BMJ Open

Efficacy of pericapsular nerve group (PENG) block on perioperative pain management in elderly patients undergoing hip surgical procedures: a protocol for a systematic review with meta-analysis and trial sequential analysis

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To cite: Zheng J, Du L, Chen G, *et al*. Efficacy of pericapsular nerve group (PENG) block on perioperative pain management in elderly patients undergoing hip surgical procedures: a protocol for a systematic review with meta-analysis and trial sequential analysis. *BMJ Open* 2023;**13**:e065304. doi:10.1136/bmjopen-2022-065304

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online (http://dx.doi.org/10.1136/bmjopen-2022-065304).

Received 31 May 2022
Accepted 28 November 2022

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ABSTRACT

Introduction An increasing number of elderly patients suffer from hip diseases associated with moderate to severe perioperative pain during the accelerating global ageing process. Optimal analgesia can decrease perioperative complications and facilitate elderly patients' perioperative recovery. Pericapsular nerve group (PENG) block is a relatively new, analgesia adequate and motor-sparing block technique for perioperative pain management of hip diseases. However, the efficacy of PENG block remains unclear as the limited clinical evidence. Then, we will perform a protocol for a systematic review and meta-analysis to identify the efficacy of PENG block for perioperative pain management.

Methods and analysis PubMed, Ovid Medline, Cochrane Library, Embase, Web of Science, China National Knowledge Infrastructure, Chinese BioMedical Literature, Wanfang and VIP databases will be searched from inception to August 2022 to identify randomised controlled trials of elderly patients accepting PENG block for hip diseases. The primary outcome will be the pain intensity after pain management. Secondary outcomes will be quadriceps strength, perioperative rescue analgesia information and perioperative complications. Assessment of heterogeneity will be primarily inspected by forest plots. If there is no indication of funnel plot asymmetry, a random-effects meta-analysis will be performed. The Cochrane risk-of-bias tool, Grading of Recommendations Assessment, Development and Evaluation and trial sequential analysis will be conducted to evaluate the evidence quality and control the random errors. Funnel plots and Egger's regression test will be performed to evaluate publication bias.

Ethics and dissemination Ethical approval was not required for this systematic review protocol. The results will be disseminated through peer-reviewed publications.

PROSPERO registration number CRD42022313895

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ Application of Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols guidelines for a better quality of meta-analytical results.
⇒ Control of random errors with trial sequential analysis by calculating the diversity adjusted information size for the outcomes.
⇒ Application of Funnel plots and Egger's regression test for publication bias.
⇒ Subgroup analysis based on patients' age, types of hip disease or surgery, perioperative period, type of anaesthesia and perioperative pain management techniques for heterogeneity assessment.

INTRODUCTION

The global population over 60 years old is estimated to increase to 2.1 billion in 2050 (approximately 22% of the global population) and 3.1 billion by 2100.[1] With this accelerating ageing process, an increasing number of elderly patients suffer from hip diseases such as hip fractures and hip osteoarthritis.[2–4] Hip surgery, including hip arthroplasty, hip fracture internal fixation and hip arthroscopy procedures, is the main treatments for hip diseases.[5–8] Hip surgery is often associated with moderate to severe postoperative pain, particularly in hip fracture patients undergoing surgical treatment and severe pain persists throughout the perioperative period.[9–11] As a minimally invasive approach, arthroscopic hip surgery is gaining popularity globally.[12] Despite being minimally invasive, patients undergoing arthroscopic hip surgery may still experience severe pain after the procedure.[13]

Perioperative pain, if inadequately controlled, can increase the risk of perioperative complications (including delirium, pulmonary complications and cardiovascular events), delay ambulation, decrease short-term mobility, interfere with rehabilitation, increase hospital length of stay, and even increase the mortality and morbidity, leading to poor functional prognosis.[14–19] In elderly patients, the risk of perioperative adverse events is higher due to polypharmacy and multimorbidity.[20–22] In contrast, adequate pain management has been shown to facilitate postoperative mobilisation, improve mobility and promote better functional recovery.[23–26] Early mobilisation has been associated with reducing postoperative complications, including pneumonia, venous thromboembolism, pressure ulcers and delirium.[27–29] Therefore, optimal perioperative analgesia can facilitate elderly patients' perioperative recovery.[13 17 30 31]

Traditionally, opioid analgesia is considered the basis of perioperative pain management.[32–35] However, opioid-related complications such as delirium, urinary retention, nausea, constipation and respiratory depression may occur and can delay patients' recovery and discharge.[36–41] Considering these adverse events, especially the higher incidence of cognitive deficits in elderly patients suffering a hip fracture, opioid analgesics are often selected hesitantly.[42–46] In addition, in light of the current opioid crisis, strategies to minimise opioid use, including the use of multimodal perioperative pain management strategies with opioid-sparing oral and intravenous medications, regional anaesthesia and analgesic techniques have become an increasing clinical focus in hip surgical procedures in elderly patients.[47–51]

Peripheral nerve blocks (including lumbar plexus block, femoral nerve block, fascia iliac compartment block, three-in-one femoral nerve block, sacral plexus block, obturator block and sciatic nerve block) and some interfascial plane blocks (such as quadratus lumborum block) have also been suggested to decrease postoperative pain and opioid use during hip surgery.[52–59] However, peripheral nerve blocks may induce weakness of the quadriceps muscles, delay hospital discharge and even predispose the patient to fall.[58 60–62] In some cases, it is difficult to position the patient as the extreme pain, particularly in hip fractures, accompanied by the deep depth of the block target, the lumbar plexus or quadratus lumborum block will become difficult.[63–65] In addition, another difficulty of adequate regional analgesia for hip pain is the complex innervation of the hip joint.[66] High branches of the femoral and obturator nerves provide innervation to the anterior hip capsule. The accessory obturator nerve was also found to innervate the medial capsule.[67 68] In this situation, the coverage of the articular nerve supply to the hip joint is critical for adequate analgesia. Hence, a simple, easy-to-perform, analgesia adequate and motor-sparing regional analgesia technique is the ideal regional analgesia technique for hip surgery.

Pericapsular nerve group (PENG) block is a relatively new peripheral nerve block technique, first described by Giron-Arango in patients with hip fractures, which was based on the complex innervation of the hip joint.[69] The target of the PENG block is the musculofascial plane between the psoas tendon anteriorly and the pubic ramus posteriorly. It can be easily performed in the supine position, avoiding the additional pain from positioning the patient for peripheral nerve block.[70–73] In theory, PENG block has potential advantages over traditional forms of regional analgesia for pain originating from the hip, as local anaesthetic deposits in this target could provide a broader and more complete block effect on the coverage area of sensory nerves innervating the hip.[9 11 74–82] Thus, it has the potential advantage of reducing postoperative pain without motor-blocking.[83–86] PENG block has been described as easy to perform in the supine position and as an effective and motor-sparing regional analgesia technique for hip surgery.[87–90]

The excellent analgesic benefit of PENG block for perioperative analgesia in hip surgery was highlighted in a significant number of publications of case reports, case series, reviews and retrospective studies,[9 11 74–78 87–90] but prospective and randomised controlled trials (RCTs) are scarce.[79–82] Inadvertent quadriceps weakness was also reported in patients following the PENG block.[91–93] Due to limited clinical evidence, the efficacy and safety of the PENG block, particularly the efficacy of motor function preservation and the incidence of block-related adverse events, remain controversial until now.[94–98]

Therefore, it is necessary to conduct a systematic review and meta-analysis to analyse the clinical efficacy of PENG block on perioperative pain management in elderly patients with hip diseases. The outcomes of this systematic review will provide evidence for better clinical decision-making and possible future directions for further clinical trials.

Objectives

We are performing this protocol of systematic review with meta-analysis and trial sequential analysis (TSA) of randomised clinical trials to evaluate the clinical efficacy and safety of PENG block on perioperative pain management in elderly patients with hip diseases.

METHODS AND ANALYSIS

Design and registration of the review

We devised this protocol according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocols (PRISMA-P) guidelines registered with PROSPERO 2022 (registration number: CRD42022313895).[99] We will perform this systematic review and meta-analysis based on the Cochrane Handbook and report the results following the PRISMA statement.[100 101] This study is anticipated to begin searching in August 2022 and will be completed in January 2023.

Inclusion criteria for study selection

Types of studies

Only RCTs involving the clinical efficacy of PENG block on perioperative pain management in elderly patients

with hip diseases will be included. There will be no language restrictions.

The exclusion criteria were as follows: (1) studies comparing PENG block versus PENG block combined with other analgesic techniques, or studies comparing PENG block under different guidance techniques (ultrasound guided or traditional landmark technique); (2) studies with data that could not be used for statistical analysis, or studies with incomplete data, or data that could not be extracted after contacting the original authors and (3) studies that were duplicate publications, published as letters or editorials, abstracts from conferences and reviews.

Types of participants

Elderly participants (≥65 years old) with any hip disease (such as hip fracture or hip osteoarthritis) accepting PENG block for perioperative pain management (including preoperative analgesia, intraoperative anaesthesia management and postoperative analgesia) will be included. There will be no limitations on participants' gender, ethnicity, body mass index or American Society of Anesthesiologists classification.

Types of interventions/controls

The intervention group will be the participants who received any kind of PENG block (including ultrasound-guided, X-ray-guided, CT-guided or traditional landmark-based techniques), alone or in combination with any other kind of analgesia technique for perioperative pain management, while the control group will receive any kind of analgesia technique other than PENG block for perioperative pain management.

Types of outcome measures

Primary outcomes

The primary outcome will be the pain intensity after perioperative pain management by PENG block or other analgesia techniques. Pain intensity, including preoperative and postoperative pain intensity, will be included and assessed by Visual Analogue Scale scores, Numeric Rating Scale scores or other scale scores. Perioperative static and dynamic pain intensity after pain management will also be included if possible.

Secondary outcomes

1. Unexpected perioperative femoral nerve block will be evaluated as follows if possible.
   - Incidence of quadriceps motor block (defined as paresis or paralysis of knee extension and hip adduction) (Knee extension was graded according to a 3-point scale: 0=normal strength (extension against gravity and resistance)); 1=paresis (extension against gravity but not against resistance); 2=paralysis (no extension possible).[102] Hip adduction scores of 0, 1 and 2 points indicated decreases in strength of 0%–20%, 21%–70% and 71%–90% compared with baseline measurement, respectively.[103]
   - Mobility of the quadriceps as defined by the Medical Research Council scale.[104]
   - Quadriceps strength was assessed by measuring the force produced by voluntary isometric contractions with any type of reliable and valid stationary dynamometer (such as the Chatillon DPPH-250 force gauge, AMETEK, USA or Chatillon; AMETEK, Largo, Florida; Lafayette Instrument, Lafayette, Indiana, USA; and MicroFET, Hoggan Health Industries, West Jordan, Utah, USA).[105 106]
2. Perioperative rescue analgesia information
   - Perioperative cumulative analgesic consumption: cumulative analgesic consumption for intraoperative anaesthesia and cumulative rescue analgesics for preoperative/postoperative analgesia will be included if possible. Any kind of analgesics, such as opioid analgesics and non-steroidal analgesics administered by different delivery methods, such as patient-controlled analgesia devices, intravenous, oral or intramuscular will be included if possible.
   - Time to first analgesic request: time from the end of the preoperative pain management procedure to the first analgesic request or time from the end of surgery to the first analgesic request will be included if possible.
3. Perioperative complications: if possible
   - Block-related adverse events included vascular puncture, paresthesia, local anaesthetic toxicity, anaphylaxis, permanent nerve injury, bleeding or infection.
   - Intraoperative adverse effects included hyoxaemia (oxygen saturation less than 90% or oxygen partial arterial pressure ≤60 mm Hg); hypotension (defined as a decrease of >20% from preanaesthetic patient baseline values or a systolic blood pressure less than 90 mm Hg); arrhythmia [including bradycardia (defined as HR <55 beats/min); tachycardia (defined as HR>100 beats/min); any other types of arrhythmias); and blood loss.
   - Other adverse effects: including postoperative nausea/vomiting, pruritus, urinary retention, respiratory depression, sweating, dizziness, pruritus, urticaria, postoperative arrhythmia and postoperative pulmonary complications, were defined as the composite of any respiratory infection, respiratory failure, pleural effusion, atelectasis or pneumothorax.
4. Patient recovery: Length of stay, recovery time (defined as the time until recovery room discharge criteria were met after surgery), the quality of postoperative recovery score (such as the Quality of Recovery-40 questionnaire)[107] and patients' ambulation (such as time-to-first ambulation and initial ambulation distance) will be included if possible.
5. Patient satisfaction:

If possible, patient satisfaction with performing the perioperative pain management techniques or postoperative analgesia will be included. Satisfaction could be measured by a 5-point Likert scale (1=very dissatisfied;

2=dissatisfied; 3=neutral; 4=satisfied; 5=very satisfied), 10-point Likert scale (1=completely unsatisfied; 10=completely satisfied) or a postoperative questionnaire whether the patient would choose the same anaesthetic or analgesia handling by the answer of 'yes' or 'no'.[108]

Exploratory outcomes

1. Perioperative sensory block: Sensory block was evaluated using a 3-point scale (0=no block, 1=analgesia (patient can feel touch, not cold), 2=anaesthesia (patient cannot feel touch)), which was assessed in the anterior, lateral and medial aspects of the mid-thigh.[102]
2. Block end time: defined as the return of motor (if initially impaired) and/or sensory function, which was acquired from patients' recall.
3. Perioperative mortality was defined as all-cause death during the operation procedure, within 30 days after surgery, or death during hospitalisation.

Search strategy

Two reviewers (Z and LD) will independently conduct the search, and any disagreements will be resolved by consulting a third reviewer (WZ) as much as possible. English and Chinese electronic databases will be searched for published literature from inception to August 2022. PubMed, Ovid Medline, Cochrane Library, Embase and Web of Science will be included in the English databases. The Chinese BioMedical Literature (Sino-Med), China National Knowledge Infrastructure, Wanfang database and VIP Database will be included in the Chinese databases. The trial registry database (Clinical Trials.gov and WHO International Clinical Trials Registry Platform) will also be scrutinised to avoid missing ongoing or unpublished clinical trials. In addition, reference lists of each study will also be scanned for missing studies.

The search strategy will use the following search terms: pericapsular nerve group block, PENG block, elderly, hip and RCT. Related search terms will also be translated into Chinese for literature research and study identification in Chinese databases. The search strategies are listed in online supplemental appendix 1. Comprehensive updating of the literature search results will be performed prior to the final publication of systematic reviews to avoid missing published studies during the systematic review preparation.

Data collection and analysis

Selection of studies

At least two review authors (JZ and LD) will be responsible for screening the potentially eligible studies by reading titles and abstracts. All identified and relevant full-text publications will be retrieved by screening the full text thoroughly, and the reasons for excluding the ineligible studies will be recorded. Any disagreement will be resolved through discussion or by consulting a third review author (JZ and GC) as much as possible. A fourth reviewer (WZ) will carefully check out all procedures before the final confirmation of the data extraction. Data extraction will be performed by at least two authors, and a third author will be consulted if there is any disagreement. Duplicate publications and companion papers of the same trial will be assessed by all review authors. The study selection process is displayed in the PRISMA flow diagram (figure 1).

Data extraction

Two review authors (JZ andLZ) will use a standardised data collection form (Excel version 2013, Microsoft, Washington DC, USA) for data extraction from each included study. The data extraction form included participants' demographic data, type of hip disease or hip surgery, type of anaesthesia: local, spinal or general anaesthesia, period of perioperative pain management (preoperative analgesia, intraoperative anaesthesia and postoperative analgesia), inclusion and exclusion criteria, detailed information of analgesia techniques (type of perioperative analgesia techniques: PENG block or other analgesia techniques; type, concentration, dose, volume and adjuvant of local anaesthetics), and any outcomes including primary, secondary and exploratory outcomes. Study design characteristics including randomisation method, allocation concealment, blinding (patients, treatment providers, outcome investigators), incomplete outcome data collection and statistical analysis and outcome reporting) will be recorded simultaneously. Continuous and dichotomous data will be recorded as the mean±SD and the percentages or the proportion. If necessary, a third review author (XD) will cross-check the data to ensure precision. When the necessary information or data for analysis is missing or incomplete, we will contact the corresponding author of the research via email for the original data as much as possible. Necessary numerical data in the graphs will be extracted by Adobe Photoshop if necessary.[109] Extracted information and data are presented in table 1.

Quality assessment

The risk of bias in each included study will be assessed independently by two review authors (LD and LZ) under the guidance of the Cochrane risk of bias tool.[110] Methodology (including random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective outcome reporting, other risks of bias and overall risk of bias) will be evaluated. Each included study will be assessed by the risk of bias assessment tool from the Cochrane Handbook for Systematic Reviews of Interventions and then categorised into three levels (low risk of bias, unclear of bias and high risk of bias).[100 111 112] Any discrepancies will be settled through discussions by all review authors or arbitration of a third reviewer (WZ). Assessment of risk of bias is listed in online supplemental appendix 2.

Measures of treatment effect

Mean differences (MDs) with 95% CIs will be used for continuous outcome data reported by the same scale, and

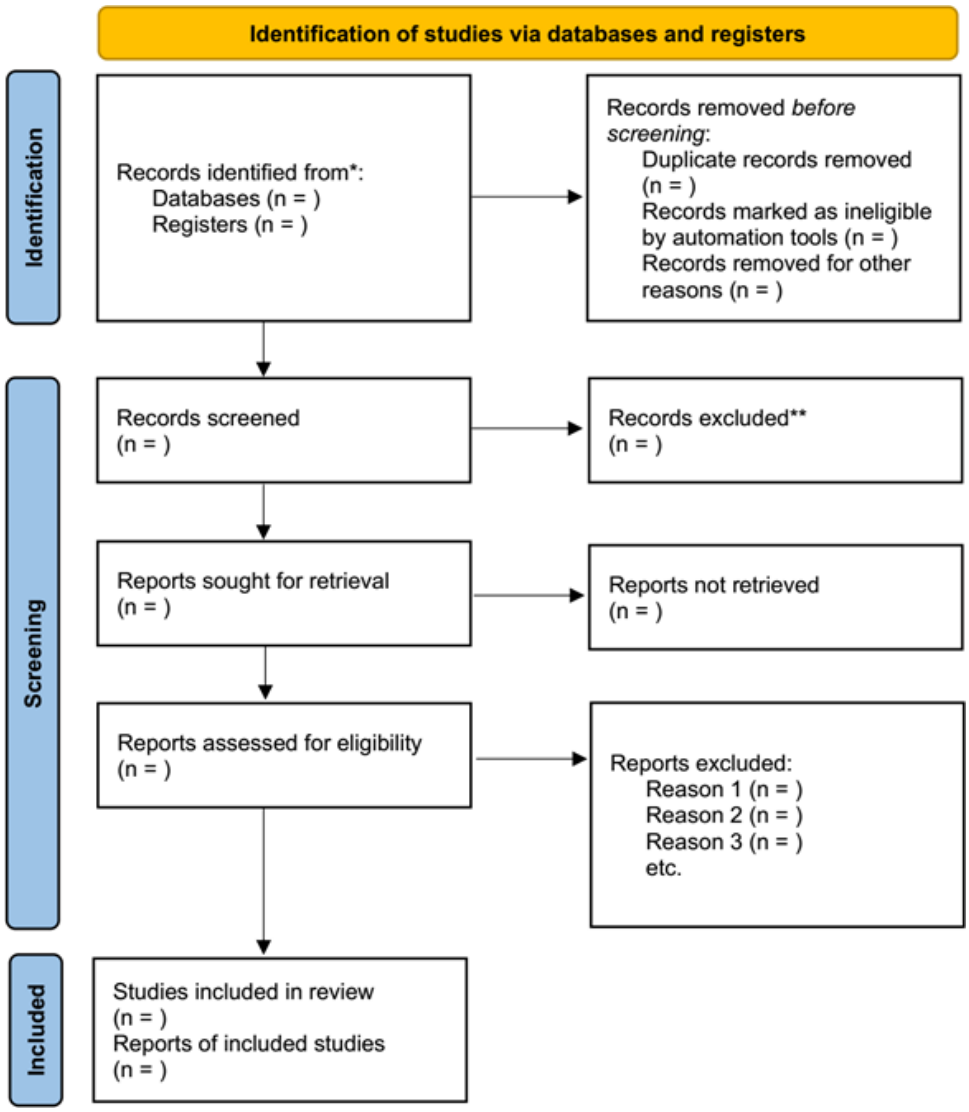

Figure 1 The PRISMA flow diagram. *Consider, if feasible to do so, reporting the number of records identified from each database or register searched (rather than the total number across all databases/registers). **If automation tools were used, indicate how many records were excluded by a human and how many were excluded by automation tools. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

standardised MDs with 95% CIs will be used for continuous outcome data reported by different scales. The relative risks (RRs) with 95% CIs will be used for dichotomous outcome data.

Assessment of heterogeneity

The application of a fixed-effects model or random-effects model based on statistical heterogeneity is not recommended by the Cochrane guidelines.[100] Assessment of heterogeneity will be primarily inspected by forest plots. If there is no indication of funnel plot asymmetry, a random-effects meta-analysis will be performed.[100] If there is an indication of funnel plot asymmetry, then both a fixed-effect and a random-effect meta-analysis are problematic. In this situation, a sensitivity analysis will be performed by excluding small studies or meta-regression will be addressed directly. A $p<0.05$ was assumed to be statistically significant.

Trial sequential analysis

The required information size (RIS) will be calculated to correct the risks of random errors by TSA using the TSA program V.0.9.5.10 Beta (Copenhagen Trial Unit, Copenhagen, Denmark).[113–115] TSA programme version is available at http://www.ctu.dk/tsa.[116] Each outcome will be detected by RIS, the cumulative Z-curve and the TSA monitoring boundaries.[117 118]

For continuous outcomes, the observed SD, an MD of the observed SD/2 (clinically meaningful value), an alpha (type I error) of 2.5%, and a beta (type II error) of 10% will be used in the TSA.[119] For dichotomous outcomes, the proportion or percentage from the control group, an RR variation of 20% (clinically meaningful value), an alpha (type I error) of 2.5%, and a beta (type II error) of 10% will be used in the TSA.[120]

Table 1 Information and data extraction schedule

Subject	Content
Publication information	Title; author; publish year; country of origin; corporate sponsorship; contact email.
Participant	Sample size; age; sex; height and weight or BMI; ASA physical status classification levels; type of hip disease or hip surgery; inclusion and exclusion criteria if necessary.
Intervention	Detail information of PENG block techniques (guidance techniques; target area of block; block needle; needle tracking techniques: in-plane and out-of-plane) detail information of local anaesthetics (type, concentration, dose, volume and adjuvant of local anaesthetics).
Control	Detail information of block analgesia techniques (including guidance techniques; target area of block; block needle; needle tracking techniques: in-plane and out-of-plane; detail information of local anaesthetics including type, concentration, dose, volume and adjuvant of local anaesthetics) and non-block analgesia techniques (including type, dose and administration method of analgesics).
Outcome	Primary outcome (pain intensity after perioperative pain management); secondary outcome measurements (perioperative quadriceps strength; perioperative rescue analgesia information: perioperative cumulative analgesic consumption; time to first analgesic request; patients' recovery; perioperative complications; patients' satisfaction); Exploratory outcomes (perioperative sensory block; block-ended time; perioperative mortality).
Study design	Randomisation method; blinding; allocation concealment; statistical analysis; sample size calculation; outcome reporting.
Other information	Type of anaesthesia: local, spinal or general anaesthesia; period of perioperative pain management (preoperative analgesia, intraoperative anaesthesia and postoperative analgesia); anaesthesia time; operation time; assessment method or equipment of outcomes.

ASA, American Society of Anesthesiologists ; BMI, body mass index; PENG, pericapsular nerve group.

Subgroup analysis

The results will be comprehensively interpreted through an analysis of subgroups or subsets as much as possible. If sufficient trials are available, data from different participants' ages, different types of hip disease or different kinds of surgical techniques of hip surgery, pain management during different perioperative periods, different pain management techniques in the control group, different types of anaesthesia and different types, concentrations, doses, volumes and adjuvants of local anaesthetics for PENG block will be analysed independently.

Different participants' ages (PENG block for perioperative analgesia in elderly patients with different ages as follows: 65 years≤patients<75 years; 75 years≤patients<80 years; patients≥80 years).

Different types of hip disease or different kinds of surgical techniques of hip surgery (hip disease, such as hip fracture and hip osteoarthritis; hip surgery, such as different kinds of surgical techniques of hip arthroplasty, hip fracture fixation and hip arthroscopy procedures).

Pain management of different perioperative periods (PENG block for preoperative analgesia, intraoperative anaesthesia and postoperative analgesia).

Different pain management techniques in the control group (such as block analgesia techniques, including lumbar plexus block, femoral nerve block, fascia-iliac compartment block, three-in-one femoral nerve block, sacral plexus block, obturator and sciatic nerve block, and quadratus lumborum block. Non-block analgesia techniques such as opioid and no-opioid analgesics).

Different types of anaesthesia (such as local anaesthesia, spinal anaesthesia or general anaesthesia).

Different volumes, concentrations, doses and adjuvants of local anaesthetics for PENG block.

The interaction p value will be considered to test the statistically significant subgroup difference; if testing for interaction $p<0.05$ (a significant difference between subgroups exists), the results for individual subgroups will be reported separately.[100]

Sensitivity analysis

Sensitivity analysis will be applied after the analysis of subgroups or subsets to evaluate the stability of the combined results, which could be affected by uncertain assumptions of data and usage. Significant changes in the pooled results may indicate significant heterogeneity in the included studies. Low-quality studies, defined as high-risk bias studies according to the Cochrane risk of bias tool assessment, will be excluded. Then, the included studies will be reanalysed to detect obvious differences between the combined effects. The stability of the pooled estimations will be detected by removing each included study if necessary.

Assessment of publication biases

Egger's regression test and funnel plot analysis will be performed to estimate the potential publication bias, while more than 10 original studies involved an outcome.[121 122] The symmetric pattern of the funnel plot by trim-and-fill analysis will also be used to confirm

the potential publication bias. The effect sizes of each included study will normally be symmetrically distributed around the centre of a funnel plot in the absence of publication bias.[123] Publication biases will be detected by Stata/MP V.16.0 (StataCorp).

Grading the quality of evidence

The quality of evidence for each outcome will be assessed using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) criteria.[124] The quality of effect estimates will be classified as high, moderate, low or very low depending on the risk of bias, consistency, directness, precision and publication bias.[124] Data from RCTs are classified as high-quality evidence according to GRADE. However, it can be degraded according to the risk of bias, imprecision, inconsistency, indirectness or publication bias.

Patient and public involvement statement

Patients or the public were not involved in the design, conduct, reporting or dissemination plans of our research.

DISCUSSION

More and more elderly patients suffer from hip diseases in the global accelerating ageing process. As the main therapy for hip diseases, hip surgery is often associated with moderate to severe perioperative pain. Optimal perioperative analgesia can decrease the risk of perioperative complications and facilitate elderly patient perioperative recovery. Opioid analgesics are often selected hesitantly as opioid-related complications, which can delay patient recovery and discharge. Regional anaesthesia and analgesic techniques for perioperative pain management have gradually become the clinical focus in elderly patients with hip diseases to facilitate patient recovery. A simple, easy-to-perform, adequate analgesia and motor-sparing regional analgesia technique is ideal for perioperative pain management of hip diseases.

The PENG block is a relatively new, easy-to-perform, analgesia adequate and motor-sparing peripheral nerve block technique. The benefit of PENG block for perioperative analgesia in hip surgery was based on many publications of case reports, case series, reviews and retrospective studies. However, prospective and RCTs are rare. Due to the limited clinical evidence, the efficacy and safety of the PENG block remain unclear.

This systematic review will provide an overview of the current state of evidence on the clinical efficacy and safety of the PENG block for perioperative analgesia in elderly patients with hip disease. We will examine the perioperative analgesia efficacy, the advantage of motor function preservation and the incidence of block-related adverse events of PENG block. The results of this systematic review will facilitate clinical decision-making on better perioperative pain management of elderly patients with hip disease.

This systematic review protocol was rigorously performed according to the PRISMA-P guidelines. The strengths of our systematic review are as follows: First, a comprehensive literature search of English and Chinese databases will be performed. Second, we will perform multivariable analysis (including subgroup analysis, TSA for random errors, sensitivity analysis, study quality assessment, funnel plots and Egger's regression test for publication bias) to improve the quality of the evidence. Third, literature retrieval, data extraction and study quality assessment will be performed independently according to the guidelines by at least two review authors. Any disagreement will be resolved through discussion or by consulting another review author as much as possible.

Limitations are as follows: First, studies with different perioperative periods, hip diseases or hip surgeries will be included, leading to potential heterogeneity. Second, PENG block is a relatively new peripheral nerve block technique, so the sample size of each included study may be limited, and the number of studies with available data for subgroup analyses may be small. Third, studies with high-level evidence such as well-designed RCTs with double-blind designs may be limited, as it is difficult to perform blinding for different block techniques in different puncture positions. Fourth, PENG block is a relatively new peripheral nerve block technique. It is difficult to define a significant clinical plausible value of MD and RR increase/decrease during literature research or clinical experience. Therefore, a significant clinical plausible value will be defined according to TSA guidelines.

Contributors JZ and LD conceived the idea for this systematic review. All authors (JZ, LD, GC, LZ, XD and WZ) developed the methodology for the systematic review. The manuscript was drafted by JZ and LD, and revised by all authors. GC and WZ will screen potential studies, and perform duplicate independent data abstraction. JZ and LZ will undertake a risk of bias assessment and assess the evidence quality. JZ and LD will conduct the data synthesis. All authors contributed to the research and agreed to be responsible for all aspects of the work.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Provenance and peer review Not commissioned; externally peer reviewed.

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