Influencing Factors for Infection in Elderly Patients After Total Hip Arthroplasty

Leibo Yang
Yang Li
Chencheng Zhao
Guangbin Duan

Objective: To explore the influencing factors for infection in elderly patients after total hip arthroplasty (THA) using logistic regression analysis. Methods: A total of 162 patients undergoing THA were selected, and their clinical data were retrospectively analyzed. The surgical treatment outcomes and postoperative conditions were recorded. They were divided into infection group (n=32) and non-infection group (n=130). The influencing factors for postoperative infection were analyzed by univariate and multivariate logistic regression analyses. A nomogram prediction model was established and validated. Results: Among the 162 elderly patients, postoperative infection occurred in 32 cases, with an infection rate of 19.75%. A total of 82 strains of pathogenic bacteria were isolated, including 48 strains of Gram-positive bacteria (58.5%) and 34 strains of Gram-negative bacteria (41.5%). There were significant differences in age, long-term use of hormones, history of hip surgery, serum albumin, procalcitonin (PCT), erythrocyte sedimentation rate (ESR), neutrophil count and lymphocyte count between infection and non-infection groups (P<0.05). Age >70 years old, long-term use of hormones, history of hip surgery, serum albumin <35 g/L, PCT >44.74 ng/mL, ESR >5.83 mm/h, neutrophil count >2.57×10^9/L and lymphocyte count >2.94×10^9/L were influencing factors. The nomogram prediction model had high predictive value. Conclusion: THA has obvious clinical treatment outcomes. Age >70 years old, long-term use of hormones, history of hip surgery, serum albumin <35 g/L, PCT >44.74 ng/mL, ESR >5.83 mm/h, neutrophil count >2.57×10^9/L and lymphocyte count >2.94×10^9/L were independent influencing factors for infection after THA in elderly patients.

Keywords: Logistic Regression Analysis; Total Hip Arthroplasty; Elderly Patient; Infection; Influencing Factor
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With the aging of population, total hip arthroplasty (THA) has become a common treatment method for hip fractures and osteoarthritis, [1, 2] which can help patients restore joint function and relieve pain. Wound is prone to inflammatory response due to surgical trauma and antibiotics, and the patient's immunity declines, thus causing infection easily.[3] Infection is also considered as one of the common complications after THA, which has been widely studied in clinical practice. There have been a large number of analyses and studies on the influencing factors for infection after THA in China and foreign countries, but the conclusion remains controversial.[4] There is a close correlation between the infection and the body's immunity. Age, length of preoperative hospitalization, intraoperative blood loss, duration of surgery, time of postoperative urinary catheter indwelling, underlying diseases and medications all have significant impacts on infection after THA.[5] Elderly patients have lower tolerance to surgical trauma, anesthetics, pain and stimulation, and poor immunity, so they are more vulnerable to infection. Postoperative infection in elderly patients has become a hot spot of clinical concern.[6] In the present study, 162 patients undergoing THA in our hospital were enrolled, and the influencing factors for postoperative infection were analyzed, so as to provide references for reducing postoperative infection and improving the quality of life of patients.

*Leibo Yang, Yang Li, Chencheng Zhao, Guangbin Duan, Department of Orthopedics, Jincheng People's Hospital, Jincheng 048000, Shanxi Province, China, *Corresponding author: Guangbin Duan, Email: (czk71094@163.com)*

MATERIALS AND METHODS

Clinical data

This study has been approved by the ethics committee of our hospital, and written informed consent has been obtained from all patients. A total of 162 patients undergoing THA in our hospital from November 2019 to September 2020 were selected, including 94 males and 68 females aged 61-82 years old, with an average of (73.29±9.16) years old. According to whether postoperative infection occurs, they were divided into infection group (n=32) and non-infection group (n=130).

Related criteria

Inclusion criteria were as follows: 1) Patients who needed to undergo THA due to fracture of the femoral head diagnosed by X-ray and CT examination, 2) those without a history of hip surgery on the operative side, 3) those with mature skeletal development, 4) those aged >18 years old, and 5) those who voluntarily participated in this study, signed the informed consent, and knew the purpose, methods and significance of this study.

Exclusion criteria were as follows: 1) Patients undergoing joint revision, 2) those complicated with severe heart, brain, kidney or liver disease, or malignant tumors, 3) those with incomplete clinical data, 4) those with mental illness, or 5) those receiving antibiotic therapy.

Criteria for infection: The diagnosis of periprosthetic infection was based on the latest diagnostic criteria recommended by the Musculoskeletal Infection Society and the American Academy of Orthopaedic Surgeons, as follows: (1) There is connection between the joint sinus tract and the prosthesis, (2) the same pathogen is cultured twice in the tissue or liquid samples collected from the diseased joint, and (3) at least 4 of the following 6 criteria are met: a) erythrocyte sedimentation rate (ESR) >30 mm/h or C-reactive protein (CRP) >10 mg/L, b) neutrophil ratio in synovial fluid >65%, c) white blood cell (WBC) count in synovial fluid >3,000×10^6, d) visible pus in the infected joint, e) pathogenic microorganisms are isolated from tissue or synovial fluid samples, and f) neutrophil count >5 in at least 5 high-power visual fields (×400) in frozen sections of periprosthetic tissues in microscopy.

Surgical methods

All patients underwent ultrasound-guided nerve block combined with laryngeal mask general anesthesia, and lumbar plexus block was performed with the aid of an ultrasound instrument. Specifically, the patient lay in a conventional lateral bent-knee position, a psoas major space block approach was made at the puncture point near the L3-4 space, and the ultrasound probe was moved orderly and perpendicularly to the spine to fully display the cross-sectional images of L3-5 transverse process and lumbar plexus. Then the needle was inserted at the site of probe, and 12.5 mL of 0.5% ropivacaine was injected into the L3-4 and L4-5 psoas major space after no bleeding was confirmed. After the above operations, the ultrasound probe was placed at the midpoint between the greater trochanter of femur and the posterior superior iliac spine, and the medial 1/2 lower edge of the midpoint, and adjusted accordingly until the sciatic plexus nerve could be fully displayed. Later, 15 mL of ropivacaine was injected in the same way, and the nerve block status was determined by acupuncture. Besides, 0.1 μg/kg sufentanil and 1.0-1.5 mg/kg propofol were injected respectively after the nerve block met the requirement, and a laryngeal mask was worn. During operation, sevoflurane was inhaled and propofol was pumped.

Observation indices

Before treatment and at 1, 3 and 7 d after treatment, peripheral venous blood was collected and centrifuged in the two groups. The serum was harvested for detection of infection-related indices. Inflammatory factors and other common infection indices were detected, including interleukins (IL-1β, IL-4, IL-6 and IL-10), tumor necrosis factor-α (TNF-α), high-sensitivity CRP (hs-CRP), monocyte chemotactic protein 1 (MCP-1), procalcitonin (PCT), ESR and WBC, using enzyme-linked immunosorbent assay and an automatic biochemical detector.

Statistical analysis

SPSS 16.0 software was used for statistical analysis. The χ^2 test was performed for numerical

data in univariate analysis, independent *t* test for measurement data, and logistics regression analysis for multivariate analysis. P<0.05 was considered statistically significant.

RESULTS

Postoperative infection and distribution of pathogenic bacteria

Among the 162 elderly patients, postoperative infection occurred in 32 cases, with an infection rate of 19.75%. A total of 82 strains of pathogenic bacteria were isolated, including 48 strains of Gram-positive bacteria (58.5%) and 34 strains of Gram-negative bacteria (41.5%) (Table 1).

Univariate analysis results for infection after THA

Postoperative infection occurred in 32 cases, with an infection rate of 19.75%. Infection after THA was significantly related to age, long-term use of hormones, history of hip surgery, serum albumin, PCT, ESR, neutrophil count and lymphocyte count (P<0.05), but had no significant correlations with gender, operation time, drainage time, diabetes, drinking history, smoking history, body mass index (BMI), serum CRP and WBC count (P>0.05) (Table 2).

Multivariate logistic regression analysis results for infection after THA

According to multivariate logistic regression analysis, age, long-term use of hormones, history of hip surgery, serum albumin, PCT, ESR, neutrophil count and lymphocyte count were independent risk factors for infection after THA (*OR*=7.125, 7.246, 7.352, 7.635, 7.698, 7.736, 7.896 and 7.960, P<0.05) (Table 3).

Predictive model for infection after THA in elderly patients

The nomogram model was established based on the influencing factors for infection after THA in elderly patients. The score of age, long-term use of hormones, history of hip surgery, serum albumin, PCT, ESR, neutrophil count and lymphocyte count was 39.11 points, 39.97 points, 41.15 points, 42.39 points, 47.26 points, 54.86 points, 62.73 points and 64.86 points, respectively. The value corresponding to the total score (392.33 points) was the infection rate after THA in elderly patients (12.36%) (Figure 1).

Model validation

After THA, 52 non-infection cases and 5 infection cases were correctly predicted, while 10 non-infection cases and 1 infection case were incorrectly predicted by the nomogram model. The prediction accuracy = (52+5)/ (52+5+10+1) ×100% = 83.82%, and the prediction accuracy of the test set was 85.26%. It can be seen that the nomogram prediction model has a high predictive value for infection after THA (Figure 2).

DISCUSSION

THA can effectively correct the hip deformity, restore the hip function, and relieve the pain of patients, so it has become one of the effective treatment methods for joint diseases in orthopedics, but the technical requirements are relatively high.[7] With the development of laminar flow operating room, air purification and sterilization technique and high-pressure lavage technique, the risk of infection after THA has been significantly reduced, but postoperative complications such as hip dislocation, lower limb deep venous thrombosis and periprosthetic infection cannot be fully avoided.[8] Once infection occurs after THA, it will seriously affect the patient's prognosis, prolong the length of stay, and increase the medical costs and patient's suffering. In particular, the postoperative infection will lead to the failure of THA. Hence, understanding the risk factors for infection after THA and taking preventive measures are the key to guiding the clinical use of antibacterial drugs, saving the lives of patients and reducing medical costs.[9] Moreover, the complications of infection after THA are serious, and the clinical prognosis is usually very poor. Therefore, it is of important value to determine the influencing factors for postoperative infection, which can provide references for clinical treatment.[10,14]

In the present study, according to multivariate logistic regression analysis, age, long-term use of hormones, history of hip surgery, serum albumin, PCT, ESR, neutrophil count and lymphocyte count were all influencing factors for infection after THA in elderly patients. Li *et al.* found that long-term use

of hormones and history of hip surgery were influencing factors for postoperative infection in patients,[11] being consistent with the results herein. The possible reason is that elderly patients who use hormones for a long time suffer from immunosuppression and weakened postoperative healing ability, so the risk of infection is higher. After hip surgery, the surgical field is exposed and affected by microorganisms such as bacteria in the air, so the wound is prone to infection. PCT reflects the activity of systemic inflammatory response, and it can induce the translocation of cytokines or bacteria, and increase the risk of postoperative infection. Serum albumin can maintain the normal plasma osmotic pressure and carry fatty acids for normal vital activities. With the decline in serum albumin content, the content of fatty acid decreases, and the osmotic pressure becomes unstable, thus reducing the ability to resist bacteria and increasing the risk of infection. Ma *et al.* showed that ESR and neutrophil count were not only routine blood test items, but also independent risk factors for infection after hip replacement.[12] Due to the increases in ESR and neutrophil count, inflammation occurs in the body, and the tissue repair ability becomes poor, thus increasing the risk of postoperative infection. In addition, age ≥60 years old, types of antibacterial drugs ≥3, operation time ≥3 h and surgical history are all influencing factors for infection after hip replacement, similar to the results of this study.[13] Herein, the nomogram model was established to validate the infection after THA. Postoperative infection was affected by multiple factors, and the prediction accuracy of nomogram model in test set was higher, indicating that the nomogram prediction model has higher predictive value for infection after THA.

In conclusion, infection after THA is significantly related to various clinical factors. Active prevention and early clinical intervention of a variety of risk factors are necessary for reducing the risk of infection after THA.

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Figure and Table Legends

Figure 1.
Nomogram model for predicting infection after THA in elderly patients.

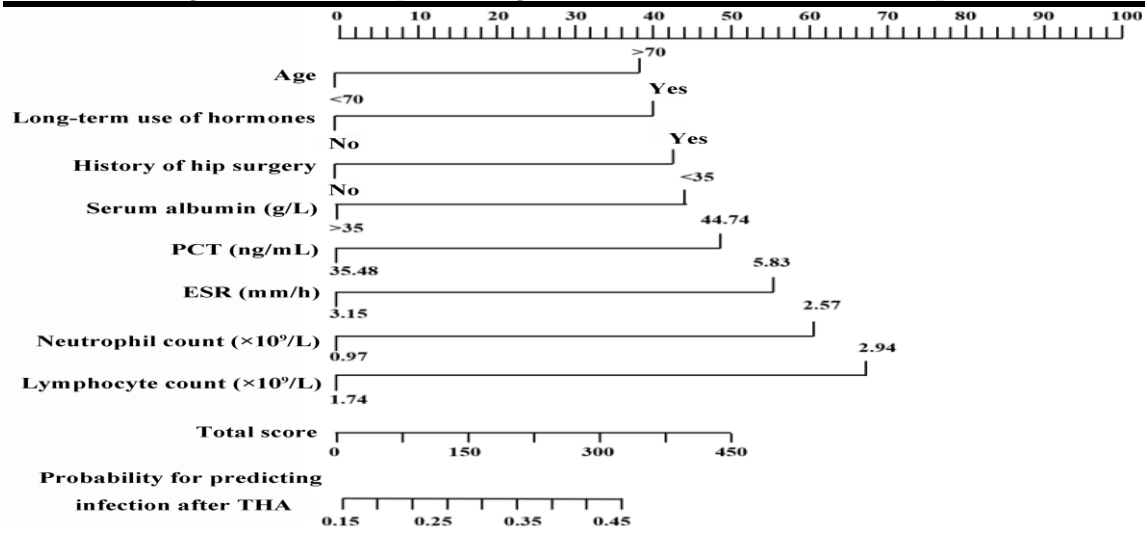

Figure 2.
Calibration of nomogram model. A) Calibration of nomogram model in training set, B) calibration of nomogram model in test set.

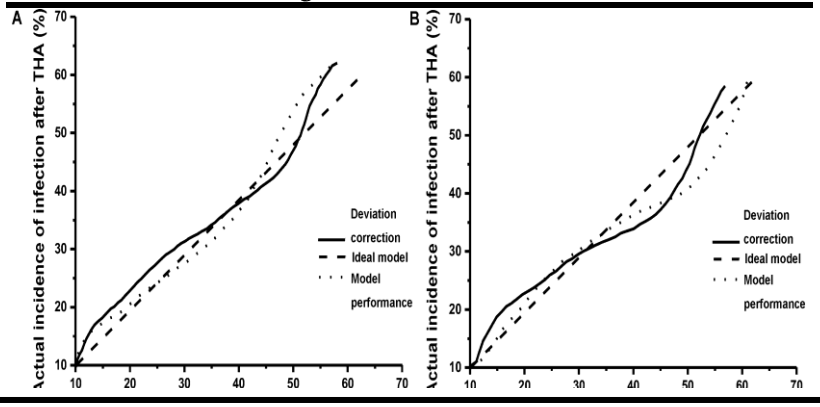

Table 1.
Distribution and composition ratio of pathogenic bacteria in patients with postoperative infection

Pathogenic bacteria	Number of stains	Composition ratio (%)
Gram-positive bacteria	48	58.5
Staphylococcus aureus	12	14.6
Staphylococcus haemolyticus	11	13.4
Staphylococcus epidermidis	8	9.8
Enterococcus faecium	7	8.5
Enterococcus casseliflavus	10	12.2
Gram-negative bacteria	34	41.5
Pseudomonas aeruginosa	15	18.3
Acinetobacter baumannii	10	12.2
Escherichia coli	6	7.3

Klebsiella pneumoniae	2	2.4
Enterobacter cloacae	1	1.2
Total	82	100.0

Table 2.
Univariate analysis results for infection after THA

Influencing factor		Non-infection group (n=130)	Infection group (n=32)	χ^2/t	P
Age [n (%)]	≤70Y	40 (30.77)	2 (6.25)	3.92	0.009
	>70Y	90 (69.23)	30 (93.75)		
Gender [n (%)]	Male	76 (58.46)	18 (56.25)	0.96	1.254
	Female	54 (41.54)	14 (43.75)		
Operation time [n (%)]	<160 min	74 (56.92)	6 (18.75)	4.93	0.069
	≥160 min	56 (43.08)	26 (81.25)		
Drainage time [n (%)]	<2 d	62 (47.69)	8 (25.00)	4.00	0.306
	≥2 d	68 (52.31)	24 (75.00)		
Long-term use of hormones [n (%)]	Yes	20 (15.38)	10 (31.25)	7.46	0.001
	No	110 (84.62)	22 (68.75)		
Diabetes [n (%)]	Yes	32 (24.61)	9 (28.13)	6.33	0.236
	No	98 (75.39)	23 (71.87)		
History of hip surgery [n (%)]	Yes	26 (20.00)	5 (15.63)	7.22	0.001
	No	104 (80.00)	27 (84.37)		
Serum albumin [n (%)]	<35 g/L	68 (52.31)	19 (59.38)	4.39	0.001
	≥35 g/L	62 (47.69)	13 (40.62)		
Drinking history [n (%)]	Yes	75 (57.69)	25 (78.13)	3.63	0.363
	No	55 (41.31)	7 (21.87)		
Smoking history [n (%)]	Yes	76 (58.46)	21 (65.63)	4.03	1.211
	No	54 (41.54)	11 (34.37)		
BMI ($\bar{\chi} \pm s$, kg/m^2)			0.30±0.08	0.38±0.08	5.99
PCT ($\bar{\chi} \pm s$, ng/mL)			40.11±4.63	41.11±4.23	3.25
Serum CRP ($\bar{\chi} \pm s$, ng/mL)			20.36±2.56	22.36±2.52	4.29
ESR ($\bar{\chi} \pm s$, mm/h)			4.49±1.34	5.49±1.85	6.01
WBC count (×10^9/L)			2.19±2.72	4.19±2.63	6.33
Neutrophil count (×10^9/L)			1.77±0.80	1.53±0.14	5.21
Lymphocyte count (×10^9/L)			2.34±0.60	3.31±0.74	4.96

Table 3.
Multivariate logistic regression analysis results for infection after THA

Factor	SE	β	95%CI	OR	*P*
Age	0.632	2.413	6.398~14.002	7.125	0.002
Long-term use of hormones	0.555	2.693	6.015~16.025	7.246	0.000
History of hip surgery	0.637	2.635	6.010~14.263	7.352	0.001
Serum albumin	0.612	2.418	6.639~16.325	7.635	0.000
PCT	0.521	2.996	6.471~15.743	7.698	0.002
ESR	0.693	2.104	6.302~16.035	7.736	0.000
Neutrophil count	0.547	2.574	6.003~16.012	7.896	0.001
Lymphocyte count	0.693	2.001	6.540~15.320	7.960	0.000