Re-amputations and mortality after below-knee, through-knee and above-knee amputations

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ABSTRACT

INTRODUCTION: From January 2013, we changed the surgical strategy in our department and ceased to perform the through-knee amputation (TKA). The primary aim of this study was to investigate re-amputation rates ≤ 90 days after non-traumatic major lower-extremity amputations performed before and after this change of practice. Furthermore, we reported mortality before and after the change of practice.
METHODS: All non-traumatic major lower-extremity amputations performed in a single centre in two study periods (before and after the change of practice); 2009-2012 (cohort A) and 2014-2015 (cohort B) were included. Re-amputations and all-cause mortality ≤ 90 days after the index amputations were analysed.
RESULTS: Cohort A: Included 180 amputations with 27 below-knee amputations (BKA), 68 TKAs and 85 above-knee amputations (AKA). 86.7% of patients were American Society of Anesthesiologists (ASA) score 3-5. The re-amputation rate ≤ 90 days was 29.6% (95% confidence interval (CI): 12.7-47.3%) after BKA, 33.8% (95% CI: 22.7-45.3%) after TKA, 9.4% (95% CI: 2.9-15.1%) after AKA and 21.6% (95% CI: 15.6-27.6%) overall. The overall mortality ≤ 90 days was 35.2% (95% CI: 26.2-44.2%). Cohort B: Included 116 amputations with 21 BKA and 95 AKA. 92.7% of patients were ASA score 3-5. The re-amputation rate ≤ 90 days was 19.1% (95% CI: 7.7-40.0%) after BKA, 2.1% (95% CI: 0.6-7.4%) after AKA and 5.2% (95% CI: 2.4-10.8%) overall. The overall mortality ≤ 90 days was 32.8% (95% CI: 26.2-44.2%).
CONCLUSIONS: The overall re-amputation rate ≤ 90 days following major lower-extremity amputation decreased significantly from 22% to 5% after cessation of the TKA procedures, but mortality remained unchanged.
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Major amputation of the lower extremity has been reported to be associated with high levels of re-amputation and high mortality rates [1-5].

The few studies addressing re-amputation rates of major lower-limb amputations report rates of conversion from below-knee amputation (BKA) to above-knee amputation (AKA) at 9-28% [2, 4, 6]. An alternative to BKA and AKA is a through-knee amputation (TKA). The TKA procedure is performed more rarely, and limited data exist on the outcome after this procedure. A literature review reported healing rates between 60% and 90% after TKA procedures [7].

BKA and AKA have been associated with 30-day mortality rates of 5-10% and 10-17%, respectively [2, 8, 9]. A Danish single-centre study reported a mortality of more than 30% within 30 days and 50% within one year post-operatively in a cohort of both BKA and AKA procedures [3].

As from January 2013, we changed the surgical strategy in our department ceasing to perform the TKA procedure due to suspicion that more re-amputations may be associated with this procedure. Hence, the aim of this study was primarily to investigate re-amputation rates ≤ 90 days after non-traumatic major lower-extremity amputations performed before and after this change of practice; secondarily, to report the all-cause post-operative mortality before and after the change of practice.

METHODS

This was a retrospective comparative study investigating the outcome after non-traumatic major lower-extremity amputations performed in two study periods; before and after change of surgical practice, respectively. Before 2013, BKA, TKA and AKA procedures were performed in our department according to local guidelines and on indication. The BKA procedure was to be performed in patients who were leg-prosthesis candidates and who had sufficient skin perfusion (> 40 mmHg and > 55 mmHg in diabetics) below the knee, whereas TKA was to be performed in patients who were not prosthesis candidates, but with sufficient skin perfusion below the knee. The AKA procedure was to be performed if BKA and TKA were not possible, e.g., due to insufficient skin perfusion or wound problems around the knee.

After 2013, local guidelines were changed, and the TKA procedure was no longer performed. The indication for BKA remained the same, but the AKA proced-

ure was to be performed in all patients with no potential for a leg prosthesis.

The local guidelines for the surgical technique did not change either before or after the change of practice. Anterior and posterior skin flaps were used for the AKA [10, 11]. A long anterior skin flap and a shorter posterior flap were used for the TKA. For all procedures, skin closure was performed with non-absorbable nylon sutures.

To evaluate the effect of the change of surgical treatment protocol, we investigated a consecutive cohort (cohort A) of non-traumatic major lower-extremity amputation patients before the change of practice and another cohort after the change (cohort B). In order to ensure that the new guidelines were followed, the second study period (cohort B) started one year after the change of practice.

Using a computerised surgery booking system (ORBIT), a transcript of all major lower-limb amputations performed in the two study periods was collected; from 1 January 2009 to 31 December 2012 (cohort A) and from 1 January 2014 to 31 December 2015 (cohort B). Surgery was performed at Bispebjerg Hospital, Denmark, situated in an urban area accommodating 410,000 people. Consultant orthopaedic surgeons or orthopaedic trainees performed the amputation procedures. Re-amputations (all limb-shortening procedures) and mortality within 90 days following the index amputation were registered through examination of medical records. Indications for re-amputations were wound rupture, wound necrosis and infection when soft tissue debridement was considered insufficient following clinical assessment. All re-amputations performed in any hospitals within the Capital Region were registered based on evaluation of patient records. All-cause mortality was determined and confirmed through the National Central Office of Civil Registration (CPR), which is based on the unique personal social security number given to all residents of Denmark. Mortality was analysed as the number of deaths in the total number of patients, also in case of bilateral amputation.

Furthermore, basic demographics such as smoking habits, alcohol consumption, skin perfusion test results and whether patients came from a nursing home (residential accommodation providing 24-hour nursing care) were registered based on evaluation of patient records. An American Society of Anesthesiologists (ASA) score at the time of surgery was collected from the Danish Anaesthesia Database.

Patients with a BKA index procedure and a subsequent AKA were only registered in the BKA group.

Statistical analysis
Means with ranges were reported for normally distrib-

uted data and proportions were expressed as percentages with 95% confidence intervals (CI). Crude comparisons of proportions were done using the chi-squared test. Any p-value of 0.05 or less was considered statistically significant. Statistical analyses were done using SPSS, version 20.

Ethics
As this study was retrospective and non-interventional, no ethical approval was required. Permission was acquired from the Danish Data Protection Agency, authorisation number 2012-58-0004.

Trail registration: not relevant.

RESULTS
Cohort A
From 1 January 2009 to 31 December 2012 (**Table 1** and **Table 2**). A total of 180 major lower-extremity amputations were performed in 167 patients. A total of 13 patients were bilaterally amputated. Skin perfusion tests were performed before 21 of the 27 BKA procedures (78%), 51 of the 68 TKA procedures (75%) and 39 of the 85 AKA procedures (46%).

The 90-day re-amputation rate was 30% (95% CI: 12.7-47.3%) after BKA, 34% (95% CI: 22.7-45.3%) after TKA, 9% (95% CI: 2.9-15.1%) after AKA and 22% (95% CI: 15.6-27.6%) overall. Causes of re-amputations after AKA were infection in four cases, wound necrosis in two cases and wound rupture in two cases. After TKA, the re-amputations were caused by infection in nine cases, wound necrosis in nine cases and wound rupture in five cases. After BKA, re-amputations were caused by infection in three cases and wound necrosis in six cases. The overall all-cause mortality within 90 days post-operatively was 35% (95% CI: 26.2-44.2%); 31% (95% CI: 9.1-61.4%) (four out of 13 patients) who underwent bilateral amputation died within 90 days post-operatively.

Cohort B
From 1 January 2014 to 31 December 2015 (**Table 3** and **Table 4**). A total of 116 major lower-extremity amputations were performed in 108 patients. Eight patients were bilaterally amputated. Skin perfusion tests were performed before 16 of 21 the BKA procedures (75%) and 24 of the 95 AKA procedures (25%).

The 90-day re-amputation rate was 19% (95% CI: 7.7-40.0%) after BKA, 2% (95% CI: 0.6-7.4%) after AKA and 5% (95% CI: 2.4-10.8%) overall. Causes of re-amputations after BKA were infection in two cases and wound rupture in two cases. The two re-amputations after AKA were also caused by infection (n = 1) and wound rupture (n = 1). The overall all-cause mortality within 90 days post-operatively was 33% (95% CI:

TABLE 1

	BKA (N = 27)	TKA (N = 68)	AKA (N = 85)	Overall (N = 180)
Age, yrs, mean (range)	71 (44-97)	75.4 (44-97)	76.1 (42-95)	75.1 (42-97)
Male, %	66.7	58.8	49.4	57.4
Previous or current smokers, n (%)	24 (89)	49 (72)	61 (72)	134 (74)
Alcohol consumers above recommendation, n (%)[a]	10 (37)	36 (53)	27 (32)	73 (41)
Medically treated diabetes, n (%)	19 (70)	32 (47)	51 (60)	102 (57)
Heart failure, n (%)	6 (22)	30 (44)	31 (37)	67 (37)
Chronic obstructive pulmonary disease, n (%)	4 (15)	19 (28)	19 (22)	42 (23)
From nursing home, n (%)[b]	9 (33)	28 (41)	17 (20)	54 (30)
ASA score, n (%)				
1-2	6 (22)	4 (6)	14 (16)	24 (13)
3-5	21 (78)	64 (94)	71 (84)	156 (87)
Re-amputation rate, ≤ 90 days, % (95% CI)	30 (12.7-47.3)	34 (22.7-45.3)	9 (2.9-15.1)	22 (15.6-27.6)
Mortality rate, ≤ 90 days, % (95% CI)	0	38 (26.5-49.5)	44 (33.3-54.4)	35 (28.4-42.4)

AKA = above-knee amputation; ASA = American Society of Anesthesiologists; BKA = below-knee amputation; CI = confidence interval; TKA = through-knee amputation.
a) The Danish Health Authority recommends a weekly consumption ‹ 14/21 U alcohol for women/men, respectively.
b) Residential accommodation providing 24-h nursing care.

Cohort A (January 2009-December 2012): patient characteristics and outcomes after be-low-knee amputation, through-knee amputa-tion and above-knee amputation.

26.2-44.2%). Four out of eight patients who underwent bilateral femoral amputation died within 90 days post-operatively. The overall re-amputation rate was signifi-cantly reduced from 22% (95% CI: 15.6-27.6%) in co-hort A to 5% (95% CI: 2.4-10.8%) in cohort B after the change of practice (p = 0.002), but the overall 90-day mortality rate remained at the same level before and after the change of practice (p = 0.8).

DISCUSSION

In this retrospective single-centre study, we compared re-amputation rates and mortality before and after a change of major lower-extremity amputation practice involving discontinuation of the TKA procedure. The main finding was a significant reduction in the overall 90-day re-amputation rate from 22% to 5% after the change of practice. The re-amputation rate of 34% after the TKA procedure was high, and it was the main cause of the higher overall re-amputation rate after major lower-extremity amputations before the change of practice. The higher re-amputation rate after TKA in our study may be due to multiple factors. The proced-ure itself with limited soft tissue coverage over the bone may provide part of the explanation, and atrau-matic surgical technique may be even more important when handling the skin in this procedure than in the other amputations. Hence, the TKA procedure may place greater demands on surgical experience. Poor skin perfusion at the level of the amputation is also im-portant. In our study, the skin perfusion test was > 40 mmHg in 18 of the 19 TKA patients who were subse-quently re-amputated. However, another 15 patients

TABLE 2

Skin perfusion test data from below-knee amputation, through-knee amputation and above-knee amputation patients in cohort A (January 2009-December 2012). The values are n.

Skin perfusion, mmHg	BKA (N = 21)	TKA (N = 51)	AKA (N = 39)
‹ 40	2	1	24
40-70	14	45	13
› 70	5	5	2

AKA = above-knee amputation; BKA = below-knee amputation; TKA = through-knee amputation.

were re-amputated but had no skin perfusion test per-formed, making interpretation of the result difficult. In future prospective studies, skin perfusion tests should be performed prior to all amputation procedures to fa-cilitate conclusions on the importance of skin perfusion in relation to healing rates. Finally, patient comorbidity may play an important role, and in our study the TKA patients had the highest comorbidity burden (95% ASA score 3-5), which may also increase risk of complica-tions and re-amputations.

The cessation of the TKA procedure may only ex-plain part of the significant drop in the re-amputation rate. We found a drop in the re-amputation rate in both the BKA (30% to 19%) and the AKA (9% to 2%) group from cohort A to cohort B, which also contributed to the decrease in the overall re-amputation rate. The demographics also changed between the two cohorts. We found a lower rate of smokers, alcohol abusers, dia-

📄 **TABLE 3**

Cohort B (January 2014-December 2015): patient characteristics and outcomes after below-knee amputation and above-knee amputation.

	BKA (N = 21)	AKA (N = 95)	Overall (N = 116)
Age, yrs, mean (range)	67 (46-85)	78 (40-99)	76 (40-99)
Male, %	86	59	64
Previous or current smokers, n (%)	11 (52)	65 (68)	76 (66)
Alcohol consumers above recommendation, n (%)a	5 (24)	25 (26)	30 (26)
Medically treated diabetes, n (%)	15 (71)	29 (31)	44 (38)
Heart failure, n (%)	2 (10)	28 (30)	30 (26)
Chronic obstructive pulmonary disease, n (%)	2 (10)	24 (25)	26 (22)
From nursing home, n (%)b	1 (5)	43 (45)	44 (38)
ASA score, n (%)c			
1-2	3 (15)	5 (6)	8 (7)
3-5	17 (85)	85 (94)	102 (93)
Re-amputation rate, ≤ 90 days, % (95% CI)	19 (7.7-40.0)	2 (0.6-7.4)	5 (2.4-10.8)
Mortality rate, ≤ 90 days, % (95% CI)	0	40 (33.5-52.8)	33% (26.2-44.2)

AKA = above-knee amputation; ASA = American Society of Anesthesiologists; BKA = below-knee amputation; CI = confidence interval.
a) The Danish Health Authority recommends weekly consumption ‹ 14/21 U alcohol for women/men, respectively.
b) Residential accommodation providing 24-h nursing care.
c) 6 missing ASA scores.

📄 **TABLE 4**

Skin perfusion test data from below-knee amputation and above-knee amputation patients in cohort B (January 2014-December 2015). The values are n.

Skin perfusion, mmHg	BKA (N = 16)	AKA (N = 24)
‹ 40	0	8
40-70	6	8
› 70	10	8

AKA = above-knee amputation; BKA = below-knee amputation.

betics and heart failure patients, which is expected to influence the lower re-amputation rate. In addition, more patients (38% compared with 30%) came from a nursing home. We speculate that patients from nursing homes may receive better overall treatment and wound treatment than patients returning to their own home. Finally, the change of practice at our institution may by itself have brought an enhanced focus on the specific patient group yielding an improved overall treatment.

Limited data exists on re-amputation rates after TKA, but low healing rates of about 60% after TKA have been reported previously [7]. Lim et al reported re-amputation rates of 17.6% after BKA, 20% after TKA and 0% after AKA [5], while Kristensen et al reported an overall re-amputation rate of 40% in a cohort of 71 BKA and 58 AKA procedures [12]. Due to the lack of

conformity between the few previously performed studies mentioned above and our study, direct comparison of re-amputation rates is difficult, and this confirms the need for more outcome data following these procedures.

The 90-day mortality rates of 33-35% overall remained unchanged in our institution in the two examined cohorts, representing an important challenge. Our results may indicate that mortality is not linked to the frequency of re-amputation, and that patients with a TKA or higher are frail and have a high mortality rate that are not associated with ASA scores and confounding factors. A recent Danish study reported a reduction in mortality after implementation of an enhanced multidisciplinary programme with increased attention to amputation patients. The patients' 30-day and one-year overall mortality rates dropped from 35% and 59% to 16% and 37%, respectively [12]. A remarkable discrepancy was found when comparing the BKA/AKA ratio of 21/95 in our cohort B with the 71/58 ratio reported by Kristensen et al [12]. The known frailty in AKA patients with poor rehabilitation potential [13] may therefore be a part of the explanation for the high mortality rate found in our cohort. Furthermore, the bulk of amputation patients in our cohort had an ASA score of 3-5 (87% in cohort A and 93% in cohort B), while Kristensen et al reported 69% with ASA score 3-5. Finally, we chose to include bilateral cases and found that mortality was even higher in these cases (50% in cohort B), which could add to the higher mortality rate compared with other studies in which bilateral cases were excluded. Thus, the patients analysed in our study seem to have been more at risk than the patients from the recently published Danish single-centre study [12].

A future and already initiated strategy to lower mortality is to assemble major lower-extremity amputation patients in a specialised unit with uniform treatment protocols. Hence, early mobilisation and introduction of guidelines for oxygen administration, fluid resuscitation and transfusion limits that are specific to amputation patients have been introduced [12].

The retrospective nature of this study is an obvious limitation, but to our knowledge no prospective studies comparing major lower-extremity amputation procedures exist. Another limitation is that we report all-cause mortality and not only surgically related mortality. Furthermore, we only had data available on re-amputations performed within the Capital Region and hence we may underestimate re-amputation rates slightly as a limited number of re-amputations might have been performed outside the Capital Region. A strength of our study is the large total cohort of major lower-extremity amputations including the largest amount of TKA procedures reported on so far.

CONCLUSIONS

In conclusion, we found a significant decrease in the overall 90-day re-amputation rate following major lower-extremity amputation from 22% to 5% after a change of practice with discontinuation of the TKA procedures, indicating that the TKA procedure may be associated with higher re-amputation rates. However, future comparative prospective studies with fewer confounding factors are needed to validate our results. The overall all-cause 90-day mortality rate was 35% before and 33% after the change of practice and this remains a challenge in this group of very frail patients.

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