



# Analysis of the status quo of perioperative antibiotic prophylaxis in dermatosurgery in Germany: results of the DESSI-study

Galina Balakirski<sup>1</sup>,  
Moritz Felcht<sup>2</sup>, Hans Bayer<sup>3</sup>,  
Laurenz Schmitt<sup>4</sup>

(1) Department of Dermatology and Allergology, University Hospital of Bonn, Bonn, Germany

(2) Department of Dermatology, Venereology and Allergology, University Medicine Mannheim, Ruprecht-Karls-University of Heidelberg, Mannheim, Germany

(3) Department of Dermatology and Venereology, University Hospital of Freiburg, Freiburg, Germany

(4) Department of Dermatology and Allergology, University Hospital of RWTH Aachen, Aachen, Germany

## Summary

**Background:** Perioperative antibiotic prophylaxis (PAP) is recommended for the prevention of postoperative infections by the Commission for Hospital Hygiene and Infection Prevention (KRINKO) at the Robert Koch Institute. However, how PAP is currently used in the field of dermatosurgery in Germany is unclear.

**Methods:** All members of the German Society for Dermatosurgery (DGDC) were asked to participate in a web-based survey in order to investigate the use of PAP by German dermatological surgeons.

**Results:** 78 DGDC members completed the questionnaire. Of these, 89.7 % (70/78) were medical specialists with a median work experience of 15 years in the field of dermatosurgery, and 53.8 % (42/78) of the respondents regularly use PAP in dermatosurgery. Of these, 35.7 % (15/42) reported that they perform PAP for immunocompromised patients. Only a small proportion of skin surgeons stated that they administer PAP parenterally (5.9 %, 4/67). The most commonly used drug was cephalosporin cefuroxime. The duration of the PAP varied between single-dose and prolonged administration for more than five days.

**Conclusion:** Currently, the use of PAP in dermatosurgical procedures in Germany is not standardized. Prospective randomized dermatosurgical studies are needed in order to investigate whether the PAP recommendations of KRINKO are applicable to the field of dermatological surgery.

## Introduction

Perioperative antibiotic prophylaxis (PAP) is a part of surgical procedures and is defined as a short-term, usually single-dose administration of an antibiotic agent before, or in exceptional cases, during surgery [1–3]. The use of PAP is expected to reduce both systemic and local postoperative infectious complications, and in particular the rate of surgical site infections (SSIs) [2, 3]. The guideline of the Association of the Scientific Medical Societies in Germany (AWMF) was updated in 2012 and provides general recommendations on PAP in surgery [2]. There are also a

few recommendations on the administration of PAP specifically for dermatosurgery [4–9]. However, they are based on recommendations and guidelines from other surgical fields, and only partially reflect the needs of skin surgery [9].

The aim of PAP in dermatosurgery is to prevent SSIs and further SSI-associated complications such as unsatisfactory cosmetic results, infective endocarditis, septic arthritis, or sepsis. Generally, SSIs are rarely observed after skin surgery [9–12]. However, there is a significant variation in the rates of SSI rates among various studies, from < 1 % to 11 % [9–14].

The significant variance of SSI rates in dermatosurgical studies reflects the fact that the definition of SSI in skin surgery appears to be unclear. According to the Center of Disease Control (CDC), a wound infection is defined by the presence of at least one of the following four criteria:

1. Purulent drainage from the superficial incision;
2. Detection of a microorganism from a sterile liquid culture or wound swab from the superficial incision;
3. Any of the following signs: localized pain or tenderness, localized swelling, redness or local increase of temperature, and the following decision of the surgeon to open the superficial incision based on these signs. However, this criterion cannot be applied if the results of a microbiological culture from the superficial incision are negative;
4. Diagnosis of SSI by the physician.

The last point is particularly subjective, which may partially explain the heterogeneity of wound infection rates in the scientific literature.

Nevertheless, it has been reported that some groups of patients are at high risk of developing SSI after skin surgery. For example, the SSI rate may be up to 18 % in patients with diabetes mellitus [15]. In addition to diabetes mellitus, other risk factors have been identified for SSI after dermatosurgical procedures. These are: surgical site contamination (in the context of septic surgery), older age of the patient, involvement of certain areas (e.g. lower extremities), and low experience of the surgeon [9–15]. However, previous clinical studies are very heterogeneous and there are insufficient data on the benefit-risk profile of PAP in these special dermatosurgical cases.

Given the development of resistance and other potential side effects of antibiotics, PAP should only be used in dermatosurgery in carefully selected cases. In order to reduce unnecessary antibiotic use by dermatological surgeons, the American Academy of Dermatology created an advisory statement with clear algorithms for application of PAP in skin surgery [16]. However, a survey among the members of the American College of Mohs Surgery has shown that PAP is widely performed by US dermatological surgeons, even in ways not recommended by the guideline [17].

At present there is no guideline on the use of PAP in dermatosurgery in Germany, and it is unclear how PAP is currently used by skin surgeons. This survey aims to investigate the status quo of this topic.

## Methods

A web-based questionnaire was developed in order to systematically investigate current PAP standards in dermatosurgery in Germany. All members of the German Society for Dermatosurgery (DGDC) received emails with a request to participate in the survey and a description of the current

study. The email contained a link to the web-based survey. A second reminder was sent by email eight weeks after the initial request. The completed questionnaires were accepted for a total of twelve weeks, or four weeks after the last request.

The survey consisted of a total of eight questions and included the following topics: indications for the use of PAP, method of administration, choice of antibiotics, duration of prophylaxis, personal attitudes towards the use of antibiotics in skin surgery and the existence of an in-house guideline on the use of PAP. The eight questions can be found in Table 1.

## Conformance with the ethical guidelines

With the exception of a few questions, such as field of specialization, years of work experience, and information on the work environment (for example, university hospital, community hospital, private practice), the questionnaire was designed to be anonymous. Identification of the names or clinics of the survey participants was not possible. The study was approved by the Ethics Committee of the University Hospital RWTH Aachen in Aachen, Germany (internal identification number EK260/17).

## Statistics

Statistical analysis was performed using IBM SPSS Statistics (Version 22.0, Armonk, NY: IBM Corp.) and visualized using Microsoft Excel 2016 for Windows.

The distribution of the categorical (nominal) data was presented as absolute and relative frequencies and compared between groups using chi-square tests ( $\chi^2$ -tests). Statistical significance was calculated using two-tailed hypothesis tests at a significance level of 5 %. Descriptive statistics of metric data were given as median and interquartile ranges (1<sup>st</sup> to 3<sup>rd</sup> quartile).

## Results

### Respondents

A total of 968 emails were sent to DGDC members. Of these 968 email addresses, 12.5 % (121/968) could not be reached. From the 847 DGDC members who were contacted, 78 completed questionnaires were received, so the response rate was 9.2 % (78/847). 52.6 % (41/78) of respondents stated that they work in private practice in an outpatient setting, 43.6 % (34/78) worked in a hospital, and the remaining 3.8 % (3/78) did not report their professional environment (Table 2). 86 % (67/78) of respondents were medical specialists in the field of dermatology and venereology. A further 3.8 % (3/78) of the respondents specialized in other surgical fields (1/3 maxillofacial surgery, 2/3 plastic surgery). 5.1 %

**Table 1** Questions on the topic of PAP that were sent to the members of the German Society for Dermatosurgery (DGDC) with the current survey.

No.	Questions	Predefined answer options.
1.	How many inpatient surgical procedures for malignant or benign skin tumors are performed at your medical facility per year?	None; < 500; > 500; > 1000
2.	Approximately how many of these patients are immunocompromised or receive immunosuppressive therapy?	Percentage (total)
3.	Does your clinic/hospital practice perioperative antibiotic prophylaxis for dermatosurgery in some cases?	No, perioperative antibiotic prophylaxis is never used for skin surgery; Yes
3.1	In patients undergoing immunosuppressive treatment (e.g. systemic corticosteroids, calcineurin inhibitors, methotrexate, TNF- $\alpha$ inhibitors etc.)	Always; often; rarely; never
3.2	In immunocompromised patients (e.g. due to a hematological disease such as leukemia or lymphoma)	Always; often; rarely; never
3.3	For extensive surgery on certain areas (e.g. ear, nose, forehead etc.)	Always; often; rarely; never If yes, please specify the area(s)
3.4	For skin surgery involving mucous membranes	Always; often; rarely; never If yes, please provide details
3.5	In case of a special diagnosis (e.g. hidradenitis suppurativa lymphadenectomy, sentinel lymph node resection etc.)	Always; often; rarely; never If yes, please specify the diagnosis
3.6	For multistage procedures	Always; often; rarely; never If yes, please provide details
3.7	In patients with risk of infective endocarditis	In all high-risk patients for all surgical procedures, irrespective of the area undergoing surgery; In patients with any prosthetic valves for all surgical procedures, irrespective of the area undergoing surgery; In patients with a previous episode of infective endocarditis for all surgical procedures irrespective of the area undergoing surgery; In patients with any prosthetic valves, as well as in patients with a previous episode of infective endocarditis for all surgical procedures irrespective of the area undergoing surgery; Only for surgery involving mucous membranes; never; other (if other please provide details)
3.8	For contaminated wounds (e.g. ulcerated tumors, inflammation etc.)	Always; often; rarely; never
3.9	Other indications	Please specify
4.	<i>If you choose to perform perioperative antibiotic prophylaxis, how it is applied?</i>	
4.1	Orally	Always; often; rarely; never
4.2	Intravenously	Always; often; rarely; never
4.3	Topically (e.g. fusidic acid)	Always; often; rarely; never
4.4	Other	If other, please specify

Continued

Table 1 Continued.

No.	Questions	Predefined answer options.
5.	What agents do you use when you perform perioperative antibiotic prophylaxis?	
5.1	Penicillin	Always; often; rarely; never
5.2	Amoxicillin	Always; often; rarely; never
5.3	Cefuroxime	Always; often; rarely; never
5.4	Clindamycin	Always; often; rarely; never
5.5	Ciprofloxacin	Always; often; rarely; never
5.6	Other	If other, please specify.
6.	If you choose to perform perioperative antibiotic prophylaxis, what is the duration of medication?	
6.1	One dose before surgery	Always; often; rarely; never
6.2	One dose after surgery	Always; often; rarely; never
6.3	For one day, a regular daily dosage	Always; often; rarely; never
6.4	For 1–3 days	Always; often; rarely; never
6.5	For 3–5 days	Always; often; rarely; never
6.6	> 5 days	Always; often; rarely; never
6.7	Other	If other, please specify
7.	Please state your opinion on perioperative antibiotic prophylaxis:	
7.1	Perioperative antibiotic prophylaxis significantly reduces the occurrence of postoperative infections after dermatosurgical procedures	Agree; disagree
7.2	Only isolated groups of patients benefit from perioperative antibiotic prophylaxis in skin surgery, therefore, I prescribe PAP only in these rare cases	Agree; disagree
7.3	Perioperative antibiotic prophylaxis does not prevent the occurrence of postoperative infections after skin surgery, so I do not prescribe it for this indication	Agree; disagree
8.	Personal information	
8.1	You are ...	A medical specialist in the field of dermatology; a medical specialist in the field of plastic surgery; a medical specialist in maxillofacial surgery; a medical specialist in another field; not a medical specialist yet.
8.1.1	Other medical field?	If you work in another medical field, please specify it
8.2	Are you a resident physician undergoing training?	Yes; no
8.2.1	If yes, please specify the field of training	Please specify the field of training
8.3	How long have you been practicing dermatological surgery?	Number of years
8.4	In what setting do you perform skin surgery?	At a university hospital; at a teaching hospital affiliated with a medical school; at a community hospital; at a private clinic; at a private practice
8.5	Is there an internal guideline on the use of PAP in dermatosurgical patients at your institution?	Yes; no

**Table 2** Distribution of survey participants working in a hospital setting (n = 34).

Institution	Frequency in % (n)
University hospital	53 (18)
Teaching hospital affiliated with a medical school	26 (9)
Community hospital	9 (3)
Private clinic	12 (4)
Total	100 (34)

(4/78) were resident physicians (3/4 in the field of dermatology, 1/4 provided no information on his/her field of training) and the remaining 5.1 % (4/78) provided no information on their medical qualifications.

The median professional experience of the survey participants in the field of dermatosurgery was 15 years (10–20 years). 24.4 % (19/78) of the respondents stated that they only treat dermatosurgical patients in an outpatient setting. 75.6 % (59/78) also treated inpatients. 24.4 % (19/78) reported that they treat less than 500 dermatosurgical inpatients per year. 23.0 % (18/78) and 28.2 % (22/78) of the respondents treated over 500 patients per year and over 1000 inpatients per year, respectively.

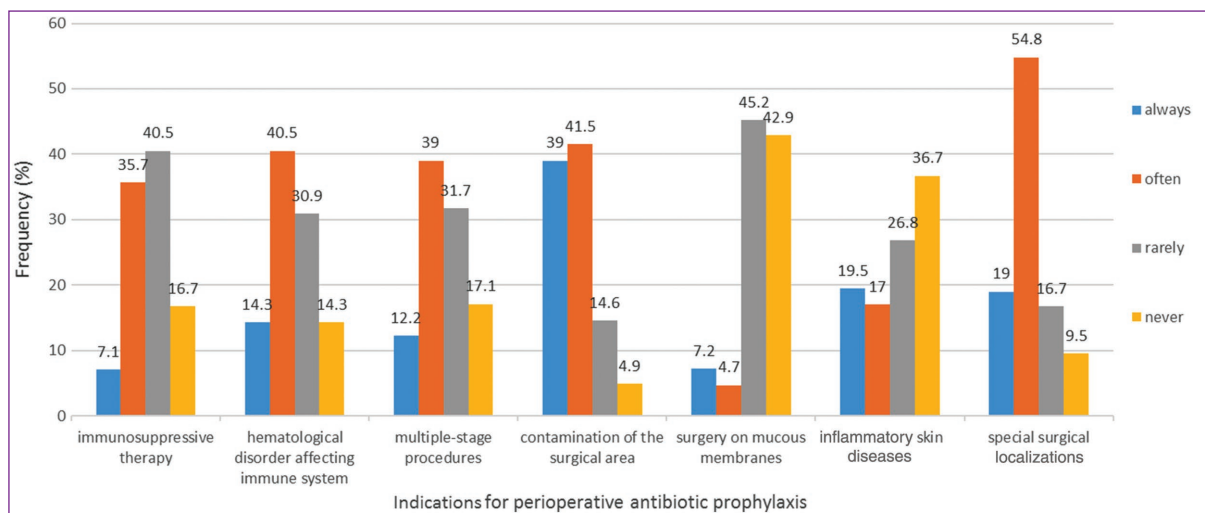
The median proportion of immunosuppressed patients was reported to be 5 % (2–10 %) of the total number of dermatosurgical patients.

### Indication for perioperative antibiotic prophylaxis

Of the 78 respondents, 53.8 % (42/78) reported that they perform PAP with dermatosurgical patients on a regular basis. Of these, 59.5 % (25/42) worked in a hospital and the remain-

ing 40.5 % (17/42) worked in private practice in an outpatient setting. About 42.4 % (33/78) did not make regular use of PAP with dermatosurgical patients and 3.8 % (3/78) provided no information on their use of PAP. Doctors working in a hospital setting used PAP significantly more frequently than their colleagues working in private practice (p = 0.003).

Of the 42 respondents who reported regular use of PAP with dermatosurgical patients, immunosuppressive therapy of the patients was “always” considered to be an indication for PAP in dermatosurgical interventions by 7.1 % (3/42), “often” by 35.7 % (15/42), “rarely” by 40.5 % (17/42) and “never” by 16.7 % (7/42). For patients with a hematological disorder affecting the immune system, 14.3 % (6/42) of the respondents stated that they always use PAP, 40.5 % (17/42) perform it often, 30.9 % (13/42) rarely and 14.3 % (6/42) never. Multistage procedures with the use of microscopically controlled surgery were always an indication for PAP for 12.2 % (5/41), often for 39.0 % (16/41), rarely for 31.7 % (13/41), and never for 17.1 % (7/41) of the doctors. Contamination of the surgical site (e.g. an ulcerating tumor) was always considered to be an indication for PAP by 39.0 % (16/41), often by 41.5 % (17/41), rarely by 14.6 % (6/41), and never by 4.9 % (2/41) of the respondents. In cases of a specific diagnosis associated with inflammation (e.g. hidradenitis suppurativa [acne inversa]), PAP was always used by 19.5 % (8/41), often by 17.0 % (7/41), rarely by 26.8 % (11/41) and never by 36.7 % (15/41) of doctors. Surgical procedures involving mucous membranes (including nasal or oral mucosa) were always viewed as indications for PAP by 7.2 % (3/42), often by 4.7 % (2/42), rarely by 45.2 % (19/42) and never by 42.9 % (18/42) of the surgeons. 19.0 % (8/42) of the doctors stated that when surgery is performed on certain areas, they always administer PAP, 54.8 % (23/42) responded that it is often an indication for PAP, 16.7 % (7/42) rarely and 9.5 % (4/42) never (Figure 1). 61.9 % (26/42) of the respondents



**Figure 1** Indication and frequency of perioperative antibiotic prophylaxis in dermatosurgical patients.

**Table 3** Preferred surgical sites for the use of perioperative antibiotic prophylaxis in dermatosurgical patients (n = 26).

Localization	Frequency % (n)
Nose	58 (15)
Ear	42 (11)
Scalp	23 (6)
Lips	19 (5)
Face (generally)	12 (3)
Forehead	8 (2)
Axillary region	8 (2)
Inguinal region	8 (2)
Lower extremities	8 (2)
Trunk	4 (1)
Nails	4 (1)

specified the surgical areas that they believe require PAP. The following locations were named: nose (57.7 % [15/26]), ear (42.3 % [11/26]), scalp (23.1 % [6/26]), lip (19.2 % [5/26]), face in general (11.5 % [3/26]), forehead, axilla, inguinal region, lower limbs (7.7 % each, [2/26]) and trunk and nails (3.8 % each, [1/26]) (Table 3). 11.5 % (3/26) of physicians added that they routinely perform PAP for autologous skin grafting. Furthermore, 15.4 % (4/26) of respondents reported that they administer PAP for extensive surgery or when wound closure is performed using large skin flaps.

### Perioperative antibiotic prophylaxis for prevention of infective endocarditis

Of the 42 physicians who reported regular use of PAP in dermatosurgical patients, 97.6 % (41/42) stated that they use PAP to prevent the development of infective endocarditis. Approximately 46.3 % (19/41) of the respondents reported using PAP in all dermatosurgical patients with an increased risk of endocarditis, regardless of the location of the surgical site. 9.8 % (4/41) of the skin surgeons stated that they only use PAP for endocarditis prophylaxis in patients with an increased risk of endocarditis while performing surgery on mucous membranes (Table 4).

### Performance of perioperative antibiotic prophylaxis

Most of the respondents reported that they administer PAP in the form of oral medication (always by 44.3 % [31/70], often by 20.0 % [14/70], rarely by 27.1 % [19/70], and never by 8.6 % [6/70] of the doctors). This was followed by local application of PAP (always by 5.8 % [4/69], often by 23.2 %

**Table 4** Use of PAP in skin surgery in patients with an increased risk of infective endocarditis (n = 41).

	In % (n)
In all high-risk patients for all surgical procedures, irrespective of the area undergoing surgery	46 (19)
In patients with any prosthetic valves for all surgical procedures, irrespective of the area undergoing surgery	7.2 (3)
In patients with a previous episode of infective endocarditis for all surgical procedures irrespective of the area undergoing surgery	2.4 (1)
In patients with any prosthetic valves, as well as in patients with a previous episode of infective endocarditis, for all surgical procedures irrespective of the area undergoing surgery	10 (4)
Only for surgery involving mucous membranes	10 (4)
Never	2.4 (1)
Other	22 (9)
<b>Total</b>	<b>100 (41)</b>

[16/69], rarely by 27.5 % [19/69] and never by 43.5 % [30/69] of the physicians) and intravenous administration (always by 6.0 % [4/67], often by 10.4 % [7/67], rarely by 23.9 % [16/67] and never by 59.7 % [40/67] of the surgeons) (Figure 2).

Cefuroxime was the systemic antibiotic agent used most frequently for PAP (always by 17.4 % [12/69], often by 50.7 % [35/69], rarely by 13.0 % [9/69], and never by 18.9 % [13/69] of the doctors), followed by clindamycin (always used by 3.0 % [2/67], often by 22.4 % [15/67], rarely by 47.8 % [32/67] and never by 26.8 % [18/67] of the physicians). The other systemic antibiotics used for PAP in skin surgery were amoxicillin (always by 6.1 % [4/66], often by 18.2 % [12/66], rarely by 31.8 % [21/66] and never by 43.9 % [29/66] of the respondents), penicillin (often by 3.0 % [2/66], rarely by 19.7 % [13/66] and never by 77.3 % [51/66]) as well as ciprofloxacin (often in 6.2 % [4/65], rarely in 32.3 % [21/65] and never in 61.5 % [40/65]) (Figure 3). In addition, about one fifth (20.2 % [14/69]) of the respondents stated that they use the following antibiotics for PAP in skin surgery as part of the clinical routine: doxycycline (especially for facial surgery in patients with rosacea [4/14]), other cephalosporins (7/14) (e.g. cephalexin [2/14], cefaclor [1/14], cefadroxil [1/14], cefazolin [1/14] and ceftriaxone [1/14]), rifampicin (1/14), ampicillin in combination with sulbactam (1/14), and tyrothricin (1/14).

Regarding the application, dosage and duration of a PAP, most of the respondents stated that they administer a single dose before surgery (14.5 % [10/69] always, 21.7 % [15/69] often, 29.0 % [20/69] rarely and 34.8 % [24/69] never) or



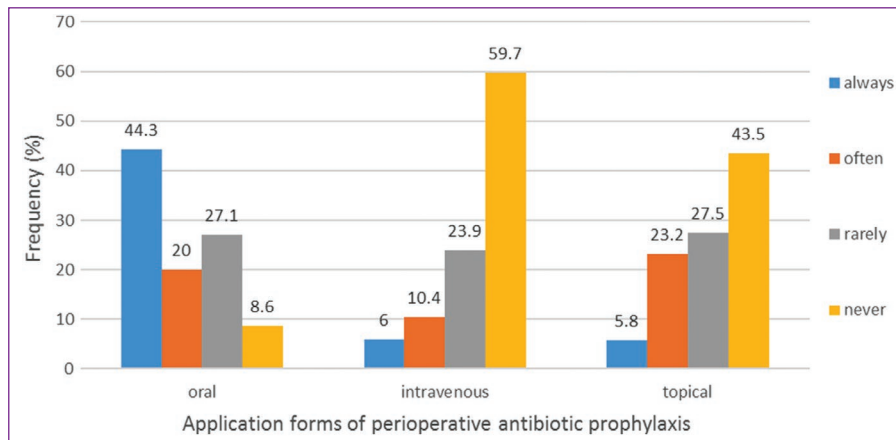


Figure 2 Selection of the route of perioperative antibiotic prophylaxis in dermatosurgical patients.

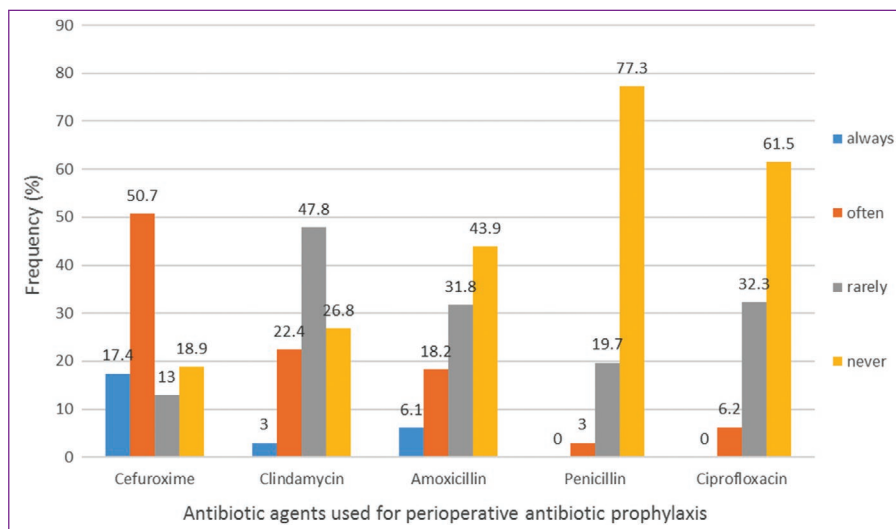


Figure 3 Selection and frequency of systemic antibiotics administered for perioperative antibiotic prophylaxis in dermatosurgical patients.

after the procedure (4.8 % [3/63] always, 9.5 % [6/63] often, 31.7 % [20/63] rarely, and 54.0 % [34/63] never). Some physicians prescribe PAP for a period of 1 to 3 days. 3.3 % (2/60) of the physicians reported that they do this always, 21.7 % (13/60) often, 40.0 % (24/60) rarely, and 35.0 % (21/60) never. Some choose a longer course of 3 to 5 days (4.8 % [3/63] always, 23.8 % [15/63] often, 46.0 % [29/63] rarely, and 25.4 % [16/63] never). Prescription of PAP for a single day was less common (1.7 % [1/60] always, 1.7 % [1/60] often, 28.3 % [17/60] rarely, and 68.3 % [41/60] never). PAP is also rarely prescribed for a period of over 5 days (always by 6.4 % [4/62], often by 11.3 % [7/62], rarely by 45.2 % [28/62], and never by 37.1 % [23/62] of the surgeons) (Figure 4).

### Attitude towards perioperative antibiotic prophylaxis in the field of dermatosurgery

About one fifth (20.5 % [16/78]) of the respondents expressed the opinion that PAP in dermatosurgery is not able to prevent SSI. In addition, 78.2 % (61/78) of physicians felt that

only certain patient groups benefit from PAP in skin surgery, and therefore use it only for these cohorts. About 38.5 % (30/78) of the surgeons believe that PAP is an effective tool for SSI prevention (Table 5).

### Presence of guidelines on the use of antibiotic prophylaxis in dermatosurgical patients

Only 33.3 % (25/75) of respondents stated that they have an in-house guideline on the use of PAP in dermatosurgical patients. Of these, 40.0 % (10/25) worked in private practice and 60.0 % (15/25) in a hospital environment. There was no statistically significant difference in the presence of a guideline between hospitals and private practice ( $p = 0.071$ ).

### Discussion

The main goal of PAP in skin surgery is prevention of SSI [1–3]. Wound infection rates vary between < 1 % and 11 % in current published sources [9–14]. These generally low SSI

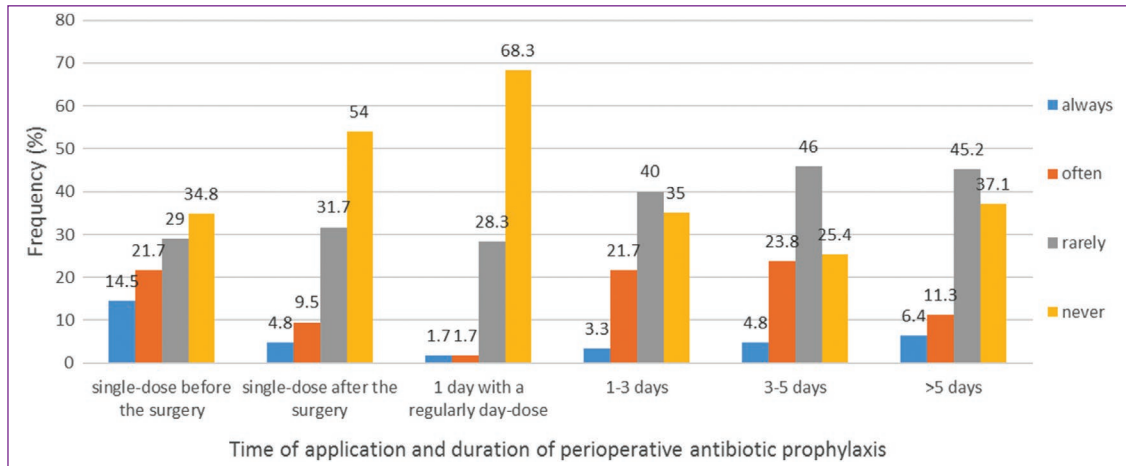


Figure 4 Time and duration of administration of perioperative antibiotic prophylaxis in dermatosurgical patients.

Table 5 Attitude of survey participants to the use of perioperative antibiotic prophylaxis in dermatosurgery (n = 78).

	Agree % (n)	Disagree % (n)	Not answered % (n)	Total % (n)
Perioperative antibiotic prophylaxis <i>reduces</i> the occurrence of postoperative infections after dermatosurgical procedures <i>significantly</i> .	38.5 (30)	55.1 (43)	6.4 (5)	100 (78)
Only isolated groups of patients benefit from perioperative antibiotic prophylaxis in skin surgery, so I only prescribe PAP in these rare cases.	78.2 (61)	16.7 (13)	5.1 (4)	100 (78)
Perioperative antibiotic prophylaxis <i>does not prevent</i> the occurrence of postoperative infections after skin surgery, therefore, I do not prescribe it for this indication.	20.5 (16)	70.5 (55)	9 (7)	100 (78)

rates may explain the lack of randomized prospective studies on wound infections in dermatosurgery, because a very large number of patients would be required in order to achieve statistically significant results, due to the low number of wound infections. The insufficient evidence in this area leads to the absence of a guideline on the use of PAP in dermatosurgery in Germany. The indications and protocol of PAP are therefore determined only by the clinical experience of the surgeon. Although there are evidence-based recommendations on PAP in the field of skin surgery in the USA [16], these guidelines are not entirely transferable to the German context. In the USA, Mohs surgery is a standardized surgical procedure, and in most cases wound closure is performed on the same day as excision of the skin lesion. This contrasts with common practice in Germany, where three-dimensional (3D) histology is often established as the standard for excision of malignant skin tumors, with wound closure on the following day or even days [18]. Therefore, physiological wound colonization that starts on the 2<sup>nd</sup> or 3<sup>rd</sup> day after the initial excision (for example,

while performing surgery on a full-thickness defect of the nose with an extension to the cheek) may occur frequently.

Based on current data, dermatologists in Germany belong to one of the five medical specialties whose members prescribe the most systemic antibiotics in an outpatient setting [7]. The proportion of this attributable to PAP is unknown [7].

Despite the relatively low response rate of 9.2 %, the current survey involved 70 medical specialists in the field of dermatology with a median professional experience of 15 years (10–20 years). The collected data therefore reflect the opinions of experienced German skin surgeons.

### Indications for perioperative antibiotic prophylaxis

Current data show that the indications for PAP in Germany are approached in very different ways (Figure 1). For example, more than one third of the respondents stated that they often perform PAP in immunocompromised



patients, both in patients on systemic immunosuppressive therapy and those with immunocompromising hematological diseases. However, there is no clear evidence in the current scientific literature that the risk of SSI is higher in immunocompromised than in immunocompetent persons [14, 16, 19]. It is also unclear whether SSIs progress to more fulminant forms or are associated with higher morbidity in immunocompromised patients than in immunocompetent individuals.

About 40 % of the survey respondents always use PAP in cases of contamination of the surgical area. Some sources suggest that the risk of SSI after excision of ulcerated (and therefore potentially contaminated) skin lesions is higher than with non-contaminated lesions [20, 21]. Nevertheless, a recent meta-analysis showed that there is still no clear evidence that PAP prevents SSI after surgery on ulcerated skin tumors [22]. Thus, it remains unclear whether PAP is beneficial for interventions on ulcerated and contaminated skin lesions in the absence of other patient-related risk factors, such signs of infection (redness, pain, local increase of temperature and/or increased serological infection parameters).

According to the results of the current survey, PAP is rarely performed for surgical procedures on mucous membranes. The data show that it is used mostly in the context of prophylaxis of infective endocarditis, as is the case with dental procedures. This approach corresponds with the current recommendations of the European Society of Cardiology [23].

In multistage dermatosurgical procedures, PAP is “always” and “often” used by 12 % and 39 % of survey participants, respectively. At most German dermatosurgical centers, a multistage surgical procedure with three-dimensional (3D) histology has become the standard, especially for surgery of malignant skin tumors on the head and facial area [18], which results in a high number of PAP prescriptions. However, neither the American findings (with Mohs surgery) nor the German findings (with 3D histology) demonstrate an increased SSI risk in skin surgery patients who require more than one excision in order to achieve tumor clearance compared to one-time procedures [14, 24]. Thus, the need for PAP for multistage skin interventions should always be approached critically and should remain a case-by-case decision with consideration of individual patient-related risk factors.

About 19 % and 55 % of those interviewed, respectively, reported that they “always” or “often” use PAP for surgical interventions in certain areas. The most often-named localizations were the nose, ear area and scalp. The data on infection rates after skin surgery at the above-mentioned sites are controversial. A study from 1997 reported an increased risk of SSI in the nose and ear areas [25]. However,

this result could not be reproduced in more recent clinical studies [12, 14], so these particular locations alone should not be considered a mandatory indication for the use of PAP. There is a minor possibility of cartilage damage as a severe complication of SSI in these areas, which may be a reason for prescribing PAP more generously for surgical procedures at these locations [26].

According to our data, over one third of physicians “always” or at least “often” use PAP in dermatosurgery with inflammatory diseases (such as hidradenitis suppurativa [acne inversa]). The rest of the respondents rarely or never recommend PAP for this indication. There is an international recommendation on antibiotic therapy for acne inversa in order to reduce the inflammatory component of the disease and thus the surgical area [27]. However, for this purpose, systemic antibiotics should be used over a longer period of time before the surgical procedure and not as PAP.

### Perioperative antibiotic prophylaxis for prevention of infective endocarditis

The European Society of Cardiology defines three groups of patients at high risk of developing infective endocarditis. These are patients with any prosthetic cardiac valves, patients with a previous episode of infective endocarditis, and patients with congenital heart disease. The latter group includes patients who underwent surgical or interventional prosthetic correction of congenital heart disease within the first six postoperative months (lifelong, if residual shunt or valvular regurgitation persists after correction) [23]. No other heart defects or diseases place patients at increased risk of developing infective endocarditis or require PAP, according to the 2015 guideline [23]. Furthermore, according to the guideline, the above-mentioned groups of high-risk patients only require perioperative antibiotic prophylaxis of infective endocarditis while undergoing surgical procedures with mucosal involvement. However, in these patients PAP should also be performed for septic surgery (e.g. surgical abscess treatment) with antibiotic agents active against staphylococci and beta-hemolytic streptococci. It therefore appears logical to extend this recommendation and view surgery of ulcerating or contaminated skin tumors and leg ulcers in high-risk patients as an indication for PAP of infective endocarditis as well.

One of the most important factors in decision-making on the use of perioperative antibiotic prophylaxis of infective endocarditis is the surgical procedure itself. A small single-stage procedure with immediate primary wound closure may not require any PAP. A multistage procedure is clean, but not fully sterile. Nevertheless, PAP is not necessarily recommended even in such surgical procedures and should remain an individualized decision [17].

## Application of perioperative antibiotic prophylaxis

Based on the results of the current survey, cefuroxime and clindamycin are the antibiotics most commonly used for PAP. Amoxicillin is used less commonly, and penicillin and ciprofloxacin are rarely used for PAP.

When prescribing PAP for prophylaxis of infective endocarditis, the main targets of antibiotic agents are oral or cutaneous streptococci. Thus, the guideline of the European Society of Cardiology recommends amoxicillin or ampicillin as the drugs of choice [23]. In cases of allergy to amoxicillin or penicillin, clindamycin can be used instead.

In high-risk patients or for interventions with increased risk of SSI, agents effective against staphylococci are recommended in the literature to reduce the risk of perioperative infections [1, 7]. These include aminopenicillins in combination with beta-lactamase inhibitors (amoxicillin/clavulanic acid and ampicillin/sulbactam) and first and second generation cephalosporins (cefazolin, cefadroxil, cefalexin, cefaclor and cefuroxime) [1, 7, 16, 28]. Although the selection of systemic antibiotics used at German dermatosurgical centers for PAP remains heterogeneous, it still reflects current national and international evidence-based recommendations.

The vast majority of PAP in German dermatosurgery is administered orally, with the intravenous route being a much less frequent choice. This differs from the current recommendations of the Commission for Hospital Hygiene and Infection Prevention (KRINKO) at the Robert Koch Institute, which favor intravenous PAP [3]. The oral route of PAP is only recommended for prevention of infective endocarditis, and only in those cases in which it cannot be replaced by intravenous therapy [23]. The current survey also revealed occasional use of local antibiotics such as fusidic acid for PAP. In the current literature, topical application of antibiotic-containing creams is highly controversial [28]. A Cochrane analysis concluded that the use of topical antibiotic agents on surgical wounds after primary closure is more likely to reduce the risk of postoperative wound infections than procedures without application of topical antibiotics [29]. However, it is important to consider the negative aspects of topical PAP, such as the potential negative influence of the substances on the wound healing process and a high possibility of allergic sensitization due to application of active ingredients on non-intact skin. Furthermore, the possibility of bacteria developing antibiotic resistance due to frequent use of antibiotic agents or insufficient concentration of the antimicrobial substances at the application site should not be ignored. In view of this, the use of topical antiseptics (such as polyhexanide) may be beneficial as a substitute for topical application of antibiotics.

The preferred duration of PAP in dermatosurgical interventions also varies among the respondents. Although PAP is administered as a single dose before surgery at most dermatosurgical centers, about one fifth of the respondents stated that they often perform PAP over a period of 1 to 3 days or 3 to 5 days. In the current literature, PAP administered as a single dose about 30 minutes before the surgical procedure is described as adequate for the prophylaxis of SSI [1, 23]. A similar consensus has been reached in the field of spinal surgery, in which research showed that a single administration of PAP was equivalent to administration of several antibiotic doses during the surgical procedure [30]. However, this evidence concerns surgical procedures with definitive wound closure during the same operation. In German clinics, three-dimensional (3D) histology with multistage surgical procedures is often the established standard for excision of malignant skin tumors. Due to this important distinction and lack of prospective studies on this topic, it is unclear whether a single administration of an antibiotic prior to each intervention in a series is equivalent to continuous administration of the drug with regular therapeutic doses over the entire duration of treatment, from the first excision to wound closure. The decision should be made individually, based on the assessment of patient-related risk factors and drug side effects and interactions.

To summarize, there is no established, standardized protocol for the use of PAP in skin surgery in Germany. However, it is worth noting that a large proportion of respondents use PAP only with caution and in a targeted manner (especially for prophylaxis of infective endocarditis), apparently without seeing a higher incidence of SSI. Excessive use of PAP may be promoted by traditions and standard procedures in individual clinics without any medical need. Large, multi-center, prospective, randomized dermatosurgical studies are needed to clarify the extent to which PAP is required in skin surgery and whether the PAP recommendations of KRINKO are also applicable to dermatosurgery.

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## Conflict of interest

Moritz Felcht MD is a board member of the German Society of Dermatology (DGDC).

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## Correspondence to

Galina Balakirski, MD  
 Department of Dermatology and Allergology  
 University Hospital of Bonn  
 Sigmund-Freud-Strasse 25  
 53127 Bonn, Germany  
 E-mail: galina.balakirski@ukbonn.de

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