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Influence of ultrasound-guided erector spinae plane block on post-operative pain and diaphragmatic dysfunction in obese patients undergoing repair of Epigastric Hernia

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ABSTRACT

Background: Repair of ventral hernia is associated with pain after operation. We wanted to study the influence of ultrasound-guided (US) erector spine plane (ESP) block on postoperative pain and diaphragmatic dysfunction in obese cases undergoing repair of epigastric hernia.

Methods: This prospective randomized-controlled double-blinded research was conducted on 50 obese cases with body mass index (30–40), aged (21–65) and scheduled for elective open repair of epigastric hernia. Cases were randomized into two equal groups to receive either general anesthesia alone (Controls) or general anesthesia combined with bilateral ultrasound-guided ESP block. Postoperative pain, 24 h postoperative analgesic dose, and postoperative diaphragmatic excursion were assessed.

Results: There was a statistically evident decrease in NRS score in the ESP versus controls (30 min, 2 hr, 6 hr, 12 hr)($p < 0.001$). There was a statistically evident decrease in the total intraoperative fentanyl ($p < 0.001$) and total 24 h morphine dose ($p < 0.001$) in the ESP versus controls. There was a statistically evident decrease in the postoperative diaphragmatic excursion in controls versus the ESP ($p = 0.001$).

Conclusions: The ESP block in obese cases undergoing open repair of epigastric hernia provided efficient postoperative analgesia. It decreased postoperative pain, reduced intraoperative and postoperative analgesic dose, and maintained diaphragmatic excursion.

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1. Introduction

Postoperative pain limits the intercostal and abdominal muscle activity resulting in reduced ventilation, prevention of cough and inability to expel secretions. This leads to postoperative pulmonary complications such as atelectasis and pneumonia especially in obese individuals because the function of the respiratory muscles is impeded by the extra body fat that compresses the chest and fills the abdomen [1].

Repair of ventral hernia is associated with pain after operation. A lot of modalities for pain relief have been described including opioids, and non-opioid analgesics as well as regional anesthesia. Postoperative pain in obese cases is challenging. Opioids, which represent the mainstay for pain management, might result in a range of unfavorable outcomes including nausea, vomiting, ventilatory depression, and physical dependence. Therefore, to enhance respiratory function and provide pain relief, regional anesthetic is frequently used [2, 3].

By injecting a local anesthetic in-between the erector spine muscle (ESM) and the transverse processes (TPs), the erector spine plane block (ESP) paralyzes the thoracoabdominal spinal neurons [4].

Regarding previous studies, ESP Block proved efficient in postoperative pain control in many surgeries such as breast surgeries, abdominal surgeries, spine surgeries, and thoracic surgeries. Also, it provided lower pain score in cases with chronic shoulder pain and fracture ribs [5, 6].

This research aimed to determine the influence of US-guided ESP block on postoperative pain and diaphragmatic dysfunction in obese cases undergoing repair of epigastric hernia.

2. Patients and methods

This prospective, randomized, controlled, double-blind study examined 50 obese patients with body mass index (BMI) (30–40), aged (21–65) years ASA (II and III), and scheduled for elective open repair of epigastric hernia in Tanta University Hospital for one year from June 2021 to May 2022.

The research was conducted with permission from the Tanta University Ethics Board (Ethics committee approval code: 34579/3/21). The patient's informed written permission was acquired. The research was registered regarding the standards

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of clinical trial registry on clinicaltrial.gov under the number (NCT05516901).

Cases with a history of local anesthetic allergy, localized infection at the block site, coagulation abnormalities, renal, liver, and cardiac dysfunction, spine deformities, cognitive disorders, and chronic pulmonary disease were excluded from the research.

Cases were randomized into two equal groups by opaque sealed envelope technique: Controls received general anesthesia (GA) alone and erector spine group (ESP) received general anesthesia combined with bilateral US guided ESP block. The patient and the outcome assessor were blinded.

All cases underwent: Preoperative assessment (history taking, clinical examination, routine laboratory investigations).

On entering the operation theatre, a peripheral IV cannula was established and standard monitoring was started. HR and BP baseline values were recorded. Cases were premedicated with H2 blocking agent (rantidine 150 mg) and (ondansetron 8 mg) as antiemetic.

2.1. Ultrasonographic assessment of diaphragmatic excursion

Patient laid in the supine position. Using curvilinear probe (2–5 MHz) Philips US, the probe was positioned in the subcostal area, in-between the midclavicular and anterior axillary lines, so that the US beam enters the posterior third of the right hemidiaphragm perpendicularly. In B mode, the diaphragm is detected as an echogenic line in-between lung and liver interfaces. At the end of normal expiration, the patient was instructed to inhale as deeply as possible, and then M-mode was used to display the motion of the diaphragm and measure diaphragmatic excursion in centimetres on vertical axis from beginning to the end of inspiration.

2.2. Intraoperative management

Cases were pre-oxygenated for 3 min, then GA was induced using propofol 1–2 mg/kg lean body weight and fentanyl 1 µg/kg lean body weight. Atracurium 0.5 mg/kg ideal body weight was administrated to assist the ease of endotracheal intubation. Capnogram was attached and anesthesia was maintained using sevoflurane (1–1,2) MAC in oxygen–air mixture (50%–50%). Mechanical ventilation parameters were adjusted to maintain end-tidal carbon dioxide at (35–40).

After induction of GA, cases in group II received bilateral US-guided ESP block with the application of 20 ml bupivacaine 0.25% on each side.

2.3. Technique of ESP block

The patient was positioned in lateral decubitus position. Under strict aseptic condition, palpation of spinous processes starting from the C7 downward till T7 spinous process was reached. Using ultrasound (Phillips Cx-50, Amsterdam, Netherlands), the linear array high-frequency US probe (5-13 MHZ) was used. Then, the ultrasound transducer was placed in the midline of the back at level T7. The probe then progressively pushed laterally until the TPs were seen. A 100-mm, 25-gauge needle was inserted using an in-plane approach in the cephalad to caudal direction and advanced under ultrasound guidance toward the TPs; once the needle tip reached TPs, a small local anesthetic bolus of 2 ml was administered. The ESM was visualized, separating from the TPs. After aspiration, the local anesthetic 20 ml of 0.25% bupivacaine was injected. Technique was repeated on the other side.

The operation started 20 min after performing the blocks. Any increase in HR and MAP more than 20% of baseline values was considered as insufficient analgesia and fentanyl 0.5 µg/kg was given, and total intraoperative fentanyl was recorded. After completion of the surgical procedure, GA was discontinued, and the endotracheal tube was removed after reversal of the influence of the muscle relaxant with 0.05 mg/kg neostigmine and 0.01 mg/kg atropine. The patient was transferred to post-anesthesia care unit (PACU) for continuous vital signs' monitoring and discharged when Aldrete score is more than 9. Paracetamol 1 gm was given as a regular analgesia and repeated every 6 h.

The primary outcome was assessing the postoperative pain using Numeric Rating Scale (NRS) after 30 min at recovery room then at 2, 6, 12, 24 h, and if NRS$^{>}$3 morphine 3 mg IV bolus was given as rescue analgesia. The secondary outcomes were postoperative analgesic dose (total 24 h morphine dose) and diaphragmatic excursion measurement was at 30 min after recovery at PACU.

2.4. Sample size calculation

G.power 3.1.9.2 was utilized for determining the necessary sample size. Based on a prior research [7], the mean standard deviation (SD) of the NRS after 2 h (the primary outcome) was 3.5 (1.36) in controls and 2.27 (1.46) in the ESP group. We calculated a sample size of 22 cases for each group, with a 95% confidence limit and 80% power. Three extra cases were added to each group to compensate for the dropout. This resulted in a total of 25 cases being allocated in each research arm.

2.5. Statistical analysis

Statistical analysis was performed using SPSS version 20.0. (Armonk, NY: IBM Corp). Histograms and

the Shapiro–Wilks test were employed to determine whether or not the data were normally distributed. The unpaired student t-test was utilized to examine the quantitative parametric data and it was reported as a mean ± (SD). The Mann–Whitney test was utilized to assess the non-normally distributed quantitative data, and the resulting median and IQR were reported. Chi-square test or Fisher's exact test was used to interpret the relationships between qualitative variables provided as frequencies and percentages. The period until surgical pain medication was needed as shown on a Kaplan–Meier curve. Statistical significance was assumed when the two-tailed *P* value was<0.05.

3. Results

Sixty one cases were assessed for eligibility, five cases did not meet the inclusion criteria (two uncontrolled DM, one patient had coagulation disorder, one patient BMI more than 40, one patient had chronic kidney disease), and six cases refused to participate in the research. The remaining 50 cases were randomly divided into two groups (25 cases in each one) (Figure 1).

The two groups were comparable regarding age, sex, BMI, and duration of operation. There was no difference (Table 1).

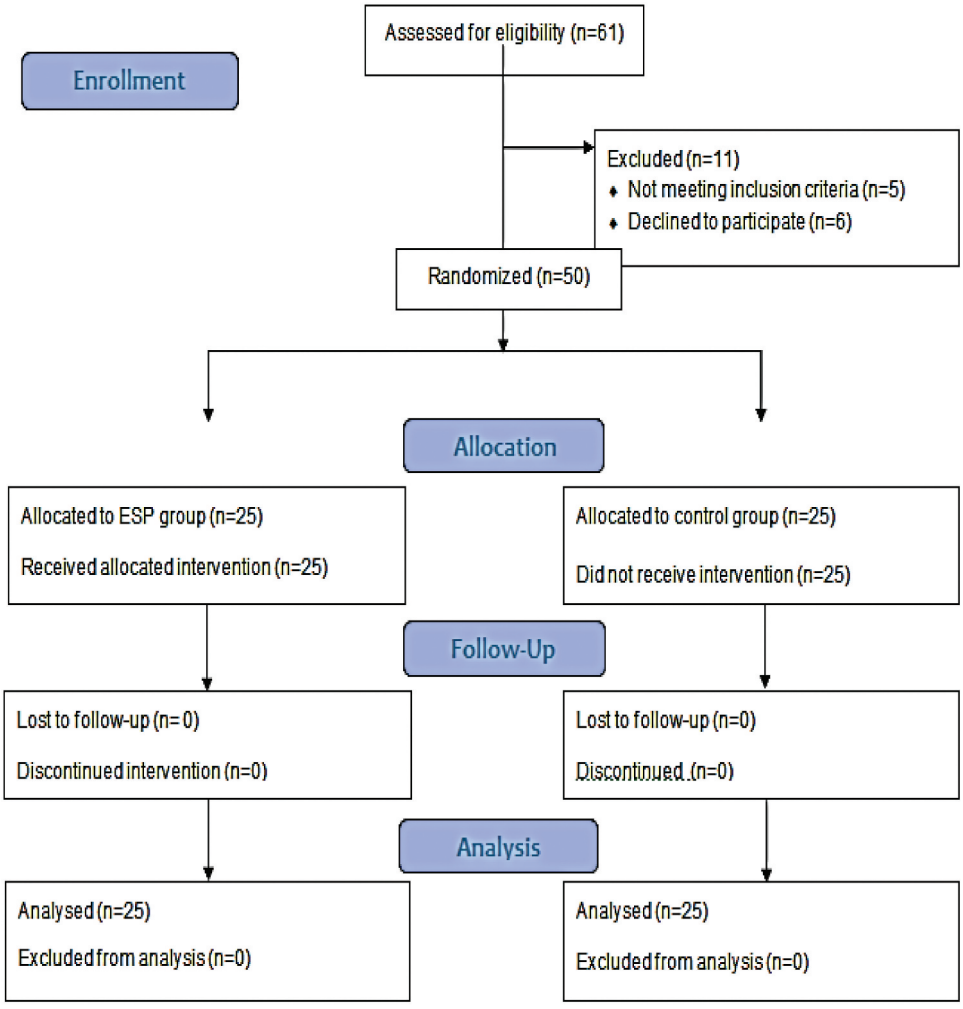

Figure 1. CONSORT flow diagram of the participants through each stage of the randomized trial.

Table 1. Demographic data in both studied groups.

Demographic data		Control (*n* = 25)	ESP (*n* = 25)	P value
Age (years)		40.48 ± 11.98	42.84 ± 12.29	0.495
Sex	Male	12 (48.0%)	13 (52.0%)	0.777
	Female	13 (52.0%)	12 (48.0%)	
BMI (kg/m^2)		36.68 ± 2.32	37.0 ± 2.66	0.653
Duration of operation (min.)		63.20 ± 8.70	63.80 ± 8.52	0.806

Data are presented as mean ± SD, BMI: Body mass index, p: *p* value for comparing between the two studied groups.

Table 2. Comparison between the two studied groups according to the total intraoperative fentanyl consumption (mcg).

Total intraoperative fentanyl (mcg)	Control (n = 25)	ESP (n = 25)	P value
Min – Max.	0.0–100.0	0.0–60.0	<0.001*
Median (IQR)	60.0(50.0–60.0)	0.0(0.0–0.0)	

ESP:Erector spine plane, IQR: Inter quartile range , p: p value for comparing between the two studied groups, *: Statistically significant at $p < 0.05$.

Comparing the mean values of MAP, no statistically evident changes were shown at baseline but showed a statistically evident increase in MAP values in controls versus ESP (skin incision, 15 min, 30 min, 45 min, 60 min).

There was a statistically evident decrease in the total intraoperative fentanyl dose in the ESP versus controls (Table 2).

There was a statistically evident decrease in NRS values in the ESP versus controls (30 min, 2 h, 6 h, 12 h), and there was no variations between the two investigated groups at 24 h (Figure 2).

There was evident delay in the onset of first rescue analgesia in the ESP versus controls (Figure 3).

There was a statistically evident decrease in the total 24 h morphine dose in the ESP versus controls (Table 3)..

Comparing preoperative diaphragmatic excursion showed no evident variations. But there was

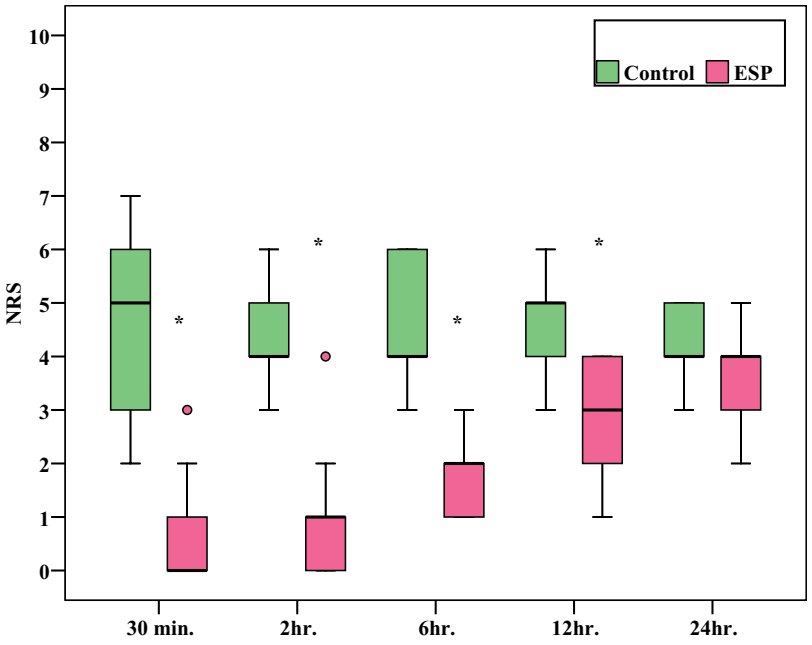

Figure 2. Comparison between the two studied groups according to NRS.

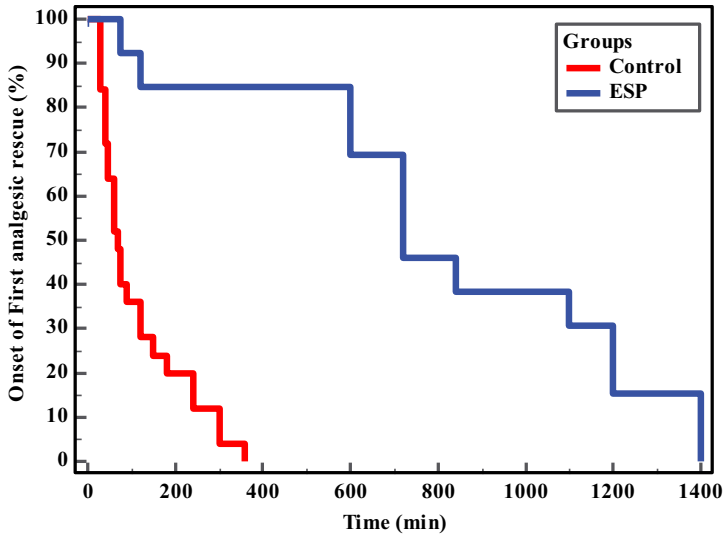

Figure 3. Kaplan–Meier survival curve for onset of 1st analgesic request (min).

Table 3. Comparison between the two studied groups according to the total 24 h rescue morphine consumption.

Morphine consumption in 24 h (mg)	Control (n = 25)	ESP (n = 25)	P value
Min – Max.	(6.0–15.0)	(0.0–9.0)	<0.001*
Median (IQR)	9.0 (9.0–12.0)	3.0 (0.0–3.0)	

ESP:Erector spine plane, IQR: Inter quartile range , p: p value for comparing between the two studied groups, *: Statistically significant at $p < 0.05$.

Table 4. Comparison between the two studied groups according to diaphragmatic excursion.

	Control (n =25)	ESP (n =25)	P value
Preoperative Mean ± SD	3.72 ± 0.26	3.78 ± 0.25	0.380
Postoperative Mean ± SD	3.37 ± 0.38	3.71 ± 0.27	0.001*

ESP:Erector spine plane, SD: standard deviation, p: p value for comparing between the two studied groups, *: Statistically significant at $p < 0.05$.

a statistically evident decrease in the postoperative diaphragmatic excursion in controls versus the ESP (Table 4).

There were no statistical evident changes in the complication incidence between the two investigated groups as regards hypotension and bradycardia. Infection, hematoma, and local anesthetic toxicity were not observed in the investigated groups.

4. Discussion

After inguinal hernia repair, ventral hernia repair is the second-most common hernia operation performed and associated with evident postoperative pain [2].

The ESP block is a paraspinal fascial plane block in which local anesthetic is administered in-between the ESM and the TPs, blocking the thoraco-abdominal spinal nerves [4].

Using ultrasound guidance, we were able to locate the erector spine planes on both sides of the patient's back, which led to a dramatic decrease in postoperative NRS pain ratings, with less intraoperative fentanyl dose, prolonged time of first request of rescue analgesia as well as less rescue morphine dose during the first 24 h postoperative versus controls. In addition, there was an evident decrease in diaphragmatic excursion in controls versus the ESP block.

Acute postoperative pain treatment after repairing ventral hernia [2, 8], thoracic operation [9, 10], bariatric operation [11, 12], rib fracture [12], post thoracotomy pain syndrome [13], and chronic shoulder pain [14] have all been successfully treated using the ESP block [5].

Various randomized trials have been conducted to assess the analgesia influence of ESP block in different types of procedures.

Singh et al [13] who investigated the influence of bilateral US-guided ESP block on postoperative analgesia in lumbar spinal operation found that postoperative analgesic dose and pain score were evidently lower in the ESP versus controls.

Sahin et al [14] investigated the influence of bilateral US-guided cases undergoing nephrectomy who had an ESP block with evidently less pain and lower NRS pain ratings from 0 to 24 h postoperative versus those who did not get the block. In the ESP, cases used considerably less opioids and rescue analgesics than those in the non-ESP.

Krishna et al. [15] investigated the influence of bilateral ESP block on acute postsurgical pain in adult cardiac surgeries. The cases were split into two groups at random. Group 1 (ESP block, $n = 53$) cases had US-guided bilateral ESP block prior to T6 TPs level induction of anesthesia. Tramadol (50 mg/8 h) and paracetamol (1 gm/6 h) were administered intravenously to cases in Group 2 (Paracetamol and tramadol group, $n = 53$) in the immediate postoperative period. In group 1, the median resting pain score was 0 out of 10 till hour 6, 3 out of 10 at hour 8, and 4 out of 10 at h 10 and 12. Versus group 2, cases in group 1 experienced considerably longer periods without pain.

It is unclear how local anesthetics work or how far they go in an ESP block. In a research using cadavers, Forero et al. [4] injected all samples using US guidance for all interventional operations. By blocking the spinal nerve roots and the branches communicating with the sympathetic ganglia, they showed that local anesthetics infiltrate the thoracic paravertebral region anteriorly through connective tissues and ligaments. Regarding imaging studies, the widespread sensory block found after a single application at T5 TPs propagated craniocaudally in-between C7 and T8, perhaps because of the columnar architecture of the ESM and its retinaculum. This also suggests that the dissemination to the lower thoracic nerves feeding the belly should occur after injection at levels caudal to T5 [2]. In contrast, Ivanusic et al.'s [16] cadaveric research showed that the vertebral column muscles are firmly attached to the TPs, preventing any anterior spread of dye toward the paravertebral space. This would have affected the thoracic spinal nerves. Dorsal ramus blockage was suspected to have occurred behind the costotransverse foramen, with the lateral cutaneous branches of the intercostal nerves likely being involved.

Concerning the patients' characteristics and demographic data of the investigated groups: there were no

statistically evident variations as regards age, sex, BMI, and duration of operation.

Concerning postoperative pain, postoperative analgesia dose and time of first rescue analgesia:

The NRS pain score was prominently lower, as shown by our findings, in the ESP versus controls at 30 min, 2, 4, 6, and 12 h postoperative. There was an evident decrease in 24 h postoperative analgesia dose and prolonged time of first rescue analgesia in the ESP versus controls.

Similar to our results, Elyazed et al. [7] investigated the influence of bilateral US-guided ESP block on postoperative pain following epigastric hernia open repair. Their research was carried out on 69 cases aged (18–65). Cases in ESP received preoperative 20 ml bupivacaine 0.25% at erector spine plane at level of T7 TPs, while other group received sham block, compared to the controls, patients in the ESP block had considerably less pain at 2 h postoperative on VAS and remained lower until 12 h postoperative. There were no statistically evident variations in pain level at 18 and 24 h on the visual analogue scale. There were only four cases who needed intraoperative fentanyl in the ESP block versus controls. Ten cases in the group that received ESP blocks required rescue pethidine after operation, while 25 controls did not. After operation, cases who had an ESP block required much less rescue pethidine than those who did not. Compared with controls, those who had an ESP block had a much longer time before they needed rescue analgesia.

In contrast to our results, Kim et al [17] investigated the influence of US-guided ESP block on postoperative analgesia following laparoscopic liver resection. The research was carried out on 70 cases, 35 cases received US-guided ESP block (the ESP) and the other group did not received intervention (controls). The research results showed that there was no variations in median postoperative analgesic dose (within 24 h of operation, the median [IQR] opioid intake was 48.2 [17.1] mg in controls and 45.5 [35.8] mg in the ESP Block), and there was no variations in NRS score at any time.

Concerning postoperative diaphragmatic excursion: our results revealed that there was an evident decrease in diaphragmatic excursion in controls compared with ESP.

Qaiser et al [18] investigated diaphragmatic excursion and its correlation with PFT. The research included 26 COPD cases and 18 self-reported healthy control. However, Rocha et al. [19] showed that diaphragmatic mobility is connected to pulmonary parameters (FEV1, FEV1/FVC, and FVC). They reported that diaphragmatic excursion correlates with FEV1/FVC and slightly correlates with FEV1.

With respect to the complication incidence in our research, there were no variations as regards pneumothorax, hematoma, local anesthetic toxicity, hypotension, and bradycardia.

The safety of ESP block was demonstrated by Elyazed et al. [7] who investigated the influence of bilateral ESP block on postoperative pain after open Epigastric hernia and Fu J *et al* [20] who studied ESP block in postoperative pain relief after hepatectomy.

5. Conclusions

The ESP block in obese cases undergoing open repair of epigastric hernia provided efficient postoperative analgesia. It decreased postoperative pain, reduced intraoperative and postoperative analgesic dose and maintained diaphragmatic excursion.

Disclosure of interest

The authors report no conflict of interest.

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Author contributions

Each contributor contributed in conceptualizing and drafting the plan for the research. Organizing, collecting, and analyzing data were performed by Asmaa Ragab Eid and Mona Blough El Mourad. The first draft of the manuscript was written by Salah Eldeen Ibrahim Alsherif and Shaimaa Waheed Zahra, in addition, all contributors provided feedback on drafts of the publication. The final manuscript was reviewed and accepted by all contributors.

Disclosure statement

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

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