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Daytime and scheduled surgery for major dysvascular lower extremity amputation

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ABSTRACT

INTRODUCTION. Patients undergoing a major dysvascular lower extremity amputation (LEA) often have a poor outcome with a high risk of complications and mortality despite improvements in care and perioperative programmes. We evaluated whether scheduled surgery would reduce the failure rate in patients with a major LEA.

METHODS. A total of 328 consecutive patients undergoing a major LEA from 2016 to 2019 were enrolled at a single centre. Early failure was defined as re-amputation or revision within 30 days of the index amputation. In 2018, a new regime comprising two scheduled surgery days was implemented. The risk of failure comparing the two cohorts (2016-2017, n = 165 versus 2018-2019, n = 163) was calculated for amputation on scheduled versus non-scheduled days and for other potentially influencing factors.

RESULTS. The median (25-75% quartiles) age of all patients was 74 (66-83) years, 91% had an American Society of Anesthesiologists (ASA) grade ≥ 3 and 92% had atherosclerosis or diabetes mellitus. The index amputee levels were 36% below-knee, 60% transfemoral and 4% bilateral transfemoral. In the intervention cohort, 59% were amputated on the scheduled days versus 36% in the control group (p < 0.001). Correspondingly, more patients (72.4% versus 57.6%, p = 0.005) were amputated during daytime and the 30-day failure rate was reduced to 11.0% (n = 18) versus 16.4% (n = 27) (p = 0.2). Risk of failure on scheduled days in the intervention group was 8.3% versus 14.9% on any other day (p = 0.2). Correspondingly, daytime surgery reduced the risk of failure (6.8% versus 22.2%, p = 0.005).

CONCLUSION. Daytime and scheduled surgery for major LEA may possibly reduce early risk of failure.

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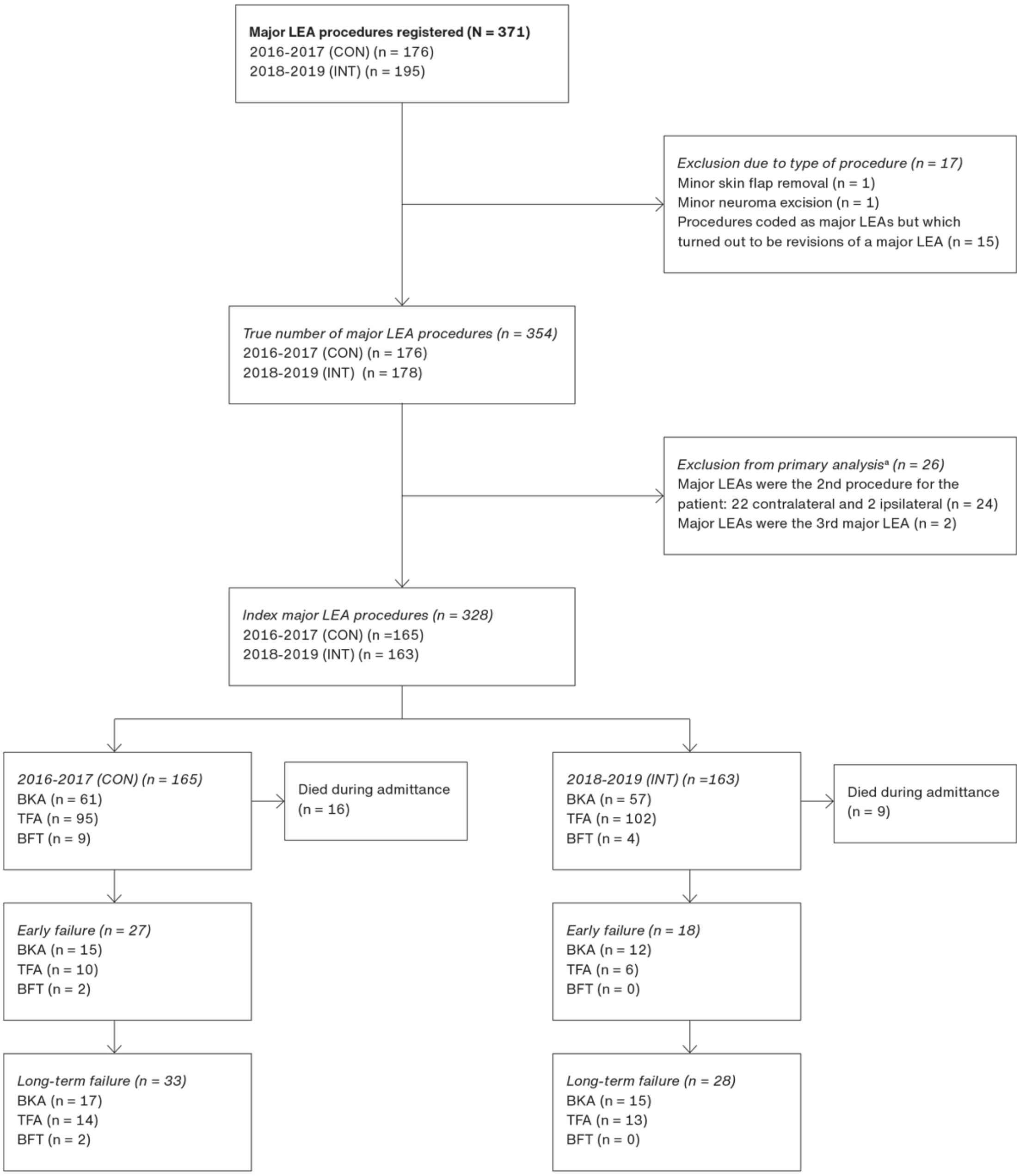
Patients who undergo a major dysvascular lower extremity amputation (LEA) often have a poor outcome. Despite advancements in perioperative risk stratification and care, the mortality and complications after LEA remain high [1-3]. Around 1,800 major LEAs are conducted annually in Denmark [4, 5], primarily related to diabetes mellitus and peripheral arterial disease [6, 7]. No new regime of amputation surgery has been introduced since 1992 [7, 8]. Risk factors for early failure (EF) of major LEA procedures are sparse [9, 10], and with conflicting evidence related to the experience of the surgeon [4, 5, 7, 11, 12]. Another risk factor for EF may be the timing of surgery, but the influence of, e.g., planned amputee days and amputation during dayshifts has to our knowledge - not been thoroughly investigated. In comparison, surgery within 24 hours after hip fracture seems critical based on mortality and morbidity rates [13].

Early failure after major LEA is an ongoing challenge. We hypothesised that scheduled surgery would lower the EF rate. We primarily examined this by evaluating the early and later risk of failure related to a new regime consisting of two scheduled surgery days for patients with a major dysvascular LEA. Secondarily, we evaluated the influence of other factors potentially influencing the risk of failure within the six months following the index LEA.

METHODS

We studied a consecutive four-year series of patients who underwent a major LEA at the Copenhagen University Hospital, Hvidovre, Denmark, from Jan 2016 through Dec 2019. In total, 371 consecutive major LEA procedures were registered of which 328 were index LEAs (**Figure 1**). In January 2018, a new regime was implemented dividing patients from the years 2016-2017 (n = 165) and 2018-2019 (n = 163) into a historical control group (CON) and an intervention group (INT), respectively. The new regime comprised two scheduled surgery days (Tuesday and Friday) and, if possible, a senior surgeon participating in all surgeries. No senior surgeon was assigned for the scheduled days, but a surgeon with special interest in amputations was preferred. If this was not possible, and depending on availability, a senior surgeon participated in the amputations. No other changes were made to the enhanced standard care and perioperative programme described by Kristensen et al. [1].

FIGURE 1 Flow chart.



BFT = bilateral transfemoral amputation; BKA = below-knee amputation; CON = historical control group; INT = intervention group; LEA = lower-extremity amputation; TFA = transfemoral amputation

a) > 1 major LEA procedure/patient, either as an ipsilateral amputation after 6 months or the index amputation or contralateral amputation > 24 h after index during the study period.

A major LEA was defined as a below-knee amputation (BKA) approximately 15 cm below the knee joint line, or a more proximal level, being either transfemoral (TFA) or bilateral transfemoral (BTF). The enhanced programme [1] includes pre-amputation tests of toe and ankle pressure, and skin perfusion, if deemed possible. Otherwise, the level of amputation was based on clinical examination by the surgeon [10]. Incorrectly registered procedures were excluded, i.e. neuromas or skin flaps. When a patient had multiple LEA procedures within the study period, further revision at the same level or amputation at a higher level was registered as a failure if it was done within six months of the index amputation. In line herewith, if performed on the same leg more than six months after the index amputation or on the contralateral leg more than 24 hours after the index amputation, it was registered as a new amputation and given a new ID number (Figure 1).

A total of 26 patients had more than one LEA procedure according to the above description; 24 patients had two and two patients had three. The 328 major index LEAs were included in the primary analysis of failures, whereas the 354 procedures, in total, were included in the secondary analysis.

Data collection was performed prospectively by one of the authors (GH) for each patient and provided with an ID number retraceable to their national social security number; if this was not possible, data were collected retrospectively.

Variables

A failure was defined as re-amputation or revision at the same or a higher level within 30 days (early) and six months (long-term) from the index amputation.

A senior surgeon was defined as a consultant or a senior registrar and any surgeon under training to become was defined as a house officer [10].

Vascular surgery history was not registered because the standard regime at the study hospital includes consideration of whether the patient should be evaluated in a vascular department before the amputation, if this was not done previously [10]. Thus, we assumed that each patient had been offered vascular surgery in cases in which limb saving was deemed possible.

Statistics

Q-Q plots indicated that continuous data did not follow a normal distribution.

Follow-up (until death, 30 days or six months after amputation) and data analysis comparing the two cohorts (CON; 2016-2017, n = 165 versus INT; 2018-2019, n = 163) was done for continuous (Mann-Whitney test) and categorical data (χ^2 test), as appropriate.

A multivariable logistic regression model was used to evaluate the odds of a scheduled surgery day to reduce the EF rate in the INT group, following adjustment for age, sex, timing of surgery, surgeons' position and amputee level. A Kaplan-Meier plot illustrated the time to failure for the INT and CON group.

Statistical significance was set at $p < 0.05$. Microsoft Excel 2016 and IBM SPSS Statistics 25 were used for the analyses.

Ethics and potential conflicts of interest

Data collection was registered with the regional data protection agency (01 HVH-2012-053), and access to patient charts was approved by the local ethics committee (wz19001024-2019-14).

Trial registration: not relevant.

RESULTS

No significant differences were observed for characteristics between the two cohorts. Please see **Table 1** for further description of the 328 included patients. Less than half of the patients had a pre-amputation distal pressure and/or skin perfusion assessment (**Table 2**), and the index amputee levels were 36% BKA, 60% TFA and 4% BTF, yielding a BKA/AKA ratio below 0.6. All amputations were performed by orthopaedic surgeons.

TABLE 1 Characteristics of 328 patients with an index amputation prior to and after 2018 when a new regime was introduced.

	2016-2017 (N = 165)	2018-2019 (N = 163)
Age, median (25-75% quartiles), yrs	75 (67-83)	73 (66-80)
Gender, n (%)		
Women	62 (38)	65 (40)
Men	103 (62)	98 (60)
Primary diagnosis, n (%)		
Diabetes	70 (42)	78 (48)
Arteriosclerosis	85 (52)	68 (42)
Other	10 (6)	17 (10)
Primary cause of amputation, n (%)		
Wounds	55 (33)	49 (30)
Infection	16 (10)	22 (13)
Necrosis	62 (38)	59 (36)
Ischaemic pain	8 (5)	7 (4)
Thrombosis/embolic	9 (5)	11 (7)
Complication to surgery	10 (6)	8 (5)
Wound revisions with no further prospects of local revision	2 (1)	7 (4)
Trauma	2 (1)	0
Other	1 (1)	0
Time from admittance to index amputation, median (25-75% quartiles), days	2 (1-4)	2 (1-6)
Index amputee level, n (%)		
Below knee amputations	61 (37)	57 (35)
Transfemoral amputations	95 (58)	102 (63)
Bilateral transfemoral amputations	9 (5)	4 (2)
Health status: ASA grade 1-5, n (%)		
2	16 (10)	13 (8)
3	126 (76)	123 (75)
4	22 (13)	27 (17)
5	1 (1)	0
Length of stay, median (25-75% quartiles), days	13 (9-20)	13 (9-18)
Time from surgery to discharge, median (25-75% quartiles), days	12 (7-15)	10 (7-12)
Discharged to, n (%)		
Own home including nursing home	89 (54)	69 (42)
Temporary 24-h setting in municipality	48 (29)	61 (37)
Another department	12 (7)	24 (15)
Died in acute hospital	16 (10)	9 (6)
Mortality, n (%)		
30-day	30 (18)	33 (20)
6-mo.	62 (37)	58 (35)

ASA = American Society of Anesthesiologists.

TABLE 2 Perioperative and post-operative data from 328 patients with an index amputation prior to and after the year 2018 when a new regime with scheduled amputee days was implemented.

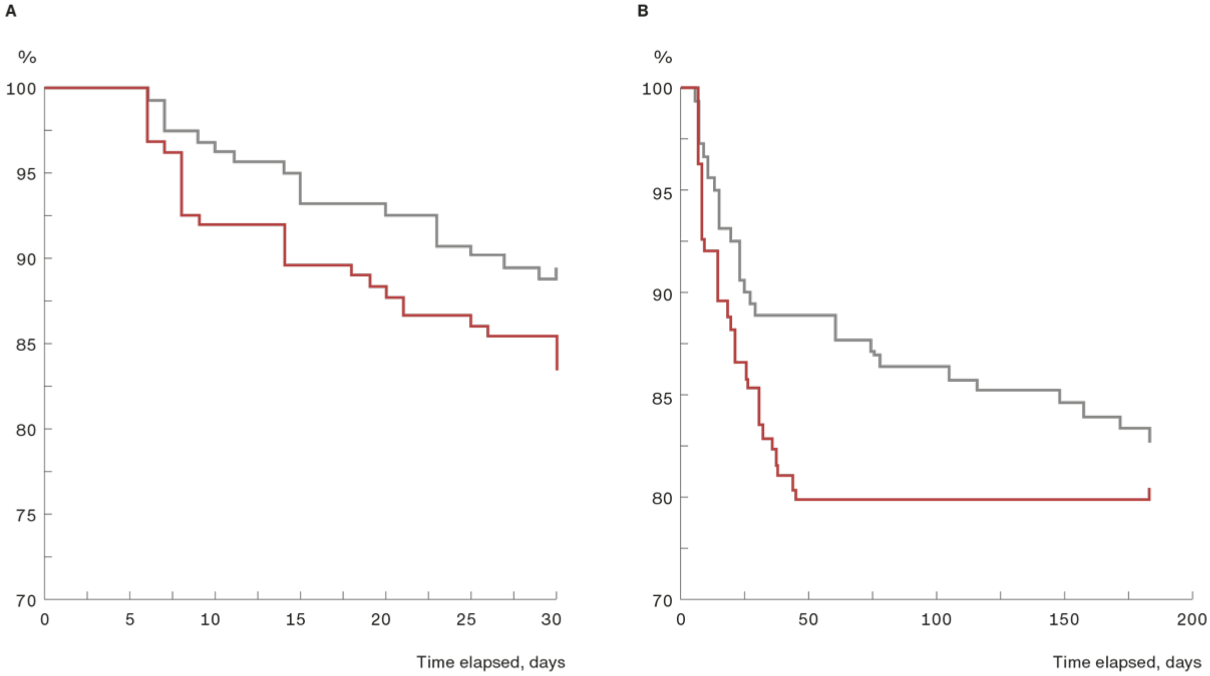
	2016-2017 (N = 165)	2018-2019 (N = 163)	p value
Pre-amputation assessments			
Toe pressure test, n (%)	57 (35)	58 (36)	0.8
Ankle pressure test, n (%)	46 (28)	69 (42)	0.006
Skin perfusion test, n (%)	51 (31)	49 (30)	0.9
Surgery time, median (25-75% quartiles), min.	90 (73-112)	83 (65-100)	0.05
Blood loss, median (25-75% quartiles), ml	350 (150-600)	410 (225-875)	0.02
Time of day for the start of the amputation, n (%)			0.005
Dayshift, 8 a.m.-2 p.m.	95 (58)	118 (72)	
Other shifts, 2 p.m.-8 a.m.	70 (42)	45 (28)	
Senior surgeon participating in surgery, n (%)	89 (54)	100 (61)	0.2
Surgery on a scheduled day, n (%)			< 0.001
Tuesday/Friday	59 (36)	96 (59)	
Any other day	106 (64)	67 (41)	
Early failure: within 30 days, n (%)	27 (16)	18 (11)	0.2
Long-term failure: within 6 mos. n (%)	33 (20)	28 (17)	0.5
Time to failure within 6 mos., median (25-75% quartiles), days	14 (8-30)	23 (11-75)	0.05
Primary cause of early failure, n (%)			0.3
Infection	15 (56)	11 (61)	
Necrosis	10 (37)	5 (28)	
Other	2 (7)	2 (11)	

In the INT group, 72% of the LEAs were done during daytime versus 58% in the CON group (p = 0.005); 59% were done on the scheduled surgery day versus 36% in the CON group (p < 0.001). Otherwise, no significant differences between groups were seen for senior surgeons present during LEA, length of stay and mortality (Table 1 and Table 2).

The cause of EF was primarily related to infections or necrosis (90%), but reduced to 11.0% (n = 18) in the INT group versus 16.4% (n = 27) in the CON group (p = 0.2) (Table 2). The EF rate in the INT group was 8.3% (n = 8) for amputation on the scheduled days versus 14.9% (n = 10) when done on other days (p = 0.2), whereas this was 16.9% and 16.0% in the CON group (p = 0.2). Dayshift versus afternoon or night shift surgery showed that the risk of EF was reduced to, 6.8% versus 22.2% (p = 0.005) in the INT group, whereas no significant difference was recorded for the CON group (p = 0.3), (**Supplementary Table 1 https://www2.ugeskriftet.dk/files/a07220435_-_supplementary.pdf**). Having a pre-amputation distal pressure and/or skin-perfusion test was not significantly associated with a reduced EF rate in any of the two cohorts (p > 0.3).

The long-term failure rate was 17.2% (n = 28) in the INT group versus 20% (n = 33) in the CON group (p = 0.5) (Table 2), whereas time to failure seemed prolonged for the INT versus the CON group (**Figure** 2).

FIGURE 2 Failures within 30 days (**A**) and six months (**B**) of the index amputation in 328 patients divided equally into a historical control group (–) and an intervention group (–).



The multivariable analysis for the INT group showed a non-significantly reduced risk of EF for LEAs performed on the scheduled days OR = 0.66 (95% confidence interval (CI): 0.22-2.0) versus other days, a significantly reduced risk if performed during dayshifts, OR = 0.29 (95% CI: 0.10-0.90) versus other shifts, and a significantly increased risk for BKA amputations, OR = 4.3 (95% CI: 1.3-13.8) versus TFA or BTF (**Supplementary Table 2 https://www2.ugeskriftet.dk/files/a07220435_-_supplementary.pdf**).

Analysis of patients with a second, third or more new amputations of the contralateral extremity or any of the extremities more than six months after the index LEA revealed only one patient with an EF in the CON group and one with a failure within the six months follow-up in the INT group.

Including all 354 procedures in analysis of factors influencing failures provided similar results as for those related to the 328 index amputations.

DISCUSSION

We found a trend towards a lower EF rate when a major LEA was done on scheduled surgery days (8.3%) versus any other day (14.9%), corresponding to a non-significantly reduced risk of 34%. Furthermore, we found a reduction in risk of EF for the INT group to 6.8% for surgery during dayshift time versus 22.2% in the CON group (71% reduced risk in the adjusted analysis). Though the finding related to the scheduled days was not significant, it indicates that the turnout of a planned surgery yields a higher success rate when it comes to preventing EF. Furthermore, this warrants a stronger recommendation that all amputations are performed during dayshift working hours. A 2020 Danish national clinical guideline recommends that the amputation is done during daytime. The guideline also recommends optimising pain management and rehabilitation, shortening fasting time and making sure that highly competent staff are available [5]. As these recommendations are based on sparse data with a low evidence level from two international guidelines [3, 7], the recommendations could have been substantiated further if solid evidence-based studies had been conducted. The significant reduction of 71% for EF related to daytime surgery versus later supports the recommendation of daytime surgery.

Generally, the risk of EF falls in the 4-30% range [9, 10, 14], which was reduced to 11.0% in the INT group versus 16.4% in the CON group in the present study, indicating a good outcome. Patients with an index BKA experienced a significant, 4.3 times greater risk of having an EF than did higher level index amputees. Despite this higher complication rate in BKA than AKA, the BKA is preferred, if considered safe at the time of amputation, as it makes ambulation easier if provided with a prosthesis and is also often a patient preference. Balancing this is an ongoing ethical dilemma as a low failure rate is desired [15, 16]. Still, as the index BKA/TFA ratio for the entire cohort was already as low as 0.56 in the present study, converting more BKA to TFA seems problematic [10, 17, 18].

Having a pre-amputation assessment of distal pressure and/or skin perfusion in the present study was no guarantee for a "safe amputation, which highlights the need for better methods for establishing the correct index amputee level. The long-term (six-month) risk of failure was similar in the two cohorts. Still, a trend towards a delay was observed in the number of days before failure occurred in the INT group (median of 23 days) compared with the CON group (14 days), see Figure 2. This is somehow considered ambiguous as it is preferable to postpone time to failure thereby giving the patient more time to recover, but, on the other hand, this delays time to final recovery.

We found a trend towards lowering the EF rate while the length of stay and mortality stayed unchanged. This indicates that the patients can tolerate waiting for the right time for surgery, allowing optimising efforts to be made before-hand and thereby increasing the success rate for the patient.

An additional hypothesis of the study was that having a senior surgeon present would reduce the EF rate. However, we found no significant change between the two cohorts (54% versus 61%), and no significant effect on EFs from having a senior surgeon present. Thus, the findings of the present study cannot confirm or reject the hypothesis. Other studies have yielded conflicting results in relation to surgeon experience. Thus, revisions were significantly more frequent when a major LEA was performed by an unsupervised junior surgeon than when they were performed by a senior surgeon [4]. White et al. [11] found that significantly fewer patients were ambulated with a prosthesis when a junior trainee rather than a senior surgeon performed the surgery and reported that more stump complications occurred.

However, the same association was not found by Campbell et al. [12] who found no association between seniority of surgeon and any outcomes after major LEA, including complications, revision and death. Even so, a systematic review on the volume-outcome relationship for lower limb vascular surgery found an association between better outcomes by high-volume specialist surgeons in higher-volume hospitals than in low-volume hospitals and found that they may be interrelated in determining outcome [19]. The new Danish national clinical guideline recommends that the amputation is done by or under supervision of a specialised surgeon [5]. This is also the recommendation in the Dutch guideline [7], but it seems that this may need further evaluation.

Strengths and limitations

A strength of the present study is that the data, to a large extent, were collected prospectively and were retrieved retrospectively only in the rare case of missing data. This was done to reduce the risk of selection bias. Still, with the amount of data collected and analysed in the course of the study period, missing data bias cannot be ruled out. The cohorts consisted of a historical and an intervention cohort. The patient groups were from the same hospital and no significant difference between the two cohorts were found. Even so, we cannot exclude the possibility of sampling bias. The sample size was selected according to the available data. No power calculation was made and a larger sample size may potentially have produced different findings. Also, external validation of the positive trends related to the planned and dayshift LEAs is warranted. The regime of the Capital Region of Denmark and the study hospital prescribes that patient should be evaluated by a vascular surgeon before being amputated to secure that other options are considered. This has been a consistent focus for more than ten years at the study hospital. Still, a limitation of the present study is that information to establish whether this was done or not was not extracted from patient charts.

CONCLUSION

We found a trend towards a lowering of the EF rate of major dysvascular LEAs by scheduling surgery day. Furthermore, performing LEAs during dayshifts rather than during afternoon or night shifts reduced the risk of EF significantly in the INT group. Even so, higher-evidence studies are needed that explore the planning of major LEAs in addition to other potentially influencing factors to underpin new recommendations reducing the risk of EF. Optimally, this should be based on data from a national lower extremity amputee database.

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REFERENCES

1. Kristensen MT, Holm G, Krasheninnikoff M et al. An enhanced treatment program with markedly reduced mortality after a transtibial or higher non-traumatic lower extremity amputation. Acta Orthop. 2016;87(3):305-11.
2. Stern JR, Wong CK, Yerovinkina M et al. A meta-analysis of long-term mortality and associated risk factors following lower extremity amputation. Ann Vasc Surg. 2017;42:322-7.
3. VA/DoD clinical practice guideline for rehabilitation of individuals with lower limb amputation. 2017. Version 2,0:1-28.
4. Cosgrove CM, Thornberry DJ, Wilkins DC et al. Surgical experience and supervision may influence the quality of lower limb amputation. Ann R Coll Surg Engl. 2002;84(5):344-7.
5. Madsen UR, Popp H, Jensen PS et al. National klinisk retningslinje for perioperative behandling, pleje samt tidlig rehabilitering til patienter som får foretaget større benamputationer. Fagligt Selskab for Ortopædkirurgisk Sygepleje, 2020.
6. Unwin N. Epidemiology of lower extremity amputation in centres in Europe, North America and East Asia. Br J Surg. 2000;87(3):328-37.
7. Geertzen J, van der Linde H, Rosenbrand K et al. Dutch evidence-based guidelines for amputation and prosthetics of the lower extremity: amputation surgery and postoperative management. Part 1. Prosthet Orthot Int. 2015;39(5) 351-60. doi: 10.1177/0309364614541460.
8. Murdoch G, Jacobs NA, Wilson AB Jr. Report of ISPO consensus conference on amputation surgery, University of Strathclyde, Scotland, 1-5 October, 1990. Copenhagen: ISPO, 1992.
9. O'Brien PJ, Cox MW, Shortell CK, Scarborough JE. Risk factors for early failure of surgical amputations: an analysis of 8,878 isolated lower extremity amputation procedures. J Am Coll Surg. 2013;216(4):836-42.
10. Kristensen MT, Holm G, Gebuhr P. Difficult to predict early failure after major lower-extremity amputations. Dan Med J. 2015;62(12):A5172.
11. White SA, Thompson MM, Zickerman AM et al. Lower limb amputation and grade of surgeon. Br J Surg. 1997;84(4):509-11.
12. Campbell WB, Marroitt S, Eve R et al. Factors influencing the early outcome of major lower limb amputation for vascular disease. Ann R Coll Surg Engl. 2001;83(5):309-14.
13. Welford P, Jones CS, Davies G et al. The association between surgical fixation of hip fractures within 24 hours and mortality: a systematic review and meta-analysis. Bone Joint J. 2021;103-B(7):1176-86.
14. Taylor SM, Kalbaugh CA, Cass AL et al. "Successful outcome" after below-knee amputation: an objective definition and

influence of clinical variables. Am Surg. 2008;74(7):607-12.

15. Dormandy J, Heeck L, Vig S. Major amputation: clinical patterns and predictors. Semin Vasc Surg. 1999:12(2):154-61.
16. Gugulakis AG, Lazaris AM, Vasdekis SN et al. Rehabilitation outcome in patients with lower limb amputations because of arterial occlusive disease: is it worth trying for the lowest possible amputation level? A prospective study. Int J Rehab Health. 2000;5(1):65-70.
17. Moxey PW, Hofman D, Hinchliffe RJ et al. Epidemiological study of lower limb amputation in England between 2003 and 2008. Br J Surg. 2010;97(9):1348-53.
18. Scott SW, Bowrey S, Clarke D et al. Factors influencing short- and long-term mortality after lower limb amputation. Anaesthesia. 2014;69(3):249-58.
19. Awopetu AI, Moxey P, Hinchliffe RJ et al. Systematic review and meta-analysis of the relationship between hospital volume and outcome for lower limb arterial surgery. Br J Surg. 2010;97(6):797-803.