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Risk factors for perioperative blood transfusion in total hip arthroplasty: a meta-analysis

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Abstract

Objective The present study assessed and synthesized the potential risk factors for perioperative blood transfusion in total hip arthroplasty from various studies through Meta-analysis.

Methods We systematically searched for relevant studies in databases including Web of Science, PubMed, Embase, and Cochrane Library from the time of database creation to 1 February 2025 and included all observational studies exploring perioperative transfusion risk factors in patients undergoing total hip arthroplasty. All included studies were assessed for quality using the Newcastle–Ottawa Scale (NOS) scale. Data were analyzed using Stata 15 software.

Results A total of 18 articles ($n = 424{,}158$) were included, meta-analysis results suggest that increased intraoperative bleeding [OR = 1.13, 95%CI (1.02, 1.24)], increased postoperative drainage [OR = 2.24, 95%CI (1.24, 4.83)], body mass index ≤ 18.5 [OR = 1.10, 95%CI (1.02, 1.20)], preoperative anemia [OR = 1.82, 95%CI (1.62, 2.03)], age ≥ 80 [OR = 1.49 95%CI(1.21, 1.83)], female [OR = 1.92, 95%CI (1.71, 2.15)], ASA class ≥ 3 [OR = 2.06, 95%CI (1.63, 2.61)] in patients with total hip arthroplasty (THA) increases the incidence of perioperative blood transfusion.

Conclusion The results of the current study suggest that increased intraoperative bleeding, increased postoperative drainage, low body mass index (≤ 18.5), preoperative anemia, advanced age (≥ 80 years), female gender, and high ASA classification (≥ 3) were significantly associated with the likelihood of needing blood transfusion. These findings highlight the importance of preoperative risk assessment and perioperative management strategies to reduce the need for blood transfusion and improve patient outcomes.

Keywords Risk factors, Total hip arthroplasty, Blood transfusion, Meta-analysis

Introduction

Total Hip Arthroplasty (THA) is one of the common surgeries for the treatment of advanced hip osteoarthritis, necrosis of the femoral head and other diseases, aiming at relieving pain, restoring joint function and improving patients'quality of life [1, 2]. With the aging of the population, the number of hip arthroplasties is increasing every year. However, despite the significant technological advances that have been made in THA surgery, perioperative bleeding remains a significant challenge, affecting patients'postoperative recovery and complications [3]. During THA surgery, control of bleeding is critical to the patient's prognosis. Excessive bleeding may lead to anemia, shock and even the need for blood transfusion [4, 5]. Blood transfusion is one of the common interventions after THA, but excessive blood transfusion may also trigger a series of complications, such as immune response, infection, and thrombosis [6, 7]. Therefore, identifying and evaluating risk factors affecting intraoperative and postoperative

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blood transfusion in THA is important for optimizing treatment strategies, reducing complication rates, and improving patients'postoperative recovery [8, 9].

Various factors affect postoperative blood transfusion in THA, including the underlying pathological status of the patient, surgical approach, type of anesthesia, bleeding control techniques, and preoperative hemoglobin level [10]. Studies [11, 12] have shown that factors such as age, gender may be associated with the need for blood transfusion, but these factors may manifest themselves differently in different patient groups [13].

This study investigates the key factors affecting perioperative blood transfusion in THA through meta-analysis of the existing literature, which can not only help clinicians to develop personalized transfusion strategies, reduce unnecessary transfusions, and lower postoperative complications, but also improve the overall prognosis of patients.

Methods

This systematic evaluation and meta-analysis will strictly follow the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines [14]. The systemic review was supported by the online PROSPERO international prospective register of systemic reviews of the National Institute for Health Research, registration number: CRD42025643020.

Inclusion and exclusion criteria

Inclusion criteria included a study design that was a prospective or retrospective cohort study, a case–control study, and explored risk factors associated with perioperative blood transfusion in patients undergoing THA. The study population was adult (≥ 18 years) patients undergoing primary total hip arthroplasty, the study had to report blood transfusion as the primary outcome and should provide sufficient data to estimate the effect size, including the number of patients who did and did not receive a transfusion or the volume of blood transfused.

Exclusion criteria included: study designs that were case reports, review articles, meta-analyses, conference abstracts, or unoriginal literature; studies were conducted in non-adult patients (< 18 years of age) or patients involved only in revision THA; studies did not explicitly report data related to perioperative transfusions or were unable to provide sufficient data for effect size estimation; and the results of these studies could not be broadly applied to the general population of total patients with THA; and the results of these studies cannot be widely applied to the general population of total hip arthroplasty patients to ensure consistent data extraction and analysis.

Literature retrieval

A systematic search of Web of Science, PubMed, Embase, Cochrane Library and other databases for relevant studies from inception to 1 February 2025 was performed to include all observational studies exploring perioperative blood transfusion risk factors in patients undergoing total hip arthroplasty, with the search terms risk factors; blood transfusions; total hip arthroplasty, and the specific search strategy is described in Supplementary Material Table S1.

Study selection

During the literature screening process, two researchers independently used EndNote 21 software to initially screen the literature obtained from the search, first through the titles and abstracts, and then to exclude literature that clearly did not meet the inclusion criteria. Subsequently, the remaining literature was reviewed by reading the full text in its entirety to further determine whether it met the inclusion and exclusion criteria. In case of disagreement between the two researchers during the screening process, it would be resolved through discussion and negotiation; if the negotiation still failed to reach a consensus, a third researcher would be invited to adjudicate to ensure the objectivity and consistency of the screening process.

Data extractions

This study was conducted by two researchers who independently extracted relevant data from the eligible literature using an Excel sheet based on the inclusion criteria. The extraction included the basic information of the study (first author, year of publication, and type of study), the basic characteristics of the study population (sample size, gender, and mean age), the type of procedure, transfusion-related indexes, the statistical model used in the regression analysis (e.g., multifactorial regression, univariate analysis, etc.), and the effect sizes of the exposure factors and the outcome indexes (e.g., the ratio than the ORs and their 95% confidence intervals). In the process of data extraction, if two investigators disagreed on the data, it would be resolved through negotiation, and if no agreement could be reached, a third investigator would adjudicate to ensure the accuracy and consistency of data extraction.

Quality evaluation

This study assessed the quality of the included studies using the Newcastle–Ottawa Scale (NOS) [15]. The NOS scale assesses study quality through three dimensions: selection bias, comparison bias, and outcome assessment. First, the selection dimension assesses whether the case and control groups in the study were selected in a representative manner, whether clear selection criteria were followed, and whether the similarity of baseline characteristics of the samples was controlled. Second, the comparison dimension assesses whether potential confounders, such as age, gender, and lifestyle, were effectively controlled for and whether appropriate statistical methods were used to reduce confounding bias. Finally, the outcome dimension assessed whether the study outcomes were clearly defined and accurately measured and examined the completeness of the follow-up data and whether lost visits or missing data were reasonably addressed. Each dimension was scored as 0 to 4 (selection), 0 to 2 (comparison), and 0 to 3 (outcome), with a total score of 9. Higher scores indicated better study quality. To ensure the scientific validity and reliability of the Meta-analysis, we will weigh the studies in the assessment process, with higher quality studies carrying more weight, and ensure the objectivity and consistency of the assessment through independent reviewer scoring.

Statistical analysis

In this study, the risk ratio (OR) and the corresponding 95% confidence interval (CI) of each included study were combined using Stata 15 software. First, for each study, we extracted the corresponding effect size OR and its 95% confidence interval. To combine these ORs, we pooled them using a random effects model, which can account for heterogeneity between studies, i.e., variability in effect sizes across studies. ORs and 95% CIs were calculated for each study and combined into an overall effect size. Heterogeneity of the model was assessed by the I^2 statistic; if the I^2 was greater than 50%, it was considered that there was a high degree of heterogeneity and that the sources of heterogeneity needed to be further explored. For high heterogeneity, we may conduct sensitivity analyses to identify potential factors that may affect the combined effect sizes. In addition, funnel plots and Egger's test were used to assess the likelihood of publication bias. If bias exists, it may have an impact on the interpretation of the results. The combined effect sizes will be reported as ORs and their 95% CIs to allow for interpretation of results and statistical inference.

Results

Literature screening results

A total of 1625 articles were obtained through the search (PubMed (n = 216), Embase (n = 361), Cochrane library (n = 91), Web of science (n = 827), CNKI(n = 56), medRxiv(n = 74)), 500 duplicates were removed by removing duplicates, 1100 articles were removed by reading titles and abstracts, and 7 articles were removed by reading the full text. The final 18 articles [16–33] were included in the analysis. The specific screening process of the literature is shown in Fig. 1.

Basic characteristics of literature

A total of 18 articles (n = 424,158) were included, with an age distribution of 41.5–79 years, of which 10 articles [16, 18, 20, 26, 28–33] were from China, 2 articles were from USA, 1 article was from UK, 1 study was from Virginia, 1 study was from Denmark, 1 study was from Thailand, 1 study was from Pakistan and 1 study was from Brazil. Postoperative blood transfusion occurred in 22.36% (94,846/424158). All of them used Multivariate logistic regression, and the specific basic characteristics of the articles are tabulated in Table 1.

NOS results

The NOS score was used in this study, in which 6 studies [16, 19, 22, 24, 25, 28] scored 9, 2 studies [17, 18] scored 8, and 10 studies [20, 21, 23, 26, 27, 29–33] scored 7. The quality of this study was of high quality, and the specific quality evaluation table is shown in Table 2.

Meta-analysis results

Increased intraoperative bleeding

6 articles mentioned increased intraoperative bleeding, heterogeneity test (I^2= 82.5%, P= 0.001), random effects model was used for the analysis, and the results of the analysis (Fig. 2) suggested that increased intraoperative bleeding in patients with THA increases the incidence of perioperative blood transfusion [OR =1.13, 95%CI (1.02, 1.24)], and due to the large heterogeneity, sensitivity analyses were performed using a literature-by-exclusion analysis, and the results of the analysis (supplementary material figure S1) suggested that the analysis was relatively unstable.

Increased postoperative drainage

4 articles mentioned increased postoperative drainage, heterogeneity test (I^2= 93.4%, P= 0.001), random effects model was used for the analysis, and the results of the analysis (Fig. 3) suggested that increased postoperative drainage in patients with THA increases the incidence of perioperative blood transfusion [OR =2.24, 95%CI (1.24, 4.83)], and due to the large heterogeneity, sensitivity analyses were performed using a literature-by-exclusion analysis, and the results of the analysis (supplementary material figure S2) suggested that the analysis was relatively unstable.

Body mass index ≤ 18.5

9 articles mentioned body mass index ≤18.5, heterogeneity test (I^2= 74.3%, P= 0.001), random effects model

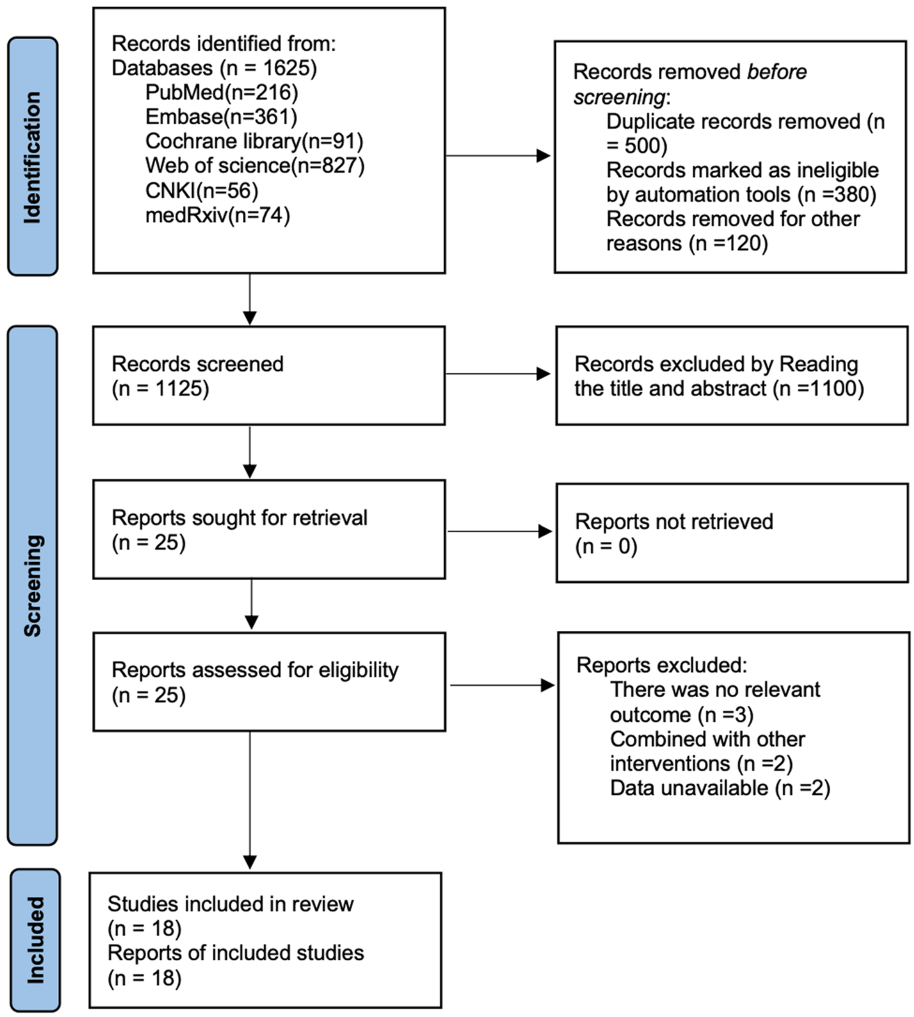

Fig. 1 Literature search flow chart

was used for the analysis, and the results of the analysis (Fig. 4) suggested that body mass index ≤18.5 in patients with THA increases the incidence of perioperative blood transfusion [OR =1.10, 95%CI (1.02, 1.20)], and due to the large heterogeneity, sensitivity analyses were performed using a literature-by-exclusion analysis, and the results of the analysis (supplementary material figure S3) suggested that the analysis was relatively unstable.

Preoperative anemia

12 articles mentioned preoperative anemia, heterogeneity test (I^2= 98.1%, P= 0.001), random effects model was used for the analysis, and the results of the analysis (Fig. 5) suggested that preoperative anemia in patients with THA increases the incidence of perioperative blood transfusion [OR =1.82, 95%CI (1.62, 2.03)], and due to the large heterogeneity, sensitivity analyses were performed using a literature-by-exclusion analysis, and the results of the analysis (supplementary material figure S4) suggested that heterogeneity may be derived from Cao (2018), G Liao (2024) and Song (2019).

Age ≥ 80

8 articles mentioned age ≥80, heterogeneity test (I^2= 99.4%, P= 0.001), random effects model was used for the analysis, and the results of the analysis (Fig. 6) suggested that age ≥80 patients with THA increases the incidence of perioperative blood transfusion [OR =1.49 95%CI(1.21, 1.83)], and due to the large heterogeneity, sensitivity analyses were performed using a literature-by-exclusion analysis, and the results of the analysis (supplementary material figure S5) suggested that heterogeneity may be derived from Browne (2013).

Table 1 Table of Basic Characteristics

study	year	country	study design	sample size	No of blood transfusions	gender(M/F)	mean age(years)	Regression model
Bian	2023	China	cohort study	331	113	290/41	41.5	Multivariate logistic regression
Browne	2013	Virginia	cohort study	129,901	27,552	NR	NR	Multivariate logistic regression
Cao	2018	China	cohort study	414	207	280/134	46.5	Multivariate logistic regression
Gylvin	2017	Denmark	cohort study	8402	809	NR	NR	Multivariate logistic regression
Hong	2025	China	cohort study	228	43	154/74	69.3	Multivariate logistic regression
Luangwaranyoo	2020	Thailand	cohort study	323	126	91/232	79	Multivariate logistic regression
Mufarrih	2017	Pakistan	cohort study	658	153	131/527	62.5	Multivariate logistic regression
Pava	2023	Brazil	cohort study	1028	114	280/748	69.26	Multivariate logistic regression
Salt	2018	USA	cohort study	3270	230	862/2408	58.5	Multivariate logistic regression
Slover	2017	USA	cohort study	275,169	64,670	106,439/168730	55.4	Multivariate logistic regression
Song	2019	China	cohort study	541	105	97/444	67.4	Multivariate logistic regression
Walsh	2012	UK	cohort study	210	120	46/164	71.2	Multivariate logistic regression
Wang	2021	China	cohort study	341	44	289/52	53	Multivariate logistic regression
G Liao	2024	China	cohort study	347	184	151/196	70.1	Multivariate logistic regression
Z Yan	2021	China	cohort study	1814	134	639/1175	70	Multivariate logistic regression
Q Lin	2022	China	cohort study	237	60	110/127	60.1	Multivariate logistic regression
R Shen	2020	China	cohort study	692	127	216/376	55	Multivariate logistic regression
Y Tian	2025	China	cohort study	252	55	116/136	65	Multivariate logistic regression

Table 2 NOS scores

cohort study									
Study	**Representativeness of the exposed group**	**Selection of non-exposed groups**	**Determination of exposure factors**	**Identification of outcome indicators not yet to be observed at study entry**	**Comparability of exposed and unexposed groups considered in design and statistical analysis**	**design and statistical analysis**	**Adequacy of the study's evaluation of the outcome**	**Adequacy of follow-up in exposed and unexposed groups**	**Total scores**
Bian2023	*	*	*	*	**	*	*	*	9
Browne2013	*	*	*	*	*	*	*	*	8
Cao2018	*	*	*	*	*	*	*	*	8
Gylvin2017	*	*	*	*	**	*	*	*	9
Hong2025	*	*	*	/	*	*	*	*	7
Luangwaran-yoo2020	*	*	*	/	*	*	*	*	7
Mufarrih2017	*	*	*	*	**	*	*	*	9
Pava2023	*	*	*	/	*	*	*	*	7
Salt2018	*	*	*	*	**	*	*	*	9
Slover2017	*	*	*	*	**	*	*	*	9
Song2019	*	*	*	/	*	*	*	*	7
Walsh2012	*	*	*	/	*	*	*	*	7
Wang2021	*	*	*	*	**	*	*	*	9
G Liao2024	*	*	*	/	*	*	*	*	7
Z Yan2021	*	*	*	/	*	*	*	*	7
Q Lin2022	*	*	*	/	*	*	*	*	7
R Shen2020	*	*	*	/	*	*	*	*	7
Y Tian2025	*	*	*	/	*	*	*	*	7

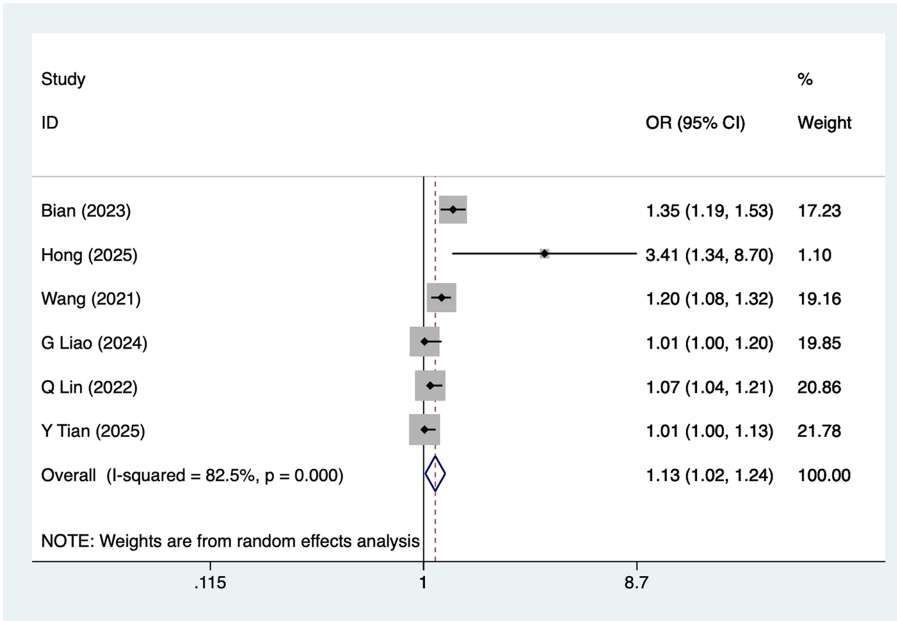

Fig. 2 Forest plot of increased intraoperative bleeding meta-analysis

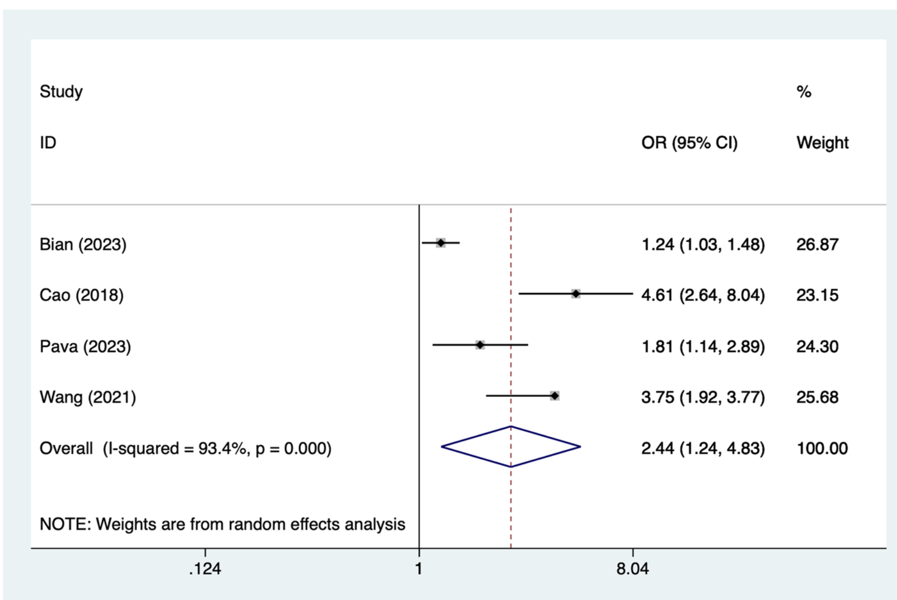

Fig. 3 Forest plot of increased postoperative drainage meta-analysis

Female

12 articles mentioned female, heterogeneity test (I^2 = 66.3%, P = 0.001), random effects model was used for the analysis, and the results of the analysis (Fig. 7) suggested that female patients with THA increases the incidence of perioperative blood transfusion [OR = 1.92, 95%CI (1.71, 2.15)], and due to the large heterogeneity, sensitivity analyses were performed using a literature-by-exclusion analysis, and the results of the analysis (supplementary material figure S6) suggested that the analysis was relatively unstable.

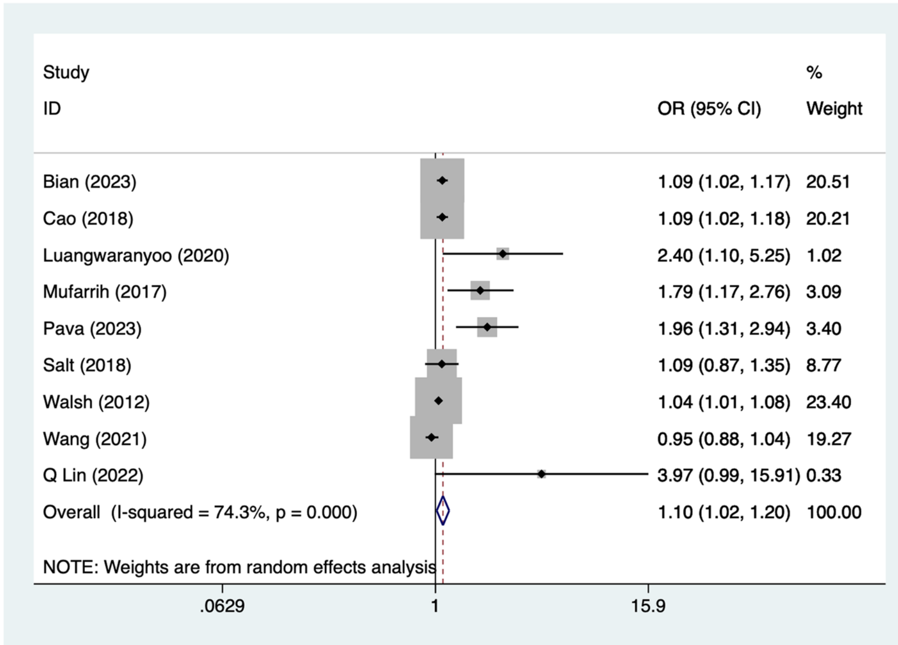

Fig. 4 Forest plot of body mass index ≤ 18.5 meta-analysis

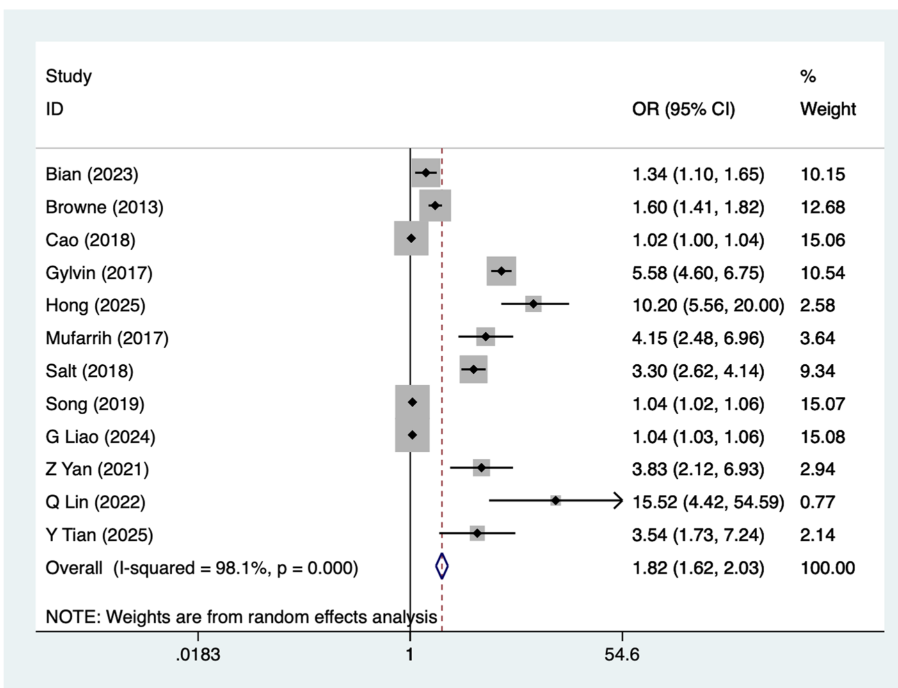

Fig. 5 Forest plot of preoperative anemia meta-analysis

ASA class ≥ *3*

7 articles mentioned American society of Anesthesiologists (ASA) class ≥3, heterogeneity test (I^2= 26.8%, P= 0.224), fixed effects model was used for the analysis, and the results of the analysis (Fig. 8) suggested that ASA class ≥3 patients with THA increases the incidence of perioperative blood transfusion [OR =2.06, 95%CI (1.63, 2.61)].

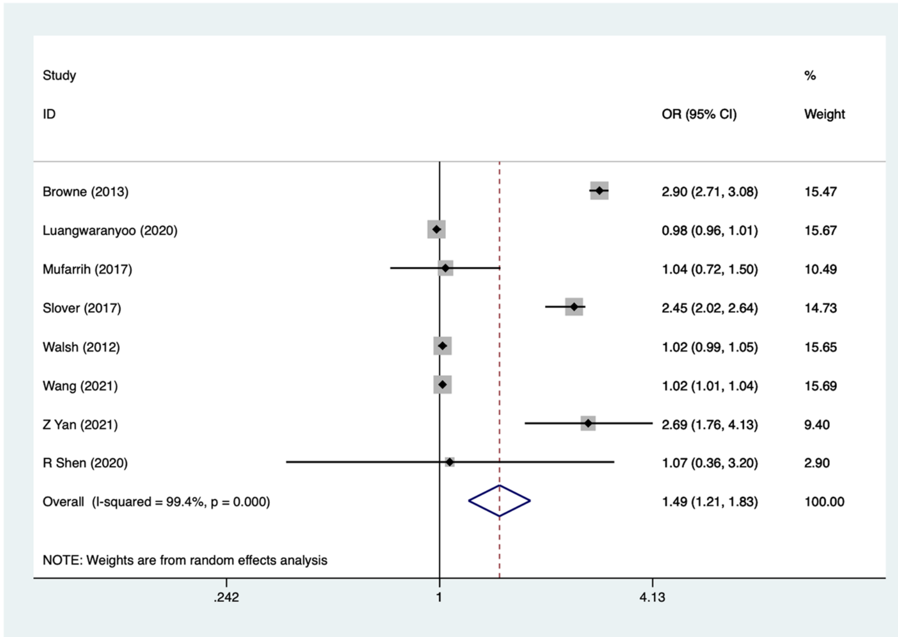

Fig. 6 Forest plot of age ≥ 80 meta-analysis

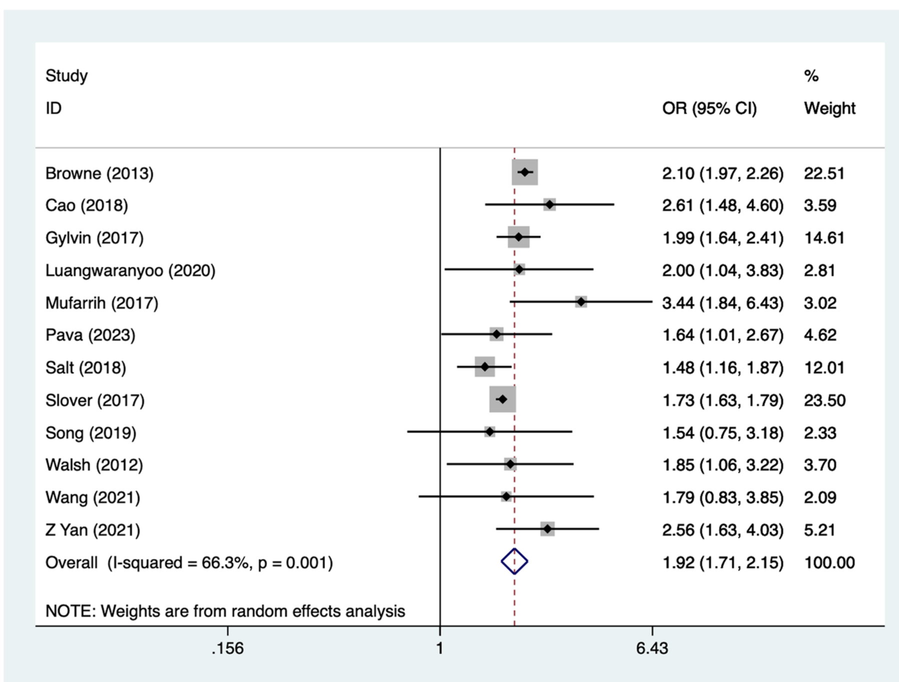

Fig. 7 Forest plot of female meta-analysis

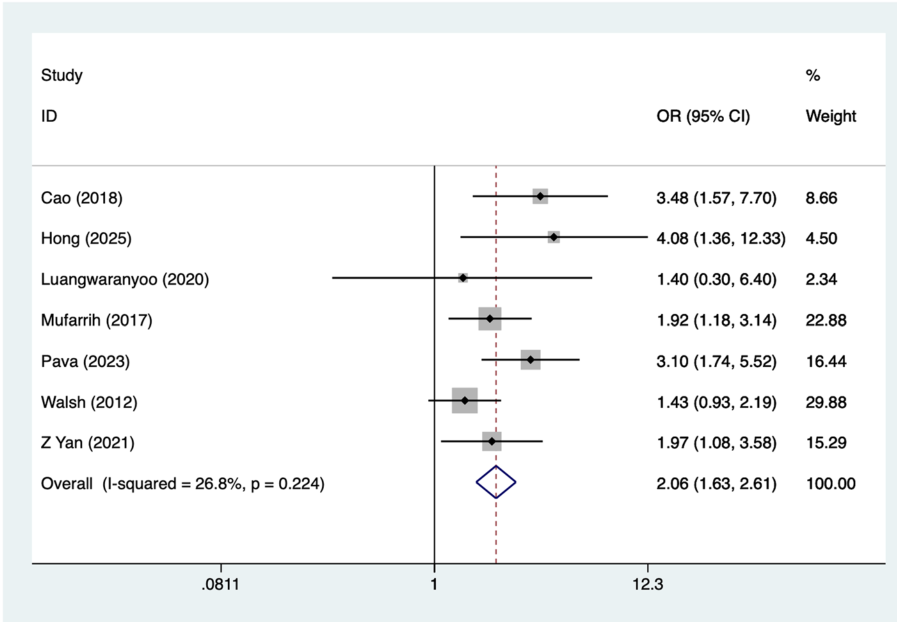

Fig. 8 Forest plot of ASA class ≥ 3 meta-analysis

Table 3 Comparison of fixed effects results and random effects results

Risk factors	Number of studies	Fixed model OR95%CI	Random model OR95%CI
Increased intraoperative bleeding	6	1.08 (1.04, 1.12)	1.13 (1.02, 1.24)
Increased postoperative drainage	4	1.73 (1.50, 2.01)	2.44 (1.24, 4.83)
Body mass index	9	1.05 (1.03, 1.08)	1.10 (1.02, 1.20)
Preoperative anemia	12	1.05 (1.04, 1.06)	1.82 (1.62, 2.03)
Age ≥ 80	8	1.05 (1.04, 1.07)	1.49 (1.21, 1.83)
Female	12	1.84 (1.71, 1.91)	1.92 (1.71, 2.15)
ASA class ≥ 3	7	2.06 (1.63, 2.61)	2.15 (1.61, 2.86)

Table 4 Meta-regression analysis results

Risk factors	Coef	Std. Err	P	95% Conf. Interval
Increased intraoperative bleeding	−0.39	0.03	0.24	[−1.18, 0.39]
Increased postoperative drainage	−0.99	0.37	0.12	[−2.57, 0.59]
Body mass index	0.001	0.007	0.88	[−0.14, 0.16]
Preoperative anemia	−0.70	0.14	0.63	[−0.39, 0.24]
Age ≥ 80	−0.07	0.10	0.49	[−0.31, 0.17]
Female	−0.07	0.04	0.07	[−0.17, 0.01]
ASA class ≥ 3	0.02	0.12	0.13	[−0.23, 0.12]

Random-effect and fixed-effect models

The results (Table 3) were suggested as increased intraoperative bleeding, increased postoperative drainage, body mass index, preoperative anemia, age ≥ 80, female, ASA classification ≥ 3 The OR of the random effects model was greater than the fixed effects model.

Meta regression

Because of the large heterogeneity of the studies, meta-regression was used to test the results of the analysis (Table 4) suggesting that year of publication, age, were not sources of heterogeneity.

Publication bias

In the current study, funnel plots and egger's test (increased intraoperative bleeding ($P = 0.001$), increased postoperative drainage ($P = 0.02$), body mass index ≤ 18.5($P = 0.045$), preoperative anemia ($P = 0.033$), age ≥ 80 ($P = 0.02$) were used to detect publication bias, and the results were analyzed (supplementary material figure S7-figure S11), and the asymmetry of the funnel plots suggests that there is publication bias for this outcome. female ($P = 0.112$), ASA class ≥ 3 ($P = 0.32$) (supplementary material figure S12-figure S13) of the funnel plots suggests that there is no publication bias for this outcome.

Trim and fill were used for those with publication bias, and the analysis results (Supplementary Material fig. S14-figure S18) suggest that after trim and fill the results suggest little change, all of which were statistically significant.

Discussion

To the best of our knowledge, this is the first time that a meta-analysis has been used to explore the risk factors for perioperative blood transfusion occurring in elderly hip fractures, and the current study concluded that increased intraoperative bleeding, increased postoperative drainage, low body mass index (≤ 18.5), preoperative anemia, advanced age (≥ 80 years), being female, and a high ASA classification (≥ 3) were significantly associated with perioperative blood transfusion.

Increased intraoperative bleeding in THA may affect perioperative transfusion rates through several mechanisms. Firstly, massive intraoperative blood loss may lead to a dramatic decrease in the patient's hemoglobin level, triggering the indication for blood transfusion [34]. Second, persistent intraoperative blood loss may trigger coagulation disorders, leading to further bleeding in a vicious circle. In addition, the inflammatory response and surgical trauma may activate the fibrinolytic system and increase the risk of microvascular bleeding, thus further exacerbating bleeding [35]. Increased intraoperative bleeding in THA not only raises the need for perioperative transfusion, but also has a range of adverse consequences, including transfusion-related complications (increased risk of transfusion reactions, immunosuppression, and infections), delayed postoperative recovery, prolonged hospital stays, and increased healthcare costs [36]. Therefore, in clinical practice, surgeons should adopt proactive blood management strategies, such as optimizing preoperative hemoglobin levels, applying antifibrinolytic drugs, improving surgical techniques, and strictly controlling intraoperative bleeding, to reduce the transfusion requirements of patients with THA and to improve the postoperative prognosis. There was a significant association between increased postoperative drainage and the incidence of perioperative blood transfusion. This suggests that increased postoperative drainage may be an important factor contributing to the increased need for perioperative blood transfusion. Increased drainage may reflect higher intraoperative hemorrhage or higher blood loss in the postoperative period, which increases the patient's need for blood transfusion. Increased postoperative drainage is often an indication of more intraoperative bleeding [37]. In THA surgery, more significant intraoperative bleeding may occur due to the proximity of the operative area to the great vessels and the pelvis. If intraoperative bleeding cannot be completely stopped, postoperative drainage may be required to drain the accumulated blood [38]. Significant intraoperative blood loss may lead to a hypovolemic state in the patient, which may require blood transfusion to maintain normal hemoglobin levels and circulatory stability, suggesting that more attention should be paid to the control of the drainage volume in postoperative management and more aggressive blood management in patients presenting with high levels of postoperative drainage in order to reduce the need for unnecessary blood transfusion [39]. Low body weight (BMI) patients undergoing THA surgery may be more susceptible to intra- or post-operative blood loss due to a lower baseline blood volume. A low BMI may reflect the patient's overall poorer health, resulting in a weaker ability to recover after surgery [40]. Lower blood reserve and tissue nutritional status may make such patients more susceptible to postoperative bleeding, hypovolemia and anemia, which may require blood transfusion [41]. Clinicians should pay particular attention to intraoperative bleeding and postoperative recovery when dealing with patients with lower BMI and may need to manage blood and blood volume more aggressively and take steps in advance to minimize unnecessary transfusions, by optimizing preoperative nutritional management and postoperative monitoring to minimize the risk of bleeding. Patients with preoperative anemia usually face a higher need for blood transfusion during surgery and postoperative recovery [42]. This is because anemic patients have lower blood reserves and intraoperative bleeding or postoperative drainage may rapidly reduce their hemoglobin levels to dangerous levels, increasing the need for blood transfusion [43]. Preoperative anemia not only increases the need for perioperative transfusion but may also be associated with other surgical complications. Anemia may increase the risk of postoperative infection, cardiac complications, and poor wound healing. Therefore, the presence of preoperative anemia may signal an increased risk for the patient during recovery from surgery and requires special attention to postoperative monitoring and recovery management [44]. The current study showed that age ≥ 80 years and female are important risk factors for perioperative blood transfusion, and that physiological functions of elderly patients gradually decline during surgery, especially hematopoietic and recovery capacity [45]. Higher intraoperative hemorrhage and poorer postoperative recovery may lead to a greater need for blood transfusion in older patients than in younger patients. In addition, older patients often have multiple chronic diseases (hypertension, diabetes) that increase the risk of intraoperative and postoperative bleeding [46]. Women are usually physiologically endowed with lower blood volume and smaller body weight, resulting in them being more susceptible to hypovolemia during bleeding, which in turn requires supplemental blood transfusion [47]. Special attention should be paid to preoperative screening and treatment of anemia and effective intraoperative blood management strategies in patients aged ≥ 80 years and in women, especially when undergoing THA. In high-risk patients, a transfusion plan should be prepared in advance and prophylactic measures (reduction of intraoperative bleeding, control of postoperative complications) should be taken to optimize the patient's recovery process. Patients with higher ASA scores usually have pre-operative anemia or other blood problems that make their intra- and post-operative blood recovery poorer [48]. Even with the same amount of bleeding, these patients are more likely to develop anemia and require blood transfusion to restore normal blood volume. For these high-risk patients, in addition to the need for enhanced pre-operative health assessment and anemia treatment, intraoperative blood management should be more careful and prudent [49]. Through early intervention, control of intraoperative bleeding and timely postoperative blood transfusion, surgical complications can be significantly reduced and the speed and quality of postoperative recovery of patients can be improved.

Strengths of this study:

1. A total of 13 papers were included through a multi-database search (PubMed, Embase, Cochrane, Web of Science) and the quality of all papers was assessed by the NOS scale, which showed high quality of the studies (most of them scored 8 or 9).
2. The included studies involved a total of 420,816 patients, which is statistically significant and broadly representative.
3. due to the high heterogeneity, the studies were analyzed using a random effects model to improve the robustness of the analyses, and the results were more stable when sensitivity analyses were performed.
4. The study analyzed the correlation with perioperative blood transfusion through multiple factors (body mass index, preoperative anemia, age), which provided a multifaceted assessment and enhanced the breadth of the study.

Limitations of this study:

1. Heterogeneity was high in many analyses (I^2 values higher than 70%) and may have been influenced by different study designs, sample sources, measurement methods, and other factors. Potential bias may exist despite sensitivity analyses.
2. All included studies were retrospective, which may have led to a certain selection bias and did not control for all potential confounders.
3. Different studies had different follow-up times, which may affect the stability and comparability of postoperative results.

Clinical significance

Although current perioperative blood management measures (intraoperative controlled hypotension, iron and erythropoietin use, intraoperative retrieval) have been widely used in total hip arthroplasty and have effectively reduced postoperative transfusion rates, postoperative blood transfusion still occurs in some high-risk patients. The significance of our study is to further identify independent risk factors related to blood transfusion through retrospective analysis, to provide a basis for preoperative risk assessment and individualized management. Especially in elderly patients or patients with many underlying diseases, identifying high-risk groups that may require blood transfusion in advance can help optimize preoperative preparations, develop more appropriate perioperative management strategies, and ultimately reduce transfusion-related adverse events and healthcare costs. Therefore, this study has practical value in the current clinical context of "low transfusion rate but still need to be continuously optimized".

Conclusion

The results of the current study suggest that increased intraoperative bleeding, increased postoperative drainage, low body mass index (≤ 18.5), preoperative anemia, advanced age (≥ 80 years), female gender, and high ASA classification (≥ 3) were significantly associated with the likelihood of needing blood transfusion. These findings highlight the importance of preoperative risk assessment and perioperative management strategies to reduce the need for blood transfusion and improve patient outcomes.

Abbreviations

NOS	Newcastle-Ottawa Scale
THA	Total Hip Arthroplasty
OR	Risk ratio
CI	Confidence interval

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12891-025-08801-x.

Supplementary Material 1.

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Clinical trial number
Not applicable.

Authors' contributions
PCH and QLY: manuscript preparation and data analysis; PCH and QLY: manuscript editing; PCH: final approval.

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Data availability
All the data used in this manuscript have been included in the tables and figures.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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