of cells have count < 5.

IV, intravenous.

PVRBV, postvoid residual bladder volume.

DISCUSSION

Transmission of efferent and afferent action potentials on the nerve fibers of S2-S4 spinal cord segments to and from the UB is inhibited by spinal injection of anesthetic medication^[9]. Inhibiting the transmission of afferent nerve fibers from the UB to the micturition center in the brain results in analgesia of the UB. The urge to urinate fades 0.5-1 minutes following spinal anesthesia, however, a dull feeling of tension on maximal UB filling is preserved^[10,11]. The detrusor contraction is totally eliminated 2-5 minutes following spinal injection of the anesthetic medication. The

duration of restoration of detrusor activity is dependent on how long the sensory block was present above the sacral segments S2 and S3^[5].

The prevalence of CS have increased dramatically in the 20th century in both low- and high-income nations. Nowadays, CS is the most prevalent obstetric procedure worldwide^[1]. Spinal anesthesia is a popular type of anesthesia used in pregnant women delivering by CS operation. POUR occurs in 3.3-24.1% of cases following CS, and it is considered one of the most frequent voiding adverse effects of spinal anesthesia. The recommended traditional approaches for managing POUR include controlling pain, early ambulation, washing the hands of the patient, having a warm shower, and avoiding constipation. Anticholinesterases, including neostigmine, have been tried in cases with POUR^[12-14].

This current study was conducted to assess the efficacy of IM injection of neostigmine for accelerating UB emptying and preventing POUR after CS performed under spinal anesthesia. In the current study, the mean age of the participants was approximately 27 years. The mean age reported in the current study was slightly lower than the ages reported in other studies (approximately 31 years)^[15-17]. The mean BMI reported in the current study (approximately 31 kg/m²) was slightly higher than what was reported in the studies of Liang and colleagues (approximately 28.5 kg/m²), who investigated the voiding dysfunctions after CS^[15,16], however, it was slightly lower than what was reported by Ferrarezi *et al* (approximately 32 kg/m²). These minimal differences could be attributed to cultural and ethnic differences. In the current study, the mean gestational age at delivery was approximately 38.7 weeks. Another study reported that the mean gestational age was 38.1 weeks at the time of CS^[18], which is near to the one reported in results of the current study. Also, Lang *et al*^[15] reported a mean gestational age around 37 weeks at CS.

In our study, spinal anesthesia was performed by hyperbaric bupivacaine, which is the most commonly used anesthetic drug for elective and urgent CS^[19]. The mean sensory block latency in our study (2 minutes) was similar to what was reported by Ferrarezi *et al* in the bupivacaine group (2.1 minutes), however, the mean time for complete motor recovery and the mean duration of analgesia were higher than what was reported by Ferrarezi *et al* in the bupivacaine group (133 vs 71 minutes and 126 vs 67 minutes, respectively)^[17]. These difference could be attributed to the use lower local anesthetic dose than in our study (2 ml vs 2.8 ml).

In the current study, the mean operative time was 45 minutes. This agrees with the current literature which reported that the operative time of CS is about 45 minutes^[20,21]. Another study reported that the mean duration of CS operation was 49 minutes^[16] which confirms our findings regarding the operative time. On the other hand, Ferrarezi and colleagues reported a higher operative time

for CS (approximately 77 minutes)^[17]. In general, there was no significant difference between two groups of the current study regarding any pre or intraoperative parameter, and this ensures that proper randomization was performed in the study. Also, that should negate any bias that might have skewed the results in favor of one group rather than the other one.

Urinary catheterization is a commonly used perioperative procedure in CS aiming to decompress the UB, improve the exposure of the lower uterine segment, decrease the incidence of UB injury, and prevent POUR^[22], however, some obstetricians prefer non-use of urinary catheter in CS aiming to lower the risk of urinary tract infection^[23-25]. If an indwelling urinary catheter is used in CS, the removal of the catheter in the uncomplicated cases may be early (immediately or within 2 hours after CS) or delayed (12-24 hours after CS). The time of catheter removal depends usually on practical custom, however, early catheter removal significantly lowers the incidences of frequency and dysuria, decreases in the rates of significant bacteriuria and urinary tract infections, and reduces the periods of postoperative immobilization and hospital stay^[26,27]. In the current study, and according to our practical custom, we used the indwelling urinary catheter to get the benefit of its use but we removed it early after complete recovery of motor function (i.e. within 2 hours after CS) to get the benefits of early catheter removal.

When it comes to the primary outcomes of the current study, the times to first voiding after treatment and after catheter removal showed significant reduction with IM administration of neostigmine ($P = 0.027$ and 0.036 , respectively). In agreement with our findings, Senapathi and colleagues reported that times to first voiding after spinal anesthesia and after treatment were significantly reduced with neostigmine administration^[9].

The preceding observations could be explained by the fact that neostigmine inhibits the acetylcholinesterase enzyme, causing acetylcholine to accumulate near cholinergic nerve terminals. Acetylcholine stimulates the postsynaptic muscarinic receptors M2 and M3 on the detrusor muscle of the UB. These receptors are considered as the most important for detrusor contraction. Although M2 receptors predominate over M3 receptors in the detrusor, it has been proven that the M3 subtype is the predominant contraction receptor. Accumulation of acetylcholine leads to more activation of M3 receptors, enhancing UB evacuation^[28-31].

When it comes to the secondary outcomes of the current study, the efficacy of IM neostigmine to accelerate UB emptying was not followed by significant increase in the volume of excreted urine or reduction in the PVRBV or urinary catheterization rate. In agreement with our results, Senapathi and colleagues did not report significant increase in the volume of excreted urine or reduction in the catheterization rate, however, they reported significant reduction in the PVRBV with IM neostigmine

administration^[9]. The non-reflection of the efficacy of IM neostigmine on the catheterization rate in our study could be masked by the lower incidence of the need for urinary catheterization in our study (1-3%) as compared by other studies that investigated the incidence of POUR after CS (approximately 11%)^[15].

Our study's key advantage came from the fact that it was a randomized study with reliable randomization and allocation concealment that appeared in absence of significant difference between the two groups regarding any pre or intraoperative parameter. Another strength point in our study is that it was done as a placebo-controlled trial with blinding of participants and assessors. Moreover, to the best of our knowledge, this is the first study that evaluated the role of neostigmine in the acceleration of UB emptying and prevention of POUR after CS performed under spinal anesthesia.

A limitation of the current study lies in the small sample size which may have limited the study's power to detect significant differences in the secondary outcomes including the volume of excreted urine, PVRBV and urinary catheterization rate. Nevertheless, despite this limitation, this study has detected a significant difference in relation to acceleration of UB emptying. This will serve as a proof-of-principle foundation for the start of a larger multicenter trial with greater power.

CONCLUSION

IM injection of neostigmine can effectively accelerate UB emptying after CS under spinal anesthesia but it does not appear to decrease PVRBV or catheterization rate.

CONFLICT OF INTERESTS

There are no conflicts of interest.

ETHICAL CONSIDERATIONS

This paper has been adapted from the MSc. thesis written by Misses Aml Mohamed Aljaml. The study was prospectively registered with ClinicalTrials.gov, number NCT04364607, registered on 28-04-2020. The study was approved by the Mansoura Faculty of Medicine Institutional Research Board (Code # MS.19.12.937.R1).

REFERENCES

- Boerma T, Ronsmans C, Melesse DY, Barros AJ, Barros FC, Juan L, *et al.* Global epidemiology of use of and disparities in caesarean sections. *The Lancet*. 2018;392(10155):1341-8.
- Rachaneni S, McCooty S, Middleton LJ, Parker VL, Daniels JP, Coomarasamy A, *et al.* Bladder ultrasonography for diagnosing detrusor overactivity: test accuracy study and economic evaluation. *Health Technol Assess*. 2016;20(7):1-150.
- Baldini G, Bagry H, Aprikian A, Carli F. Postoperative urinary retention: anesthetic and perioperative considerations. *Anesthesiology*. 2009;110(5):1139-57.
- Chooi C, Cox JJ, Lumb RS, Middleton P, Chemali M, Emmett RS, *et al.* Techniques for preventing hypotension during spinal anaesthesia for caesarean section. *Cochrane Database Syst Rev*. 2017;8(8):CD002251.
- Choi S, Mahon P, Awad IT. Neuraxial anesthesia and bladder dysfunction in the perioperative period: a systematic review. *Canadian journal of anaesthesia = Journal canadien d'anesthesie*. 2012;59(7):681-703.
- Ozturk NK, Kavakli AS. Use of bladder volume measurement assessed with ultrasound to predict postoperative urinary retention. *Northern clinics of Istanbul*. 2016;3(3):209.
- Buckley BS, Lapitan MC. Drugs for treatment of urinary retention after surgery in adults. *The Cochrane database of systematic reviews*. 2010(10):Cd008023.
- Taylor P. Anticholinesterase agents. *Goodman & Gilman's The Pharmacological Basis of Therapeutics Twelfth edition* New York, Macmillan. 2011:239-54.
- Senapathi TGA, Wiryana M, Subagiarta IM, Suarjaya IPP, Widnyana IMG, Sutawan I, *et al.* Effectiveness of intramuscular neostigmine to accelerate bladder emptying after spinal anesthesia. *Therapeutics and clinical risk management*. 2018;14:1685-9.
- Lawrie CM, Ong AC, Hernandez VH, Rosas S, Post ZD, Orozco FR. Incidence and Risk Factors for Postoperative Urinary Retention in Total Hip Arthroplasty Performed Under Spinal Anesthesia. *J Arthroplasty*. 2017;32(12):3748-51.
- Agrawal K, Majhi S, Garg R. Post-operative urinary retention: Review of literature. *World Journal of Anesthesiology*. 2019;8(1):1-12.
- Olapour A, Akhondzadeh R, Rashidi M, Gousheh M, Homayoon R. Comparing the Effect of Bupivacaine and Ropivacaine in Cesarean Delivery with Spinal Anesthesia. *Anesth Pain Med*. 2020;10(1):e94155.
- Erin R, Agirbas DB, Erin KB, Kulaksız D. Prolonged Postpartum Persistent Urinary Retention After Cesarean Section: A Case Report and Literature Review. *Gynecology Obstetrics & Reproductive Medicine*. 2019;25(2):120-2.
- Lim JL. Post-partum voiding dysfunction and urinary retention. *Aust N Z J Obstet Gynaecol*. 2010;50(6):502-5.
- Liang CC, Chang SD, Chang YL, Chen SH, Chueh HY, Cheng PJ. Postpartum urinary retention after cesarean delivery. *International journal of gynaecology and obstetrics: the official organ of the International Federation of Gynaecology and Obstetrics*. 2007;99(3):229-32.
- Liang CC, Wu MP, Chang YL, Chueh HY, Chao AS, Chang SD. Voiding dysfunction in women following cesarean delivery. *Taiwanese journal of obstetrics & gynecology*. 2015;54(6):678-81.

17. Ferrarezi WPP, Braga AFA, Ferreira VB, Mendes SQ, Brandão MJN, Braga F, *et al.* Spinal anesthesia for elective cesarean section. Bupivacaine associated with different doses of fentanyl: randomized clinical trial. *Brazilian journal of anesthesiology (Elsevier)*. 2021;71(6):642-8.
18. El-Khayat W, Adel D, Abd El-Bar M, Waly M. Cesarean Section Rate at a Tertiary University Hospital in Egypt in Five Years Period (2008-2012). *KAJOG*. 2013;4(3):66-74.
19. Uppal V, Retter S, Casey M, Sancheti S, Matheson K, McKeen DM. Efficacy of Intrathecal Fentanyl for Cesarean Delivery: A Systematic Review and Meta-analysis of Randomized Controlled Trials With Trial Sequential Analysis. *Anesthesia and analgesia*. 2020;130(1):111-25.
20. Torloni MR, Betran AP, Souza JP, Widmer M, Allen T, Gulmezoglu M, *et al.* Classifications for cesarean section: a systematic review. *PLoS One*. 2011;6(1):e14566.
21. McCourt C, Weaver J, Statham H, Beake S, Gamble J, Creedy DK. Elective cesarean section and decision making: a critical review of the literature. *Birth*. 2007;34(1):65-79.
22. Saint S, Wiese J, Amory JK, Bernstein ML, Patel UD, Zemencuk JK, *et al.* Are physicians aware of which of their patients have indwelling urinary catheters? *The American journal of medicine*. 2000;109(6):476-80.
23. Barnes JS. Is it better to avoid urethral catheterization at hysterectomy and caesarean section? *The Australian & New Zealand journal of obstetrics & gynaecology*. 1998;38(3):315-6.
24. Ghoreishi J. Indwelling urinary catheters in cesarean delivery. *International journal of gynaecology and obstetrics: the official organ of the International Federation of Gynaecology and Obstetrics*. 2003;83(3):267-70.
25. Senanayake H. Elective cesarean section without urethral catheterization. *The journal of obstetrics and gynaecology research*. 2005;31(1):32-7.
26. Basbug A, Yuksel A, Ellibeş Kaya A. Early versus delayed removal of indwelling catheters in patients after elective cesarean section: a prospective randomized trial. 2020;33(1):68-72.
27. Menshawy A, Ghanem E, Menshawy E, Masoud AT, El-Sharkawy M, Taher A, *et al.* Early versus delayed removal of indwelling urinary catheter after elective cesarean delivery: systematic review and meta-analysis of randomized controlled trials. *The journal of maternal-fetal & neonatal medicine : the official journal of the European Association of Perinatal Medicine, the Federation of Asia and Oceania Perinatal Societies, the International Society of Perinatal Obstet*. 2020;33(16):2818-25.
28. Nakahara T, Kubota Y, Sakamoto K, Ishii K. The role of cholinesterases in rat urinary bladder contractility. *Urol Res*. 2003;31(3):223-6.
29. Hegde SS, Eglen RM. Muscarinic receptor subtypes modulating smooth muscle contractility in the urinary bladder. *Life Sci*. 1999;64(6-7):419-28.
30. Mokry J, Svihra J, Nosalova G, Kliment J. Mechanisms of reactivity of urinary bladder smooth muscle. *Bratisl Lek Listy*. 2002;103(9):279-82.
31. Giglio D, Tobin G. Muscarinic receptor subtypes in the lower urinary tract. *Pharmacology*. 2009;83(5):259-69.