Abstract

Objective: Critical limb ischaemia (CLI) is the most severe state of peripheral arterial disease and is one of the major causes of lower-limb amputations. One of the treatment choices is prosthetic vascular grafts. Despite treatment, CLI may lead to amputation owing to infection or progressive ischaemia. The aim of this study was to show that multidisciplinary planning and surgery for CLI patients with prosthetic grafts decreased the duration of hospital stay, costs, risk of infection and ascending conversion of the amputation level.

Methods: Forty-two above-knee amputation patients with prosthetic grafts were retrospectively evaluated. Group A patients (n = 24) had partial excision and group B patients (n = 18) total excision with or without saphenous patch-plasty, according to the patency of the deep femoral artery. Growth in wound culture, antibiotic therapy duration, conversion to hip disarticulation and hospitalisation periods were compared.

Results: Differences in growth of wound culture (p = 0.007), antibiotic duration (p = 0.003), hip disarticulation (p = 0.029) and duration of hospital stay (p = 0.0001) between the two groups were found to be statistically significant (p < 0.05).

Conclusion: Management of CLI patients is a complex process, and a multidisciplinary approach is key to avoiding undesirable outcomes. Meticulous planning, including excision of the total graft, while ensuring the vascular supply, is essential.

Keywords: critical limb ischaemia, above-knee amputation, prosthetic vascular graft, multidisciplinary approach

Peripheral arterial disease (PAD) of the lower limb is a chronic problem that is associated with a large variety of symptoms from claudication to ischaemic tissue loss. Critical limb ischaemia (CLI) is the most severe state of PAD and is one of the major causes of lower-limb amputations. Treatment choices include conservative/pharmaceutical therapies, endovascular interventions, prosthetic or autogenous bypass graft surgeries, and amputation for end-stage disease. More than half of the surgical procedures are performed for femoropopliteal arteries. Despite vascular intervention, progression of the disease leads to lower-limb amputation in some patients.

Since lower-limb amputation has catastrophic functional, social and economic outcomes, ascending conversion of the amputation level doubles or even triples these burdens, especially for above-knee amputation (AKA) patients. Therefore, a multidisciplinary approach that foresees and avoids further surgeries should be used for these patients.

Wound infection and stump ischaemia are the main reasons for ascending conversion of the amputation level. For CLI patients with prosthetic grafts, these grafts can be a cause of infection after amputation. Pre-operative planning should be carried out meticulously to avoid further complications, such as excessive blood loss, graft infection and ischaemia.

In this study, we aimed to show that multidisciplinary planning and surgery for CLI patients with prosthetic grafts decreased the duration of hospital stay, costs, risk of infection and ascending conversion of the amputation level.

Methods

Among 357 major limb amputations performed in our institution between 2016 and 2021, 63 patients who underwent AKA were retrospectively evaluated after approval by the institutional board. Forty-two patients with prosthetic grafts without underlying graft infection were included in this study. Before amputation, all patients were consulted with cardiovascular surgery for a decision on amputation level, and computerised tomographic angiography (CTA) was performed to evaluate the graft and vascular patency.

In 24 of the 42 patients, a femoropopliteal bypass graft was ligated proximal to the amputation site, and AKA was performed with partial excision of the prosthetic graft (group A). In 18 patients (group B), in the same session with intra-operative cardiothoracic surgery consultation, the entire prosthetic graft was excised via an additional incision made at the ipsilateral inguinal ligament level, by dissecting the artery from the proximal part of the graft, and AKA was performed. In nine patients in group B, in which patency of the deep femoral artery (DFA) was documented via CTA, additional saphenous vein patch-plasty was applied simultaneously to the common femoral
artery, and for only these patients, the heparinisation protocol (maintaining the activated clotting time between 150 and 200 seconds) was carried on. The femoral artery was ligated in the rest of the group B patients.

Postoperative wound discharge, growth of wound culture, antibiotic and vacuum-assisted closure (VAC) requirements, conversion to hip disarticulation, and hospitalisation periods of the patients were compared.

Statistical analyses

Descriptive data were used to define the variables (mean, standard deviation, frequencies, Kolmogorov–Smirnov test for data that showed normal distribution). Pearson’s correlation coefficient was calculated to determine the relationship between normally distributed continuous variables. As the parameters did not show a normal distribution, the Mann–Whitney U-test was used to identify the group that caused the difference. Differences between discrete variables were determined using chi-squared and Fisher’s exact tests. The results were evaluated at a 95% confidence interval and $p < 0.05$ significance level, and the statistical analyses were performed with PSPP 1.4.1 and Microsoft Excel 16.47.1 software.

Results

The mean age was 66.86 (53–75) years (group A: 68.1; group B: 65.6). The study group consisted of 28 males and 10 females (group A: 18 M, 6 F; group B: 14 M, 4 F). Aetiological factors and co-morbidities are shown in Table 1. Mean duration of hospital stay was 19.6 days (4–112) for group A and 5.6 days (4–14) for group B. The mean duration of hospital stay for group A, excluding patients with infection/revision, was 5.5 days (4–7).

For group A, nine of the 24 patients had surgical site/residue graft infections postoperatively. Eight of those needed surgical intervention and six patients underwent conversion of the amputation level. Prolonged antibiotic therapy regimens were carried out for two to five weeks according to growth in wound cultures in eight patients with VAC therapy, and six of those ended up with hip disarticulation. In only one patient with superficial wound infection, antibiotic therapy alone had a successful outcome.

For group B, all 18 patients underwent total excision of the prosthetic graft simultaneously with AKA, and nine patients with a patent DFA in pre-operative CTA had saphenous vein patch-plasty to the common femoral artery in the same surgical session. Three patients in group B had superficial wound infection, and in one, VAC therapy with short-term antibiotic therapy was used after wound debridement surgery. None of the patients in group B had prolonged antibiotic therapy and needed conversion of the amputation level.

Differences in positive wound cultures ($p = 0.007$), prolonged antibiotic therapy ($p = 0.003$), conversion to hip disarticulation ($p = 0.029$) and duration of hospital stay ($p = 0.0001$) between the two groups were found to be statistically significant (Table 2). Demographics, aetiological factors and co-morbidities showed no statistically significant correlation in either group (Table 3).

Discussion

The importance of DFA patency is a well-known fact for AKA patients since it is the major vascular supply of the thigh, and...
therefore the AKA stump. Several studies throughout the decades have shown the importance of the DFA for the viability of the stump and wound healing.

In our study, even in the group with partial graft removal (group A), none of the patients with a patent DFA needed revision surgery or prolonged antibiotic therapy or had wound-healing problems. Most of the CLI patients had vascular interventions prior to end-stage disease, leading to amputation. The DFA should be evaluated thoroughly, not only in patients with prosthetic grafts but also in those with other vascular interventions such as endovascular stent or autogenous grafts. To take this one step further and minimise the risk of the study group being relatively small, operational planning should be regulated to maintain DFA patency.

Lower-limb amputation per se is a procedure that increases metabolic load, and the higher the amputation level, the higher the energy usage. When the metabolic burden of underlying disease is also evaluated, surgery is the second impact. In addition, a meticulous approach is necessary to avoid the metabolic burden of infection, new tissue ischaemia and consecutive surgeries. In current studies, it has been stated that prosthetic graft infection requires a multidisciplinary approach and has serious consequences. For these reasons, it is important to prevent more destructive consequences by taking a multidisciplinary approach from the beginning in prosthetic graft patients without infection.

Standard below- or above-knee amputations are and should be procedures with lower re-amputation rates compared with more distal amputations. Therefore, every effort should be made to make these approaches the ultimate treatment. Infection in the stump region, especially considering the underlying ischaemic condition, cannot be controlled without surgical debridement or conversion of the amputation level. In our study, the rate of conversion of the amputation level was statistically significantly lower for group B than for group A (p = 0.029).

Transected, ligated and retracted prosthetic grafts can lead to colonisation and eventually infection (Fig. 1). As in our study, conditions such as a high number of co-morbidities, immune deficiency and ischaemia in the surgical field may cause delayed wound healing, infection and new ischaemic tissue loss in these patients. In our study, there were 12 wound-infection patients: nine in group A and three in group B. Eight of the nine patients in group A had positive wound cultures and needed surgical intervention. None of the three patients in group B had positive wound cultures or needed surgical intervention. These results were found to be statistically significant (p = 0.007).

Fig. 1. Two examples of partial graft-excision patients with infection. A. After debridement, total excision of the graft and VAC therapy, this patient ended up with hip disarticulation. B. The patient was managed with wound debridement, later, excision of the total graft, and VAC therapy.
Probably the most imperative step of surgical planning in the CLI patient group is to achieve a viable and healable stump. This step is crucial to restoring the maximal amount of daily functioning. For this reason, the vascular supply of the remaining extremity should be meticulously evaluated before the procedure. The results of this study show that the excision of the entire prosthetic graft and the performance of saphenous patch-plasty in patients with a patent DFA were associated with better amputation results in these CLI patients. This can be interpreted in two different but related ways. First, pre-operative planning should be multidisciplinary in order to avoid undesirable medical, functional and economic results. Second, even though this is an extended procedure, it prevents the patient from undergoing multiple surgical and medical procedures with a higher metabolic load.

Economic and psychological consequences are non-negligible factors in the course of amputations.11,12 The duration of hospital stay has an integral impact on these factors. Restoring daily function as soon as possible and minimising the duration of hospital stay will decrease the costs to the healthcare system and psychological decline of the patient.

The mean duration of hospital stay in patients with infection/revision was 43.2 days, and that of the rest of the patients was 5.7 days. The mean duration of hospital stay in group B patients with complications was 11.2 days, whereas that of group B patients with no complications was 4.7 days. These results were found to be statistically significant (p = 0.0001) and show that an elaborate multidisciplinary approach is helpful in these aspects.

Prolonged antibiotic therapy is another economic and medical aspect in these patient groups since multiple co-morbidities are present and multidrug regimens are carried out. In our study, the duration of antibiotic therapy was found to be longer for group A than for group B, and the difference was statistically significant (p = 0.003).

In consideration of these aspects, amputations and the management of these patients in our institution are joint decisions by the orthopaedic and cardiovascular surgery departments. All patients are clinically and radiologically evaluated by the two departments before a procedural decision is made.

**Conclusion**

Treatment management and surgical planning in PAD patients with failed prosthetic vascular grafts are complicated processes. To avoid undesirable outcomes and even more complicated medical, functional and economic situations, all planning and treatment steps should be taken in a multidisciplinary manner. Meticulous planning that includes the excision of the total prosthetic vascular graft while ensuring the continuity of the vascular supply is essential.

**References**