ORIGINAL ARTICLE
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UDC: 617.581-053.9:616.8-009.7-08
DOI: https://doi.org/10.2298/VSP220429002Z

Analgesic effect of pericapsular nerve group block on elderly patients undergoing hip replacement

Analgetski efekat blokade grupe perikapsularnih nerava kod starijih osoba koje su podvrgnute zameni kuka

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Abstract

Background/Aim. Pericapsular nerve group block (PNGB) does not affect the motor nerve while blocking the obturator and femoral nerves. The aim of the study was to determine the application value of PNGB for hip replacement in the elderly. **Methods.** Ninety elderly patients who underwent hip replacement from March 2019 to October 2020 were randomly divided into the fascia iliaca compartment block (FICB) group and the PNGB group. FICB and PNGB were performed prior to subarachnoid block (SAB). Their baseline data, operation conditions, incidence of adverse reactions, visual analog scale (VAS) score, heart rate (HR), mean arterial pressure (MAP), plasma cortisol (COR), and epinephrine (E) levels were compared. **Results.** VAS score, E, and plasma COR levels in the PNGB group were lower than those in the FICB group at time points T_2–T_4 (T_2: 10 min after nerve block; T_3: at position changing; T_4: after position changing) ($p < 0.001$). There were no significant differences in HR and MAP between the two groups at any time point ($p > 0.05$). In the PNGB group, the ultrasonic imaging time was shorter, the time point of pressing patient-controlled analgesia (PCA) for the first time was later, and the numbers of pressing PCA were fewer than those of the FICB group ($p < 0.001$). No local anesthetic poisoning took place after the nerve block, and no hematoma at the puncture site, nerve injury, nausea and vomiting, dizziness, or delirium occurred. **Conclusion.** Both FICB and PNGB prior to SAB were highly safe for hip replacement in the elderly; however, PNGB has shorter ultrasonic imaging time, better analgesic effect, and milder oxidative stress, so it is worth applying it clinically.

Key words:
aged; analgesia; anesthesia, conduction; arthroplasty, replacement, hip; methods.

Apstrakt

Uvod/Cilj. Blokada grupe perikapsularnih nerava (BGPN) ne utiče na motorni nerv a blokira opturatorne i femoralne nerve. Cilj rada bio je da se utvrdi vrednost primene BGPN tokom zamene kuka kod starijih osoba. **Metode**. Ukupno 90 starijih osoba, podvrgnutih zameni kuka od marta 2019. do oktobra 2020, nasumično su podeljene u grupu bolesnika kojima je izvršena blokada odeljka ilijačne fascije (BOIF) i grupu onih kojima je izvršena BGPN. BOIF i BGPN izvedene su pre subarahnoidnog bloka (SAB). Upoređivani su osnovni podaci bolesnika, uslovi operacije, incidenca neželjenih reakcija, skor na vizuelnoj analognoj skali (VAS), brzina otkucaja srca (BOS), srednji arterijski pritisak (SAP), nivoi kortizola u plazmi (KOP) i epinefrina (E). **Rezultati.** Skor VAS, nivoi E i KOP bili su niži kod bolesnika u grupi BGPN nego u grupi BOIF, u vremenskim terminima T_2–T_4 (T_2: 10 min posle bloka nerva; T_3: pri promeni položaja; T_4: posle promene položaja) ($p < 0{,}001$). Nije bilo značajnih razlika u vrednostima BOS i SAP između dve grupe ispitanika ni u jednoj od vremenskih tačaka ($p > 0{,}05$). U grupi BGPN, vreme ultrazvučnog snimanja bilo je kraće, moment u kome je prvi put korišćena analgezije koju kontroliše bolesnik (*patient controlled analgesia* – PCA) se desio kasnije, a broj korišćenja PCA bio je manji u poređenju sa grupom BOIF ($p < 0{,}001$). Nakon blokade nerva nije došlo do toksičnog efekta lokalne anestezije, ni do stvaranja hematoma na mestu uboda, povrede nerva, mučnine i povraćanja, vrtoglavice i delirijuma. **Zaključak.** I BOIF i BGPN primenjeni pre SAB-a bili su veoma bezbedni tokom procesa zamene kuka kod starijih osoba, ali BPGN ima kraće vreme ultrazvučnog snimanja, bolji analgetički efekat i blaži oksidativni stres, stoga ga vredi primeniti klinički.

Ključne reči:
stare osobe; analgezija; anestezija, provodna; kuk, artroplastika; metode.

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Introduction

Severe pain occurs following hip fractures, especially during early repositioning and examinations [1]. Therefore, minimizing this pain is of great significance for improving patients' comfort and reducing their morbidity and mortality rates. For these patients, oral administration or intravenous infusion of nonsteroidal analgesics is often performed during preoperative hospitalization, which increases the incidence rate of adverse reactions such as dizziness and nausea [2]. In severe cases, some patients may suffer from gastrointestinal bleeding and renal function impairment.

Intraspinal anesthesia is a preferred anesthesia method recommended in the Guidelines on Anesthesia and Perioperative Management of Elderly Hip Fracture Patients in China in the case of no contraindications [3]. However, when the patient is placed in a lateral position before a spinal puncture, the pain can be aggravating, thus increasing cardiovascular risk. Therefore, fascia iliaca compartment block (FICB) can be performed on the affected side before positioning the patient. It was later found in clinical practice that FICB has insufficient analgesia on the medial hip joint due to insufficiency of obturator nerve block, resulting in pain during position changing [4, 5]. Pericapsular nerve group block (PNGB) does not affect the motor nerve while blocking the obturator nerve and femoral nerve [6, 7]. Currently, there are few reports on the application value of PNGB combined with subarachnoid block (SAB) in the elderly with hip replacement.

In this study, the analgesic effect and safety of FICB and PNGB were compared among elderly patients undergoing hip replacement, aiming to provide a basis for clinical application.

Methods

Subjects

This prospective study included a total of 90 elderly patients undergoing a hip replacement in Puren Hospital (Wuhan, China) from March 2019 to October 2020. All included patients were selected and divided into the FICB group (n = 45) and PNGB group (n = 45) using a random number table. Inclusion criteria were as follows: 1) patients aged 65–85 years; 2) patients undergoing unilateral hip replacement for the first time; 3) patients with an American Society of Anesthesiologists (ASA) standard classification of I–II; 4) patients with a preoperative mini-mental state examination (MMSE) score above 24 points; 5) patients with complete clinical medical records; 6) patients with preoperative pain; 7) patients who voluntarily participated and whose families were informed. Exclusion criteria were as follows: 1) patients with coagulation dysfunction or other blood system diseases; 2) patients with severe organ dysfunction, tumor, or serious systemic infectious diseases difficult to be controlled; 3) patients with mental or neurological diseases, communication disorders, cognitive or sleep disorders; 4) patients with a history of chronic pain or long-term use of opioids; 5) patients with poor control of chronic diseases; 6) patients allergic to the drugs used in this study; 7) patients unable to tolerate anesthesia or surgery due to other reasons. This study was reviewed and approved by the Medical Ethics Committee of Puren Hospital (approval No. 20190211004, from March 4, 2019).

Anesthesia methods

Before the operation, all patients were deprived of food and water according to the hospital protocol, and no medication was given. After the patient entered the operating room, the changes in vital signs were routinely monitored by electrocardiography, and peripheral venous access was made. The ultrasound-guided nerve block and subarachnoid anesthesia were performed by the same experienced anesthesiologist.

In the FICB group, while in a supine position, the patient was routinely draped. A line was made between the anterior superior iliac spine and the pubic tubercle, and 2 cm away from the mid-lateral, one-third of the line was selected as the puncture point and disinfected. The 5–13 MHz high-frequency linear array probe covered with a sterile lens jacket and placed parallel to and below the inguinal ligament was used to identify the femoral artery and iliac muscle, and then it was moved outward to the mid-lateral inguinal ligament. After the fascia iliaca image was observed, a bevel-shaped puncture needle (type D, 22 G, 0.71 mm × 80.00 mm) was inserted at an angle of 30–50° and 1 cm above the inguinal ligament, and the needle tip reached the upper iliopsoas in the fascia iliaca compartment through the in-plane puncture technique. Then, 30 mL of 0.25% ropivacaine (Qingyuan Jiabo Pharmaceutical Co., Ltd., China, 2019) was slowly injected after no blood and gas were withdrawn.

In the PNGB group, the patient was routinely draped and disinfected around the puncture point in a supine position. The 5–13 MHz low-frequency convex array probe covered with a sterile lens jacket and placed parallel to the inguinal ligament and slightly above the femoral head was used to identify the iliac crest eminence, anterior inferior spine, pectineal muscle, femoral artery, iliopsoas muscle and its tendons. Then a bevel-shaped puncture needle (type D, 22 G, 0.71 mm × 120.00 mm) was inserted from the lateral to the medial side of the skin 1 cm outside the long axis of the ultrasonic probe; the needle tip was guided onto the musculofascial plane between the posterior pubic branch and the rear of psoas major tendon through the in-plane puncture technique. Then, 30 mL of 0.25% ropivacaine was slowly injected after no blood and gas were withdrawn. During puncture, the movement of the puncture needle should be noticed to avoid damage to the organs. In addition, to avoid local anesthetic poisoning, the presence of blood return should be repeatedly observed during injection.

At 15 min after the block, 2% lidocaine (Jumpcan Pharmaceutical Group Co., Ltd., China, 2019) was used for local infiltration at the optimal space below L_2 in a lateral position with the affected limb upward, and 2.5–3.0 mL of hypobaric local anesthetic solution (2 mL of sterile water for injection containing 1 mL of 1% ropivacaine, self-prepared) was injected into the subarachnoid space. After the operation, patient-controlled analgesia (PCA) was applied to all patients: 10 mg of tropisetron (Beijing Wellso Pharmaceutical Co., Ltd., China, 2019) and 100 μg of sufentanil (Yichang Renfu Pharmaceutical Industry, China, 2019) were diluted with normal sa-line to 100 mL, the background infusion rate was 2 mL/h, and the patient-controlled dose was 2 mL/time. PCA was locked for 15 min and withdrawn after 48 hrs.

Surgical method of hip replacement

Articular Surface Replacement XL (ASRTMXL) large-diameter metal-to-metal total hip replacement prosthesis (DePuy, Warsaw, USA, 2018) was used. The diameter of the femoral head was 39–63 mm, and the acetabulum had a sub-hemispheric, microporous/hydroxyapatite double-coated design, which was conducive to early fixation and bone in-growth. Corail femoral stems (DePuy, Warsaw, USA, 2018) were fully hydroxyapatite-coated and bio-type titanium alloy tapered. Summit femoral stems (DePuy, Warsaw, USA, 2018) were microporous/hydroxyapatite double-coated, proximally fixed, and bio-type titanium alloy tapered.

After successful anesthesia, an incision of about 12 cm was made, extended 5 cm outward from the lateral femur at the position between the greater trochanter and mid-lateral 1/3 of the line connecting the posterior superior iliac spine to the greater trochanter. The femoral neck was sawed off at 2 cm above the lesser trochanter, and the surrounding related ligaments and joint capsules were cut off. Then the femoral head was taken out, and the stump was reamed repeatedly. Finally, the acetabular prosthesis was placed.

Observation indices

The baseline data of patients, operation conditions, and incidence of adverse reactions were recorded.

The visual analog scale (VAS) score was given before nerve block (T_1), at 10 min after nerve block (T_2), at the time of position changing (T_3), and after position changing (T_4). The scoring system was – 0 points: no pain; ≤ 3 points: mild pain that can be tolerated; 4–6 points: pain affecting sleep; 7–10 points: severe pain that cannot be tolerated. The patient chose a number from 0 to 10 to represent their own pain degree. The higher the score, the more severe the pain.

At T_1, T_2, T_3, and T_4, the hemodynamic indices, heart rate (HR), and mean arterial pressure (MAP) were recorded.

At T_1, T_2, T_3, and T_4, the blood was drawn from the median cubital vein without receiving an intravenous injection, and plasma cortisol (COR) and epinephrine (E) were detected using a UniCel DXI800 automatic chemiluminescence immunoassay analyzer (Beckman Coulter, USA).

Statistical analysis

The experimental data were statistically analyzed using the SPSS 16.00 software (IBM Inc., USA, 2018). The count data were expressed as numbers (percentages) and compared by the chi-squared (χ^2) test. All measurement data were subjected to the homogeneity of variance and normal distribution tests, and the normally distributed data were expressed as mean ± standard deviation (SD). First, repeated measures analysis of variance was used to analyze the difference between the two groups and the time difference of each measured value. If there was a difference, the least significant difference (LSD)-*t*-test was further employed to compare the intergroup difference at each time point, and Newman-Keuls or Student-Newman-Keuls (SNK)-q-test was used to compare the time difference in each group. The value of $p < 0.05$ suggested a statistically significant difference.

Results

Baseline clinical data

There were no statistically significant differences in age, height, weight, gender ratio, chronic diseases, ASA grade, surgical site, and primary diseases between the two groups ($p > 0.05$) (Table 1).

Table 1

Baseline clinical data

Group	FICB (n = 45)	PNGB (n = 45)	t/χ^2	*p*
Age (years)	71.98 ± 5.84	72.46 ± 6.03	0.384	0.702
Height (cm)	165.12 ± 8.39	164.89 ± 8.27	0.131	0.896
Weight (kg)	54.73 ± 7.68	55.24 ± 7.79	0.313	0.755
Male	20 (44.4)	17 (37.78)	0.413	0.52
Female	25 (55.5)	28 (62.2)		
Chronic disease				
arrhythmia	16 (35.56)	19 (42.22)	0.421	0.517
hypertension	26 (57.78)	24 (53.33)	0.18	0.671
coronary heart disease	10 (22.22)	8 (17.78)	0.278	0.598
ASA grade				
I	34 (75.56)	37 (82.22)	0.6	0.438
II	11 (24.44)	8 (17.78)		
Surgical site				
left	20 (44.44)	22 (48.89)	0.179	0.673
right	25 (55.56)	23 (51.11)		
Primary disease				
femoral head necrosis	18 (40.00)	21 (46.67)		
osteoarthritis	14 (31.11)	12 (26.67)	0.425	0.809
coxitis	13 (28.89)	12 (26.67)		

Intergroup comparisons of measurement data: least significant difference (LSD)-*t*-test; intergroup comparisons of count data: χ^2 test.
FICB – fascia iliaca compartment block; PNGB – pericapsular nerve group block.
All values are expressed as mean ± standard deviation or numbers (percentages).

VAS scores

The VAS score had no statistically significant difference between the two groups at T_1 ($p > 0.05$), while it was lower in the PNGB group than that in the FICB group at T_2–T_4 ($p < 0.001$). The VAS score declined at T_2, rose at T_3, and dropped again at T_4 in the two groups, and the difference was statistically significant between any two adjacent time points ($p < 0.05$) (Table 2).

Hemodynamic indices

No statistically significant differences were found in HR and MAP between the two groups and at each time point ($p > 0.05$) (Table 3).

Stress responses

E and COR had no statistically significant differences between the two groups at T_1 ($p > 0.05$), while they were lower in the PNGB group than those in the FICB group at T_2–T_4 ($p < 0.001$). E and COR declined at T_2, rose at T_3, and dropped again at T_4 in the two groups, and the differences were statistically significant between any two adjacent time points ($p < 0.001$) (Table 4).

Operation conditions

There were no statistically significant differences between the two groups concerning the duration of puncture injection, operation time, and recovery time ($p > 0.05$). In the PNGB group, the ultrasonic imaging time was shorter, the time point of pressing PCA for the first time was later, and the numbers of pressing PCA were fewer, with statistically significant differences compared with the FICB group ($p < 0.001$) (Table 5).

Adverse reactions

No local anesthetic poisoning took place in either of the groups after the nerve block, and no hematoma at the puncture site, nerve injury, nausea and vomiting, dizziness, or delirium occurred after the operation.

Table 2

Visual analog scale (VAS) scores at different time points (T_1–T_4)

Group	T_1	T_2	T_3	T_4
FICB	5.71 ± 0.63	1.46 ± 0.52*	2.39 ± 0.75*#	1.58 ± 0.61*a
PNGB	5.83 ± 0.67	0.29 ± 0.14*	1.17 ± 0.38*#	0.35 ± 0.17*a
t	0.875	14.574	9.734	13.030
p	0.384	< 0.001	< 0.001	< 0.001

T_1 – VAS score before nerve block; T_2 – VAS score at 10 min after nerve block; T_3 – VAS score at the time of position changing; T_4 – VAS score after position changing. For other abbreviations, see Table 1.

*** $p < 0.05$ vs. T_1; # $p < 0.05$ vs. T_2; a $p < 0.05$ vs. T_3.**

Number of patients = 90 (two groups of 45 patients).

All values are expressed as mean ± standard deviation.

Table 3

Hemodynamic indices at different time points (T_1–T_4)

Group	Heart rate (beats/min)				Mean arterial pressure (mmHg)			
	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
FICB	79.85 ± 14.56	76.37 ± 14.11	82.05 ± 15.86	78.24 ± 15.39	110.46 ± 13.82	105.27 ± 12.36	108.64 ± 13.12	106.53 ± 12.78
PNGB	80.24 ± 15.07	77.04 ± 14.25	79.68 ± 14.73	77.81 ± 14.56	109.78 ± 13.27	104.61 ± 12.05	107.59 ± 12.74	105.48 ± 12.16
t	0.125	0.224	0.735	0.136	0.238	0.256	0.385	0.399
p	0.901	0.823	0.465	0.892	0.812	0.798	0.701	0.691

For abbreviations see Tables 1 and 2.

Number of patients = 90 (two groups of 45 patients). All values are expressed as mean ± standard deviation.

Table 4

Stress responses at different time points (T_1–T_4)

Group	Epinephrine (ng/mL)				Cortisol (pg/mL)			
	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
FICB	58.37 ± 6.53	39.41 ± 4.86*	45.62 ± 5.47*#	40.39 ± 5.12*a	201.45 ± 21.67	163.58 ± 17.49*	187.32 ± 19.83*#	170.68 ± 17.92*a
PNGB	60.12 ± 6.69	31.25 ± 4.34*	37.78 ± 4.93*#	33.26 ± 4.48*a	198.76 ± 20.85	132.37 ± 14.28*	159.61 ± 16.07*#	137.45 ± 14.53*a
t	1.256	8.401	7.142	7.030	0.600	9.272	7.283	9.662
p	0.213	< 0.001	< 0.001	< 0.001	0.550	< 0.001	< 0.001	< 0.001

For abbreviations see Tables 1 and 2. * $p < 0.05$ vs. T_1; # $p < 0.05$ vs. T_2; a $p < 0.05$ vs. T_3.

Number of patients = 90 (two groups of 45 patients). All values are expressed as mean ± standard deviation.

Table 5

Operation conditions at different time points (T_1–T_4)

Group	Ultrasonic imaging time (s)	Duration of puncture injection (s)	Operation time (min)	Recovery time (min)	Extubation time (min)	Time point of pressing PCA for the first time (h)	Number of pressing PCA
FICB	44.27 ± 9.63	104.39 ± 18.51	135.58 ± 19.72	12.46 ± 2.53	16.75 ± 2.94	11.73 ± 2.25	2.34 ± 0.64
PNGB	23.56 ± 7.82	103.16 ± 17.94	134.02 ± 18.96	11.85 ± 2.34	15.99 ± 2.86	30.98 ± 4.17	1.61 ± 0.45
t	11.199	0.320	0.383	1.187	1.243	27.253	6.259
P	< 0.001	0.750	0.703	0.238	0.217	< 0.001	< 0.001

PCA – patient controlled analgesia. For other abbreviations, see Tables 1 and 2.
Number of patients = 90 (two groups of 45 patients). All values are expressed as mean ± standard deviation.

Discussion

When there are no contraindications, the Guidelines on Anesthesia and Perioperative Management of Elderly Hip Fracture Patients in China recommend intraspinal anesthesia as the preferred anesthesia method in a completely lateral position; however, hip fracture patients are often unable to position themselves in such a way due to severe pain, thus increasing the difficulty of administering the anesthesia and reducing the success rate [8, 9]. It is reported in the literature that after local anesthetics are injected into the fascia iliaca compartment and diffused, they can simultaneously block the obturator nerve, femoral nerve, and lateral femoral cutaneous nerve, thereby exerting a good analgesic effect. Therefore, it is recommended that FICB be conducted on the affected side before positioning the patient [10, 11]. Girón-Arango et al. [12] anatomized the anterior hip articular capsule carefully and summarized the direction, distribution, and bony landmarks of the hip articular branch from the lumbar nerve branch based on which the latest anatomical research on hip innervation was published, and PNGB for a sensory block on the anterior hip articular capsule was further proposed. On patients with hip pain caused by different factors, 20 mL of local anesthetics had a good effect. Afterward, Tran et al. [13] applied 10 mL of dye solution for PNGB and found that the dye could completely wrap the anterior hip articular capsule. The above studies suggest that PNGB can be performed before positioning the patient receiving intraspinal anesthesia for hip replacement. A certain volume of local anesthetics is required to fully block the large fascia iliaca compartment, so 30 mL of 0.25% ropivacaine was injected in this study to avoid the research results being affected by the amount of anesthetics.

The effective analgesic duration of FICB can be up to 36–48 hrs. However, it has been found that FICB cannot completely block the obturator nerve, so there is often a problem of insufficient analgesia [14–17]. Cui et al. [18] showed that both FICB and PNGB could relieve well the acute early pain of elderly patients with hip fractures, but PNGB took effect quickly and had a better analgesic effect. The above reports were further supported by the results in this study because FICB has an incomplete blocking effect on the obturator nerve. During position changes, the pain was aggravated in the two groups, which is consistent with the study of Xie et al. [19]. Possibly, the posterior hip articular capsule is blocked insufficiently, and the hip fracture end shifts during position changes, stimulating the surrounding muscle tissues. According to the previous data, bradycardia and hypotension can occur when ropivacaine is epidurally injected [20–22]. In this study, HR and MAP fluctuated at each time point but kept certain stability in the two groups, and the possible reason is that only the effects of nerve block on HR and MAP were observed in this study. Moreover, 0.25% ropivacaine was used, which could maintain stable hemodynamics in FICB and PNGB.

Fracture trauma is one of the important causes of oxidative stress. Surgery with greater trauma and severe pain can aggravate the oxidative stress response, which is mainly manifested as the enhancement of COR secretion from the pituitary-adrenal cortex and E secretion from the adrenal medulla [23–25]. In this study, the changes in E and COR at different time points within and between the groups showed that both FICB and PNGB could effectively block the influx of peripheral injury stimuli and inhibit the sympathetic nerve excitement, thereby reducing the secretion of E and COR. On the contrary, the pain during position changing could also cause a certain degree of oxidative stress, thereby enhancing the secretion of E and COR. PNGB exerted a better analgesic effect to reduce the oxidative stress level, being in accordance with previous literature [26, 27]. In this study, the PNGB group had a shorter ultrasonic imaging time because it is easier to distinguish the bony landmarks used for positioning in PNGB. In FICB, the femoral artery is first found below the groin, and then the probe is moved outward and rotated. Moreover, due to loose tissues in elderly patients, the ultrasound image of the fascia iliaca compartment is unclear, so it takes a longer time. In both FICB and PNGB, 0.25% ropivacaine is injected into the nerve trunk to temporarily block the nerve conduction, exerting a regional anesthetic effect without blocking the visceral nerves in the abdominal and pelvic cavities. In addition, the nerve is accurately positioned under ultrasonic guidance without directly affecting the femoral nerve so that the occurrence of postoperative complications is reduced.

Conclusion

In conclusion, both FICB and PNGB have good safety prior to SAB in the elderly undergoing hip replacement; however, PNGB has shorter ultrasonic imaging time, a better analgesic effect, and a lower oxidative stress level, hence it is worthy of clinical popularization and application.

Conflict of interest

The authors declare no conflict of interest.

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Received on April 29, 2022
Revised on December 1, 2022
Accepted on January 4, 2023
Online First January 2023