Original Article

Comparison of ultrasound-guided erector spinae plane block with ultrasound-guided pericapsular nerve group block for paediatric hip surgery: A randomised, double-blinded study

Address for correspondence:
Dr. Tarek A. H. Mostafa, 1st EL Geish Street, Tanta, Al Gharbia Governate, Postal Code: 31527, Egypt.
Email: Dr.tarek311@yahoo.com

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Tarek A. H. Mostafa, Amany F. Omara, Naglaa K. Khalil
Department of Anesthesiology and Intensive Care, Faculty of Medicine, Tanta University, Tanta, Egypt

ABSTRACT

Background and Aims: Postoperative pain after hip surgeries in children could be classified as severe, requiring combined intra- and postoperative opioid analgesia with regional blocks. This study was carried out to investigate ultrasound-guided pericapsular nerve group (PENG) block versus ultrasound-guided erector spinae plane (ESP) block for pain management after paediatric hip surgery. The primary objective was to assess the time of the first request for morphine rescue analgesia. **Methods:** In this randomised study, 56 children scheduled for elective unilateral hip surgery were distributed randomly to ESP and PENG groups. Intraoperative haemodynamics, fentanyl consumption, postoperative pain measurement, morphine consumption, time of first rescue analgesia, adverse effects and parents' satisfaction score were studied. The primary outcome was the time of the first request for morphine rescue analgesia. The Chi-square test, Student's *t*-test and the Mann–Whitney *U* test were used, where applicable, to compare the groups. **Results:** The time to first rescue analgesia was significantly longer in Group ESP than in Group PENG ($P < 0.001$), with significantly higher postoperative morphine consumption in Group PENG than in Group ESP ($P = 0.04$). The pain scores of Group ESP were lower than those of Group PENG at 2 and 4 h postoperatively ($P = 0.006$ and $P < 0.001$, respectively). At 8 h postoperatively, the score was significantly higher in Group ESP than in Group PENG ($P = 0.005$). Other outcomes were comparable between both groups ($P > 0.05$). **Conclusion:** ESP and PENG could be both effective for intraoperative and postoperative analgesia in paediatric hip surgeries, but the ESP block prolonged the time of first rescue analgesia more than the PENG block.

Keywords: Children, erector spinae plane block, ESP, opioid analgesia, paediatric, pain management, pericapsular nerve group block, PENG, postoperative pain, ultrasound

INTRODUCTION

Postoperative pain due to hip repair surgeries in children is a major concern, requiring opioid analgesia with regional blocks.[1] The most frequently used regional methods in children are neuraxial, particularly caudal and epidural blocks.[2] Regional blocks such as erector spinae plane (ESP) block and pericapsular nerve group (PENG) block in adjuvant with general anaesthesia are alternative perioperative analgesic techniques that lead to lesser side effects, including motor weakness, postoperative nausea and vomiting with decreased opioid consumption.[3] ESP block is an interfascial plane that is situated between the erector spinae muscle (ESM) laterally and the tips of the thoracic transverse processes medially.[4] PENG block is the plane lying between

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the psoas muscle and tendon and the ilio-pubic eminence (IPE).[5,6]

This study was carried out to assess ultrasound-guided PENG block versus ESP block for their efficacy, safety and pain management in paediatric hip surgery. The primary objective was to assess the first-time request for rescue analgesia in patients undergoing hip surgery receiving either PENG or ESP block. The secondary objectives included heart rate (HR), mean arterial blood pressure (MAP), postoperative pain scores, adverse effects and parents' satisfaction. We hypothesised that the ESP and PENG blocks could offer satisfactory perioperative analgesic strategies for hip surgery in children.

METHODS

After approval from the ethics committee of the Faculty of Medicine, Tanta University (approval code: 33765/4/20, dated 5 April 2020), the study was registered on Clinical Trials.gov (ClinicalTrials.gov ID: NCT04373577, dated 28 April 2020, accessible at https://clinicaltrials.gov/study/NCT04373577). The parents of all the recruited children received a full demonstration of the procedure, aims, advantages and potential risks of the research; then, these parents signed the informed consent for participation in the study and use of the patient data for research and educational purposes. The 2013 Declaration of Helsinki and the 2010 Consolidated Standards of Reporting Trials (CONSORT) randomised controlled trial declaration with good clinical practice served as the study's guiding principles. The study started in May 2020 and ended in October 2022.

A randomised, double-blinded study was designed for 56 children of both genders, aged above 1 year, belonging to American Society of Anesthesiologists (ASA) physical status class I–II and scheduled for elective unilateral hip surgery due to hip avascular necrosis, dislocation, dysplasia or fracture. Children diagnosed with neurological, spinal, or coagulation disorders, infections suspected or confirmed to be related to block sites, histories of allergies to local anaesthetics (LAs), bilateral or redo hip surgeries, and parents who refused to participate in the study were excluded.

After preoperative assessment and basic laboratory investigations, the children were premedicated for at least 30 min duration required with oral midazolam 0.5 mg/kg. All children were connected to standard monitoring, and baseline haemodynamics values were recorded. Inhalational induction was done using 4%–8% sevoflurane in 100% oxygen until the patient became unconscious. A peripheral intravenous (IV) line was established using a 22G cannula and an IV infusion of 7 ml/kg dextrose 5% and half normal saline was started. Then, IV propofol 1 mg/kg was given to deepen the anaesthesia level. IV 0.5 mg/kg atracurium was administered, and a suitable-size endotracheal tube was placed. Anaesthesia was maintained with sevoflurane 2% in 50%:50% oxygen to air to preserve a bispectral index between 40 and 60. The incremental IV 0.1 mg/kg atracurium was administrated as a maintenance dose during the procedure. Mechanical ventilation was adjusted with parameters to maintain end-tidal carbon dioxide between 35 and 40 mmHg.

A randomisation method was formulated using an independent data manager. This data manager allocated the enroled patients to groups depending on a computer-generated randomisation program. This random allocation was introduced in a sealed, numbered, opaque envelope. The investigator measured outcomes, and the patients were blinded to the technique and the method of allocation concealment. An anaesthesiologist performing the blocks did not participate in the study or data analysis. The approach and the allocation concealment method were kept a secret for the patients and the investigator. To ensure that there was no chance of them inadvertently affecting the outcomes, the anaesthesiologist performing the blocks were blinded and did not take part in the trial or data processing. It was unknown to the investigators evaluating the results (effectiveness, adverse effects, etc.) and which technique or intervention each patient underwent. In addition, the patients were oblivious to the approach they were given. To lessen the chance of selection bias, the process of allocating patients to the two groups (Group ESP versus Group PENG) was kept a secret for both patients and researchers. Children were distributed randomly to the ESP and PENG groups (28 patients each).

In Group ESP, the patient was positioned in the lateral position with the surgical side up. After skin preparation, a superficial linear (9–12 MHz) transducer (Philips CX 50 Extreme Edition, Amsterdam, the Netherlands) was positioned at the sacral level in a longitudinal view, about 1–2 cm lateral to the midline. The second lumbar level was marked by computing upwards, starting from the sacrum. After distinguishing the

ESM, the transverse process, and the interfascial plane in between, a 22-gauge, the 50-mm needle was introduced gradually to reach the plane lying deep to ESM in a craniocaudal direction. To avoid intravascular injection, 0.5–1 ml of normal saline was administered to ensure the correct position of the needle. After negative aspiration, 0.5 ml/kg of bupivacaine 0.25% combined with adrenaline 1:200,000 (a maximum dose of 2 mg/kg bupivacaine) was administrated in the interfascial plane. Successful block placement was demonstrated by the craniocaudal hydrodissection of fluid within the erector spinae tissue plane.

In Group PENG, the patient was positioned in a supine position. The anatomical landmarks, including IPE, the iliopsoas muscle and tendon, the femoral artery and vein, and the pectineus muscle, were identified using a 9–12 MHz superficial linear transducer. A lateral to medial in-plane technique was used to insert a 22-gauge, 50-mm needle. After skin preparation, it was injected gently until the needle's tip was positioned at the musculofascial plane, located between the ilio-pubic ramus posteriorly and the psoas tendon anteriorly.

Following negative aspiration to avoid intravascular injection, 0.5–1 ml of normal saline was injected to confirm the correct needle site. A 0.5 ml/kg plain bupivacaine 0.25% was added to adrenaline 1:200,000, and a maximum dose of 2 mg/kg bupivacaine was injected. The prominence of the tendon of the underlying IPE with LA distribution in the medial and lateral directions evidenced a successful block.

The skin incision was allowed 20 min after the LA injection. A haemodynamic response of more than 20% on incision suggested inadequate analgesia and prompted the administration of rescue IV fentanyl analgesia (1 μg/kg). At the end of the surgery, inhalational anaesthesia was terminated. Residual neuromuscular blockade was reversed using IV neostigmine 0.05 mg/kg and atropine 0.02 mg/kg. The patients were transferred to the postoperative care unit. The patients received IV paracetamol 15 mg/kg postoperatively every 6 h.

The time of the first request for morphine rescue analgesia, defined as the interval from the conclusion of the procedure to the first request for rescue analgesia, was the primary outcome. The secondary outcomes were MAP and HR, the number of children who required intraoperative rescue IV fentanyl analgesia (1 μg/kg) (with a haemodynamic response of more than 20% on incision), intraoperative fentanyl and postoperative IV morphine consumption, postoperative pain scores, side effects and parents' satisfaction. MAP and HR were recorded before block performance (baseline), 20 and 30 min after the block and then every 30 min till the surgery ended. The Face, Legs, Activity, Cry, Consolability (FLACC) scale was used to assess postoperative pain.[7] The FLACC score was described as follows: 0 = relaxed and comfortable, 1–3 = mild discomfort, 4–6 = moderate pain and 7–10 = severe discomfort/pain. It was measured before discharge in the recovery unit and 2, 4, 6, 8, 12, 18 and 24 h after surgery. If the pain score was >3, the child was given 0.1 mg/kg of IV morphine (did not exceed 0.3 mg/kg/day) by an anaesthesiology resident who was blinded to group allocation. Parent satisfaction was defined on a 3-point scale. This scale was described as 1 = unsatisfied, 2 = neither satisfied nor unsatisfied, 3 = satisfied. It was measured and recorded at the end of the first postoperative day.

Any perioperative adverse effects, including LA toxicity, bradycardia, hypotension, pruritus, urine retention, localised haematoma, postoperative nausea and vomiting, were noted. Bradycardia was diagnosed according to each child's age-appropriate-HR. Almost 20% lower than the child's resting HR was recognised as bradycardia. Hence, a child's HR of less than 80 beats per minute would usually be deemed bradycardia. A decrease in MAP of more than 20% from the initial value was considered hypotension.

A pilot study was conducted on 10 patients who presented for paediatric elective hip surgery. They were randomly and equally allocated to receive ESP and PENG blocks. These patients were excluded from the final study, and the first time of rescue analgesia (primary outcome) significantly increased to [mean (standard deviation {SD}) =322 (74) min] when ESB was performed, compared to that when PENG was performed [mean (SD) =223 (49.7) min] (P = 0.041). Based upon the results of the pilot study, 23 patients were required in each group to detect a significant difference in the first time of rescue analgesia of at least 75 min at an α value of 0.05 and a 90% power of the study with an allocation ratio of 1:1, as determined using Minitab version 18. Twenty-eight patients were included in each group to compensate for the possibility of discarded cases.

Statistical Package for the Social Sciences Version 24 program (SPSS Inc., Chicago, IL, USA) was used for statistical analysis, and the Kolmogorov–Smirnov and the Shapiro–Wilk tests were used to verify the assumption of normality. Categorical data, including gender, number of children who needed intraoperative rescue analgesia, adverse effects and parents' satisfaction scores, were presented as percentages and numbers and examined using Fisher's exact test or the Chi-square test, as appropriate. An unpaired *t*-test was used to assess parametric and normally distributed data, such as age, weight, operation time, fentanyl and morphine intake, and the first time for rescue analgesia. The results are shown as mean (SD). The pain score assessment was performed using the Mann- Whitney U test, expressed as a median and the interquartile range. The P value < 0.05 was deemed statistically significant.

RESULTS

We recruited 63 children, of whom 56 were eligible for the study, with 28 children randomly allocated to two groups, namely ESP and PENG [Figure 1]. Both groups were comparable in age, gender, body weight and surgery duration [Table 1].

Although the number of children who needed intraoperative rescue analgesia and intraoperative fentanyl consumption was comparable in both groups, the first-time morphine rescue analgesia was significantly longer in Group ESP than in Group PENG. The postoperative morphine consumption was significantly higher in Group PENG ($P = 0.04$). The parents of the children in both groups were satisfied with postoperative analgesia, with no significant difference between them ($P = 0.928$) [Table 2]. FLACC scores of Group ESP were lower than those

Table 1: Demographic data

	Group ESP (*n*=28)	Group PENG (*n*=28)
Age (years), mean (SD)	6.21 (2.01)	5.61 (2.06)
Gender - male/female (*n*)	12/16	17/11
Weight (kg), mean (SD)	28.0 (7.9)	24.7 (8.3)
Duration of surgery (min), mean (SD)	95.4 (10.2)	89.9 (14.3)

Data presented as mean (standard deviation) or numbers. *n*=Number of patients, ESP=Erector spinae plane, PENG=Pericapsular nerve group, SD=Standard deviation

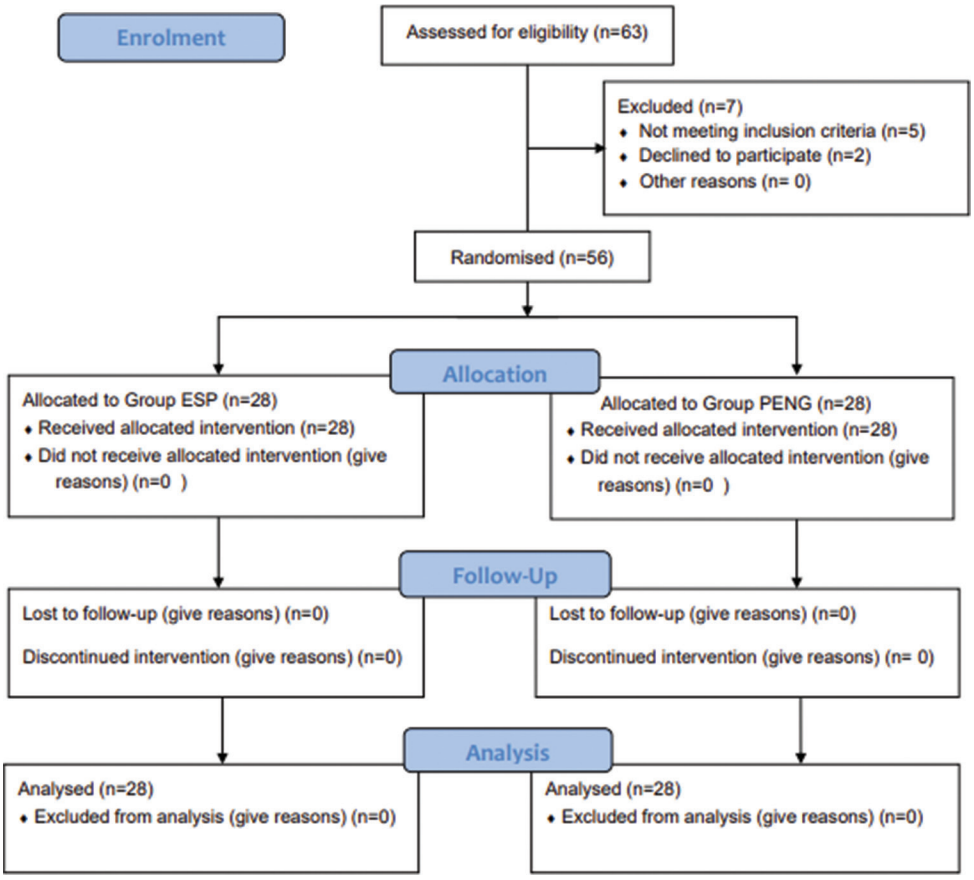

Figure 1: Consolidated Standards of Reporting Trials (CONSORT) flow chart of the studied groups. ESP = erector spinae plane, FLACC = Face, Legs, Activity, Cry, Consolability, PENG = pericapsular nerve group

Table 2: Study parameters in the two groups

	Group ESP (*n*=28)	Group PENG (*n*=28)	*P*
Number of children who needed intraoperative rescue analgesia, *n*	9	8	0.773
Intraoperative fentanyl consumption (μg), mean (SD) [95% CI]	9.57 (14.868) [3.81–15.34]	7.43 (12.662) [2.52–12.34]	0.564
Postoperative morphine consumption (mg), mean (SD) [95% CI]	2.8 (0.79) [2.49–3.10]	3.3 (0.978) [2.92–3.67]	0.040
First rescue analgesia (h), mean (SD) [95% CI]	8.39 (1.641) [7.76–9.03]	6.64 (1.224) [6.17–7.12]	<0.001
Parents' satisfaction score, *n*			
Satisfied	15	14	0.928
Neither satisfied nor unsatisfied	8	10	
Unsatisfied	5	4	
Adverse effects, *n*			
None	24	25	0.989
PONV	1	2	
Pruritus	1	0	
Urinary retention	2	0	
Localised haematoma	0	1	
Local anaesthetic toxicity	0	0	
Bradycardia	0	0	
Hypotension	0	0	

Data presented as mean (standard deviation) [95% confidence interval] or numbers. *n*=Number of patients, CI=Confidence interval, ESP=Erector spinae plane, PENG=Pericapsular nerve group, PONV=Postoperative nausea and vomiting, SD=Standard deviation

of Group PENG at 2 and 4 h postoperatively. At 8 h postoperatively, the scores were significantly higher in Group ESP than in Group PENG. The comparisons of FLACC scores between both groups were statistically insignificant in the recovery room at 6, 12, 18, and 24 postoperative hours, as in Table 3.

Regarding intraoperative HR and MAP measurements, both groups had statistically insignificant differences at all recorded times [Figures 2 and 3]. Incidence of adverse effects, including postoperative nausea, vomiting, hypotension and bradycardia, pruritus, urinary retention, localised haematoma and LA toxicity, was not different between both groups [Table 2].

Table 3: Postoperative pain score (FLACC score)

Time of recording	Group ESP (*n*=28)	Group PENG (*n*=28)	*P*
Recovery room	1 (0, 2)	1 (1, 2)	0.265
2 h	1 (0, 1)	1 (1, 2)	0.006
4 h	1 (1, 2)	2.5 (2, 3)	<0.001
6 h	3 (3, 3)	4 (2, 4)	0.075
8 h	4 (3, 4)	3 (2, 4)	0.005
12 h	3 (2, 3)	2 (2, 3)	0.132
18 h	2 (2, 3)	2 (2, 3)	0.180
24 h	3 (2, 3)	2.5 (2, 3)	0.721

Data presented as median (Q1, Q3). *n*=Number of patients, ESP=Erector spinae plane, FLACC=Face, Legs, Activity, Cry=Consolability, PENG=Pericapsular nerve group, h=Hour

DISCUSSION

We observed that the first-time morphine rescue analgesia was significantly longer in Group ESP than in Group PENG. The postoperative morphine consumption was significantly higher in Group PENG than in Group ESP.

Studies examining the roles of PENG and ESP blocks for postoperative analgesia following surgeries other than those of the lower limbs, in comparison with other regional blocks such as lumbar plexus block, lumbar epidural, caudal block, femoral nerve block, sciatic nerve block, fascia iliaca block, or obturator nerve block with their lower limb weakness.[8,9] These studies did not report lower limb weakness with ESP and PENG.

The results of this study showed that Group ESP experienced rescue analgesia for a significantly longer period than Group PENG, and they also showed a significant decrease in postoperative opioid consumption and a significantly lower FLACC score. Group PENG, with the shorter time of first rescue analgesia (6 h) compared to Group ESP, led to greater postoperative pain scores of Group ESP at 8 h than those of Group PENG, but the pain scores of both groups still did not exceed the FLACC score 4. However, there was no significant difference in intraoperative opioid consumption. Other outcomes were comparable between both groups.

Many case reports reported that ESP block had good analgesia after paediatric pelvic operations.[10-13] In addition, Holland and Bosenberg's[14] systematic review used HR rise in reaction to a skin incision to gauge the intraoperative effectiveness of ESP block in children. They only noted a 10% rise in HR at the moment of incision. These results about the intraoperative analgesic

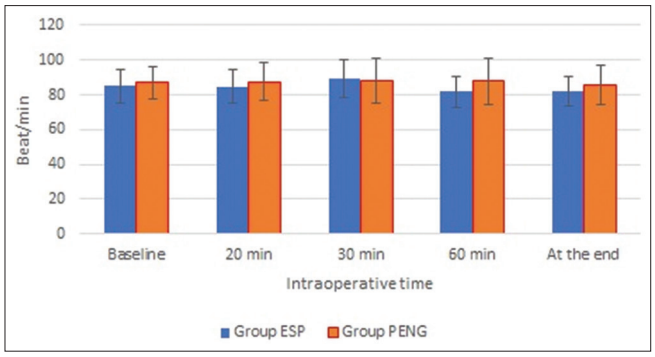

Figure 2: Heart rate among patients in the studied groups. ESP = erector spinae plane, HR = heart rate, PENG = pericapsular nerve group

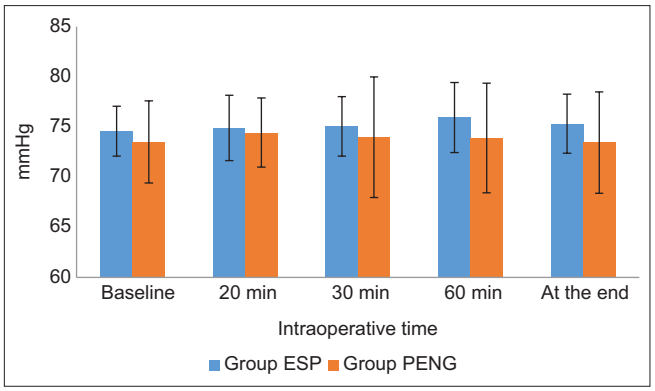

Figure 3: Mean arterial blood pressures among patients in the studied groups. ESP = erector spinae plane, MAP = mean arterial blood pressure, PENG = pericapsular nerve group

effectiveness of regional blocks in paediatric patients supported ESP and PENG's intraoperative analgesia in paediatric hip surgery. Moreover, the current results are in agreement with Abdelrazik *et al*.,[15] who recorded that the postoperative FLACC score was lower in the ESP block than in the caudal block in paediatric lower abdominal surgery. Mostafa *et al*.[16] concluded that ESP block was an effective analgesic block for open paediatric midline splenectomy with lower postoperative pain scores and intraoperative fentanyl intake. Following Abduallah *et al*.'s results,[17] this study recorded that ESP blocks for paediatric hip surgeries could result in a longer first request for postoperative analgesia, minimising intraoperative fentanyl and postoperative morphine consumption and pain measurements. This research did not observe a change in the frequency of adverse effects and the level of parental satisfaction. Similarly, Mysore *et al*.[18] found that in patients who underwent total hip arthroplasty surgery, hydromorphone consumption at 24 h postoperatively was less in patients receiving PENG blocks.

Numerous case reports supported the performance of PENG block in paediatric hip surgeries, and their findings followed our study results. Xu *et al*.,[19] Anido Guzmán *et al*.,[20] Orozco *et al*.[21] and Wyatt *et al*.[22] believed that the PENG block could be a selective and sensory regional block for hip surgeries.

The limited sample size of the study was one of the study limitations. Single-centre research and the rarity of studies, particularly randomised controlled studies, comparing the various regional blocks utilised for paediatric hip operations were the causes of this shortcoming. In addition, the motor block in our study could not be assessed postoperatively due to immobilisation by spica casting for six weeks in all patients. This is considered the gold standard after hip surgeries to avoid secondary dislocation, especially in patients with spasticity.

CONCLUSION

The ESP block for paediatric hip surgery could provide a longer first request duration for postoperative rescue analgesia with lower postoperative rescue morphine analgesia than the PENG block. Both blocks provided adequate intraoperative analgesia, showed comparable postoperative side effects and resulted in comparable parents' satisfaction.

Study data availability

De-identified data may be requested from the authors (send an email to the corresponding author) with appropriate justification, and it will be released upon permission under the authors' institution policy.

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Conflicts of interest

There are no conflicts of interest.

ORCID

Tarek Abdel-Hay Mostafa: https://orcid.org/0000-0002-8437-6595

Amany Faheem Omara: https://orcid.org/0000-0002-9025-632X

Naglaa Khalil Khalil: https://orcid.org/0000-0002-4653-5831

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