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ORIGINAL ARTICLE

Risk factors and predictors of prolonged hospital stay in the clinical course of major amputations of the upper and lower extremity a retrospective analysis of a level 1-trauma center

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Abstract

Purpose The objective was to analyze the treatment and complications of the patients after a major amputation of the upper and lower extremities. Risk factors and predictors of a prolonged hospital stay should be outlined.

Methods This is a retrospective study of a national Level-1 Trauma center in Germany. In a 10-year period, patients were identified by major amputations in the upper and lower extremities. The medical reports were considered and the results were split into four main groups with analysis on basic-, clinical data, the course on intensive care unit and the outcome. A recovery index was established. The patients' degree of recovery was summed up. Statistical analysis was performed.

Results 81 patients were included. A total of 39 (48.1%) major amputations were carried out on the lower leg and 34 (42.0%) involved the thigh. There were two instances (2.5%) of hip joint disarticulation. 6 major amputations were done on the upper extremities ($n=3$ on the upper arm, $n=3$ on the forearm). 13.83 ± 17.10 days elapsed between hospital admission and major amputation. The average length of hospital stay was $38.49 \pm 26{,}75$ days with 5.06 ± 11.27 days on intensive care unit. Most of the patients were discharged home followed by rehabilitation. A significant correlation was found between the hospital length of stay and the increasing number of operations performed ($p=0.001$). The correlation between the hospital length of stay and the CRP level after amputation was significant ($p=0.003$).

Conclusions Major amputations in trauma patients lead to a prolonged stay in hospital due to severe diseases and complications. Especially infections and surgical revisions cause such lengthenings.

Keywords Major amputation · Trauma · Complications · Hospital stay

Introduction

Major amputations of the upper and lower extremities have a significant impact on the quality of life of the affected patients. From the indication of amputation to the reintegration into private and professional life, patients usually go through a longer stay in the hospital, followed by inpatient and outpatient rehabilitation measures [1].

Amputation of the extremities is one of the most ancient surgical procedures [2]. In the beginning, the surgical amputation was crude and had to be carried out extremely rapidly because it was performed without anesthesia after removing the amputated extremity, the stump was crushed in hot oil to generate hemostasis. Amputation is the oldest major operation and has been practiced for punitive, ritualistic, and therapeutic reasons for thousands of years [3].

The reasons that lead to an amputation can be manifold, including infectious diseases, peripheral and central vascular diseases, diabetes mellitus (DM), diseases of the musculoskeletal system and the connective tissues, cancer, external causes like trauma, skin diseases, and congenital malformations [4].

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Amputation procedures may therefore be urgent operations or may be scheduled electively. Currently, major amputations are performed obviously under anesthesia and monitoring, it is performed as an ultima ratio measure, after all procedures and treatments to save a extremity have been exhausted, since major amputations have a high rate of complications such as bleeding and hematoma, postoperative infection, surgical wound necrosis, contractures, pain, dermatological problems and lastly in a not so small percentage is a cause of death; in a systematic review van Netten et al. [5] reported that the 30 days mortality in patients that underwent a major amputation ranged from 7 to 22%.

The care and complications of major amputations in the public health system in Germany have not been well described so far. The objective of this article was to analyze, in a retrospective cohort of a national Level-1 Trauma center in Germany, the treatment and complications of the patients that underwent a major amputation of the upper or lower extremity in a ten-year follow-up.

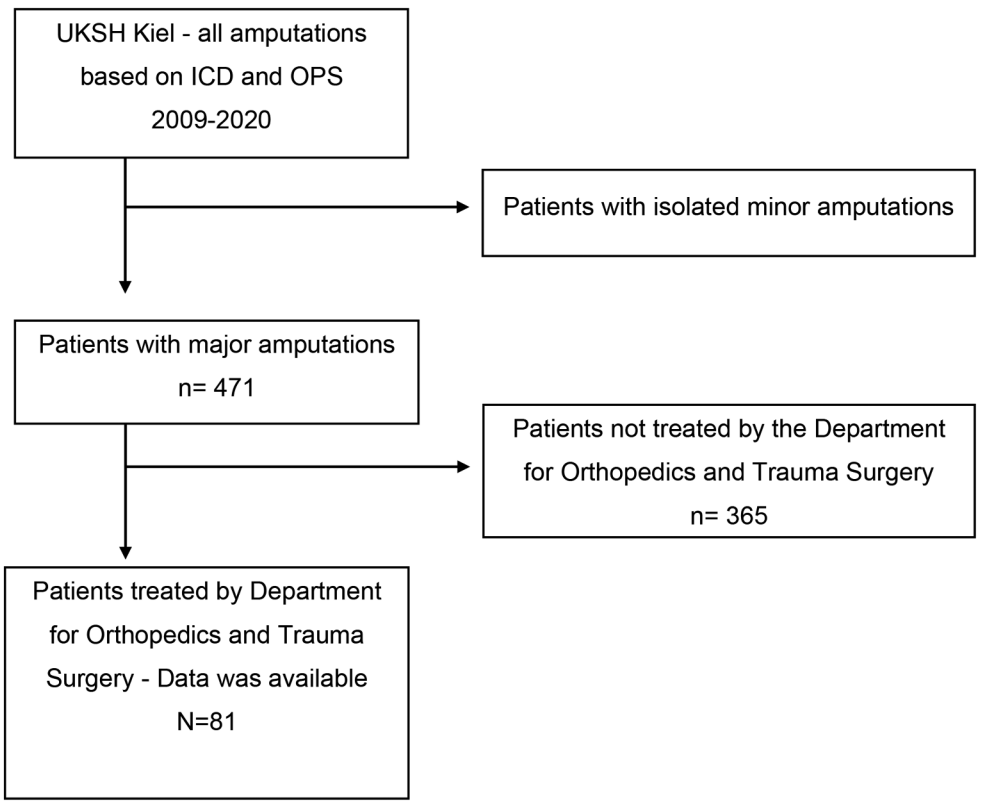
Methods

Patient cohort

This retrospective study was performed at the Department for Orthopedics and Trauma Surgery at the University Hospital Schleswig-Holstein, Campus Kiel. The study period was from January 2009 to December 2020. The study was approved by the local ethics committee (number D 434/19). Major amputations were defined as amputations above the wrist and ankle. The patients were identified according to the International Statistical Classification of Diseases and Related Health Problems (ICD-10) as well as the Operation and Procedure Code (OPS). They were assigned either by ICD-10 code identifying traumatic major amputations in the upper and lower extremities (ICD S38.3, ICD S48.1, ICD S78.1, ICD S88.0, ICD S88.1) or by the OPS code identifying amputations and disarticulations of extremities (OPS 5-862, OPS 5-864). The resulting sample contains both male and female patients with a minimum age of 16 years Graph. 1.

Data collection

The patients´ medical documentation, surgical reports and discharge letters were considered from the digital hospital information system Agfa ORBIS (Version 08043701.04000. DACHL). The results were split into four main data groups: (1) Basic data, (2) Clinical data, (3) Intensive Care Unit and (4) Outcome. A recovery index was established in the context of major amputations. Furthermore, the patients' degree of recovery was summed up according to three distinct parameters: degree of mobility, level of care and type of physiotherapy. Each parameter is comprised of three levels to which we assigned 0, 1 and 2 points, respectively. A



Graph. 1 Inclusion and exclusion criteria

Table 1 Point distribution for the representation of the degree of recovery

Score	Characteristics
Mobility	0 points: The patient is bedridden. 1 point: The patient needs assistance transferring to a wheelchair. 2 points: The patient is independently mobile with a prosthesis /assistive device/wheelchair.
Care	0 points: The patient requires complete assistance with care. 1 point: The patient needs support with care. 2 points: The patient manages care largely independently.
Physiotherapy	0 points: No mobilization is possible. 1 point: The patient can participate in simple physiotherapeutic exercises. 2 points: Extended physiotherapeutic early rehabilitation is conducted.

Table 2 Grading of the recovery index based on point assignment

Degree	Points
1	0–1
2	2–4
3	5–6

higher level and thus a higher number of points is associated with a higher degree of recovery (see Tables 1 and 2*)*. Finally, we assigned patients to three distinct groups based on the sum of their three individual scores. Group 1 consists of patients with 0–1 points implying that these patients achieved level 1 at most in one category. Group 2 consists of patients with 2–4 points. Finally, group 3 consists of patients with 5–6 points representing patients that achieved level 3 at least in 2 categories.

Statistical analysis

Retrospective analysis of data collected from patient records. Results are provided as mean ± standard deviation (SD). Statistical analysis was performed using IBM®, SPSS Statistics version 24. The T-test, Mann-Whitney-U-test, Kruskal-Wallis-test and Pearson-analysis were applied. A p-value ≤ 0.05 was considered statistically significant.

Results

Epidemiological data

In the 10-year period 81 patients out of 471 patients were included due to the criteria.

The average age of the patients was 60.79 ± 16.07 years. The patient group consisted of 65 (80.2%) male patients and 16 (19.8%) female patients. The distribution of the different ages is shown in Fig. 1.

The medical conditions appeared mainly as arterial hypertension (59,3%), diabetes (34,6%), and coronary artery disease (28,4%). 57 patients (70,4%) had at least one newly diagnosed postoperative comorbidity Figs. 2 and 3.

A total of 39 (48.1%) major amputations were carried out on the lower leg and 34 (42.0%) involved the thigh. There were two instances (2.5%) of hip joint disarticulation. In the

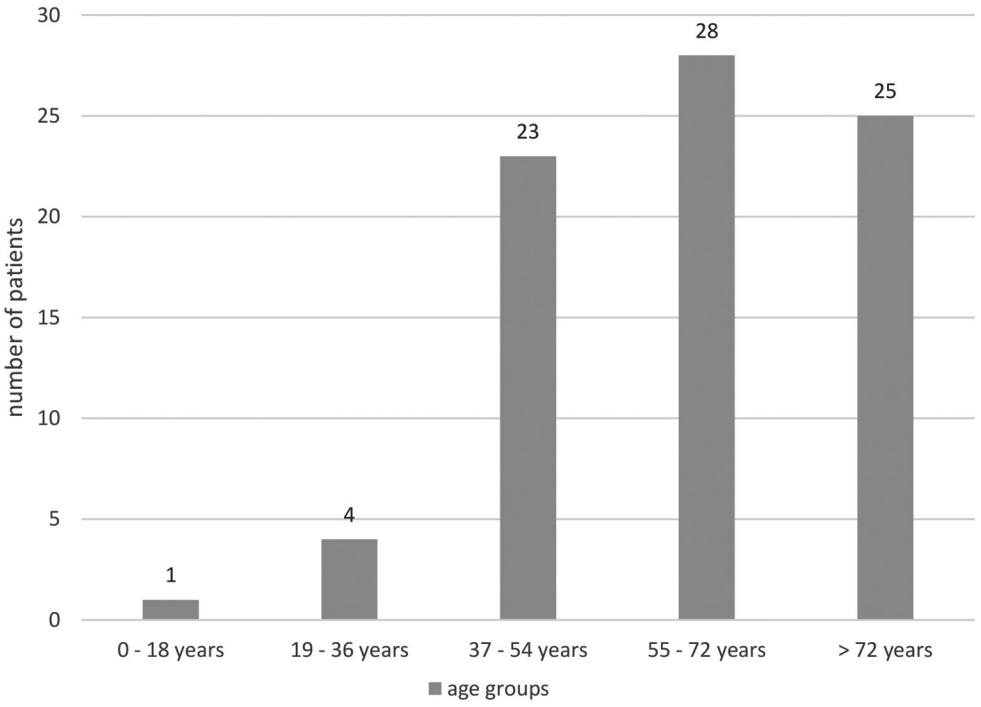


Fig. 1 Ages of patients. Cohorts by age

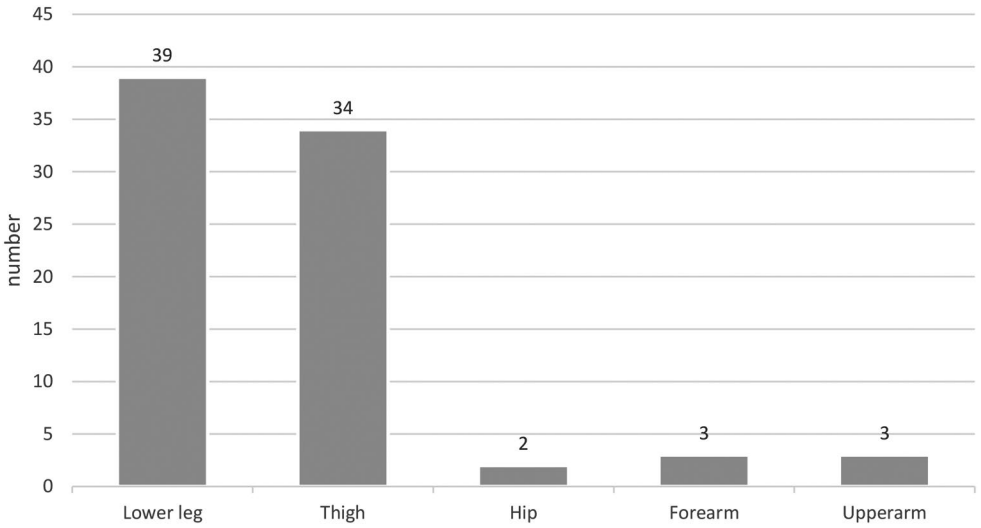


Fig. 2 The anatomical topography of major amputations. X-axis: Representation of different anatomical amputation locations; Y-axis: Number of patients with each respective amputation

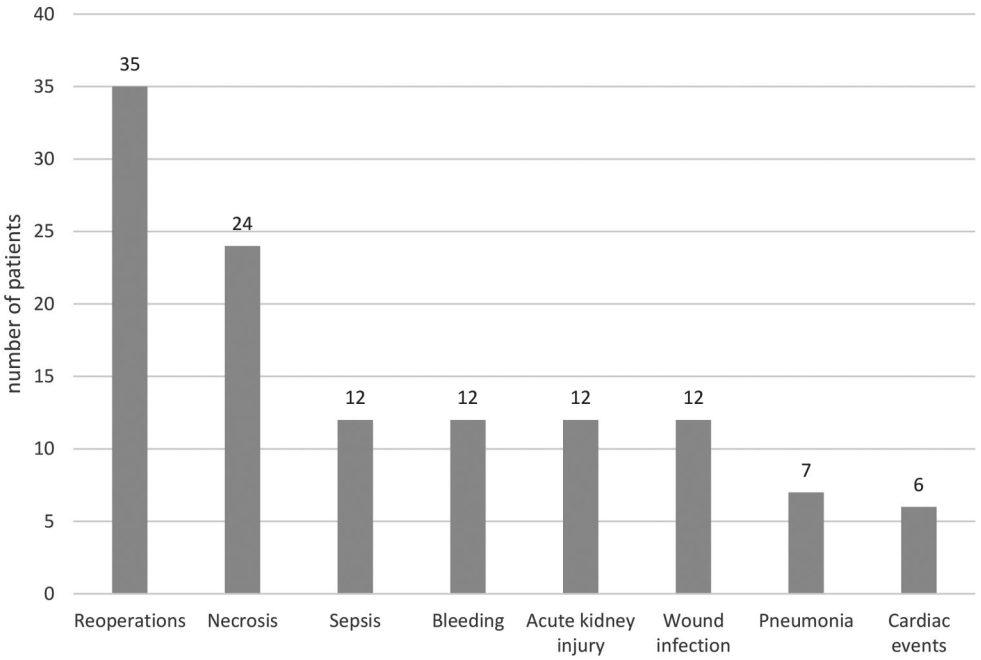


Fig. 3 Postoperative complications. Eight groups of complications were documented. Numbers in total

Table 3 Number of operations

	N	Min.	Max.	Mean	SD
Number of operations	81	1	17	4,70	3,696

Minimum (Min.), Maximum (Max.), Mean, Standard deviation (SD) and number of patients (N)

Table 4 Days between admnission and operative treatment

	Min.	Max.	Mean	SD
Time between admission and major amputation	0	76	13,83	17,097

Minimum (Min.), Maximum (Max.), Mean, Standard deviation (SD) in days. Number of patients (N)

upper extremity, three (3.7%) major amputations were performed each on the forearm and on the upper arm. In total, 41 (50,6%) patients were amputated at their left extremity and 35 (43,2%) patients at their right extremity. In 5 (6,2%) patients the amputation was performed on both sides. The average number of operations conducted per major amputation was 4.7 ± 3.7. Various reasons and symptoms were detected that occurred in the cohort of 81 patients. Infections of the extremities were present in 46 cases. Amputation due to traumatic injury was carried out in 29 patients. A peripheral arterial disease was present in 17 patients. 11 patients had a diabetes, 8 patients had a cancerous disease and drug abuse was observed in 1 patient Tables 3 and 4.

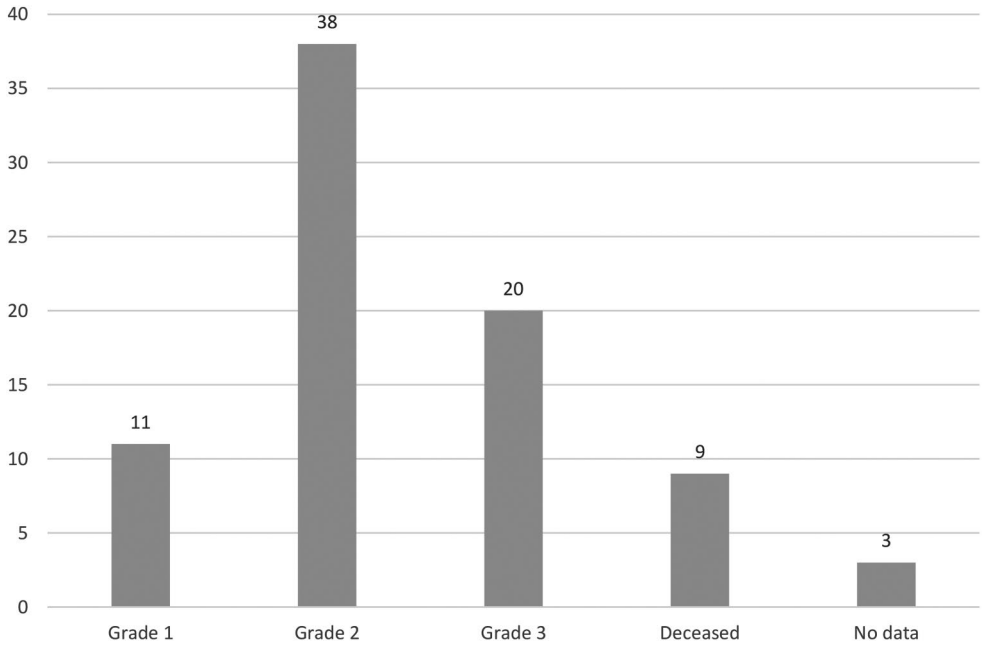


Fig. 4 Representation of the various degree classifications of the recovery index. Numbers in total

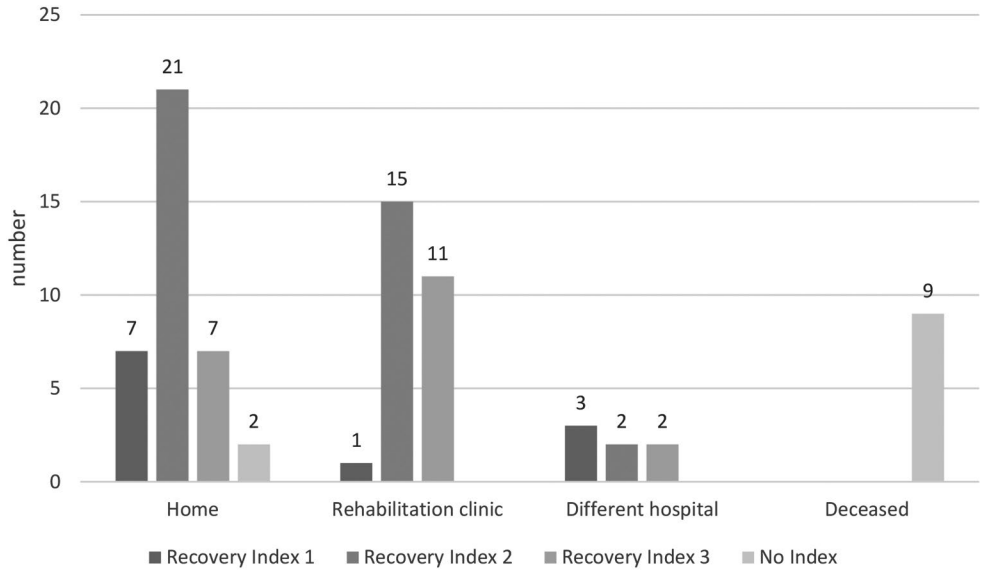


Fig. 5 Representation of the type of discharge based on the recovery index

Table 5 Pearson correlation analysis using the hospital length of stay as the dependent variable and listing the independent variables

Correlational analysis length of stay in the hospital vs.	Pearson	
	N	*P*
Age	81	0,738
Number of operations	81	0,001
CRP on admission	78	0,883
CRP post-operative	78	0,003
Days in the ICU	81	0,002
Number of days intubated	81	0,000

N = number of patients. P = probability

Clinical course

On average, 13.83 ± 17.10 days elapsed between hospital admission and major amputation. In 45 (55.6%) cases, one hospital stay was required for treatment, with a maximum of 9 stays (1.85 ± 1.48). In 16 (19,8%) cases, the major amputation took place on the day of admission Figs. 4 and 5.

The shortest period of hospitalization was 8 days. The longest one was 174 days (38,49 ± 26,75 days). The average length of hospital stay was 38.49 ± 26,75 days. 35 (43.2%) patients spent at least one night in the intensive care unit. The mean number of days in the intensive care unit was 5.06 ± 11.27 days. 22 patients had mechanical ventilation (Max 44 days, mean 2,18 ± 7,10 days) Tables 5, 6 and 7.

Table 6 Conducting a Kruskal-Wallis-test to evaluate differences in mean ranks, with the dependent variable as hospital length of stay, and listing the independent variables

Testing the different middle ranks length of stay in the hospital vs.	Kruskal-wallis-test	
	P	*P* adjusted
No multi-drug resistant bacteria – no bacteria	0,920	1,00
No multi-drug resistant bacteria - multi-drug resistant bacteria	0,014	0,043
No bacteria – multi-drug resistant bacteria	0,018	0,053

P = probability, P adjusted = significance values are adjusted for multiple tests after Bonferroni correction

Table 7 Performing a t-test to compare different mean values, with the dependent variable being hospital length of stay and listing the independent variables

Testing the different mean values length of stay in the hospital vs.	t-Test	
	t	*P*
Place of amputation	0,312	0,756
Postoperative complications - pneumonia	-1,031	0,341
Postoperative complications - wound healing disorder	-3,814	0,000
Using a VAC	-2,066	0,042

t = test value t-Test, P = probability

The most common postoperative complications included re-operations and necrosis. Microbiological swabs were taken in 68 (84%) patients. In 16 (19.8%) patients, both microbiological and pathological tissue examinations were performed. A positive detection of bacteria was found in 57 (70.4%) patients. 23 (28,4%) patients had a negative result, and in 1 (1,2%) case there was no finding being documented. 35 (61,4%) patients were multi-drug resistant.

Outcome

A total of 37 (45,7%) patients were discharged home, 27 (33,3%) patients were transferred to a rehabilitation facility, 8 (9,9%) patients to another hospital, and 9 (11,1%) patients passed away during their hospital stay. 18 with a lower leg amputation and 13 patients with a thigh amputation were directly discharged home. Additionally, 14 patients with a lower leg amputation and 11 patients with a thigh amputation were subsequently transferred from the acute care hospital to an inpatient rehabilitation facility. Before their demise, 6 (66,7%) patients underwent a major amputation on the thigh, while 3 (33,3%) patients experienced such a procedure on the lower leg. 77,8% ($n=7$) of the deceased patients were male.

The results regarding the hospital length of stay and patient age showed no significant correlation ($p=0.738$). Similarly, there was no significant correlation found between the hospital length of stay and gender ($p=0.962$). In the analysis of different topographic amputations in relation to hospital length of stay, no significant differences were observed, whether considering equal variance ($p=0.752$) or unequal variance ($p=0.756$). Regarding the number of surgeries, a significant correlation was found between the hospital length of stay and the increasing number of operations performed ($p=0.001$). The analysis of red blood cell transfusions revealed no significant impact on the hospital length of stay ($p=0.341$). The C-reactive protein (CRP) level upon admission showed no significant indications of influencing the hospital length of stay ($p=0.883$). However, a significant positive correlation was identified between the hospital length of stay and the CRP level after amputation, characterized by a moderate strength ($p=0.003$). The different types of infections leading to major amputation showed no significant differences and correlations concerning the hospital length of stay ($p=0.678$). A significant difference was observed between the detection of a multidrug-resistant pathogen and a non-multidrug-resistant pathogen concerning the hospital length of stay ($p=0.043$). Intensive care support demonstrated a positively significant correlation with the number of days in the intensive care unit of moderate strength ($p=0.002$). If the patient was additionally intubated, the analysis revealed a significantly positive correlation with the hospital length of stay of moderate strength ($p=0.000$). Concerning the hospital length of stay and postoperative complications, there were no significant correlations found between the duration of stay and cardiac complications ($p=0.325$), postoperative sepsis ($p=0.720$), or postoperative pneumonia ($p=0.572$). However, a significant association was identified between postoperative acute kidney injury ($p=0.016$) and postoperative wound healing disturbances ($p=0.000$), leading to subsequently prolonged hospital length of stay.

Discussion

The reasons for a major amputation can be manifold. Diseases such as diabetes or vascular disorders show a global variation [6] and are the two major diseases leading to amputation of the lower extremity in industrial nations [7]. Amputations can be caused by severe trauma [8]. Extended soft tissue injuries and complex injuries can cause major amputation during hospital stay. Trauma represents the most common reason for major amputation of the upper extremity [9].

Compared to other countries, amputation rates are relatively high in Germany [7]. Over 70% of lower extremity amputations are necessary due to diabetes or vascular diseases [10].

In our evaluation, infections due to systemic disease were the primary cause for major amputations (56.8%), followed

by amputation due to traumatic injuries (35.8%). We wanted to evaluate the risk factors that led to a deterioration in outcome after major amputation. Especially microvascular diseases cause increased infection susceptibility and impairs wound healing [11]. Peripheral neuropathy affects nearly 50% of adults with diabetes diseases during lifetime and is associated with ulcera, infection and lower extremity amputation [12]. In addition to the depth of the ulceration, the age of the patient also plays a decisive role in the infection [13].

We detected 39 (48.1%) major amputations of the lower leg and 34 (42%) of the thigh.

Even though amputations can occur at any age, most amputations take place between the ages of 51 and 80 [13]. In our evaluation, the average age of the included patients was 60.79 ± 16.07 years. Higher age and comorbidities are risk factors for worse outcome after major amputation [14]. Comorbidities and premedication can affect wound healing after primary surgery [15]. We evaluated an average number of surgeries conducted per major amputation was 4.7 ± 3.7. Primary wound closure was performed in all cases. Postoperative wound healing disturbance was documented for 47 patients (56.8%). Compared to other evaluations, the complication rate is high. Low et al. evaluated 2879 patients and 41.8% required at least one revision and 27.5% of amputees showed at least one major post-surgical complication [16]. Besides comorbidities and higher body mass index, the level of amputation appears to play a significant role for wound complications [17].

In our evaluation, 48.1% of major amputations were hold on the lower leg and 42.0% were performed at the thigh.

Low et al. demonstrated higher complication and revision rates after trauma-related lower leg amputation compared to thigh amputation [16]. Due to swelling, reperfusion injury or extended infection, a primary wound closure is not indicated in all cases. Primary care with negative pressure wound therapy can decrease the risk of wound complications [18]. Further debridements and secondary soft tissue coverage are necessary in progress [19].

Hospital stay after major amputations show great variation and depends on patient age, preexisting diseases and complication rate [7, 20].

The average length of hospital stay was 38.49 ± 26,75 days in our evaluation. The hospital stay increased in line with the number of operations and showed a correlation with wound healing disturbance, acute kidney injury and CRP level after amputation. Patients with diabetes diseases are prone to develop renal complications [21]. Patients with diabetes generate infections more often than patients without diabetes [22].

The expression of CRP is regulated by infection or tissue inflammation. The acute-phase protein is stimulated by Cytokines [23]. A correlation of high CRP level and prolonged hospital stay has been demonstrated for other diseases before [24]. Hospital stay in case of multiresistant pathogen was longer compared to non-multiresistant pathogens. Previous evaluations showed, that infection due to multiresistant bacteria are associated with higher mortality and longer hospital stay [25]. We found no significant correlation between hospital stay and patients age and gender. These results differ from some other evaluations, although there were differences in the study design, average age and number of secondary diseases. Higher amputation and complication rates in males might be attributed to larger proportion in smoking and alcohol consumption and poor foot care [26]. Peek et al. found male patients more willing to undertake major amputation of lower extremity, but female patients showed higher mortality related to these procedures [27]. In our evaluation a mortality rate of 9 (11.1%) during hospital stay was evaluated. Postoperative mortality rates during 30 days after operation can range from 4 to 22% [5]. Risk factors for increased mortality rates are age, renal disease, and vascular disease [14]. Considering various revision procedures and complications, the outcome after 30 days evaluation appears good in international comparison. 37 patients were discharged home after hospital stay and 27 patients were transferred to a rehabilitation clinic. Early surgical treatment, prior identification of bacteria and adequate antibiotic therapy appear to be decisive for improving the outcome.

Conclusion

In our evaluation, the most common postoperative complications included re-operations, necrosis, and wound infections. The length of hospital stay was especially influenced by number of operations and CRP level after operation. Significant difference was observed between the detection of a multidrug-resistant pathogen and a non-multidrug-resistant pathogen concerning the hospital length of stay. The results underline the importance of a careful surgical approach to amputation, germ determination and antibiotic therapy. The bacterial spectrum and the primary surgical treatment appear to have a decisive influence on the duration of inpatient treatment.

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Author contributions M.W. conducted the study and wrote the manuscript. T.-M. W. undertook the study and gathered the data. T.K. and P.B. supported the process to issue the data. A.S. enabled us to conduct the study. S.F.-O. wrote the manuscript and enforced the correction.

Data availability No datasets were generated or analysed during the current study.

Declarations

Competing interests The authors declare no competing interests.

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