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What Are the Risk Factors for Infection in Hemiarthroplasties and Total Hip Arthroplasties?

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Abstract

Background Late infection is the second most frequent early complication after total hip arthroplasty (THA) and the most frequent after hemiarthroplasty. Known risk factors for infection after THA include posttraumatic osteoarthritis, previous surgery, chronic liver disease, corticoid therapy, and excessive surgical time. However, risk factors for hemiarthroplasty are not clearly established.

Questions/purposes We therefore determined the preoperative and intraoperative risk factors for late infection (more than 3 months after surgery) in patients with hemiarthroplasties and THAs.

Methods We retrospectively compared 47 patients with a hip arthroplasty (23 hemiarthroplasties, 24 total hip arthroplasties) and late infection with 200 randomly-selected patients with primary arthroplasty (100 hemiarthroplasties, 100 total hip arthroplasties) during the same time period of time without any infection during followup. Potential risk factors were identified from medical records. Minimum followup was 12 months (mean, 27 months; range, 12–112 months) for the study group and 18 months (mean, 84 months; range, 18–144 months) for the control group.

Results The following factors were more frequent in late infected hemiarthroplasties: female gender; previous surgery; obesity (body mass index greater than 30 kg/m^2); glucocorticoid and immunosuppressant treatments; prolonged surgical time; inadequate antibiotic prophylaxis; prolonged wound drainage; hematoma; dislocation; and cutaneous, urinary, and/or abdominal infections. The following were more frequent in infected total hip arthroplasties: posttraumatic osteoarthritis; previous surgery; glucocorticoids; chronic liver disease; alcohol and intravenous drug abuse; prolonged surgical time; prolonged wound drainage; dislocation; subsequent surgery; and cutaneous, urinary, respiratory and abdominal infections. Diabetes did not appear to be a risk factor.

Conclusions Our data suggest there are specific risk factors for infection in hemiarthroplasties. The major risk factors for late infection in hip arthroplasty must be recognized so they can be minimized or controlled if not possible to employ prophylactic measures.

Level of Evidence Level III, prognostic study. See Guidelines for Authors for a complete description of levels of evidence.

Introduction

Prosthetic joint infections may be classified based on the timing and presumed mechanism of infection: early

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Each author certifies that his or her institution approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.
This work was performed at Hospital Universitario La Princesa, University Hospital integrated in Universidad Autónoma de Madrid, Madrid, Spain.

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infection (acute or Fitzgerald Stage I) is defined as occurring when less than 1 month has elapsed since implantation (3 months according to Fitzgerald's classification), while delayed or late infection (chronic, Fitzgerald Stage II) is diagnosed when infection occurs months after implantation [29, 38, 43]. Late infection continues to be the second most frequent early complication in THA and the most frequent local complication after hemiarthroplasty [19, 33, 36, 38]. The reported ranges of late infection rates in THA range from 0.3% to 2.2% [14, 19, 38] and in hemiarthroplasty from 1.7% to 7.2%) [10, 14, 33, 35].

Many studies have identified factors related to infection risk after THA. A higher risk of infection for THAs is described in posttraumatic osteoarthritis [3, 25, 33], whereas influence of gender and age is still debated [19, 33]. Previous surgery, chronic liver disease, corticoid therapy, and intravenous drug abuse reportedly increase the risk [5, 9, 16, 34, 35, 46], whereas nonrheumatoid inflammatory arthritis or thalassemia do not [5, 45, 46]. The data on whether diabetes, obesity, rheumatoid arthritis, or immunosuppressants increase the risk of infection are contradictory [6, 13, 17, 20, 24, 28, 33, 35, 37, 40]. Surgical time [22, 33, 35, 38, 44] and inadequate antibiotic prophylaxis [1, 41, 44] are accepted major risk factors among intraoperative variables. Dislocation [36] and hematoma [37] are accepted risk factors, whereas the influence of prolonged drainage is debated [15, 32, 36, 37]. Cutaneous [5] and urinary tract [2, 4, 20, 36] infections are risk factors for hematogenous seeding, but the role of respiratory and abdominal infections is debated [20] as well as that of metastatic infection from oral or dental origin [21, 23, 30].

Although the information in the review literature appears comprehensive, many questions about the risk factors for late infection in hemiarthroplasties differ from those for THA [22, 33, 36, 41]. While hemiarthroplasty surgery is similar to that for THA in local tissue trauma, it is generally less intense and the surgery is typically of shorter duration. Moreover, the patients' epidemiologic characteristics and preoperative medical conditions differ. Therefore one cannot assume that infection risk factors for THA are the same as for hemiarthroplasties. On the contrary, although many studies report risk factors for THAs, most focus on a single problem [1, 2, 6, 9, 13–16, 21–23, 26–30, 37, 40, 41, 44–46], and do not consider all risk factors in the individual patient from a global point of view. Moreover, several of those studies are not primarily focused on infection, although they contain information on infected patients [11, 13, 17, 18, 24, 36, 40, 45, 46]. Finally, the level of evidence in many of them is low; we have found seven case series (Level of Evidence IV) [3, 6, 13, 16, 17, 21, 40, 46] and many nonsystematic reviews (Level of Evidence V) [1, 18, 23, 25, 28, 34, 38, 45] and expert opinions (Level of Evidence V) [2, 4, 30]. We believe it important to learn and identify these risk factors in the individual patient for to check for and minimize risk factors or, when not possible to consider specific prophylactic measures.

We therefore addressed the following questions: (1) Which patient characteristics and preoperative conditions are more frequent in hemiarthroplasties with a late infection? (2) Which patient characteristics and preoperative conditions are risk factors for late infection in THAs? (3) Which intraoperative facts, postoperative events, and distant septic foci are more frequent in hemiarthroplasties with a late infection? (4) Which intraoperative facts, postoperative events, and distant sepsis are statistically related to late infection in THAs?

Patients and Methods

We retrospectively reviewed patients with a hemiarthroplasty or THA comparing different parameters between infected arthroplasties and control arthroplasties without infection so as to identify the incidence and prevalence of risk factors associated with infection. We retrospectively reviewed all 47 patients diagnosed with a late infection of a hip arthroplasty who had primary arthroplasty between January 1997 and December 2007. We defined late infection as occurring more than 3 months after primary surgery and the absence of a concomitant distant septic focus, which could be responsible for an acute hematogenous infection; acute postoperative and acute hematogenous infections were specifically excluded. These patients had been implanted with an uncemented HAP-coated THA (24 patients) or received a cemented hemiarthroplasty for a femoral neck fracture (23 patients). A diagnosis of infection required: (1) clinical symptoms and signs (unexplainable pain and/or draining sinus and/or persistent local erythema plus swelling; (2) CRP greater than 1 mg/dl and ESR greater than 30 mm in the first hour—Katz index; (4) microbiological confirmation (three or more positive cultures with the same organisms from intraoperative samples and/or cultures of joint aspiration). For this study we excluded six patients: Five patients had positive cultures for coagulase-negative Staphylococcus in only one of the five samples sent to the Microbiology Department, so they were considered microbiologically as a possible contamination; the clinical evolution of their wounds and arthroplasties was uneventful after a 1-week course of antibiotics. One patient had a chronic draining sinus with repeated negative cultures, and negative intraoperative cultures. All infections were Type IV according to the classification system of Cierny and DiPasquale [7]. The minimum followup was 12 months (mean, 27 months;

range, 12–112 months). No patients were lost to followup. All data came from the charts and were reviewed by the authors of this study; no patients were seen in a followup consultation specifically for this study, but they have continued their followup with their orthopaedic surgeon.

From 1997 to December 2007, a total of 1540 patients received an uncemented HAP-coated THA and 1589 a cemented hip hemiarthroplasty (for a femoral neck fracture) in our department. Between 1997 and 2004, hemiarthroplasties employed cemented Müller-type Autoblocking stems (Surgical-Traiber, Valencia, Spain); and between 2005 and 2007, cemented Furlong stems (JRI-Furlong, London, UK). All stems were implanted with Furlong bipolar heads (JRI-Furlong, London, UK). Two types of HAP-coated THAs (stem and cup) were used between 1997 and 2007: ABG (I and II), (Howmedica/Stryker, USA); and HAP-Furlong (JRI-Furlong, London, UK). For the sample size power analysis we chose to set the effect size at a value of 0.3 (this value offers a medium level of statistical power using χ^2-test) [8], statistical power at a value of 0.8 and "p" at level of 0.05; we then calculated a sample size under these conditions, and the resulting theoretical size was 87 arthroplasties per group (this size was sufficient to determine differences). Accordingly, 100 arthroplasties were randomized to each control group, 100 with a THA and 100 with a hemiarthroplasty by means of a manual systematic randomization sampling (first patient selected from each 15 consecutively operated patients). Inclusion criteria were: (1) patients operated on during the same period as infected cases (January 1997 to December 2007); (2) patients with a complete followup according to hospital protocols (clinical and radiologic controls at 1, 3, 6, and 12 months after surgery and thereafter every year); and (3) hip arthroplasty without symptoms or signs of infection throughout followup. The minimum followup was 18 months (mean, 84 months; range, 18–144 months) for the control group. We considered any of the following clinical signs or symptoms to be possibly indicative of infection: chronic severe pain; persistent regional inflammatory signs (erythema and/or swelling); wound drainage; wound dehiscence, and/or fistula.

Standard plain anteroposterior radiographs of the pelvis and "frog leg lateral" radiographs of the hip were made with the patient in a supine position and with his/her feet together. The x-ray tube was positioned over the symphysis pubis one meter from and perpendicular to the table. One of the authors (MdD) and one radiologist (different radiologists from the radiology department of the hospital through the patients' years of followup) independently examined the radiographs for signs suggestive of infection or loosening. Radiographic signs suggestive of infection include periostitis (periosteal reaction), endosteal scalloping, and ring osteolysis (focal resorption); infection is likely if there is rapid onset of osteolysis or endosteal scalloping in the absence of obvious mechanical causes such as poorly implanted prostheses and/or excessive polyethylene wear [38, 39, 42]; early implant loosening may alert for a dormant underlying infection [31]. Radiographic signs suggestive of loosening include complete radiolucent lines, migration (change of $> 5^\circ$ in the acetabular angle or change of > 3 mm in the height of the center of the hip or the horizontal distance of the cup) [27] and stem subsidence (an increase of at least 5 mm in the distance between the top of the stem and the greater trochanter when the initial postoperative radiographs were compared to those made at the followup evaluations [12].

To identify risk factors, we reviewed the following records for each patient: general physician (GP) records; preoperative hospital history; preanesthesia evaluation; surgical, anesthetic, and nursing records from the operating room and recovery room; in-hospital postoperative medical and nursing history; out-of-hospital followup records; and all other GP and hospital postoperative events and history. We classified the risk factors described in the literature according to the period of risk: demographic variables, preoperative conditions, intraoperative factors, postoperative events, and distant septic foci after surgery (Table 1). Drug abuse refers to past intravenous drug abuse. The protocol for antibiotic prophylaxis in arthroplasties in our hospital between 1997 and 2007 was based in preoperative administration of 2 g intravenous cefazolin followed by six doses of 1 g every 8 hours (so prophylaxis lasted 48 hours); in case of allergy to beta-lactams, the patient received 1 g vancomycin intravenously preoperatively followed by four doses of 1 g every 12 hours; inadequate antibiotic prophylaxis was considered any deviation from this protocol. Deep palpable hematoma was a blood collection situated at least under the dermal layer of the skin, liquid (with palpable fluctuation), and painful. References to any distant septic foci after arthroplasty were searched for in all hospital records of the patients and control subjects and considered deep cutaneous infections, upper and lower urinary tract infections, pneumonias and bronchopneumonias, diverse abdominal infections, and severe oral and dental infections.

Contingency tables with absolute numbers were created with all variables. The Pearson chi square test was applied for statistical analysis of qualitative variables (gender, etiology of hip disease, obesity, diabetes, rheumatoid arthritis, chronic liver disease, excessive alcohol consumption, HIV infection, parenteral drug abuse, chronic glucocorticoid therapies, immunosuppressive therapy, antecedents of tuberculosis, thalassemia, brucellosis, previous surgery, adequate antibiotic prophylaxis, need for blood transfusion, intraoperative periprosthetic fractures,

Table 1. Risk factors compared between infected cases and noninfected control subjects

1. Epidemiologic characteristics:
   1.1. Age at surgery
   1.2. Gender
   1.3. Etiology (cause for arthroplasty)
2. Preoperative conditions:
   2.1. Obesity (body mass index, > 30 kg/m^2)
   2.2. Diabetes mellitus
   2.3. Rheumatoid arthritis
   2.4. Other inflammatory/autoimmune arthritis
   2.5. Chronic liver disease (chronic elevation over normal values of SGOT, SGPT, and/or gamma-GT because of a known cause: chronic hepatic viral infection by type B or type C virus, chronic alcohol abuse as defined quantitatively in point 2.6)
   2.6. Excessive alcohol consumption (> 45 g/day males, > 30 g/day females)
   2.7. HIV infection
   2.8. Past parenteral drug abuse
   2.9. Chronic therapy with glucococorticoids
   2.10. Immunosuppressive therapy (any pharmacologic treatment intended to lower activity of immune system, excluding glucocorticoids)
   2.11. Antecedents of tuberculosis
   2.12. Thalassaemia
   2.13. Brucellosis
   2.14. Previous surgery in the same hip
   2.15. Preoperative leukocyte total count
3. Intraoperative facts:
   3.1. Length of surgery
   3.2. Appropriate antibiotic prophylaxis
   3.3. Hematocrit loss (%) (preoperative minus postoperative)
   3.4. Need for blood transfusion
   3.5. Blood transfused (ml)
   3.6. Intraoperative periprosthetic fractures
4. Postoperative events:
   4.1. Persistent drainage after 10 days
   4.2. Deep palpable hematoma
   4.3. Hip dislocation at any time along all followup
   4.4. Need for reoperation along follow-up
5. Distant septic focus after arthroplasty
   5.1. Deep cutaneous
   5.2. Upper and lower urinary tract
   5.3. Pneumonia
   5.4. Abdominal
   5.5. Oral/dental

persistent wound drainage, deep palpable hematoma, hip dislocation, need for new surgery, and distant septic focus after arthroplasty). Analysis of variance and the Snedecor "F" test were used for the comparison of quantitative variables (age, preoperative leukocyte count, length of surgery, hematocrit loss, and amount of blood transfused). We used SPSS 15.0 (SPSS Inc, Chicago, IL) for all calculations.

Results

Patients with infected hemiarthroplasties were younger ($p = 0.049$) and female gender was more frequent ($p = 0.042$). Among the patients' preoperative conditions, previous surgery ($p = 0.003$), obesity ($p = 0.031$), chronic glucocorticoid therapy ($p = 0.016$), and immunosuppressive treatments ($p = 0.036$) were risk factors for infection. Among patients with hemiarthroplasties, diabetes ($p = 0.378$), rheumatoid arthritis ($p = 0.252$), chronic liver disease ($p = 0.896$), tuberculosis ($p = 0.329$), thalassemia ($p = 0.63$), and preoperative leukocyte count ($p = 0.546$) were not associated with infection (Table 2).

Posttraumatic osteoarthritis was more frequent ($p = 0.039$) in infected THAs, whereas age at surgery ($p = 0.352$) and patient's gender ($p = 0.768$) was similar in infected and noninfected THAs. Among the patients' preoperative conditions, previous surgery in the same hip ($p < 0.001$), chronic corticoid therapy ($p < 0.001$), chronic liver diseases ($p < 0.001$), alcohol abuse ($p < 0.001$), and intravenous drug abuse ($p = 0.004$) were risk factors for infection. Diabetes ($p = 0.073$), rheumatoid arthritis ($p = 0.115$), other inflammatory arthritis ($p = 0.269$), obesity ($p = 0.127$), immunosuppressive therapy ($p = 0.233$), tuberculosis ($p = 0.089$), thalassemia ($p = 0.623$), and preoperative leukocyte count ($p = 0.332$) were not associated with infection (Table 3).

A prolonged surgical time ($p < 0.001$) and inappropriate antibiotic prophylaxis ($p = 0.016$) were risk factors in hemiarthroplasties, but we found no differences in the amount of bleeding ($p = 0.456$), need for transfusion ($p = 0.334$), or intraoperative fractures ($p = 0.742$). We did find differences in the frequency of prolonged wound drainage ($p < 0.001$), deep palpable hematoma ($p < 0.001$), and dislocation ($p < 0.001$), but not in the need for new surgery ($p = 0.252$) (Table 2). Among the distant septic foci occurring in patients after hemiarthroplasty, those statistically related to deep infection were deep cutaneous infections ($p = 0.003$), upper and lower urinary tract infections ($p = 0.019$), and diverse abdominal infections ($p = 0.007$). We found no differences in the incidence of severe oral or dental infections ($p = 0.63$) (Table 2).

A prolonged surgical time ($p < 0.001$) and hematocrit loss ($p = 0.005$) were the intraoperative parameters related to deep infection in THAs. We found no differences in the need for transfusion ($p = 0.884$) or intraoperative fractures ($p = 0.274$). Among postoperative events, wound drainage

Table 2. Incidence and prevalence of risk factors in infected cases and noninfected control subjects in hip hemiarthroplasties

Suspected risk factor for infection	Hemiarthroplasties		
	Infected cases (N = 23)	Noninfected control subjects (N = 100)	"p" Value
Age (years) (mean ± SD)	81 ± 7	84 ± 7	0.049
Female/male	22/1	77/23	0.042
Previous surgery	2 (9%)	0 (0%)	0.003
Obesity	2 (9%)	1 (1%)	0.031
Diabetes	6 (26%)	18 (18%)	0.378
Rheumatoid arthritis	1 (4%)	1 (1%)	0.252
Liver disease	1 (4%)	5 (5%)	0.896
Corticoid therapy	3 (13%)	2 (2%)	0.016
Immunosuppressive therapy	1 (4%)	0 (0%)	0.036
Tuberculosis	0 (0%)	4 (4%)	0.329
Thalassemia	1 (4%)	3 (3%)	0.630
Preoperative leukocyte count (cells/ml) (mean ± SD)	10,202 ± 3966	9748 ± 3062	0.546
Length of surgery (minutes)	90 ± 36	69 ± 18	0.000
Inadequate AB prophylaxis	3 (12%)	1 (1%)	0.016
Haematocrit loss (% of total blood volume occupied by red blood cells) (mean ± SD)	10.7 ± 4.4	10.0 ± 3.9	0.456
Blood transfusion	15 (68%)	57 (57%)	0.334
Volume transfused (ml) (mean ± SD)	865 ± 695	615 ± 570	0.079
Intraoperative periprosthetic fractures	1 (4%)	3 (3%)	0.742
Persistent secretion	17 (85%)	6 (6%)	0.000
Hematoma	6 (27%)	1 (1%)	0.000
Dislocation	6 (27%)	3 (3%)	0.000
Reoperation	1 (4%)	1 (1%)	0.252
Cutaneous infection	7 (30%)	8 (8%)	0.003
Urinary infection	9 (39%)	17 (17%)	0.019
Abdominal infection	4 (17%)	3 (3%)	0.007
Pneumonia	4 (17%)	9 (9%)	0.238
Oral/dental infection	0 (0%)	1 (1%)	0.630

SD = standard deviation.

lasting more than 10 days ($p < 0.001$), dislocation of the prosthesis ($p < 0.001$), and subsequent surgery ($p < 0.001$) were more frequent. There were no differences between THAs in the presence of a deep palpable hematoma ($p = 0.175$) (Table 3). Cutaneous ($p = 0.002$), urinary ($p < 0.001$), respiratory ($p = 0.006$), and/or abdominal septic foci ($p = 0.037$) were statistically related to THA infections (Table 3).

Discussion

Late infection continues to be the second most frequent early complication in hip arthroplasty and is assumed to be the most frequent local complication in hemiarthroplasty. Risk factors for infection in hemiarthroplasty have received almost no attention in the literature [22, 33, 36, 41]. Although many studies about infection and THAs are centered on a specific problem, they are not primarily focused on infection, and their level of evidence can be low. We therefore specifically designed this study to determine risk factors for infection in hemiarthroplasties and THAs from a global view point (considering all aspects simultaneously, not centered on one or two characteristics) and with a reasonable level of evidence.

The first major limitation of this study was the relatively small number of cases. Late infection is, fortunately, a low-frequency complication in hip arthroplasty: less than 1% in THAs [19, 26, 38] and 5% in hemiarthroplasty [33]. A previous power analysis was performed to determine sample size to avoid the effect of this low incidence. Second, theoretically possible risk factors are infinite, so it is impossible to explore all of them. We have studied a large number of risk factors for any type of implant

Table 3. Incidence and prevalence of risk factors in infected cases and noninfected control subjects in THAs

Suspected risk factor for infection	Total arthroplasties		
	Infected cases (N = 24)	Noninfected control subjects (N = 100)	"p" value
Age (years) (mean ± SD)	67 ± 12	69 ± 10	0.352
Female/male	58/42	55/45	0.768
Posttraumatic	4 (17%)	3 (3%)	0.039
Osteoarthritis	15 (63%)	79 (79%)	0.039
Previous surgery	14 (60%)	6 (6%)	0.000
Obesity	8 (33%)	19 (19%)	0.127
Diabetes	6 (25%)	11 (11%)	0.073
Rheumatoid arthritis	2 (8%)	2/100	0.115
Other inflammatory arthritis	1 (4%)	1 (1%)	0.269
Liver disease	5 (21%)	2 (2%)	0.000
Alcohol abuse	3 (13%)	0 (0%)	0.000
Parenteral drug abuse	2 (8%)	0 (0%)	0.004
Corticoid therapy	3 (13%)	0 (0%)	0.000
Immunosuppressive therapy	2 (8%)	3 (3%)	0.233
Tuberculosis	0 (0%)	11 (11%)	0.089
Thalassemia	0 (0%)	1 (1%)	0.623
Preoperative leukocyte count (cells/ml) (mean ± SD)	8570 ± 2440	7410 ± 4040	0.332
Length of surgery (minutes)	133 ± 31	98 ± 22	0.000
Inadequate AB prophylaxis	0 (0%)	3 (3%)	0.913
Hematocrit loss (% of total blood volume occupied by red blood cells) (mean ± SD)	12 ± 3	15 ± 4	0.005
Blood transfusion	11 (85%)	83 (83%)	0.884
Volume transfused (ml) (mean ± SD)	925 ± 450	910 ± 570	0.937
Intraoperative periprosthetic fractures	0 (0%)	5 (5%)	0.274
Persistent secretion	6 (46%)	8 (8%)	0.000
Hematoma	2 (14%)	5 (5%)	0.175
Dislocation	6 (40%)	6 (6%)	0.000
Reoperation	4 (21%)	1 (1%)	0.000
Cutaneous infection	2 (9%)	0 (0%)	0.002
Urinary infection	8 (36%)	2 (2%)	0.000
Abdominal infection	3 (14%)	3 (3%)	0.037
Pneumonia	5 (23%)	5 (5%)	0.006
Oral/dental infection	0 (0%)	0 (0%)	

SD = standard deviation.

infection (not only hip arthroplasties), and we added some related factors specific to THA. Implementing both strategies (power analysis and registry of all suspected risk factors) identified a number of statistically significant risk factors, some novel, especially in the case of hemiarthroplasties.

In terms of epidemiologic and preoperative risk factors for hemiarthroplasties, our findings agree with a previously published paper [33] regarding the importance of female gender, age and obesity, although the latter point is controversial [20, 35] (Table 4). Obesity may not offer statistical significance in a series because of the proportion of obese patients, and is strongly dependent on the prevalence of obesity in the general population, which varies markedly across countries and regions. We have also found novel factors for infection in hemiarthroplasty including previous surgery, corticoid therapy, and immunosuppressive therapy.

The most frequent epidemiologic characteristic in infected THAs was posttraumatic osteoarthritis. This was first reported more than 20 years ago [3, 25, 33] and continues to hold true (Table 2). The influence of gender or

Table 4. Significant and nonsignificant risk factors for infection in hip arthroplasty: comparison of published papers and present series

Suspected risk factor for infection	Significant in present case-control study	Significant risk factor in these references	Not significant risk factor in these references	Type of study
Older age	Yes	[33]		Case-control
Gender	Female (hemi)	Male [19]		Case-control
		Female [33]		
Posttraumatic	Yes	[3]		Case series
		[25]		Literature review
		[33]		Case-control
Previous surgery	Yes	[5]		Case-control
		[35]		Cohort comparison
Obesity	No (total)	[24]	[20]	Cohort comparison
	Yes (hemi)	[33]	[35]	Case-control
				Case-control
				Cohort comparison
Diabetes	No	[20]	[17]	Case series
			[37]	Case-control
				Case-control
Rheumatoid arthritis	No	[6]	[5]	Case-control
			[13]	Case series
			[20]	Case series
			[46]	Case-control
				Case series
Liver disease	Yes	[9]		Cohort comparison
Alcohol abuse	Yes		[37]	Case-control
Intravenous drug abuse	Yes	[16]		Case series
		[34]		Literature review
Corticoid therapy	Yes	[46]		Case series
Immunosuppressive therapy	No (total)	[40]	[28]	Case series
	Yes (hemi)			Literature review
Thalassemia	No		[45]	Literature review
Length of surgery	Yes	[22]		Case-control
		[33]		Case-control
		[35]		Cohort comparison
		[38]		Literature review
		[44]		Cohort comparison
Inadequate AB prophylaxis	Yes	[1]		Literature review
		[41]		Meta-analysis
		[44]		Cohort comparison
Blood transfusion	No	[9]	[37]	Cohort comparison
		[18]		Literature review
				Case-control
Periprosthetic fractures	No		[11]	Case series
			[36]	Cohort comparison
Persistent wound secretion	Yes	[32]	[15]	Case-control
		[37]	[36]	Case-control
				Cohort comparison
				Cohort comparison
Hematoma	No (total)	[37]		Case-control
	Yes (hemi)			
Dislocation	Yes	[36]		Cohort comparison

Table 4. continued

Suspected risk factor for infection	Significant in present case-control study	Significant risk factor in these references	Not significant risk factor in these references	Type of study
Skin infection	Yes	[5]		Case control
Urinary infection	Yes	[2]		Expert opinion
		[4]		Expert opinion
		[20]		Case-control
		[36]		Cohort comparison
Abdominal infection	Yes		[20]	Case-control
Pneumonia	Yes (total)		[20]	Case-control
	No (hemi)			
Oral/dental infection	No	[21]	[23]	Case series
			[30]	Literature review
				Literature review

age is contradictory in the literature as some authors describe a higher infection risk in males [19], whereas others report higher risk in females and/or older individuals [33]. We found age and gender presented no differences (Tables 3, 4). The literature on preoperative conditions and late infection is abundant. Some of the demonstrated risk factors with which our data agree include previous surgery [5, 35], chronic liver disease [9], intravenous drug abuse [16, 34], or chronic corticoid therapy [46]. Nonrheumatoid inflammatory arthritis [5] or thalassemia [45] are not considered major risk factors. We did find alcohol abuse was a clear risk factor for infection, but this does not agree with others' findings [37]; this disagreement could be explained by a sociological difference (prevalence of alcohol abuse in population, highly variable among regions and cultures), or by alcohol abuse (immunosuppressant) in the perioperative period (once the patient is outside the hospital). Finally, while some preoperative conditions are not major risk factors in our case-controlled study, contradictory published data include diabetes [17, 20], obesity [20, 24, 33, 35], rheumatoid arthritis [5, 6, 13, 46], and immunosuppressants [28, 40].

There are relatively few studies identifying intra- and postoperative risk factors for infection in hemiarthroplasty. Inappropriate antibiotic prophylaxis is reported as a risk factor for infection [41], as in our series. Excessive surgical time is a controversial risk factor [22, 33]; our data affirm its importance. Intraoperative fractures are not a risk factor in either this series or the literature [36]. On the contrary, dislocation is a proven [36] risk factor, as in the present series. We found prolonged wound drainage predicted infection, but Rogmark et al. [36] did not; we suspect that if a wound is not dry after ten days, infection must be suspected and diagnostic studies must be implemented, including serology, cultures, and possibly débridement. We have also demonstrated the importance of a deep palpable hematoma. Urinary tract infections are the only distant septic focus considered to be a risk factor in the literature [36] and our data confirm this and demonstrate also the importance of deep cutaneous and abdominal infections.

Intraoperative and postoperative risk factors for infection in THA consistently include excessive surgical time [22, 33, 35, 38, 44] and our data confirm it (Table 4). We also found hematocrit loss (Table 3), which was not mentioned in the consulted literature to be important; a greater hematocrit loss reflects a more aggressive surgery, more tissue damage, and, consequently, a higher risk of infection. Also, some authors find the need for transfusion a risk factor [9, 18], but we found it to be highly dependent on the proportion of THA patients who receive transfusions, and this is quite dependent on hospital protocols. Intraoperative fractures are not a risk factor in this series or in the literature [11, 36]. Although controversial in other studies, a wound drainage time in excess of 10 days was a major predictor of infection in our study [15, 32, 36, 37]. Dislocation of the prosthesis and need for repeat surgery were more frequent with infected THAs in both our cases and the literature [36]. The presence of a deep palpable hematoma was not associated with infection here (Table 2), although it has been in one study [37] (Table 4). Deep cutaneous [5] and urinary tract [2, 4, 20] infections are reported risk factors and our data confirm this. We found respiratory and abdominal infections associated with THA infections, but the role of the latter in hematogenous seeding is not clear in the literature [20]. Although there are case reports about metastatic infection with an oral or dental origin [21], their importance is controversial [23, 30] and we found no differences in the incidence of severe oral or dental infections in our patients (Table 4) [36].

Risk factors for infection in hemiarthroplasties have received almost no attention in the literature, so the new data presented here may be helpful for the treating surgeon.

Most papers about risk factors for THA are centered on a specific problem; this case-control study analyzes all risk factors described in the literature in every patient in the series, so its results may offer a better overview of the total risk. Being able to identify these risk factors in an individual patient is to allow the surgeon to check for and minimize risk factors or, when not possible allows the institution of prophylactic measures such as additional or longer antibiotic prophylaxis. We have begun to use, in addition to protocols of intravenous cefazolin, cement with gentamicin or, alternatively, 240 mg gentamicin intravenously every 24 hours for 2 days in those patients with impossible-to- control risk factors.

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