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Risk Factors for Prosthetic Joint Infection after Primary Hip Arthroplasty

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Abstract

Prosthetic joint infection (PJI) after primary hip arthroplasty (PHA) in most cases results in severe surgical and socio-economic problems. Along with improving the technical support of arthroplasty and antibiotic prevention schemes, a key point in reducing the rate of infectious complications is predicting of PJI in each individual patient. The ***purpose of the study*** was to reveal the key features of our patients with infectious complications after PHA in comparison with the patients with a successful outcome of arthroplasty. ***Materials and Methods.*** The outcomes of 249 cases of PHA were evaluated retrospectively. 115 of them subsequently developed PJI (main group) and 134 were without infectious complications (control group). The comparative analysis of the groups was aimed at identifying the key preoperative, intraoperative and postoperative factors for PJI, as well as combinations of the factors characteristic for our patients. ***Results.*** The risk group for the development of infectious complications included patients undergone hip surgery (p<0.001), body mass index >40 kg/m^2 (p = 0.170), preoperative hemoglobin <115 g/L (p = 0.063), duration of the operation >90 min (p<0.001), intraoperative blood loss >410 ml (p<0.001), CRP >69 mg/L on day 4th to 5th after PHA (p<0.001), as well as a combination of 4 or more of the above factors (p<0.001). ***Conclusion.*** We believe that the correction of the management tactics of such patients taking into account the identified risk factors will reduce the incidence of PJI after PHA.

Keywords: revision hip arthroplasty, complications of arthroplasty, prosthetic joint infection, risk factors of infectious complications after arthroplasty.

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Introduction

Total hip arthroplasty (THA) is currently one of the most demanded orthopaedic surgery in the world [1, 2]. This is accounted for by a high clinical and cost effectiveness of the procedure for treatment both injuries and various diseases of the hip joint [3, 4, 5, 6]. Unfortunately, the progressively growing number of primary arthroplasties apart from increasing the accessibility of such medical care has certain negative consequences which are directly proportional to the increased volume of revisions [7, 8]. Causes for revision of primary joint implants are quite varying and the outcomes of revisions are not so predictable as compared to primary total hip arthroplasty [9, 10]. Undoubtedly, in some cases the adequately skilled surgeon, provided good equipment of the hospital, can achieve an excellent outcome after revision surgery [11], but only in cases not aggravated by periprosthetic joint infection (PJI).

On the one hand, literature reports PJI rate not exceeding 3% for the whole life span of the implant [12, 13]. On the other, each particular PJI case has destructive consequences compromising not only future limb function but, in some cases, even the life of patient [14, 15]. Besides, the need for a long hospital stay and secondary procedures for such patients significantly increases the financial burden on the hospital in terms of treatment of infectious complications [16]. Neither state-of-the-art OR facilities, nor absolutely adequate algorithms of antibacterial prophylaxis can prevent development of PJI after total hip arthroplasty, and infection can appear both in early postop period and long time after the surgery [7, 17]. So, identification and refinement of risk factors increasing the potential for infection for each particular patient remain one of the key tasks of scientific research [18]. Literature contains controversial data regarding various PJI predictors, such as BMI, gender, age, concomitant diseases, etc, and the importance of such factors can also vary between patients' populations [19].

Therefore, *the main aim* of the present research is to attempt and identify distinctive features of our patients who suffered infectious complications after primary hip joint arthroplasty in comparison with patients who had favorable outcomes of the procedure.

Material and Methods

Study design

Single center retrospective cross-sectional study was based on the medical data of 249 patients who underwent primary total hip joint arthroplasty from 2011 to 2018.

The main group included all PJI cases (PJI group) after primary THA known to the authors for the mentioned period of time (115 cases). The control group was randomly generated and included 134 patients without postoperative infectious complications (regardless of cause for THA) who underwent surgery in the same period of time.

To evaluate the accuracy of obtained results the authors compared the data of patients from the PJI and control groups by gender, age and cause for arthroplasty with the data of arthroplasty register of the Vreden Russian Research Institute of Traumatology and Orthopaedics (St. Petersburg) for the same period of time (overall data is available in 18404 records from 2011 to 2018). While the Vreden's arthroplasty register doesn't reflect a number of certain parameters of interest to authors, further evaluation was performed only between the PJI and control groups of patients. The following factors were analyzed.

Patient related factors:

– age;
– gender;
– BMI;
– concomitant pathologies: systemic diseases (SD), diabetes mellitus (DM), pathologies of cardiovascular system (CVS), respiratory system (RS), gastrointestinal

tract (GIT) and urinary system (US), viral hepatitis and HIV;

– prior surgeries on the affected joint;

– base blood values: hemoglobin (Hb), white blood cell count (WBC), red blood cell count (RBC), platelets (PLT), erythrocyte sedimentation rate (ESR), total protein (TP), C-reactive protein (CRP).

Surgery related factors: surgical team, time of procedure, volume of blood loss, type of implant fixation, method of wound closure (interrupted and continuous suturing), blood transfusion.

Postoperative parameters: dynamics of blood test normalization (Hb, WBC, RBC, PLT, ESR, TP, CRP), timelines of patient mobilization, postoperative hospital stay (days).

The authors also evaluated impact of algorithms for antibacterial prophylaxis (parenterally up to 3 days and over 3 days from the moment of surgery) and anticoagulating prophylaxis (low molecular heparins with transfer to oral vitamin K antagonist (VKA) on day 7th and low molecular heparins with transfer to direct oral anticoagulants (DOAC) on day 3rd) in those patients.

Statistical analysis

Analysis was made in Excel for Windows (Microsoft, USA) and SPSS (version 23.0) software. The authors used methods of descriptive statistics, representation of absolute values and share ratios. For quantitative variables mean values, 95% confidence interval and the median were given. Nonparametric Mann-Whitney U-test was used to compare mean values. Shares were compared by χ^2 and in some cases odds ratios were calculated.

Results

No statistically significant variances were observed for gender and age between the PJI group, control group and total population of our patients evaluated by the data from arthroplasty register of the Vreden Russian Research Institute of Traumatology and Orthopaedics (Table 1). However, PJI group featured the highest share of men.

All study groups were similar in percentage by the cause of primary hip arthroplasty (Table 2).

In course of further comparison of the PJI and control groups by various preoperative factors the authors did not observe statistically significant correlation between PJI and concomitant diseases and hematological parameters. At the same time earlier surgeries on the affected joint represented statistically significant risk factors for development of infectious complications. A certain impact was also observed by the base level of hemoglobin <115 g/l and bone mass index >40 kg/m^2 (Table 3).

Table 1

Comparison of patients of the three groups by gender and age

Criteria	PJI group (1)	Control group (2)	Vreden Institute Arthroplasty Register (3)	*p* 1vs3	*p* 2vs3
Age, years (95% CI)	57.1 (55.4–59.9)	57.7 (54.5–59.6)	59.2 (58.9–61.1)	0.442	0.412
Men / Women	45/70 39.1 / 60.9%	44/90 32.8 / 67.2%	6736/11668 36.6 / 63.4%	0.302	0.575

Table 2

Structure of pathologies causing THA in the study groups (*n* / %)

Initial pathology	PJI group (1)	Control group (2)	Vreden Institute Arthroplasty Register (3)	*p* 1vs2	*p* 1vs3
Idiopathic hip arthrosis	38 / 33.04	43 / 32.09	7074 / 38.44	0.873	0.236
Dysplasia	28 / 24.35	33 / 24.63	4996 / 27.15	0.960	0.502
Bone necrosis	22 / 19.13	23 / 17.16	2738 / 14.88	0.688	0.202
Posttraumatic hip arthrosis	14 / 12.17	18 / 13.43	1776 / 9.65	0.768	0.362
Nonunion of the femoral neck	6 / 5.22	8 / 5.97	932 / 5.06	0.798	0.836
Systemic diseases	6 / 5.22	8 / 5.97	740 / 4.02	0.798	0.516
Bone ankylosis	1 / 0.87	1 / 0.75	148 / 0.80	0.547	0.938

Table 3

Preoperative factors influencing the PJI development in the study groups

Factor	PJI group	Control group	*p*
Prior surgeries OR = 2.871 (95% CI 1.539–5.356)	37/115 (32.17%)	19/134 (14.18%)	<0.001
Hemoglobin <115 g/l OR = 2.457 (95% CI 0.815–7.411)	10/115 (8.70%)	5/134 (3.73%)	0.170
BMI >40 kg/m^2 OR = 4.935 (95% CI 1.026–23.727)	8/115 (6.96%)	2/134 (1.49%)	0.063

The analysis of procedure related factors did not reveal any statistically significant impact on PJI by surgical team ($p = 0.613$). type of implant fixation ($p = 0.712$). technique of wound closure ($p = 0.584$) and blood transfusion ($p = 0.529$).

Risk of PJI development increased along with increasing surgery time >95 min and with correlating (R^2 linear = 0.521) average intraoperative blood loss >410 ml (Table 4).

When analyzing specifics of postoperative period the authors did not report any statistically significant correlation between infection rate and the majority of general parameters (hospital stay in days, antibiotics prophylaxis, anticoagulants) and laboratory findings (Hb, WBC, RBC, PLT, ESR, TP).

The only laboratory finding which illustrated risk of PJI development was CRP >69 mg/l on days 4-5 after surgery, OR = 5.304 (95% CI 2.555–11.012) $p<0.001$.

Table 4

Intraoperative factors influencing PJI in the study groups

Factor	PJI group	Control group	*p*
Time of surgery >95 min OR = 2.753 (95% CI 1.537–4.932)	49/115 (42.61%)	28/134 (20.89%)	<0.001
Blood loss >410 ml OR = 2.905 (95% CI 1.613–5.233)	49/115 (42.61%)	27/113 (20.14%)	<0.001

A combination of 6 earlier identified risk factors for infectious complications was additionally evaluated in the study groups. Only 4 patients in PJI group (3.48%) did not demonstrate risk factors and one factor was identified in one patient (0.87%). while in control group 52.99% patients demonstrated no more than only one risk factor (Table 5). Statistically significant variance was observed in patients with 4 and more risk factors, OR = 32.0 (95% CI 13.014–78.684), $p<0.001$.

Table 5

Combination of PJI risk factors in study groups (*n* / %)

Number of risk factors	PJI group	Control group
No risk factors	4 / 3.48	16 /11.94
One risk factor	1 / 0.87	55 / 41.04
Two risk factors	18 / 15.65	39 / 29.10
Three risk factors	24 / 20.87	18 / 13.43
Four risk factors	25 / 21.74	3 / 2.24
Five risk factors	26 / 22.61	3 / 2.24
Six risk factors	17 /14.78	–

Discussion

Infection still holds a considerable place in the structure of complications after primary hip joint arthroplasty. Some publications indicate the correlation between PJI rate with gender, age, concomitant diseases and initial hip joint pathology resulting in arthroplasty [20, 21, 22]. It's entirely possible that high risk of PJI in men can be due to initially higher muscular mass and, consequently, more traumatic procedures resulting in more substantial damage to the tissues, as well as due to the prevalence of bad habits in men — smoking and alcoholism. There is also no reason to doubt that inflammatory arthropathy or hormone-induced bone necro-

sis of the femoral neck as well as elderly age and diabetes mellitus can be independent risk factors for infection. However, the authors did not observe correlation between PJI and gender, age, concomitant diseases in the present research (p>0.05 for all parameters). Perhaps the risk depends not on the diagnosed disease itself but on its severity and impact on wound healing process.

Results of the present study demonstrate that medical history of prior surgeries on the affected joint was a statistically significant PJI predictor and this finding matches the results of other researchers [16, 22, 23]. The authors of the present study also observed statistically insignificant correlation between PJI with BMI over 40 kg/m^2 and base hemoglobin less than 115 g/l.

No less important are the potential risk factors related to surgery. Currently the impact of implants fixation method on development of surgical site infection is under active discussion. Thus, use of bone cement without additional antibacterial agents in its composition substantially increases the risk of PJI [24, 25]. At the same time, Norway and Sweden track the trend for increased PJI risk after use of uncemented implants [26]. The effect of other factors like wound irrigation, suture type, surgeon's experience, OR ventilation on PJI remains also disputable [22, 27, 28]. Based on above the authors evaluated the role of the main factors on PJI, and no statistically significant correlation was found. In our patients the invasiveness of surgery, namely procedure time over 95 min and blood loss over 410 ml (p<0.001 for both), had the major impact. Surgeon related factors were minimal in the present study while all surgical teams had extensive experience of such procedures. The analysis demonstrated that values exceeding the above mentioned threshold parameters are directly related to the two "patient factors" reported earlier. In particular, more traumatic cases of arthroplasty were reported in the group of patients with medical history of previous joint procedures and obesity. This fact was quite predictable and did not vary from the reports of other researchers [22, 26].

No statistically significant correlation between infection manifestation and applied algorithms of antibacterial and anticoagulating prophylaxis was found during analysis of postoperative period despite the fact that the importance of those criteria for PJI prevention is indicated in the literature [22, 29, 30, 31]. The possible explanation can be that the authors did not deviate from antibacterial and anticoagulation prophylaxis algorithms approved at Vreden Institute when treating all patients of the study.

Currently, a number of researchers indicate the need for not only an isolated assessment of a particular risk factor, but also an integrated approach to understanding possible combinations in every particular patient [14, 15]. Presumably, medical history of a patient reporting only joint surgery along with adequate antibacterial prophylaxis would not be so critical in terms of infectious complications. However, a combination of this factor with longer time of surgery, technical challenges during the procedure and large blood loss significantly increases the risk of infectious process [22].

In conclusion, the authors want to emphasize once again that the infection still holds a significant place among the causes of revisions after total hip joint arthroplasty.

The present research as the majority of similar publications has substantial limitations in respect of size of study groups, but the observed statistically significant risk factors should be taken into consideration by surgeons when determining the indications for surgery and, probably, require more serious measures to prevent infectious complications.

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Authors' contributions

A.A. Myasoedov — coordination of research participants, interpretation and analysis of obtained data, statistical processing of obtained data, preparing text of the paper.

S.S. Toropov — collecting and processing of material.

G.V. Berezin — collecting and processing of material.

V.V. Karelkin — collecting and processing of material.

Z.A. Totoev — analysis and interpretation of obtained data.

I.I. Shubnyakov — analysis and interpretation of obtained data, statistical processing of obtained data, editing of the paper.

R.M. Tikhilov — study concept and design, interpretation and analysis of obtained data, editing of the paper.

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