Introduction

In 2009, the National Vascular Database (NVD) report highlighted several crucial issues regarding major amputation rates in the UK (1). In particular, mortality rates were deemed unacceptably high. Unsurprisingly, mortality was shown to increase exponentially with ASA score and age, and patients over 70 were identified as a high risk group. The quality improvement framework for major amputation was developed, by the Vascular Society of Great Britain and Ireland, with the aim of improving these outcomes, with particular focus on reducing the perioperative mortality rate to less than 5% by 2015 (2). The framework aimed to provide a standard for care which local centres could use to audit their own outcomes and improve the quality of care provided.

In particular, early involvement of a multidisciplinary team, at a consultant level, and a rehabilitation team was highlighted as essential to good patient care. The guideline also stipulated that the ratio of below knee (BKA) to above knee (AKA) amputation should be > 1, and at least 75% of major amputations should be performed on a planned operating list within 48 h of a decision to operate. Finally, the framework suggested that postoperative involvement of physiotherapists and the amputee rehabilitation team was of paramount importance to recovery.

Moxey et al. investigated lower limb amputation trends in England between 2003 and 2008, based on Hospital Episode Statistics (HES) data. Overall in-hospital mortality rate was 16.8%. Forty percentage of patients had diabetes mellitus. Forty-three percentage of patients underwent revascularisation procedures performed (from 60 to 120 per year). Ten patients underwent a revision from BKA to AKA because of an inadequate profunda femoris artery (PFA), whereas all those with a healed BKA stump either had a good PFA or a named crural vessel.

Conclusion: The overall number of amputations is decreasing from year to year. By doubling our crural revascularisation procedures we are saving more limbs. Thirty-day mortality is higher than expected, particularly in patients who present late. Expeditious referral may potentially improve the mortality rate among this group of patients.
procedure prior to the amputation. The BKA to AKA ratio was 0.93. They found significant geographical variations in amputation rates, mortality rates and the BKA:AKA ratio (3).

In accordance with the quality improvement guideline, we have audited all major amputations performed in our trust in the last 3 years. We aimed to elucidate the compliance with the framework guidelines, to compare our local outcomes to the national data and to look for the reasons for non-compliance.

**Method**

All major amputations carried out in our tertiary referral vascular unit between 2008 and 2010 were included. Theatre and patient records (paper as well as electronic copies) and consultant logbooks were analysed and a database created for analysis.

The following data were collected: imaging prior to amputation, revascularisation attempts, status of arterial blood supply, extent of tissue loss/infection, time to and time of surgery, type of amputation, and 30-day mortality. We assessed other aspects of the management of patients with critical limb ischaemia to offer possible explanations for the audit results. This included analysis of patients undergoing crural revascularisation and those transferred from other units, including the time of onset of symptoms, to the time of referral. Fishers exact and $\chi^2$ tests were used for statistical analysis.

**Results**

A total of 81 patients (34 women, 47 men) were included in the study; with a median age of 68 years (range 31–97 years). Forty-two BKAs and 39 AKAs were performed (1.1 : 1 ratio). Thirty-three percentage (27/81) had type 2 diabetes. A total of 75 (92%) had formal preoperative arterial investigations of which 27 (33%) had an arterial duplex, 24 (29%) had a CT angiogram and a further 24 (29%) had an intra arterial digital subtraction angiogram (IA DSA). One patient had an MR angiogram. Patients who did not have formal imaging had unsalvageable legs. Eighty-four percentage (68/81) of patients had an attempted revascularisation procedure prior to having an amputation. Eight patients underwent an angioplasty, 19 had surgery, 9 patients had both (18 of 28 patients who had surgery had a non-crural bypass) and a diagnostic IADSA was carried out in 32 patients with the view to angioplasty, but revascularisation was not possible. Fourteen of 17 patients underwent a multi level angioplasty and three patients had a subintimal angioplasty.

Patient paper notes were only available in 30 of 81 cases. All patients were given prophylactic anticoagulation. Antibiotic prophylaxis was given in 90% of cases (27/30). The amputations were performed by a senior registrar in 80% (24/30) of cases and the remainder were done by a consultant. A percentage of 86% (26/30) of the operations were done during elective hours with early mortality of 0% and 30-day mortality of 14% (11/81). 5/30 patients waited for surgery for > 48 h. These included two patients who were not initially fit for surgery, one patient who required a court order prior to surgery and two patients who were delayed because of a lack of theatre time. A percentage of 64% (19/30) of patients had an epidural catheter insertion peri-operatively. The main reasons for not having an epidural were sepsis and coagulopathy. The pain team were involved in 19/30 cases. Decision to operate was clearly documented in the notes in 28/30 cases. Median length of stay post surgery was 34 days (6–96).

The total number of amputations has decreased over the last 3 years from 34 to 21 per year (2008 $n = 34$, 2009 $n = 26$, 2010 $n = 21$), coinciding with the doubling of crural revascularisation procedures performed (2008 $n = 60$, 2009 $n = 95$, 2010 $n = 120$) (Figures 1 and 2). The number of non-crural procedures has not changed significantly during the same period. Failure rate, resulting in a major amputation, following crural bypass was 10% whereas following crural angioplasty was 6%. The number of BKAs has gone down from 22 to 7 per year (2008 $n = 22$, 2009 $n = 13$, 2010 $n = 7$) whereas the number of AKAs has gone up from 12 to 14 per year (2008 $n = 12$, 2009 $n = 13$, 2010 $n = 14$). The national infra-inguinal intervention and major amputation rates for the same period are shown in figure 3.

Fifteen amputees were transferred from other hospitals with critically ischaemic limbs. The numbers of transfers year by year were as follows: 2008:3; 2009:7; 2010:5. A percentage of 80% (12/15) of those transferred from another hospital had symptoms requiring admission for more than a week prior to the referral being made. A percentage of 58% of those were inpatients for more than a week, before the severity of the condition was recognised and the referral made.

In 12/15 cases the extent of gangrene and infection resulted in a primary major amputation (six BKAs and six AKAs). In two cases, IA DSA revealed distal disease not suitable for angioplasty and in one case iliac angioplasty was carried out, but the foot could not be salvaged. Those whose referral was delayed by a week or more from the onset of symptoms had a 50% (6/12) mortality following their amputation. There were three patients who were
referred early from another unit and had an amputation; one died in the perioperative period.

There was no significant difference in age, diabetes, hypertension, hyperlipidaemia, renal failure or smoking between those who were referred from other units late and those who were seen in our department from the beginning of their care. There was, however, a significant difference in their mortality, 50% vs. 7.2% (Fishers exact test p < 0.001).

The reasons for primary AKA were extensive infection/tissue loss, fixed knee flexion deformity and significant comorbidities. Ten patients underwent a revision from BKA to AKA. On further analysis all patients in this group had no in-line arterial flow to the level of the knee as well as an inadequate profunda femoris artery (PFA). None of them, however, would have been suitable for profundoplasty as distal rather than proximal profunda was occluded in these
cases. All those with a healed BKA stump either had a good PFA or a named crural vessel. Eleven of sixteen (69%) patients, following failed crural intervention, had a BKA rather than AKA.

**Discussion**

Standards set by the quality improvement framework for major amputations have been used, as part of an audit process, for quality control. The framework states that amputations for vascular disease and diabetes should only be undertaken after formal investigation of the arterial system, except when the leg is clearly beyond salvage (2). All patients undergoing a major amputation in our unit had preoperative arthritic imaging, unless revascularisation was not an option because of already known absence of run-off vessels, extent of gangrene/infection, fixed flexion of the knee or patient comorbidities. Over 80% had an attempted revascularisation procedure prior to the amputation.

Multidisciplinary team involvement in the care of these patients is paramount. In our department, the team includes a foot health specialist, pain and rehabilitation teams, radiology and vascular consultants, a microbiologist, an anaesthetist and a diabetologist. We strive to ensure that all patients are seen by all the specialty teams both pre- and postoperatively. There is, however, room for improvement, for example only 19/30 patients were reviewed by a pain team preoperatively. Majority of those who were not reviewed underwent urgent surgery before a formal review could take place.

The aim of the framework included reducing the perioperative mortality to less than 5% by 2015. Our 30-day mortality was 14%, which is higher than expected. Vamos et al. quoted a peri-operative mortality of 7.5% in England, based on the Hospital Episode Statistic (HES) data (4). This difference can be, at least partly, explained by a significantly higher mortality in patients who were referred late. In fact, if these patients are excluded from the analysis, our 30-day mortality is reduced to 7.2%, in line with the national data. There were only three patients who were referred early and had a major amputation, with a mortality of one of the three patients. The sample size is too small for further statistical analysis.

If we compare our results with the national data published by Moxey et al. in 2010, the outcomes are comparable: in hospital mortality (14% vs. 16.7%); revascularisation rate (44% vs. 43%); BKA to AKA ratio (1.1 vs. 0.93).

The total number of amputations has steadily decreased over the study period. During the same time frame, the number of crural interventions has doubled. We believe that by doing more distal procedures we are saving more limbs, as supported by a number of other publications (5–10).

Another possible explanation for the overall reduction in amputation rates is modification of cardiovascular risk factors. The rates of smoking, hypertension and hypercholesterolaemia have decreased significantly over the last 10 years. Although diabetes and obesity are on the increase, overall risk factor modification has resulted in a significant reduction in mortality (11). Risk factor modification is likely to also improve outcome in patients with peripheral vascular disease which may in turn result in reduction of amputation rates. In our cohort of patients, who had a major amputation, we have seen a reduction in the number of patients with diabetes (40% to 18%), hypertension (62% to 18%) and smoking (32% to 0%) over the 3-year period; because of a small sample size, however, the significance of this trend remains uncertain.

The number of AKAs in our series is increasing from year to year. Similarly, Luther et al. have shown a correlation between a high incidence of infrapopliteal surgical reconstruction and a lower number of amputations, but this correlation was found for below knee amputations only (12). A possible explanation given was that patients undergoing AKA tend to be immobile whereas BKAs were done in patients who had a good chance of walking with a prosthesis post amputation.

In our series, however, over 80% of patients undergoing a primary AKA did so because of extensive infection or tissue loss or fixed flexion of the knee. We reviewed the original scans for all patients who underwent an AKA to see if profundoplasty would potentially have been appropriate, with a possibility of a more distal amputation (13). In all cases, distal rather than proximal profunda was occluded and therefore profundoplasty would not have been possible.

A total of 15 patients were transferred from other units with no on-site vascular cover, without having any vascular intervention locally. The outcome was particularly poor in this group of patients. In 53% of cases, primary amputation was carried out because of the extent of infection/gangrene. In the remainder, endovascular revascularisation was attempted, but unfortunately the limb was not salvageable. This group of patients also has a significantly higher mortality than the rest of the cohort (30-day mortality was 50% in those with a delayed referral). Unfortunately in the majority of these cases, there was a failure to recognise the severity of their condition in a timely manner. The resulting delays in transfer may
well have contributed to the poor outcome in this group of patients.

Some of the results may be skewed as the number of patients referred from other units was small and only 30 patients’ paper medical records were available for analysis. A prospective audit has, therefore, now been established in our unit.

Conclusion

The overall increase in the number of infra-inguinal interventions, along with changing patient demographics has reduced our amputation rates, in particular the number of BKAs performed. Our data also highlights transferred patients as a high risk population and underlines the need to develop a national system to expedite referrals.

Author contributions

Jo Krysa: Concept/design; data analysis/interpretation; drafting article; data collection. Stephanie Fraser: Data analysis/interpretation; drafting article; data collection. Prakash Saha: Data collection; concept/design; data analysis/interpretation. Mathew Fuller: data collection; concept. Rachel Bell: Critical revision of article; approval of article. Tom Carrell: Critical revision of article; approval of article. Bijan Modarai: Critical revision of article; approval of article. Peter Taylor: critical revision of article; approval of article. Hany Zayed: Concept/design; critical revision of article; approval of article.

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