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Research Article

Bacteriology swabs in primary total knee arthroplasty

Prädiktiver Wert intraoperativer bakteriologischer Abstriche bei primärer Kniegelenktotalendoprothese

Maximilian Haenle[1]
Andreas Podbielski[2]
Martin Ellenrieder[1]
Andreas Mundt[1]
Helga Krentz[3]
Wolfram Mittelmeier[1]
Ralf Skripitz[1]

1 Department of Orthopaedic Surgery, University Medicine Rostock, Rostock, Germany

2 Institute for Medical Microbiology, Virology and Hygiene, University Medicine Rostock, Rostock, Germany

3 Institute for Biostatistics and Informatics in Medicine and Aging Research, University Medicine Rostock, Rostock, Germany

Abstract

Objective: An early detection of possible periprosthetic infection may lead to an earlier and potentially less invasive treatment of infected total knee arthroplasty TKA). The purpose of the present study was to evaluate retrospectively our current, affordable clinical practice of intra-operative swab taking during primary TKA.
Methods: A total of 206 primary TKA were analysed retrospectively for intra-operative bacteriology swabs and subsequent periprosthetic infection. All bacteriology swabs were obtained in a standardized manner including a tissue sample. Data was statistically evaluated concerning standard descriptive statistics and using the chi-square test.
Results: Bacteria were identified in 43.4% with coagulase-negative staphylococci being the most frequently isolated pathogens (52.2%). Regarding the contingency tables and chi-squared tests, generally no association was found between positive intra-operative swabs and subsequent periprosthetic infection as well as all other parameters investigated (timing of the antibiotic prophylaxis and pre-operative laboratory results).
Conclusions: Bacteriology swabs during primary total knee arthroplasty are no adequate measure to predict subsequent periprosthetic infections, even if augmented with a tissue sample.

Keywords: intra-operative bacteriology swab, intra-operative tissue sample, total knee arthroplasty, periprosthetic infection, peri-operative antibiotic prophylaxis, pre-operative laboratory infection markers

Zusammenfassung

Zielstellung: Die frühzeitige Diagnosesicherung und Erregeridentifizierung bei einer periprothetischen Infektion kann möglicherweise zu einer weniger invasiven Therapie von infizierten Kniegelenktotalendoprothesen (KG TEP) führen. Ziel der vorliegenden retrospektiven Arbeit war die Evaluierung unserer derzeitigen klinischen Praxis intraoperativer Abstrichentnahme bei primären KG TEPs.
Methode: Insgesamt wurden 206 KG TEPs retrospektiv bezüglich intraoperativer Abstrichergebnisse und nachfolgender KG TEP Infektion untersucht. Intraoperativ erfolgte eine standardisierte Abstrichentnahme und Gewinnung einer Gewebeprobe bei primärer KG TEP-Implantation. Die Ergebnisse wurden mittels Chi-Quadrat-Test und deskriptiver Statistik ausgewertet.
Ergebnisse: In 43,4% der Fälle konnte ein positiver Erregernachweis erbracht werden. Hiervon entfielen 52,2% auf Koagulase-negative Staphylokokken. Bezüglich der Kontingenztabellen und des Chi-Quadrat Tests konnte kein Zusammenhang zwischen einem positiven intraoperativen Abstrich und nachfolgender periprothetischer KG TEP-Infektion gefunden werden. Weiterhin wurde kein Zusammenhang zwischen positivem intraoperativen Abstrich und Zeitpunkt der perioperativen antibiotischen Prophylaxe sowie präoperativen paraklinischen Infektionsparametern gefunden.

Schlussfolgerung: Die intraoperative Abstrichentnahme stellt auch mit zusätzlicher Gewebeprobe bei der primäreren KG TEP-Implantation kein diagnostisches Instrument dar, um eine periprothetische KG TEP zu prognostizieren.

Schlüsselwörter: intraoperativer Abstrich, intraoperative Gewebeentnahme, Kniegelenktotalendoprothese, periprothetische Infektion, perioperative antibiotische Prophylaxe, präoperative paraklinische Infektionsparameter

Introduction

Total knee arthroplasty (TKA) has helped to improve the quality of life of numerous patients. Despite advances in operative techniques and environments, periprosthetic infections remain devastating complications after TKA. Deep infection accounts for roughly 20% [1] of TKA revision operations performed, with a reported incidence of up to 5% [2], [3], [4] and an increased infection rate in risk groups. A number of such risk factors for deep infection after TKA, such as male sex, rheumatoid arthritis (RA), American Society of Anesthesiologists (ASA) risk score >2, diabetes mellitus and morbid obesity have been identified [5]. Despite the fact that steroid injection into the arthritic joint may lead to infection, there is no evidence of an increased risk of deep periprosthetic infection in subsequent TKA [6]. It is currently assumed, that the majority of periprosthetic TKA infections are to be originating intra-operatively [4], with the most common types to be early and delayed infections [2]. The most frequently isolated pathogens are hereby S. *aureus* and coagulase-negative staphylococci (CoNS), which account for up to 58% of periprosthetic TKA infections [2]. Débridement with retention of the implant is only considered a reasonable option for patients with an early post-operative or acute haematogenous infection, duration of clinical signs and symptoms less than three weeks, a stable implant, good condition of the soft tissue and the availability of an agent with activity against biofilm microorganisms [7], [8]. An early detection of periprosthetic TKA infection may hence lead to an earlier and potentially less invasive treatment. In the preoperative diagnostics of a periprosthetic infection, microbiological examination of multiple tissue samples and an additional histological evaluation should be performed [9]. This however may seem uneconomical during primary TKA with an average profit of 927 € per primary TKA and costs of 21 € per microbiological examination and 24 € per histological investigation [10]. Aiming to identify patients with an infection after TKA with an affordable clinical concept, we acquired an intraarticular bacteriology swab and a tissue sample immediately after arthrotomy for microbiological evaluation. The purpose of the present study was to evaluate the results of these microbiological samples taken during primary TKA in 206 cases and a minimum follow up of 7 months.

Material and Methods

All TKA performed in the Department of Orthopaedics of the University Medicine Rostock between 1st of January 2010 and 30th of June 2011 were analysed retrospectively for intra-operative bacteriology swabs and subsequent periprosthetic infection. All patients were treated according to a standardized protocol. In brief, admission of the patients to the hospital took place 24 hours before surgery. Blood samples obtained were, amongst others, routinely examined for leucocytes (WBC) and C-reactive-protein (CRP). Prior to surgery, peri-operative antimicrobial prophylaxis was administered (Cefuroxim HEXAL® 1500 mg, HEXAL AG, Holzkirchen, Germany). Respective knee joints were then washed with an propan-2-ol and povidone-iodine combination (Braunoderm®, B. Braun, Melsungen, Germany) before sterile draping. Surgery was performed in a vertical laminar airflow operating theatre using space suits (Stryker T5 Personal Protection System®, Kalamazoo MI, U.S.A).

All bacteriology samples were obtained in a standardized manner directly after the capsule was opened and synovial fluid became visible. In order to prevent contamination, the bacteriology swab (AMIES W/O CH, Sarstedt, Nümbrecht, Germany) was held with a surgical clamp to avoid contact with the surgeons' gloves and it was ensured that bacteriology swabs did not contact the patients' skin. Furthermore, a small piece of synovial membrane was removed by the means of a fresh sterile forceps for microbiological evaluation. Every specimen was immediately placed in a dry sterile container and transported at room temperature within one hour to the diagnostic microbiology laboratory. After implantation of the prosthesis we applied a wound-drainage and finally, a sterile wound dressing.

Tissue specimens were minced in 500 µl sterile phosphate-buffered saline with a sterile mortar and pestle set. Swab and suspended tissue specimens were applied on solid culture media (Columbia agar plus 5% defibrinated sheep blood, chocolate agar, Schaedler agar; Becton Dickinson, Heidelberg, Germany) and in brain heart infusion broth (Becton Dickinson) using standard techniques of the accredited laboratory according to DIN EN ISO 15189. All inoculated media were incubated for 14 days at 37 °C under a 5% CO_2 / 20% O_2 atmosphere or under anaerobic conditions using appropriate anaerobic jars and a 80% N_2 / 15% H_2 / 5% CO_2 atmosphere (Mart Sys-

tems, Drachten, Holland). All media were inspected for bacterial and fungal growth on days 1, 2, 4, 7, 10 and 14 of incubation.

In case of microbial growth, identification of the isolates was achieved by subjecting them to Gram-staining and light microscopy, MALDI-TOF (Shimadzu/BioMerieux, Nürtingen, Germany) analysis and simultaneously, to appropriate biochemical profiling (Vitek 2, BioMerieux). If applicable, antibiotic resistance profiles were elucidated using the Vitek 2 automat and the EUCAST (European Committee on Antimicrobial Susceptibility Testing) evaluation standards. Antibiotic resistance profiles from isolates which could not be cultured in the Vitek 2 cards were obtained by e-tests utilizing culture media according to the manufacturer's instructions (Sigma, Munich, Germany).

Results from the microbiologic analyses were immediately reported to the Orthopedics Department employing internal electronic communication. Reports were principally divided into either detection or no detection of pathogens. Quantities of detected colony forming units (cfu) were noted at a semiquantitative scale (occasional +, moderate ++, plenty +++ or copious ++++) for isolates from the swab material or at a quantitative scale for isolates from tissue specimens. Microorganisms only detected in the enrichment broth were reported as "identification after enrichment".

Wound drainages were removed upon clinical judgement of surrounding soft tissue and swelling, generally 48 hours after surgery. Furthermore, during hospitalisation, wounds were evaluated for local signs of infection every other day. At least two post-operative blood samples (day 5 and 10 postoperatively) were taken and, again routinely examined for leucocytes and CRP. Decision-making about whether or not to revise was not only based upon the microbiological results but in essence was influenced by the clinical (reddening, swelling and pain) and laboratory findings (CRP and WBC).

Beside the calculation of standard descriptive statistics, the obtained data was statistically evaluated using the chi-square test regarding subsequent periprosthetic infection, timing of the prophylaxis as well as pre-operative laboratory results and identification of microbes in the specimens. Statistical analysis was performed using IBM SPSS Statistics, IBM Corp., Armonk NY, USA) with the level of significance set to $p<0.05$.

Results

Descriptive statistics

A total of 206 TKA were performed in the Department of Orthopaedics of the University Medicine Rostock between 1st of January 2010 and 30th of June 2011. Clinical data from these cases was retrospectively evaluated for bacteriology swabs and subsequent periprosthetic infections. Regarding the bacteriology swabs, a total of 89 (43.4%) were reported with a positive finding of pathogens with "after enrichment" being the most frequent notification (29.8%) (Figure 1). Thereby CoNS were the most frequently isolated potential pathogens (52.2%) with *Staphylococcus epidermidis* being the most common single species (27.8%) (Table 1). A periprosthetic infection was diagnosed in 6 primary TKA (2.9%) during the observed period of time.

Table 1: Percentage of isolated microorganisms from swabs during primary TKA

Pathogen	Percentage of isolations
Staphylococcus epidermidis	27.8
Staphylococcus hominis	15.6
Staphylococcus cohnii	3.3
Staphylococcus capitis	3.3
Staphylococcus warneri	1.1
Staphylococcus haemophilus	1.1
Staphylococcus aureus	2.2
Staphylococcus aureus (MRSA)	2.2
Propionibacterium acnes	13.4
Micrococcus luteus	4.4
Enterococcus faecalis	3.3
Enterococcus faecium	5.6
Enterococcus avium	1.1
Escherichia coli	1.1
Candida parapsilosis	3.3
Candida glabrata	1.1
Corynebacterium propinquum	1.1
Corynebacterium striatum	1.1
Corynebacterium pseudodiphtericum	1.1
Corynebacterium spp.	1.1
Lactobacillus acidophilus	1.1
Bacillus circulans	1.1
Bacillus spp.	1.1
Kocuria kristinae	1.1
Sphingomonas paucimobilis	1.1

(Multiple mentions in polymicrobial positive swabs)

In 2 cases, *S. epidermidis* was identified during the revision surgery (both after enrichment) despite a negative bacteriology swab during primary surgery. In another 2 cases, *S. epidermidis* was identified during primary implantation (after enrichment) followed by a negative bacteriology swab during the revision surgery. In one case, *E. faecium* was identified during the primary implantation, followed by the identification of *S. hominis* during revision surgery. Finally, in another single case *S. capitis* was identified during the primary implantation followed by *S. epidermidis* during the revision surgery (Table 2).

The timing of the antibiotic prophylaxis was administered within the desired time interval in 96.4%. In one case, it was administered after the incision and in 6 cases more than 60 minutes prior to the incision. In 33.3% we were

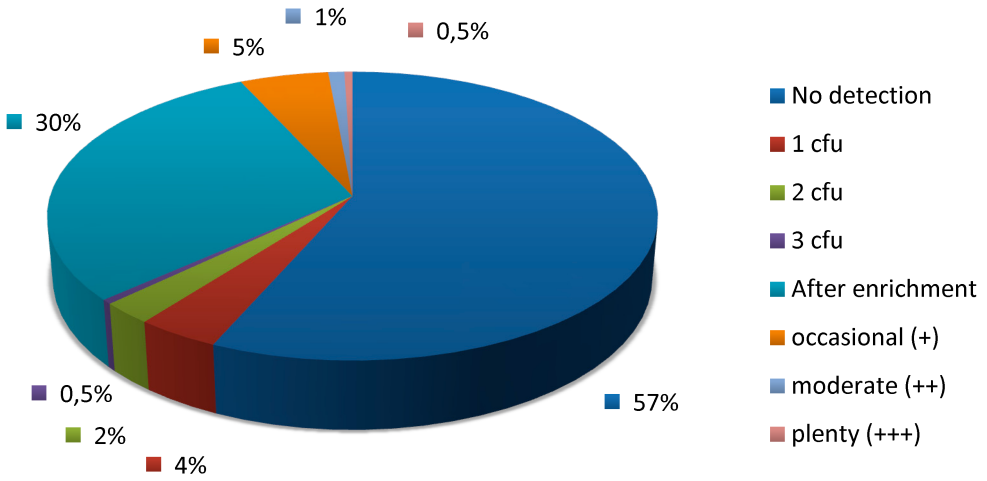

Figure 1: Notification from the microbiology department regarding detection of pathogens and semi-quantitative or quantitative measure

Table 2: Isolated microorganisms and noted quantity from the swabs during primary and revision surgery

Primary implantation	Antibiotic prophylaxis during primary TKA susceptible	Revision surgery	Antibiotic prophylaxis during primary TKA susceptible
S. epidermidis, after enrichment	yes	None detected	not applicable
None detected	not applicable	*S. epidermidis*, after enrichment	yes
None detected	not applicable	*S. epidermidis*, after enrichment	yes
S. epidermidis, after enrichment	yes	None detected	not applicable
E. faecium, after enrichment	no	*S. hominis*, after enrichment	yes
S. capitis, after enrichment	yes	*S. epidermidis*, after enrichment	no

able to observe an elevated CRP (>5 mg/l) and in 9.8% an elevated WBC (>9/nl) prior to the surgery.

Contingency tables and Chi-squared tests

Concerning the contingency tables and Chi-squared test, there is no association between a positive intra-operative swab and a subsequent periprosthetic infection ($p>0.05$). Neither can a connection be established between elevated CRP values or WBC ($p>0.05$) and a positive intra-operative swab nor between elevated CRP values or WBC and a subsequent periprosthetic infection ($p>0.05$). Furthermore, the timing of the antibiotic prophylaxis did not show a significant relationship regarding a positive intra-operative bacteriology swab ($p>0.05$). Finally, the quantity of the bacteria count is not associated with a subsequent infection ($p>0.05$).

Discussion

In our retrospective evaluation of bacteriology swabs during 206 consecutive primary TKA, a total of 89 (43.4%) were reported by the Department of Microbiology stating a positive finding of pathogens. It is known that positive cultures of up to 58% may be observed during clean orthopaedic operations [11]. The value of these positive cultures from bacteriology swabs performed during clean orthopaedic operations however still considered controversial [11], [12], [13], [14], [15], [16], [17], [18]. Some authors thus argue that cultures performed from bacteriology swabs during clean orthopaedic operations may not be considered useful for predicting post-operative infection [12]. Furthermore, bacteriology swabs are inferior to fluid specimens when collected and the use of blood culture vial specimens is therefore recommended [19], [20]. Release and recovery of bacteria is moreover subject to the incubation time and may also vary according to the manufacturer of swab transport systems [20], [21], [22].

Nevertheless swab collection remains a common practice in many healthcare institutions [22] as well as orthopaedic departments. In our study, 33.3% of the patients who developed a periprosthetic infection had negative intra-operative cultures within the primary TKA surgery (Table 2). On the other hand another 33.3% of the patients had negative bacteriology swab during revision surgery despite a positive swab during primary implantation and another 33.3% even showed a change of the microbiological spectrum detected between primary and revision surgery (Table 2). As the lack of bacterial growth does not necessarily imply a sterile surgical field [12], a subsequent periprosthetic infection remains possible. Moreover, intra-operative detection of bacteria in periprosthetic infections may be obscured by the fact that often pathogens of low virulence are observed as well as the presence of small colony variants [4]. Another plausible explanation for negative culture results is of course the administration of peri-operative antibiotic prophylaxis. According to these findings, positive cultures from bacteriology swabs during revision surgery should be regarded with caution and in the light of clinical signs and symptoms.

Another aspect of this study was the association of the bacteria count from positive intra-operative swabs and a subsequent periprosthetic infection. Our results show that the quantity of the bacteria count is not associated with a subsequent infection ($p>0.05$). This may be due to the fact that the most frequent notification of positive findings from the microbiology lab was “after enrichment” (29.8%) (Figure 1) and the treatment of the specimen with enrichment broth increases the risk of contamination. In general, the spectrum of microorganisms identified in the present study, with the majority of isolated pathogens being CoNS (52.2%) followed by *Propionibacterium acnes* (13.4%) is consistent with previous studies [11], [12]. The importance of the appropriate timing of prophylactic antibiotic administration within one hour prior to the incision has been demonstrated in the past [23]. To our knowledge however, no study previously addressed an association between positive intra-operative bacteriology swabs and the timing of prophylactic antibiotic administration. In the present study the timing of the antibiotic prophylaxis was administered within the desired time interval of one hour in 96.4%. The timing of the antibiotic prophylaxis however did not show a significant association regarding a subsequent positive intra-operative bacteriology swab ($p>0.05$). This is possibly partly due to the fact that a high rate of specimen contamination can be observed during sterile surgery [24].

In previous studies, it was expected that in view of high rates (63%) of contamination at primary surgery bacterial samples at the time of revision would also harbor contaminants which however, similar to our study, was not the case [24].

Conclusion

The practice of intra-operative bacteriology swab taking in primary TKA does not lead to an earlier detection of periprosthetic infections even if the swab is augmented with a tissue sample. Our findings are supported by similar previous findings in the literature where bacteriology swabs from clean orthopaedic operations are considered to be ineffective for predicting post-operative infection [12]. Due to these results we have now abandoned from routine swab taking during primary TKA in our department. If bacteriology sample taking is aspired during primary TKA in cases where a pre-existing infection is suspected this should be performed in accordance with current recommendations for the detection of periprosthetic joint infections. A tissue biopsy with additional fluid aspiration of at least three specimens is suggested. This however leads to an immense increase of costs in primary TKA. A pre-existing infection may then again only be considered if either the same pathogen is detected in at least two samples or a pathogen is detected in one sample and observation of at least five polymorphonuclear leukocytes per high-power field on analysis of the frozen sections [9], [25]. The finding of only one positive bacterial culture with the lack of histological signs of infection may therefore be regarded as contamination [9].

Notes

Competing interests

The authors declare that they have no competing interests. No financial support was received in order to perform this study.

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Corresponding author:

Dr. med. Maximilian Haenle
Department of Orthopaedic Surgery, University Medicine Rostock, Doberaner Str. 142, 18057 Rostock, Germany, Phone: +49-381-494-9301, Fax: +49-381-494-9303
maximilian.haenle@med.uni-rostock.de

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