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Total hospital cost, length of stay, and complications between simultaneous and staged bilateral total hip arthroplasty

A nationwide retrospective cohort study in China

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Abstract

This retrospective cohort study aimed to compare the total hospital cost, length of stay (LOS), and incidence of complications between simultaneous bilateral total hip arthroplasty (simBTHA) and staged bilateral total hip arthroplasty (staBTHA).

We identified 256 patients who underwent staBTHA and matched them to a control group of 256 patients who underwent simBTHA from 2013 to 2016. Patients' demographics, total hospital costs, complication rates, and LOS were recorded and compared.

Patients undergoing simBTHA were younger (52.0 ± 12.0 vs 54.9 ± 13.2 years, $P = .01$), were more likely to be men (55.9% vs 46.9%, $P = .04$). There was no significant difference in total hospital costs or complications within 90 days for simBTHA compared with staBTHA. The transfusion rate was higher (49.3% vs 10.4%, $P < .01$), but the LOS was shorter in the simBTHA group (8.7 ± 5.3 vs 12.1 ± 5.6 days, $P < .01$).

There were no differences in total hospital costs or complications within 90 days if patients were carefully selected for simBTHA. Considering the difference in baseline characteristics and the low level of evidence, further randomized controlled studies are necessary.

Abbreviations: ASA = American Society of Anesthesiologists, BMI = body mass index, DVT = deep venous thrombosis, LOS = length of stay, PE = pulmonary embolism, simBTHA = simultaneous bilateral total hip arthroplasty, staBTHA = staged bilateral total hip arthroplasty, THA = total hip arthroplasty.

Keywords: bilateral total hip arthroplasty, complications, hospital costs, simultaneous, staged

1. Introduction

Total hip arthroplasty (THA) is one of the most effective orthopedic procedures to relieve pain and improve function in patients with symptomatic hip arthritis.[1] It is projected that the number of THAs per year is approximately 400,000, and the amount has been increasing by 25% to 30% per year in China.[2]

A substantial percentage of older patients suffer from degenerative hip disease, which progresses bilaterally and often eventually necessitates bilateral hip arthroplasty.[3,4] Bilateral THA (BTHA) can be either simultaneous BTHA (simBTHA), which is performed under one episode of anesthesia, or staged BTHA (staBTHA), which involves 2 separate anesthesia episodes and hospitalizations. The benefits of simBTHA have been discussed, and include lower costs, a faster recovery, and a shorter length of stay (LOS).[5,4] However, the decision to perform simBTHA versus staBTHA remains controversial because of the risks and benefits of each procedure. Previous studies in America have demonstrated that simBTHA was associated with higher complication rates and greater risks to patients.[6,7] On the other hand, several studies in Swedish, Italy, Denmark, and Korea found that in selected patients, simBTHA was as safe and appropriate as staBTHA or unilateral THA, despite a higher transfusion rate.[3,8,4,9,10] Thus, there remains no consensus on whether simBTHA is equally as safe or preferable to staBTHA. In addition, there have been few studies comparing LOS and hospital costs between simBTHA and staBTHA. Furthermore, there have been no systematic reviews on nationwide outcomes in China following BTHA. Thus, the purpose of this study was to compare the hospital costs and LOS, and to evaluate if there was an increased risk of complications in simBTHA as compared with staBTHA.

2. Materials and methods

2.1. Study population and data

The study was a multicenter retrospective cohort study. The data were obtained from a multicenter database that was provided by 26 hospitals sponsored by the Chinese Health Ministry

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ZT and GC have contributed equally to this work.

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Informed consent was obtained from all individual participants included in the study.

All authors declare no conflicts of interest.

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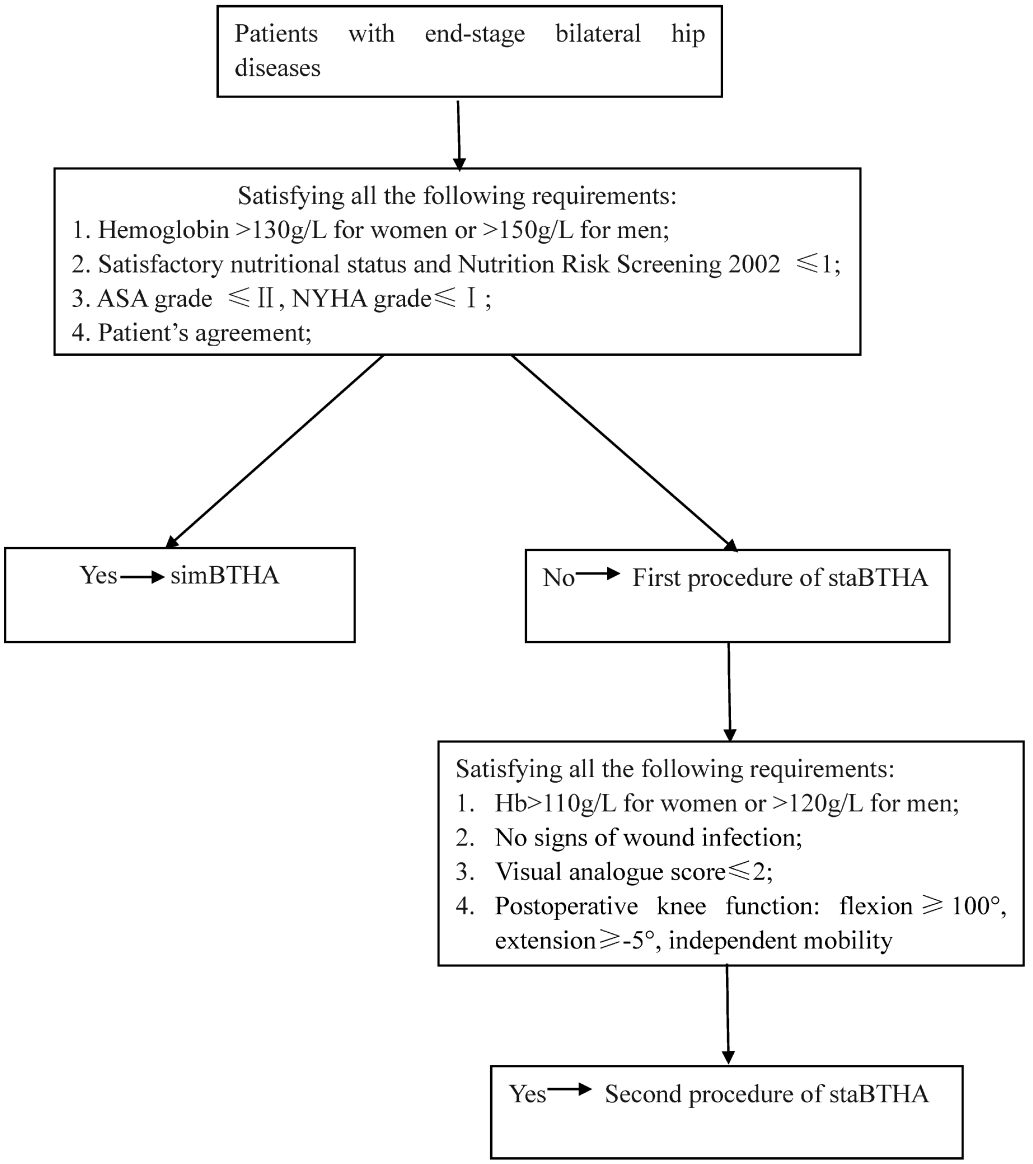

Figure 1. The flowchart of patients receiving staBTHA and simBTHA. ASA = American Society of Anesthesiologists, NYHA = New York Heart Association, SimBTHA = Simultaneous bilateral total hip arthroplasty, staBTHA = Simultaneous bilateral total hip arthroplasty.

(201302007). The data have been collected since January 2013, and include information on demographics, comorbidities, hospital LOS, total hospital costs, and complications within 90 days. This study was approved by Institutional Review Board of our medical center (2012-268). The study has been reported in line with the strengthening the reporting of cohort studies in surgery criteria.[11]

From January 2013 to December 2016, we identified all patients undergoing simBTHA and staBTHA using International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM) procedure codes. SimBTHA involved bilateral procedures that were performed under a single episode of anesthesia. StaBTHA patients were included if the procedures were performed during different hospitalizations within 1 year by the same surgeon. The patients with tumors, infections, and fractures were excluded. The requirements of undergoing simBTHA in the study included hemoglobin >130 g/L for women or >150 g/L for men, satisfactory nutritional status and Nutrition Risk Screening 2002 ≤1 and American Society of Anesthesiologists (ASA) grade ≤II, New York Heart Association (NYHA) grade ≤I, and patient's agreement. The flowchart of receiving simBTHA or staBTHA was shown in Fig. 1.

2.1.1. Perioperative care. All the operations were performed through the posterolateral approach and all patients received cementless prosthesis. Transfusions were applied if the Hb level was <70 g/L or 70 to 100 g/L with symptoms of anemia (defined as bad mental status, palpitation, or shortness of breath not due to other causes) according to the guidelines by the National Ministry of Health.

2.1.2. Outcome measurements. Outcome measurements included demographic characteristics, total hospital costs, LOS, transfusion rate, and complications within 90 days.

Total hospital cost was the total payment that the patient' primary insurance carrier provided to the hospital. The LOS and hospital costs of the staBTHA were the sum of those associated with the first and second procedures. The complications measured

Table 1

Baseline characteristics.

Demographics	simBTHA (n = 256)	staBTHA (n = 256)	P
Age, y	52.0 ± 12.0	54.9 ± 13.2	.01*
Gender			.04*
Male	143 (55.9%)	120 (46.9%)	
Female	113 (44.1%)	136 (53.1%)	
BMI, kg/m^2	23.8 ± 3.9	23.8 ± 4.0	.98
ASA class			.34
1	105 (37.0%)	97 (37.9%)	
2	124 (49.3%)	139 (54.3%)	
3	23 (12.3%)	19 (7.4%)	
4	4 (1.4%)	1 (0.4%)	
Diabetes	5 (1.9%)	3 (1.2%)	.72
Hypertension	19 (7.4%)	16 (6.3%)	.60
Smoker	50 (19.5%)	53 (20.7%)	.74
Alcohol user	41 (16.0%)	46 (18.0%)	.56
Preoperative Hb, g/L	126.4 ± 14.2	124.8 ± 11.9	.05
Preoperative Hct	0.400 ± 0.051	0.395 ± 0.047	.08

ASA = American Society of Anesthesiologists, BMI (body mass index) = Weight/Height^2, Hb = hemoglobin, Hct = hematocrit, SimBTHA = simultaneous bilateral total hip arthroplasty, staBTHA = simultaneous bilateral total hip arthroplasty.

* $P < .05$.

** $P < .01$.

*** $P < .001$.

within 90 days included death, deep venous thrombosis (DVT), pulmonary embolism (PE), revision, cerebral infarction, cardiac infarction, and wound complications. All complications were validated in the database. Blood transfusions were defined as allogeneic transfusions given between the start of surgery up to 72 hours postoperatively.

2.2. Statistical analyses

The continuous variables were compared using independent-samples *t* tests or Wilcoxon Mann–Whitney *U* tests depending on the distribution of the variables. The results were presented as mean ± standard deviation. The categorical variables were compared using Pearson chi-square tests or Fisher exact tests. The results were presented as percentage. A multivariable logistic regression model was used to examine independent risk factors for blood transfusion, complications, LOS, and hospital cost. A *P* value <.05 was considered statistically significant. All analyses were performed using SPSS version 22.0 (SPSS Inc., Illinois, USA).

3. Results

3.1. Demographics

A total of 432 patients undergoing simBTHA and 256 patients undergoing staBTHA were identified and included in this study. The patients undergoing simBTHA were matched to patients undergoing staBTHA based on age, sex, preoperative Hb, and hematocrit using Propensity Score Matching through a 1:1 matching ratio. Two hundred fifty-six patients were included in each group. A comparison of baseline characteristics between the 2 groups is shown in Table 1. Patients in the simBTHA cohort were younger (52.0 ± 12.0 vs 54.9 ± 13.2 years, $P = .01$), were more likely to be male (55.9% vs 46.9%, $P = .04$). The differences in medical comorbidities, including diabetes, hypertension, smoking, and alcohol use were not significant ($P > .05$). The ASA classification and body mass index (BMI) showed no significant difference between the groups ($P > .05$).

3.2. Hospital costs, LOS, and transfusions

As shown in Table 2, the transfusion rate and hospital costs were similar between the first and second THA, while the LOS became shorter following second THA (6.4 ± 3.4 vs 5.8 ± 3.2 days, $P = .04$).

There was no significant difference in total hospital costs for simBTHA as compared with staBTHA (124,435.5 ± 34,495.5 vs 124,689.9 ± 27,646.6, $P = .92$). The LOS in the simBTHA group was shorter than in the staBTHA group (8.7 ± 5.3 vs 12.1 ± 5.6 days, $P < .01$). The transfusion rate in patients undergoing simBTHA was 5 times as high as in patients undergoing staBTHA (49.3% vs 10.4%, $P < .01$; Table 2).

3.3. Complications

All patients were followed for 90 days. No death or PE occurred in either group. Three patients developed DVT in the simBTHA group and 1 patient developed DVT in the staBTHA group. In addition, 1 patient developed cerebral infarction and another patient cardiac infraction in the simBTHA group. The incidence was higher than those in the staBTHA group (0.23% vs 0.0%, $P = 1.00$; Table 3). There was no significant difference in the incidence of related complications between the 2 groups ($P > .05$, Table 3).

3.4. Multivariate regression

The patients was divided into 2 groups according to LOS <12 or >12 days. The patients were divided into 2 groups according to hospital cost >12,000 or <12,000 yuan. The multivariate logistic regression models for transfusion, complications, LOS, and hospital cost were listed as Tables 4–7. The results showed that the simBTHA was independent risk factor for transfusion and LOS >7 days. In addition, higher age was the risk factor of cost >12,000 yuan and preoperative higher Hb and Hct were protective factors of cost >12,000 yuan. The relevance was not

Table 2

Comparison of staBTHA (the first and second), simBTHA, and staBTHA.

Outcome	Staged (first)	Staged (second)	P	simBTHA (n = 432)	staBTHA (n = 256)	P
LOS	6.4 ± 3.4	5.8 ± 3.2	.045*	8.7 ± 5.3	12.1 ± 5.6	<.001***
Hospital cost†	62982.66.4 ± 15345.8	61484.7 ± 15227.0	.268	124435.5 ± 34495.5	124689.9 ± 27646.6	.915
Transfusion rate	31 (12.1%)	22 (8.3%)	.239	49.3%	10.4%	<.001***

The transfusion rate of staBTHA is calculated by the sum of patients receiving transfusion divided by twofold the number of patients undergoing staBTHA.

LOS = length of stay, SimBTHA = simultaneous bilateral total hip arthroplasty, staBTHA = simultaneous bilateral total hip arthroplasty.

† Results were presented as Chinese yuan.

* Represented $P < .05$.

*** $P < .001$.

Table 3

Complications.

Complications	simBTHA (n = 432)	staBTHA (n = 256)	P
Death	0	0	–
DVT	3 (0.69%)	3 (1.17%)	.515
PE	0	0	–
Revision	1 (0.23%)	1 (0.39%)	.708
Cerebral infarction	1 (0.23%)	0	1.000
Cardiac infraction	1 (0.23%)	0	1.000
Wound complications	3 (0.69%)	1 (0.39%)	1.000

DVT = deep venous thrombosis, PE = pulmonary, SimBTHA = simultaneous bilateral total hip arthroplasty, staBTHA = simultaneous bilateral total hip arthroplasty.

detected on complications and hospital cost between simBTHA and staBTHA.

4. Discussion

It was reported that about 20% of patients undergoing a primary THA undergo a contralateral THA within 5 years.[4] In addition, diseases such as avascular necrosis, rheumatoid arthritis, ankylosing spondylitis, and developmental dysplasia often affect bilateral hips, necessitating BTHA.[10] On account of potential economic and patient-related benefits, simBTHA has been the focus of many studies since it was first performed.[12] However, the safety and indications of simBTHA have been fiercely debated.[13,8,4,14] Studies relating to these procedures are rare and thus definitive conclusions have not been made.

Several studies from America, Denmark, and Korea showed that simBTHA was associated with considerably lower costs.[8,7,9] In contrast, there was no significant difference in hospital costs between the 2 groups, although LOS following staBTHA was increased in this study. The reasons may include the following: the transfusion rate in simBTHA was higher, which increased expenses; and prosthesis cost was the primary component of total hospital costs, and this was the same between the 2 groups. The daily bed cost was 40 to 200 yuan, and the prolonged LOS did not result in a significant increase in total hospital costs. The percentage of implant cost in total cost between developed and developing countries was different. Relatively low hospital service cost comparing to the implant cost in developing countries may tolerate cost of extra hospital days in staBTHA. We also found that the LOS following the second THA was shorter than after the first THA (6.4 ± 3.4 vs 5.8 ± 3.2, $P = .04$). The hospital costs and transfusion rates also trended towards being decreased with the second procedure. The reasons were possibly as follows. Firstly, some examinations were not necessary when patients received the second procedure. Secondly, the patients' experience and improvement of body tolerance after first procedure may have played a role in this.

Recently, an increasing amount of research has shown that simBTHA may not lead to a higher incidence of complications and mortality compared with staBTHA when patients are carefully selected.[3,15,16,8,9] A retrospective study that included 42,238 patients in Sweden indicated that there were no clinically relevant differences in early postoperative mortality rates between healthy patients who underwent simBTHA or staBTHA.[3] Lindberg-Larsen et al[8] compared 103 patients that underwent simBTHA with 577 patients that had staBTHA in America, and found that simBTHA was safe if patients were carefully selected, including younger patients and those who were men. Kamath et al[15] from America concluded that simBTHA and staBTHA offered equivalent early patient outcomes with acceptable safety and efficacy profiles in their center. A study in Korea by Seol et al[9] found that simBTHA compared favorably with staBTHA in terms of LOS, complications, and cost-effectiveness. In this study, comparisons of simBTHA and staBTHA revealed no significant difference in hospital costs or complications.

Unlike in Western countries, in China we lack a system of family and community physicians, so the majority of patients were discharged to their homes rather than to rehabilitation units. Following the enhanced recovery after THA, the LOS decreased gradually.[17,18] The mean LOS was 8.7 days after simBTHA and about 12 days after staBTHA, which was even shorter than reported in previous studies.[15,8,9]

The allogeneic blood transfusion rate in the simBTHA group was 49.3% in this study, which was far higher than in the staBTHA group. Transfusion related problems consisted of short- and long-term problems. Short-term problems included hemolytic reaction, allergic reaction, venous thromboembolism, graft-versus-host disease, infectious disease transmission, immunomodulation, cardiac overload, lung injury, matching errors

Table 4

Logistic regression models for transfusion after Sim/staBTHA.

Parameter	Odds ratio	95% confidence interval	P
Surgery (Sim/staBTHA)	9.770	6.024–15.846	<.001***
Age	0.995	0.981–1.009	.454
Female	1.459	0.973–2.187	.068
Preoperative Hb, g/L	1.000	0.985–1.015	.986
Preoperative Hct	1.073	0.929–1.119	.102

Hb = hemoglobin, Hct = hematocrit, SimBTHA = simultaneous bilateral total hip arthroplasty, staBTHA = simultaneous bilateral total hip arthroplasty.
*** $P < .001$.

Table 5

Logistic regression models for complications after sim/staBTHA.

Parameter	Odds ratio	95% confidence interval	P
Surgery (Sim/staBTHA)	1.197	0.366–3.912	.766
Age	0.969	0.929–1.01	.141
Female	0.698	0.194–2.514	.583
Preoperative Hb, g/L	0.990	0.939–1.043	.698
Preoperative Hct	0.989	0.935–1.039	.129

Hb = hemoglobin, Hct = hematocrit, SimBTHA = simultaneous bilateral total hip arthroplasty, staBTHA = simultaneous bilateral total hip arthroplasty.

Table 6

Logistic regression models for LOS after sim/staBTHA.

Parameter	Odds ratio	95% confidence interval	P
Surgery (Sim/staBTHA)	2.140	1.227–3.733	.007**
Age	0.982	0.965–1.001	.057
Female	1.272	0.773–2.091	.343
Preoperative Hb, g/L	0.983	0.960–0.999	.070
Preoperative Hct	2.116	0.046–8.197	.012*

Hb = hemoglobin, Hct = hematocrit, SimBTHA = simultaneous bilateral total hip arthroplasty, staBTHA = simultaneous bilateral total hip arthroplasty.
* $P < .05$.
** $P < .01$.

Table 7

Logistic regression models for hospital cost after sim/staBTHA.

Parameter	Odds ratio	95% confidence interval	P
Surgery (Sim/staBTHA)	1.193	0.837–1.688	.329
Age	1.026	1.013–1.039	<.001***
Female	1.376	0.956–1.983	.086
Preoperative Hb, g/L	0.968	0.953–0.982	<.001***
Preoperative Hct	0.971	0.950–0.991	.006**

Hb = haemoglobin, Hct = hematocrit, SimBTHA = Simultaneous bilateral total hip arthroplasty, staBTHA = Simultaneous bilateral total hip arthroplasty.
** $P < .01$.
*** $P < .001$.

and so on, which prolonged hospital stay, increased mortality and cost. In addition, long-term problems were mainly delayed infection, including surgical and overall infection.[19–21] In the study, no short-term problems which influenced enhanced recovery were reported. Moreover, the follow-up period was only 90 days so we failed to observe long-term problems in the study. Multiple studies have demonstrated a greater need for blood transfusion after simBTHA,[16,9,22] which has been shown to be a risk factor for complications and prolonged hospital stay.[23,19] The need to reduce blood transfusions is an important issue for surgeons. Seol et al[9] found that the application of appropriate transfusion protocols, such as preoperative autologous blood donation and a postoperative blood cell salvage system, may reduce allogeneic blood transfusions following simBTHA to the levels recorded after primary THA. A randomized trial conducted by Wu et al[24] in China showed that a combination of erythropoietin and tranexamic acid reduced the need for blood transfusion. These blood management strategies should be considered for patients undergoing simBTHA.

The decision to perform simBTHA or staBTHA remains controversial. The study showed that total hospital cost and incidence of complications within 90 days shown no significant difference between simBTHA and staBTHA although the LOS following simBTHA were longer. Our study supported performing BTHA in a simultaneous manner when patients were carefully selected, including younger age, male sex. When the patient reached the related conditions (hemoglobin >130 g/L for women or >150 g/L for men, no fundamental diseases, such as hypertension, diabetes, and satisfactory heart and lung function, NYHA grade ≤I), doctors could suggest patient to consider undergoing simBTHA. The results in the study could provide valid evidence that simBTHA was safe and benefit when patients were selected, especially younger age and male sex.

Since unlike Western countries, there was a systemic lack of community hospitals and rehabilitation centers in China, the majority patients went home directly after rehabilitation in hospital so LOS was longer.[25] In addition, most people in China possessed basic health insurance, which could only cover a small proportion of total cost in the setting of simBTHA and staBTHA. A few patients bought the commercial insurance. As a developing countries, Chinese economy status and health literacy were behind that in the European and American countries. Chinese have lower BMI, poorer nutrition status, longer recovery time after surgery compared with developed countries.[25–27] These elements should be considered in the study.

Limitations of this study were that follow-up at the hospitals was inconsistent, and some information about complications after 90 days was missing. The follow-up period of 90 days was too short to identify potential complications such as low grade infections and dislocations. What was more, the comparison about functional recovery of the patients was absent because of incomplete information about functional recovery, which was a major limitation of this nationwide study. In addition, perioperative management strategies, especially blood management strategies were not consistent among the different hospitals. Also, the baseline characteristics in the groups were different. Although we used Propensity Score Matching to make the 2 groups comparable. The patients in the simBTHA group were still younger, had a higher proportion of men, which indicated that patients were carefully selected for the simultaneous procedures. These variables may have contributed to the excellent results observed in the simBTHA group. The results were similar to those reported in previous studies in other countries, including America and Denmark.[6,8,26] Finally, this was a retrospective review, so studies with a higher level of evidence are necessary.

5. Conclusion

In conclusion, we found that total hospital costs and the incidence of complications within 90 days were not significantly different between simBTHA and staBTHA, although the LOS following simBTHA was shorter. Our study supported performing BTHA in a simultaneous manner when patients are carefully selected, including those with younger men who have high baseline levels of hemoglobin and hematocrit. Because of the differences in baseline characteristics between the groups and the low level of evidence of this retrospective study, randomized controlled studies on this subject are necessary.

Author contributions

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