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Dexmedetomidine versus fentanyl effect as adjuvants to bupivacaine on post spinal urinary retention in knee joint arthroscopic surgeries

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ABSTRACT

Background: Ambulatory knee surgeries are increasing in frequency, however post spinal urinary retention can represent a hazardous post-operative issue to patients. The aim of this study was to assess the impact of intrathecally injected 5 µg dexmedetomidine, or 25 µg fentanyl as adjuvants to bupivacaine in low dose spinal anesthesia for unilateral arthroscopic knee surgeries, on the incidence of post-operative urinary retention (POUR), the duration of sensory and motor blocks, time to micturition, and the number of patients who needed an indwelling (Foley's) catheter.

Methods: Seventy patients, American Society of Anesthesiologists (ASA) physical status I or II, from 21 to 50 years old, were randomly divided into two equal groups: the Bupivacaine-Dexmedetomidine group (BD) patients and the Bupivacaine-Fentanyl group (BF) patients.

Results: The incidence of POUR was statistically non-significant less in the BD group patients, than in the BF group patients. The duration of sensory and motor blocks, as well as the time to micturition, was comparable between patients in the two groups. No patient in either group required insertion of an indwelling urinary catheter at the sixth post-operative hour.

Conclusion: In unilateral arthroscopic knee surgeries, the addition of dexmedetomidine to low-dose spinal anesthesia decreased the clinical incidence of POUR compared to the addition of fentanyl.

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Dexmedetomidine; spinal anesthesia; arthroscopic knee surgery; post-operative urinary retention

1. Introduction

Arthroscopic knee surgery is commonly performed under spinal anesthesia with 10–15 mg hyperbaric bupivacaine, and 25 µg fentanyl as an adjuvant [1]. Adjuvants are used to compensate for decreasing the bupivacaine dose, thus, hastening the onset, prolonging the duration of spinal anesthesia, offering synergistic analgesia, and decreasing the risk of POUR [2]. Al-Mustafa et al [3], focused on non-opioid receptors, and found that intrathecal dexmedetomidine; a highly specific α_2-adrenoceptor agonist provides analgesia.

Patients' hospital discharge can be delayed due to POUR [4]. Improper management of POUR results in urinary bladder (UB) over distension; with transient or persistent UB dysfunction [5], catheter related urethral trauma, prostatitis, patient discomfort, and urinary tract infection; which occurs with both intermittent and indwelling catheterizations [6], with reported incidence of bacteremia after intermittent catheterization as high as 8% [7]. So, urethral catheterization is restricted to patients at increased risk of POUR and for a short time [8].

The aim of the current study was to assess the impact of 5 µg dexmedetomidine or 25 µg fentanyl, as adjuvants to low dose bupivacaine in spinal anesthesia for arthroscopic knee surgeries on; the incidence of POUR, the duration of sensory and motor blocks, time to micturition, and the number of patients who needed an indwelling urinary catheter at the 6th post-operative hour.

2. Materials and methods

This double blinded study was conducted after taking informed consent from seventy patients, ASA physical status I and II, 21–50 years old, scheduled to undergo unilateral arthroscopic knee surgeries under spinal anesthesia, at Ain-Shams University Hospitals from November 2021 to June 2022.

3. Exclusion criteria

Patients' refusal, contraindications to spinal anesthesia, known allergy to any of the study drugs, urogenital pathologies; urinary incontinence or cysto-ureteric reflux, congestive heart failure, dysrhythmia or heart block, diabetes mellitus, patients on α_2-adrenergic receptors antagonists or calcium channel blockers [9; 10] (Figure 1).

Pre-operative history taking, physical examination and investigations were done; complete blood count, the coagulation profile, kidney and liver functions tests, fasting blood glucose, electrocardiography (ECG) and echocardiography for known cardiac patients.

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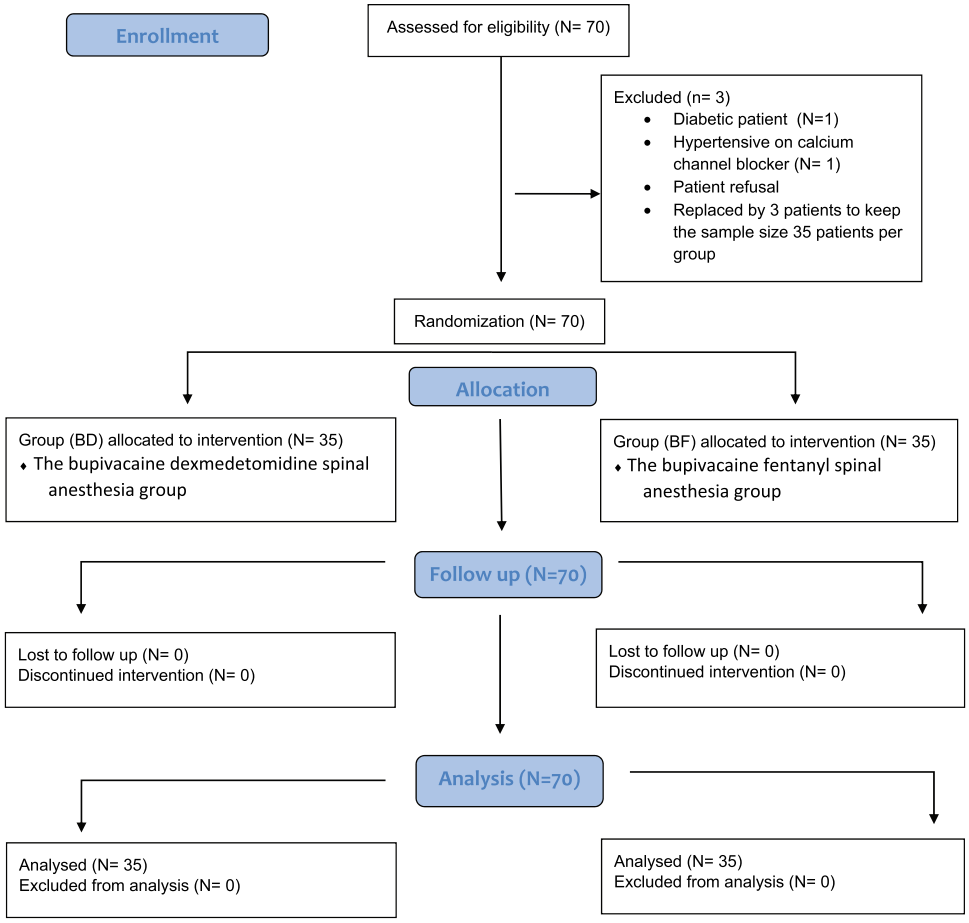

Figure 1. Consort flow chart.

On the day of operation, patients voided before transfer to the operating theater. In the induction room, patients had an 18 G intra-venous (IV) cannula inserted. Pelvic ultrasound with a low frequency curved transducer (Frequency 5–8 MHz) was done, to detect any residual UB volume, with urging patients to void any residual volume detected [11]. On arrival to the operating room, pulse oximetry and automated non-invasive blood pressure (NIBP) were applied to the patients. IV Ringer's solution was started; volume calculated for pre-operative deficit, intraoperative maintenance, and surgical wound loss as 2 ml/kg [12]. Under complete aseptic conditions and local skin infiltration, spinal anesthesia was performed in the lateral decubitus with dependent operative side, using a 26 G spinal needle, with the bevel directed towards the operative side. **Patients were then randomly divided by computer-generated random number tables and sealed opaque envelopes, into two equal groups of thirty five patients each, to receive preservative free drugs spinal anesthesia**

Bupivacaine-Dexmedetomidine group (BD)

Patients received spinal anesthesia with intrathecal 10 mg (2 ml) hyperbaric bupivacaine [13] and 5 µg dexmedetomidine [10]. In a 10 ml syringe, dexmedetomidine HCl (Precedex 200 µg/2 ml, Hospira Inc, USA) was prepared as 100 µg (1 ml) added to 9 ml of sterile normal saline (10 µg/ml). In a 3 ml syringe, 5 µg (0.5 ml) dexmedetomidine taken from the prepared 10 ml syringe was added to the 10 mg (2 ml) hyperbaric bupivacaine, to have a total volume of 2.5 ml for intrathecal spinal injection over 3 minutes [1].

Bupivacaine-Fentanyl group (BF)

Patients received spinal anesthesia with intrathecal 10 mg (2 ml) hyperbaric bupivacaine and 25 µg fentanyl [10]. In a 3 ml syringe, 25 µg (0.5 ml) fentanyl (100 µg/2 ml, Sunny Pharmaceutical, Badr City, Egypt under license of Hamelin Pharmaceuticals, Germany), was added to the 10 mg (2 ml) hyperbaric bupivacaine, to have a total volume of 2.5 ml for intrathecal spinal injection over 3 minutes [1].

After completion of spinal anesthesia, the time was recorded as a baseline for the time interval. Patients were then positioned supine after 20 minutes [1], five leads ECG monitor was applied. Heart rate and SpO_2 were continuously monitored, NIBP was measured every 5 minutes till the end of surgery.

4. Primary outcome

Post-operative urinary retention (POUR): At the 3rd post-operative hour, UB volume was assessed by the ultrasound [14], if the measured volume was more than 600 ml with no ability to void; this confirmed the diagnosis of urinary retention [15]. An intermittent urinary catheter; in-out catheterization technique was then inserted for these patients.

5. Secondary outcomes

(1) Intra-operative fluids given: The volume of IV Ringer's solution given to each patient.
(2) Duration of sensory block: The time from completion of spinal injection, till sensory level regression to the third sacral dermatome (S_3), assessed by temperature discrimination to ice pack. Assessment was done post-operative in the Post Anesthesia Care Unit (PACU), then every 30 minutes in the ward.
(3) Duration of motor block: The time from completion of spinal injection till complete recovery of the motor function, assessed by the Modified Bromage score (MBS = 0), by asking the patient to flex the hip, knee and ankle joints, in the PACU, then every 15 minutes in the ward. MBS = 0; no motor block, MBS = 1; inability to flex the hip, MBS = 2; inability to flex the hip and the knee, MBS = 3; inability to flex the hip, the knee and the ankle [16].
(4) Time to micturition or insertion of an intermittent urinary catheter: The time from completion of spinal injection till voiding or insertion of an in-out catheter.
(5) Ultrasound assessment of the UB volume before voiding.
(6) Number of patients who needed an indwelling (Foley's) catheter: After 6 post-operative hours, if the patient wasn't able to void an indwelling (Foley's) catheter was placed.

6. Statistical analysis

Sample size was calculated by G power program, setting alpha error at 0.05 and power at 80%, and assuming 5% incidence of urinary retention in the dexmedetomidine group compared to 30% in the fentanyl group. Based on these data, a sample size of 35 patients per group was needed [15].

Analysis of data was done by Statistical Package for Social Science (SPSS) version 21.0. Chicago, Illinois, USA. Qualitative variables were presented as count, and Chi square test was used to compare proportions between two parameters. Quantitative data were presented as mean and standard deviation, and the independent-samples t-test was used to compare means between the two groups. $P < 0.05$ was considered statistically significant. A binomial logistic regression was performed to ascertain the effects of age, sex, duration of operation, the amount of intraoperative fluids given, and the duration of sensory block on the likelihood of POUR, the logistic regression model was statistically significant, $\chi 2$ [5] = 30.727 $P < 0.001$. The model fitness was assessed by Hosmer and Lemeshow goodness of fit test. The model correctly classified 92.9% of cases, sensitivity was 66.7%, and specificity was 96.7%.

7. Results

The two groups were comparable regarding the patients' characteristics; age, sex, height, ASA physical status, and the mean operative duration (Table 1); with P value of 0.654, 0.356, 0.789, 0.690and 0.838respectively.

The mean volume of intra-operative fluids given was comparable between patients of the two groups, with *P* value 0.877. The UB volume assessed by the ultrasound before voiding or insertion of the in-out catheter, was statistically non-significant less in patients of the BD group than in patients of the BF group, with *P* value 0.373. The mean time to micturition was statistically non-significant less in patients of the BF group than in patients of the BD group, with *P* value 0.205 (Table 2). The incidence of POUR at the 3rd post-operative hour, and the number of patients who needed insertion of an in-out urinary catheter was statistically non-significant less in patients of the BD group (5.7%) than in patients of the BF group (20%), with *P* value 0.074 (Figure 2). At the 6th post-operative hour, no patient in either group required the insertion of an indwelling urinary catheter.

Table 1. Demographic data of patients in both groups.

Variables	Group BD (N=35)	Group BF (N=35)	P value
Age(years)	39.46 ± 7.63	40.29 ± 7.78	0.654
Sex (M/F)	27/8	30/5	0.356
Height(cm)	172.63 ± 8.52	172.14 ± 6.43	0.789
ASA(I/II)	31/4	32/3	0.690
Duration of surgery(min)	90.43 ± 17.63	91.29 ± 17.21	0.838

Data are presented as mean± SD or count. BD: Bupivacaine-Dexmedetomidine group, BF: Bupivacaine-Fentanyl group.

Table 2. Intra-operative fluids, and post-operative micturition characteristics in both groups.

Variables	Group BD (N=35)	Group BF (N=35)	P value
Intraoperative fluids (ml)	1234.3 ± 187.4	1227.1 ± 198.3	0.877
Urinary bladder volume(ml)	464.9 ± 81.8	484.1 ± 96.3	0.373
Time to micturition or catheterization (min)	222.1 ± 26.1	212.4 ± 35.7	0.205

Data are presented as mean± SD. Urinary bladder volume (ml); assessed by the ultrasound at the 3rd post-operative hour, or before voiding. BD: Bupivacaine-Dexmedetomidine group, BF: Bupivacaine-Fentanyl group.

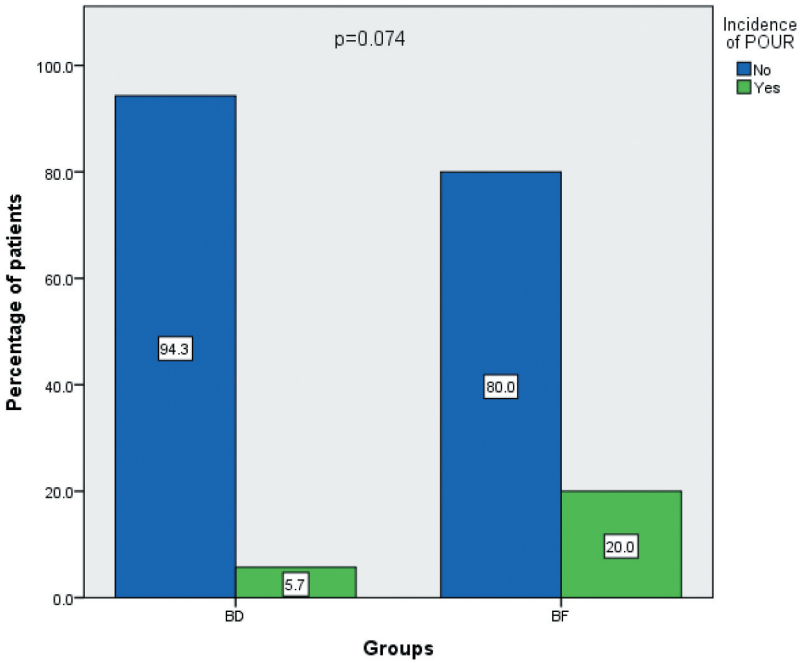

Figure 2. Incidence of POUR in both groups at the 3rd post-operative hour. Data are presented as percentage of patients. Bupivacaine-Dexmedetomidine group, BF: Bupivacaine-Fentanyl group, POUR: Post-operative urinary retention.

Table 3. Sensory and motor block durations in both groups.

Variables	Group BD (N=35)	Group BF (N=35)	P value
Duration of sensory block (min)	199.7 ± 25.15	190.3 ± 37.8	0.223
Duration of motor block (min)	167.9 ± 27.21	154.6 ± 35.74	0.085

Data presented as mean± SD. BD: Bupivacaine-Dexmedetomidine group, BF: Bupivacaine-Fentanyl group.

The durations of sensory and motor blocks were statistically non-significant more in patients of the BD group than in patients of the BF group, with P value 0.223 and 0.085 respectively (Table 3).

The binomial logistic regression showed that, the duration of sensory block was the only statistically significant predictor of POUR; for each unit increase in the duration of sensory block, the odds of having POUR increase by a factor of 1.078, with 95% confidence interval (CI) for EXP(B) 1.021–1.139 (Table 4).

8. Discussion

The incidence of post spinal urinary retention was reported to be 0%-69% [17], 5–70% [8]. The best treatment of POUR is prevention by risk factors optimization, thus identification of patients with increased risk of POUR is of great importance [18].

In the current study, the mean age (39–40 years old) was a statistically non-significant predictor for POUR. Keita et al [11] found that the risk of POUR increased by

Table 4. Variables in the equation for the binomial logistic regression.

	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. for EXP(B) Lower	Upper
Age	0.040	0.089	0.203	1	0.652	1.041	0.874	1.240
Sex	−0.833	2.018	0.171	1	0.680	0.435	0.008	22.676
Duration of operation	−0.010	0.080	0.016	1	0.900	0.990	0.846	1.158
Intraoperative fluids	0.003	0.008	0.106	1	0.745	1.003	0.987	1.018
Duration of sensory block	0.076	0.028	7.259	1	0.007	1.078	1.021	1.139

For each unit increase in the duration of sensory block, the odds of having POUR increase by a factor of 1.078.

2.4 times over 50 years old, and Kreutziger et al [17] showed that 60 years old is a risk factor for post spinal urinary retention. This could be explained by the undetected prostatic pathology in older men, the degeneration of the supra-spinal somatic and visceral neurons [11], the type of surgery performed is mainly on the lower abdomen or lower extremities, with longer operative times, requiring the use of long acting spinal anesthetics, and the use of ephedrine or atropine [19].

In the current study, sex was a statistically non-significant predictor for POUR; as the male patients represented 77% and 85.7% of patients in the BD and the BF groups respectively. Fernandez et al [20] revealed that 9% of males and 3% of females developed POUR; this was explained by the higher IPSS (International Prostate Symptoms Score) in older males [19].

In the current study, the mean operative duration (90.43–91.29 minutes) was a statistically non-significant predictor for POUR. Brouwer et al [14] found that operative duration more than 2 hours was associated with the use of long acting local anesthetics, longer undetected UB volume, with inability to void for more than 8 hours.

In the current study, patients with neurologic diseases as well as, patients on α_2 antagonists were excluded from the study, as they interfere with the UB function, by acting on the α receptors in the smooth muscle cells of the urinary tract. Also, diabetic patients were excluded due to impairment of the UB sensation, with increased UB capacity, and decreased detrusor muscle contractility [21].

In the current study, patients voided before transfer to the operating theater, as

Joelsson-Alm et al [22] found that not voiding before surgery is a risk factor for POUR, and that a preoperative UB volume≥150 mL was a significant risk factor, they also stated that voiding before transfer to the operating theater, doesn't indicate an empty UB at the start of operation. So, in the current study, the recommendation by Keita et al [11] was followed; by ultrasound assessment of the UB volume in the induction room, and urging patients to void any residual volume measured.

In the current study, the mean IV fluids volume given was a statistically non-significant predictor of POUR. Pavlin et al [23] found no relationship between the IV fluids given and the UB volume. Also, some studies showed that the IV fluids volume wasn't associated with an increased incidence of POUR, and recommended not to follow the restrictive fluids approach in order to decrease the incidence of POUR [19; 24]. Kreutziger et al [17] found that patients who micturated received significantly more IV fluids than patients with POUR, with significantly less UB volume at the 4th post-operative hour, they explained this by the difference in water balance in young patients compared to older patients; with more fluid deficiency, thus the UB volume didn't cause POUR until wearing of the sensory block and spontaneous micturition.

In the present study, the UB volume was comparable between patients of both groups, as Kreutziger et al [17] diagnosed POUR by a measured UB volume limit rather than a time limit. Pavlin et al [23] found a significant correlation between the duration of surgery and the UB volume. The present study followed the recommendation by Gosling and his colleagues [25]; by ultrasound measurement of the UB volume at the 3rd post-operative hour, as some patients may have reached their maximum bladder capacity (MBC). Brouwer et al [26] demonstrated a large inter individual variation in the MBC (400–500 ml); independent of age, sex, and body mass index, and found that transient UB volume from 500 to1000 ml is safe, if diagnosed and managed by UB catheterization within 2–3 hours, to avoid damage of the detrusor muscle.

In the current study, the mean time to micturition as well as the duration of sensory block was comparable between patients of both groups. This goes with the finding by Gupta et al [27]; as the time to void after ambulatory surgery with low dose bupivacaine was shorter due to faster regression of the sensory block with rapid recovery of the UB function, as the detrusor muscle strength starts to return to normal, 15 minutes after sensory regression to S_2-S_3 allowing voiding [28]. Ben-David and Vrahas [6] stated that intrathecal fentanyl prolongs the duration of sensory block without affecting the ability to void. Also, Al-Ghanem et al [29] stated that intrathecal fentanyl prolonged the duration of spinal anesthesia not in a dose-related pattern. However, Al-Mustafa et al [3] found that the prolonged duration of spinal anesthesia by dexmedetomidine occurs in a dose dependent manner; this is explained by the synergistic effect of dexmedetomidine, and lowering the absorption of bupivacaine from the blocked area due to α_1 adrenergic effect on the arterial system [30].

In the present study, the incidence of POUR at the 3rd post-operative hour was clinically significant less in patients of the BD group, than in patients of the BF group. This is explained by Jellish et al [31], who stated that intrathecal fentanyl is potent, short acting on the μ and δ receptors in the spinal cord, it increases the incidence of POUR by; decreasing the afferent inputs from the UB, thus decreasing the urge sensation to void and the detrusor contraction, with increasing the UB capacity. Also, it decreases the parasympathetic efferent in the sacral region [18], and alters the urethral sphincter function, thus impairs the coordination between the detrusor contraction and the internal urethral sphincter relaxation, this dysfunction is dose related [32]. Also, the rostral spread to the pontine micturition center was hypothesized by Kuipers et al [33]. Baldini et al [8] stated that the synergistic block of

the Aδ and C fibers by dexmedetomidine and bupivacaine, impairs the sympathetic system thus leaves the cholinergic system uninhibited, and Jarineshin et al [32] found that dexmedetomidine as an adjuvant to bupivacaine, induces analgesia without urinary retention.

At the 6th post-operative hour, patients of both groups were freely ambulant and able to micturate, with no patient in either group requiring insertion of an indwelling urinary catheter. This is explained by the faster regression of motor block with low dose bupivacaine [34], with comparable motor block duration with dexmedetomidine and fentanyl as adjuvants, and the complete return of the detrusor muscle strength 1–3.5 hours after ambulation [28]. The results of the current study goes with those by Iorio et al [35], who stated that UB catheterization was not required in low risk patients receiving intrathecal lipophilic opioids.

9. Conclusions

In unilateral arthroscopic knee surgery, 5 µg dexmedetomidine is alternative to 25 µg fentanyl as intrathecal adjuvant; it provides comparable sensory block duration with decreased clinical incidence of POUR, which depends on identification of high risk patients and ultrasound monitoring of the UB volume.

List of abbreviations

ASA: American Society of Anesthesiologists, BD: Bupivacaine-Dexmedetomidine, BF: Bupivacaine-Fentanyl, ECG: Electrocardiography, IPSS: International Prostate Symptoms Score, IV: Intra-venous, MBC: Maximum bladder capacity, MBS: Modified Bromage Score, NIBP: Non-invasive blood pressure, PACU: Post Anesthesia Care Unit, POUR: Post-operative urinary retention, S_3: third sacral dermatome, UB: Urinary bladder.

Authors' contributions

MB 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. TN design of the work, revised literature and collected the data. TH 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 have not been published, simultaneously submitted or accepted for publication elsewhere.

Disclosure statement

No potential conflict of interest was reported by the authors.

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Availability of data and material

The datasets generated and/or analyzed during the current study are not publicly available due [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.

Trial registration

Ethical committee approval of Faculty of Medicine, Ain-Shams University (FMASU MS 532/2021), registered on the 14th of September 2021, and with a Clinical Trials Registry (NCT 05596552) on 24 October 2022.

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