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The effect of preoperative ultrasound-guided peri-capsular nerve group block (PENG) on the postoperative analgesia after total hip arthroplasty: A randomized controlled study

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Abstract
Background: Pain can range from moderate to severe after total hip arthroplasty, a routine surgical procedure. The functional recovery and long-term functional result of a surgical patient depend on early ambulation and physical therapy. Hence, the primary goal of postoperative pain management following THA continues to be providing for maximal pain relief while safeguarding motor function.
Patients and Methods: Sixty adult cases were part of this prospective randomised double-blind controlled trial at Tanta University Hospitals from August 2021 to June 2022. Patients were randomly allocated according to technique used into two groups.
Group I (control group): Received sham PENG block (just 1 mL saline).
Group II (PENG group): Received real PENG block (20 mL of bupivacaine 0.25% +0.2 mg/mL dexamethasone).
Results: In the PENG group, pain scoring was significantly lowered, considerably longer intervals among first pain and the need for analgesia, the total dosage of morphine used up in the first twenty-four hrs was significantly decreased, patients were very satisfied, there was no motor blockage nor quadriceps muscle affection compared with control group. Inconsequential differences existed between both group in time to first sit and time to do active exercise but there was a drastic drop in time to stand and walk in PENG group in contrast to the placebo group, Following the operation, cases in the PENG group experienced a substantially reduced rate of nausea and vomiting compared to control group. But As far as bradycardia, hypotension, and respiratory depression go, there were no discernible changes among the two groups.
Conclusion: The preoperative ultrasound guided PENG block is an efficient tool for postoperative analgesia in cases undergoing total hip arthroplasty without significant effect on motor block or the incidence of complications.

Keywords: Pericapsular nerve group block (PENG), total hip arthroplasty (THA), bupivacaine

Introduction
For hip problems, (THR) is the gold standard of care. The amount of THAs performed has grown globally, along with the development of new methods and prosthetic devices [1]. In order to alleviate suffering and restore mobility, many people choose for (THR), a very inexpensive surgical procedure. The global annual volume of hip arthroplasty procedures has surpassed 1 million and is projected to increase during the next 2 decades [2].
Total joint arthroplasty postoperative discomfort is still a significant issue that prolongs length of hospital stay and hinders functional rehabilitation [3]. Although there are several alternatives for treating postoperative pain, such as opioids alone or in conjunction with other analgesics, regional analgesics, and/or a mix of the two, In the absence of a universally accepted benchmark, no progress can be made [4, 5].
Analgesia from neuraxial opioids is superior to that from systemic opioids; nevertheless, these opioids can have significant adverse consequences, including respiratory depression, GI discomfort, ileus, urine retention, pruritis, hypotension, and bradycardia [6]. Nevertheless, the increased risk of complications such as hypotension, ileus, urinary retention, motor block that prevents ambulation, compartment syndromes, and spinal hematomas is not worth the greater analgesia provided by epidural infusions [7, 8].

By isolating and cutting off the articular branches that supply the hip joint with sensory and motor innervation, the (PENG) block has been developed. Giron-Arango *et al*. (2018) presented this localised anaesthetic method for acute hip fracture analgesia [9]. It is possible that the PENG block's motor-sparing effect is beneficial for early ambulation, enhanced physical therapy, and an earlier release since it only affects the sensory branches and not the posterior mechanoreceptors [10].

The purpose of this investigation was to determine the impact of preoperative ultrasound-guided PENG block on postoperative analgesia following total hip arthroplasty, with the primary outcome being delay before initial request for rescue analgesia was made; secondary outcomes included postoperative pain and total morphine consumption within the first day following surgery.

Patients and Methods

Institutional Ethics Committee clearance (approval code: 34582/3/21) was obtained to conduct this prospective randomised double-blind trial on sixty adult cases admitted to Tanta University Hospitals from August 2021 through June 2022.The study was registered according to the standards of clinical trial registry on clininicaltrial.gov under the number (NCT04984109).

Adults ages 21-65 undergoing a single hip replacement surgery and classified as ASA physical status I-III were eligible for enrollment prior to surgery.

Patients who did not give informed permission, who were allergic to local anaesthetics, who had a BMI more than 35 kg/m2, who developed an infection at the puncture site, etc. were not included in this study. People who are uncooperative or who have mental health issues; patients with a coagulation abnormality; patients with serious heart, kidney, or liver conditions.

Patients that qualified were split into 2 groups, one receiving a PENG block and the other a sham PENG block (control group). Randomization software written on a computer was integrated with a sealed opaque envelope approach to determine group membership. The nurse who assigned participants to groups based on the numbers in the envelopes was blinded to the research and data collecting. The anesthesiologist who did all the nerve blocks was the only one.

- **Group I (Control Group):** thirty cases received sham PENG (just 1mL saline).
- **Group II (PENG Group):** thirty cases received real PENG (20mL of bupivacaine 0.25% +0.2 mg/mL dexamethasone)

Anesthetic technique

Preoperative assessment was done by

Adequate preoperative assessment was carried out through history taking, clinical examination and requesting experiments in the lab, including complete blood count, bleeding and clotting times, aPTT, liver and kidney function tests. During the pre-anesthetic evaluation, all patients were familiarized with numeric rating scale (NRS) score.

In the holding area

All patients were preloaded with 7 mL/kg of Ringer's lactate solution following the insertion of a wide-bored cannula.

On arrival at operation room,

(5-lead ECG), noninvasive blood pressure (NIBP), and pulse oximetry were used for regular heart rate monitoring.

Aseptic measures were taken prior to administering spinal anaesthesia at the L3-L4/L4-L5 intervertebral space. After confirming unobstructed CSF flow, 2 mL of a 0.5% (10 mg) hyperbaric bupivacaine solution was injected, along with 0.5 mL (25 µg) of fentanyl. Pinpoint numbness was used to determine the degree of the sensory block. Minimum sensory blockade required is T10. In addition, the motor block was evaluated using the modified Bromage score [11] until a score of 2 was achieved. Patients who did not reach the required levels of sensory and motor block within 20 minutes were deemed ineligible for the study and given general anaesthesia instead. Following successful sensory and motor blockade, the patient received a PENG block guided by ultrasound to facilitate further surgical procedures.

Technique of PENG block

The patient was positioned supine, which allowed for good groin access for the regional block. Local sterilisation with povidone iodine was followed by the placement of a low frequency (2-5 MHz) curvilinear ultrasound transducer linked to an Ultrasound Machine (Philips CX50 Extreme edition) at the anterior superior iliac spine in the transverse plane, and then the transducer was shifted caudally to identify the anterior inferior iliac spine (AIIS). When the AIIS and iliopubic eminence were in proper alignment, the probe was rotated (IPE). The femoral arteries and superficial iliopsoas muscle were exposed. The midpoint of AIIS and IPE deep to the psoas tendon was maintained while inserting a 22-G, 100-mm echogenic needle in a lateral-to-medial plane. PENG group participants had hydrodissection of the psoas tendon, and then got 20 mL of (0.25%) bupivacaine with 0.2 mg/mL dexamethasone administered in 5 mL aliquots following negative aspiration. For the sake of comparison, [12] the placebo group. Was given 1 mL of normal saline. Figure (1)

After the surgical operation, the case was moved to the Post-Anesthesia Care Unit (PACU). Paracetamol 1 gm was administered IV every 6 hours after discharging to the ward as routine postoperative analgesia.

The following measurements were recorded

Demographic data. Postoperative pain was assessed by (NRS) Pain score at PACU and at 2,4,6,8,12,16,20 and 24 h postoperative.

Also, the period till the first call of rescue of analgesia and the total dose of used morphine in the first 24h. As well, Duration of motor block and patient satisfaction was assessed. First time to ability to sit, stand, walk and do active exercise.

Assessment of quadriceps muscle power immediately post-operative then every 3 hours till 12 hours. Lastly, any undesirable side effects that occurred during the first 24 hours was recorded and treated (e.g., nausea, vomiting, bradycardia, hypotension, and respiratory depression).

Sample size calculation

Epi-Info, a statistical tool developed by the WHO and the Centers for Disease Control and Prevention, Atlanta, Georgia, USA, version 2002, was used to determine the sample size and conduct the power analysis.

The number of samples needed was determined using the time to the first analgesia request (8.2±11.39) in PENG

group according to a previous study [13]. The sample size was determined by taking into account the following elements: 95% confidence limit, 80% research power, and a 0.7 effect size.

Based on the above described parameters, the sample size was determined to be at N ≥ 26 for each study group. The sample size will be increased to 30 in each group to compensate for any dropout cases.

Statistical analysis

- SPSS version 20.0 was used for the statistical presentation and analysis in this study. IBM Corporation, Armonk, New York. The dispersal of quantitative data was tested using the Shapiro-Wilks normality test and histograms, and the kind of statistical testing (parametric or nonparametric) was chosen appropriately. The acquired findings were deemed significant at the 5% level.
- Parametric variables (e.g., age, BMI, length of operation, total abuse of morphine and time of first analgesic requirement) have been interpreted as mean ± SD and analyzed using unpaired T-test for comparison between the two groups.
- Quantitative information was shown as number (%) and analyzed using Chi-square test.
- Non parametric variables as (NRS) had been articulated as median and interquartile range (IQR) and analyzed using Mann Whitney U test.

Results

A total of 75 cases were considered for inclusion in this prospective, randomised, double-blind trial; 12 did not match the requirements, and 3 declined to take part. Sixty patients were left, and they were split into two groups (30 patients in each). Sixty patients were tracked and their data was examined statistically. Figure (2).

Demographic data includes, age, sex, BMI, ASA physical status and length of operation were insignificantly different among the 2 groups. Table (1).

Post-operative pain (NRS) has shown a statistically significant rise in NRS in group I in comparison to group II at 6hr, 8hr, 12hr, 16hr, 20hr and 24hr, while there was no significant difference at 2hr and 4hr. Figure (3).

Also, the time of 1st rescue analgesia group II had a considerably longer average life span than group I (p=0.001).Figure (4).

Moreover, morphine intake in group II had a far lower value than in group I (p<0.001) in groups I and II respectively. Figure (4).

According to the duration of motor block, there was no discernible distinction among the two groups. (P=0.096). Figure (4).

As well, Patient satisfaction was statistically substantially higher in group II compared to group I. Figure (5).

Regarding to time to rehabilitation postoperatively, there was insignificant variance among both groups in time to first sit and do active exercise (P=0.262) (P=0.093) respectively. But there was significant decrease in time to stand and walk (P=0.003) (P=0.42) respectively in group II in comparison with group I. Table (2).

There was statistically non-significant changes according to quadriceps muscle power at 3, 6, 9 and 12 hrs postoperatively with (p): 0.129, 0.405, 1.0 and 0.237 respectively. Figure (6).

According to undesirable side effects that occurred during the first 24 hrs, nausea and vomiting was statistically significant increase in group I than group II. But bradycardia, hypotension and respiratory depression were statistically insignificant among two groups. Table (3).

Discussion

Most often performed major orthopaedic operation, THA improves patients' mobility and quality of life [14]. Notwithstanding these benefits, the first few days after surgery can cause significant discomfort, which slows down the recovery process, lengthens the time spent in the hospital, and increases the likelihood of thromboembolic events [15]. One of the most common reasons for negative patient feedback following hip surgery is discomfort in the early postoperative period [16].

The articular branches of the femoral, obturator, and auxiliary obturator nerves, which innervate the anterior hip capsule, can be blocked using an ultrasound-guided technique called (PENG) block [17].

In consistence with our results, Remily *et al*. 2020 [18] who compared (PENG) block with no block. However, both groups received fascia iliaca block. The study demonstrated that postoperative pain scores in PENG group were significantly reduced comparing with control group. As well, there was a greater therapeutic window for those in the PENG group and a decrease in total morphine use in contrast to the placebo group. The PENG group had a shorter time to ambulation and a greater distance covered on their first attempt at walking, both of which contributed to more rapid discharge from the hospital. As regard complication the study showed that complications were similar between both groups.

The maximum pain scores of patients receiving PENG block were lower than those of the placebo group throughout the first 48 hours postoperatively, as shown in a study comparing repercussions of (PENG) block versus no block on postoperative analgesia and functional recovery after total hip replacement by Pascarella *et al*., 2021 [19]. In addition, all patients in the placebo group took sufentanil pills, but 10% of patients (33%) in the PENG group did not, with significant reduction in opioid consumption than control group. Moreover, Initial Requirement Time for rescue analgesia was significantly increase in PENG group in contrast to placebo group.

Furthermore, there was no motor block or quadriceps muscle weakness postoperatively in both groups. But PENG group had significant shorter time to ambulation (time to first walk) with better scope of hip motion in contrast to control group. Lastly, there was no variance in the incidence of postoperative complication.

Also, Aliste *et al*. 2021 [20] compared PENG block with suprainguinal (FICB) for total hip arthroplasty. A prospective randomized double-blind study was conducted on forty cases (20 patients in each group). It reported that the static and dynamic pain scores were comparable in both groups 48 hr. postoperatively. Also compared were the total amount of opioids used over the course of 24 and 48 hours, as well as the prevalence of any adverse effects caused by the drugs. Nevertheless, compared to supra-inguinal FICB, PENG block resulted in a decreased incidence of quadriceps motor block at three and six hrs post-THA.

Conclusions from a second prospective double-blind randomised trial of fifty-two participants (22 patients

received FICB block and 30 patient received PENG block) Mosaffa *et al*. 2022 [21] proved that the PENG block group saw a considerable decrease in pain scores compared to the FICB group. The overall amount of morphine used in 24 hrs was much lower in the PENG block in contrast to the FICB group, and the initial time of rescue analgesia was also significantly longer in the PENG block. In addition, there were no discernible variations in adverse events among the 2 groups.

Furthermore, Güllüpınar *et al*. 2022 [22] compared PENG block with conventional analgesic therapy for pain control in hip fractures. A prospective randomized study was carried out on forty-two cases with (eighteen cases in the PENG group, twenty-one cases in the control group). It demonstrated that NRS scores were significantly reduced both at rest and in passive motion after PENG block compared with control group. Also, it can be an ideal regional anesthesia technique for emergency physicians due to its effective analgesia, rapid performance, distance from risky areas, and motor function protective properties.

Zheng *et al*. 2022 [23] and Lin *et al*. 2022 [24] found no significant variance among total hip arthroplasty patients who had an intra-articular local anaesthetic injection and those who received a placebo injection (20 ml saline) when they compared the two methods. Cases in the PENG group had noticeably lower pain levels than those in the control group during recuperation, however this difference disappeared after patients were sent home. Postoperative resting pain levels were comparable among the 2 groups. The authors investigated PENG in combination with intra-articular injections of local anaesthetic, a common method of pain management following major joint arthroplasty, which explains why their findings differ from ours. No major disparity can be found in the time it takes each group to begin their initial round of mobilisation. These assessments were performed on postoperative day 1, long after the analgesic effects of the PENG block had worn off. The PENG group, on the other hand, showed no difference in motor function or quadriceps muscle strength among the active treatment and the sham treatment.

Table 1: Demographic data.

		Group I (n = 30)	Group II (n = 30)	P value
Age (years)	Range	44 - 61	42 - 65	0.538
	Mean ± SD	52.47 ±5.64	53.5 ±7.17	
Sex (M/F)	Male	12 (40%)	14 (47%)	0.602
	Female	18 (60%)	16 (53%)	
BN1I (kg//m^2)	Range	23.3-34.8	23.0-34.9	0.799
	Mean ± SD	30.08 ±3.86	29.84 ± 3.38	
ASA physical status	ASA I	6 (20%)	7 (23.3%)	0.870
	ASA II	14 (46.6%)	12 (40%)	
	ASA II	10 (33.3%)	11 (36.6%)	
Duration of surgery (min)	Range	90-140	98-128	0.147
	Mean ± SD	117.4±13.51	113.0 ±9.24	

ASA: American Society of Anesthesiologist, BMI: body mass index
Group I (control group): 30 patients received sham PENG block
Group II (PENG group): 30 patients received real PENG block

Table 3: Shows the time form to rehabilitation (hours)

	The time form to rehabilitation (Hours)							
	Ability to sit		Ability to stand		Ability to walk		Ability to do active exercise	
	Group I	Group II	Group I	Group II	Group I	Group II	Group I	Group II
Range	4-S	3-6	8-16	6-12	14-26	10-20	45-90	39-51
Mean	5.26	4.57	10.56	6.97	15_03	12.23	60.1	61.4
±SD.	123	1.07	1.16	1.18	338	227	12A7	10.07
(p)	(0.262)		(0.003)		(0.042')		(0.093)	

*: Statistically significant at $p \leq 0.05$

Table 3: Two groups were compared in this study according to undesirable side effects

	Undesirable side effects							
	Nausea, vomiting		Bradycardia		Hypotension		Respirators depression	
	Group I	Group II	Group I	Group II	Group I	Group II	Group I	Group II
No	18 (60.0%) 26	26 (86.7%)	26 (86.7%)	27 (90.0%)	25 (83.3%)	28 (93.3%)	29 (96.7%)	30 (100%)
Yes	12 (40.0%)	4 (13.3%)	4 (13.3%)	3 (10.0%)	5 (16.7%)	2 (6.7%)	1(3.3%)	0 (0.0%)
(p)	(0.020')		(0.694)		(0.235)		(p=0.321)	

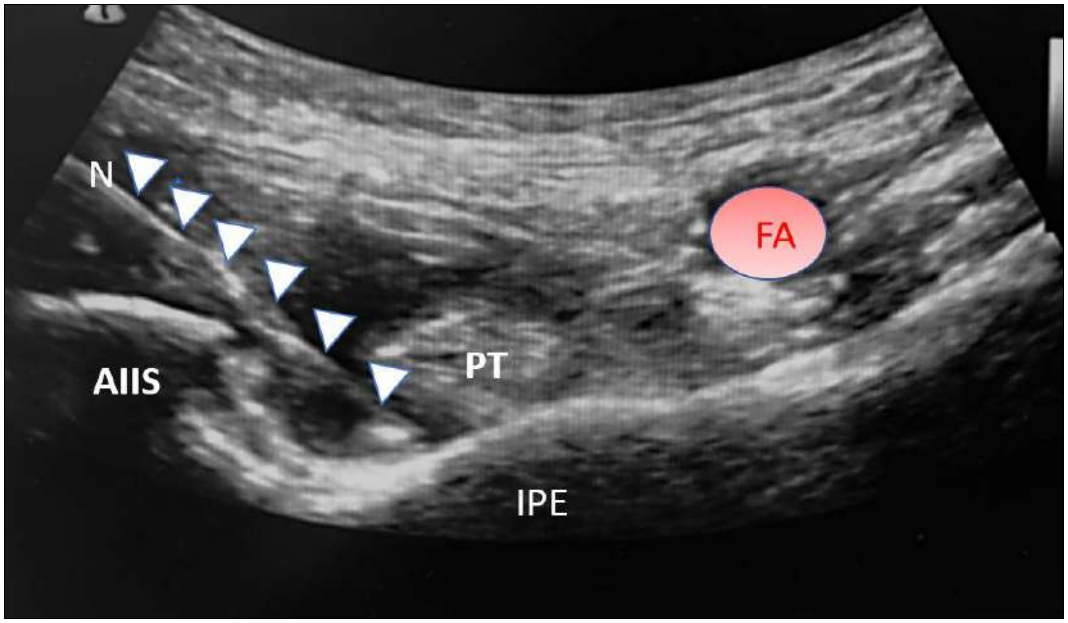

Fig 1: PENG block after needle insertion. AIIS: anterior inferior iliac spine, PT: psoas tendon, IPE: iliopubic eminence, FA: femoral artery, N: needle, white triangles: needle track.

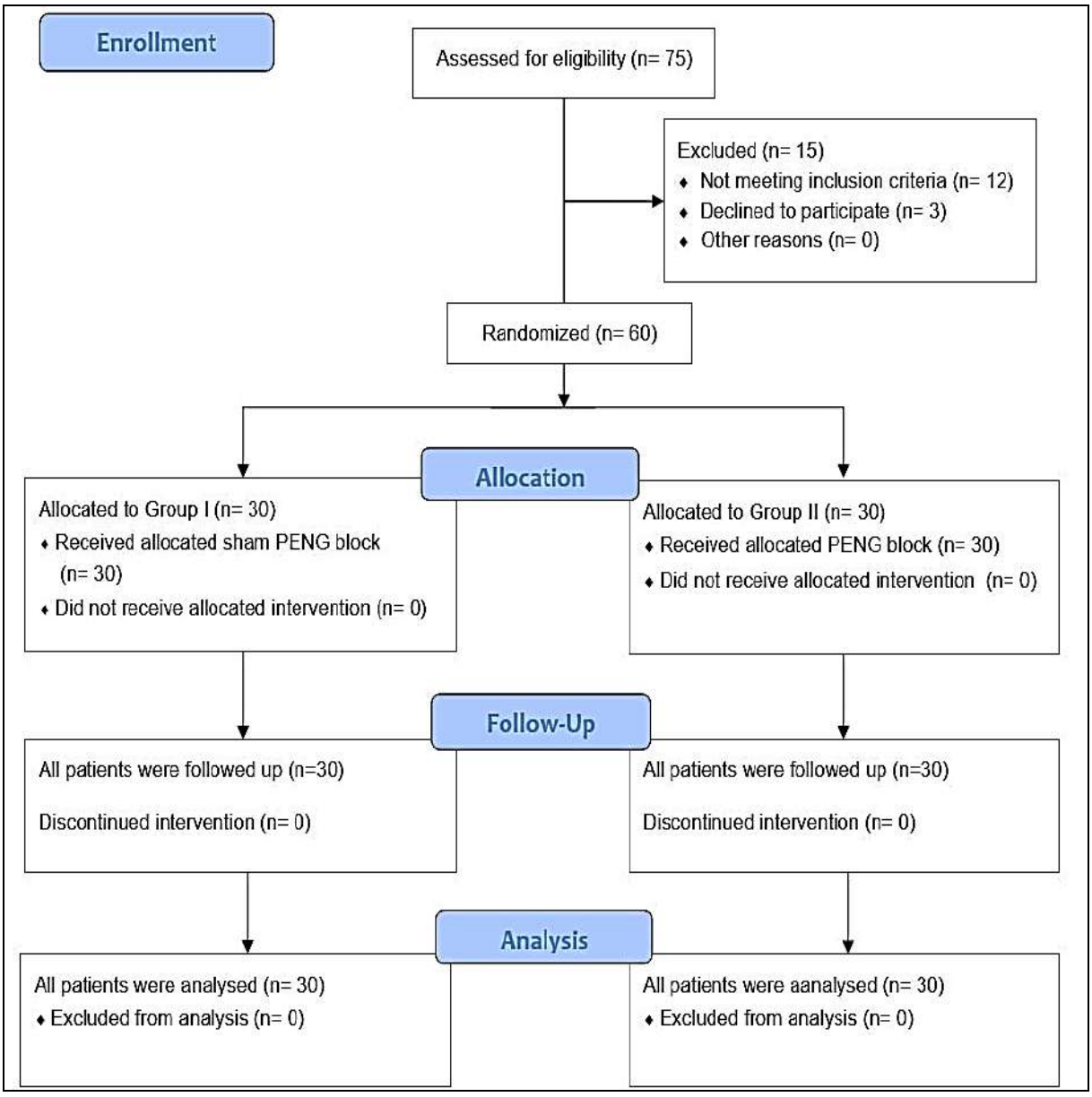

Fig 2: Consort flow diagram of participants through each stage of the randomized trial.

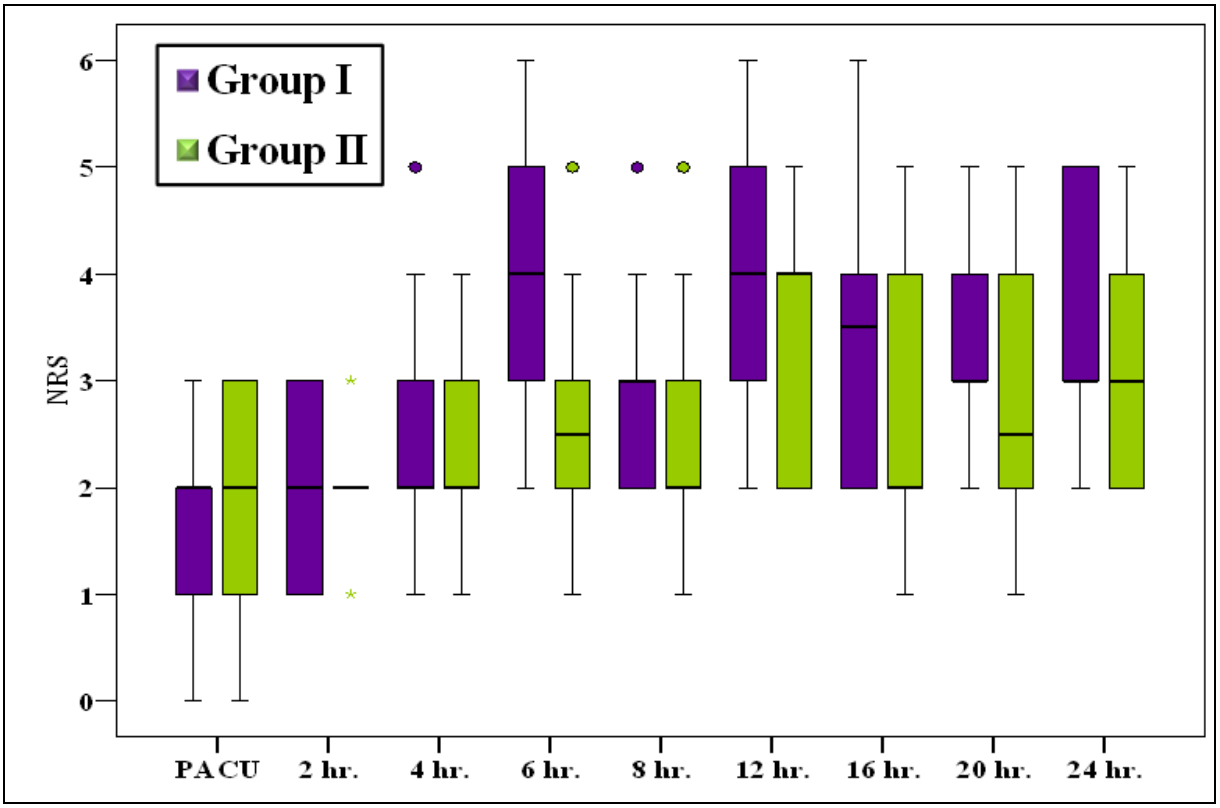

Fig 3: Comparison between the two studied groups according to NRS

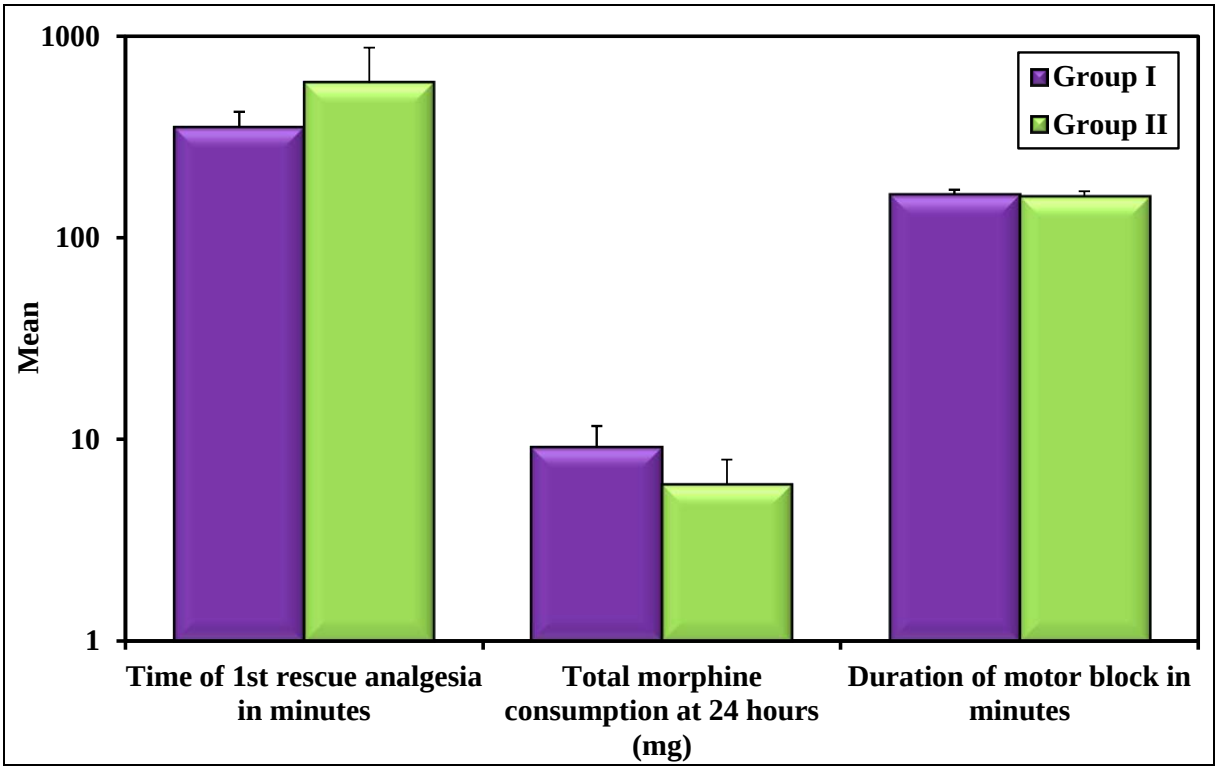

Fig 4: Comparison between the two studied groups according to time of 1st rescue analgesia in minutes, total morphine consumption at 24 hours (mg) and duration of motor block in minutes

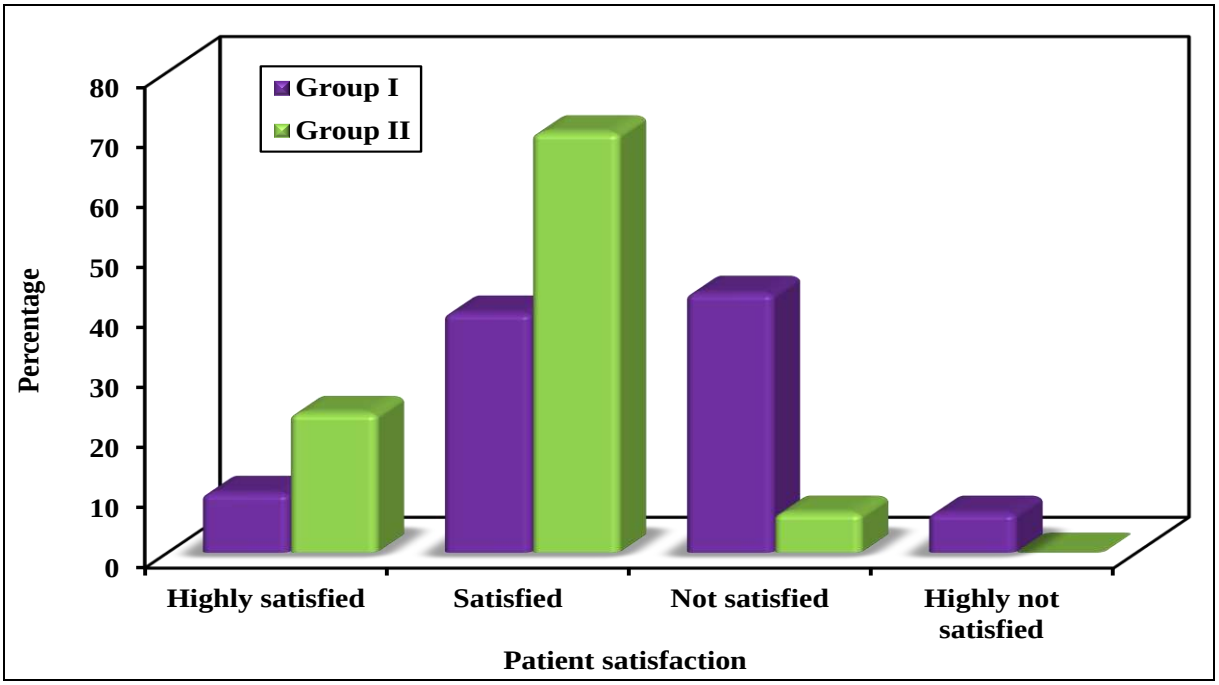

Fig 5: Comparison between the two studied groups according to patient satisfaction

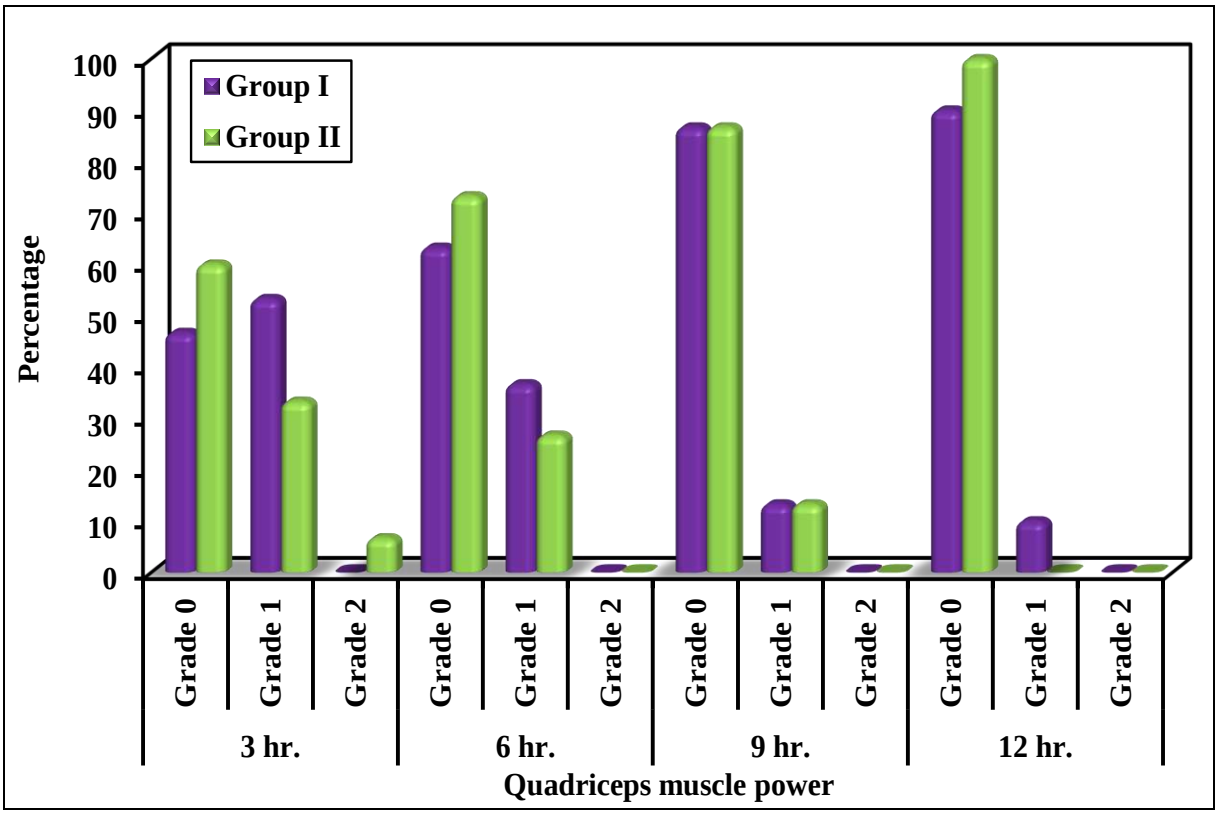

Fig 6: Comparison between the two studied groups according to quadriceps muscle power

Conclusion

The preoperative ultrasound guided PENG block is an efficient tool for postoperative analgesia in cases undergoing total hip arthroplasty as it prolongs time for emergency analgesia., decreases of postoperative overall morphine intake, decreases postoperative pain scores, increases of patient satisfaction without significant effect on motor block or the incidence of complications.

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Conflict of Interest: No competing interests emerged during the implementation of this work

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