

Clinical Versus Doppler Based Assessment in Determining Amputation Level in Diabetic Foot Gangrene; A Prospective Cross-Sectional Study at Atbuth, Bauchi

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Abstract

Background: Amputation is defined as the surgical removal of a limb or part of a limb through the bone. If the amputation is done above or below the knee, they are termed major while minor amputations involve the partial removal of foot including forefoot resections, ray amputation of the digits or parts of the digits. Significant number of patients with diabetic foot ulcers end with amputations. In the past the amputation level was decided by clinical assessment alone, such as physical examination using color, temperature, peripheral pulses and wound bleeding during surgical procedure. The use of Doppler ultrasound to measure arterial blood pressure at the proposed amputation site has been advocated as a predictor of amputation success. An optimal choice of the level of amputation can reduce amputation complications. **Methodology:** A Prospective comparative randomized cross-sectional study carried out between 1st January 2022 and 1st January 2024 in ATBUTH, Bauchi amongst patients with diabetic foot Wagener stage IV and V scheduled for amputation. Outcome measures of wound break down, flap necrosis and re-amputation were assessed amongst the clinical based level assessment group and the doppler based level assessment group. **Results:** A total of 171 patients were recruited into the study. Males 103 and 68 are females, giving a male to female ratio of 1.5:1. mean age 47 years. There were 84 patients in the clinical based level assessment group and 87 patients in the doppler based level assessment. **Conclusion:** Diabetes mellitus foot disease is a significant risk factor for non-traumatic lower limb amputation and doppler level as-

assessment is superior to clinical level in determining amputation level among diabetic patients scheduled for amputation. *P-value* 0.003.

Keywords

Diabetics, Amputation, Foot Gangrene, Doppler, Clinical

1. Introduction

Amputation is defined as the surgical removal of a limb or part of a limb through the bone. If the amputation is done above or below the knee, they are termed major while minor amputations involve the partial removal of foot including forefoot resections, ray amputation of the digits or parts of the digits [1]. Amputation is performed on patients with critical ischemia who cannot be treated with reconstructive vascular surgery or in whom vascular surgery has failed and for patients with diabetic foot infection with various level of foot gangrene [2].

For the patient, a failed lower limb amputation represents a tragedy which can result in prolonged hospital stay with increased cost of care and disabling illness and at worst cost the patient his life. For the surgeon, the need to revise an amputation is often regarded as a partial diagnostic failure, and is a painful necessity to impute more time and energy into the subsequent revision of the procedure to ensure full recovery and adequate return to function for the patient. A full understanding of the selection of amputation level will lead to reduction in the occurrence of this avoidable tragedy. No formula exists to completely avoid this terrible complication of amputation, vast majority of surgeons performing amputations during the last three decades had no preoperative diagnostic test to aid determination of amputation level [3].

Historically, surgical amputation was a crude procedure, however with better understanding of biology, physiology and surgical technique, the outcome of surgical amputation has improved [4]. Before amputation is done, a complete preoperative work up included assessment of healing potential and preoperative ambulatory status, control or optimization of co-morbidities where possible, such as the good and optimal control of glucose level in diabetic patient and the control of high blood pressure among hypertensive. Determination of amputation level using modern diagnostic modalities may reduce the rate of surgical failures and the need for revision [5]. In selecting such a level, a surgeon must balance the necessity of obtaining primary wound healing against the need of maintaining maximum limb length [6]. The more distal the amputation, the better the length salvaged but the greater the risk of infection, wound breakdown and flap necrosis resulting in re-amputations [7]. Thus, choice of optimal level of amputation is necessary to prevent these unwanted cascades.

Some methods have been described for determining a patient's ability to heal an amputation site, but the majority of them involve assessment of distal blood flow [8]. In the past the amputation level was decided by clinical assessment alone,

such as physical examination using color, temperature, peripheral pulses and wound bleeding during surgical procedure. With these clinical criteria, the common failure rate of Below Knee Amputation was high ranging between 10% - 50% with an average of 20% [9] [10]. The use of Doppler ultrasound to measure arterial blood pressure at the proposed amputation site has been advocated as a predictor of amputation success. Barnes and Coworkers showed that transtibial amputations healed in all patients with popliteal systolic pressures of more than 70 mmHg [9]. This study seeks to establish the difference in outcome between the use of clinical method with that of doppler ultrasound method in choosing the level of amputation in diabetic foot syndrome scheduled for amputation.

2. Methodology

A Prospective cross sectional comparative study carried out in ATBUTH, Bauchi among diabetic foot Wagener stage IV and V patients scheduled for amputation. Patients were informed and educated concerning the study and informed consent was obtained. Patients were randomized into two groups/cohorts; Clinical level assessment or Doppler assessment, simple randomization technique was employed using the random number table to eliminate bias and ensure balance in group/cohort allocation. Those for clinical level assessment were assessed clinically and findings recorded (**Table 1**), while those for doppler level assessment were sent for doppler ultrasound scan and findings were also noted and recorded (**Table 2**), both using a structured questionnaire. Level of amputation was chosen based on both clinical findings for clinical level assessment groups and doppler ultrasound findings for doppler assessment groups. Those patients with clinical findings as recorded in table1 above confined to the foot and distal part of the leg were offered below knee amputation while findings involving the foot and leg up to mid or proximal leg are offered above knee amputation. Those with doppler level assessment also had level of amputation chosen based on the level of occlusion of the vessels demonstrated by doppler ultrasonography of the lower limb. Those with partial or complete occlusion below the popliteal vessels were offered below knee amputation while partial or complete occlusion of vessel above the popliteal vessels were offered above knee amputation. Outcomes after amputation which include; the frequency of wound breakdown, flap necrosis and re-amputation for both clinical and doppler level assessment groups were noted and recorded. Other information and results relevant to the study were collected and recorded. Data obtained were gathered, prepared and analyzed using the SPSS version 29.

3. Results

A total of 171 patients were recruited into the study. Males 103 and 68 are females, giving a male to female ratio of 1.5:1. There were 84 patients in the clinical level assessment group and 87 patients in the doppler level assessment. Of the 84 patients who had amputations based on clinical level assessment of the level of amputation, 41 had below knee amputations with flap necrosis seen in 16 pa-

tients, 9 patients had re-amputation and 11 patients had complete wound break down. Forty-three had above knee amputations among which 15 had flap necrosis, 7 had re-amputation and 7 had complete wound breakdown (**Table 3**).

Table 1. Clinical features among diabetic foot patients going for lower limb amputation (n = 84).

s/n	Clinical features	No.	%
	Paraesthesia	36	42.8
1)	Shiny shin	22	26.2
2)			
3)	Loss of leg hair	16	19.1
	Darkening of the skin	13	15.5
4)	Absent dorsalis pedis pulsation	30	35.7
5)	Superficial ulcers	33	39.3
6)	Toe gangrene	23	27.4
	Deep ulcers	15	17.9
7)			
8)	Forefoot gangrene	17	20.2
9)	Whole foot gangrene	15	17.9
10)	Faint/Absent popliteal artery pulsation	29	34.5

Table 2. Findings of doppler ultrasonography for diabetic patients with foot syndrome going for lower limb amputation (n = 87).

Arteries	Clear	Partial occlusion	Complete occlusion
Femoral	74 (87)	13 (15)	0 (0)
Popliteal	45 (52)	20 (23)	22 (25)
Dorsalis pedis	23 (26)	17 (20)	53 (61)

Table 3. Comparison of frequency of flap necrosis, wound breakdown and re-amputation among patients that had clinical level assessment and Doppler level assessment for determining amputation level.

Level of amputation	Clinical	FN	RA	WBD	Doppler	FN	RA	WBD
BKA	41 (48.8)	16 (39.0)	9 (21.9)	11 (26.8)	42 (48.3)	10 (23.8)	9 (21.4)	7 (16.7)
AKA	43 (51.2)	15 (34.9)	7 (16.3)	7 (16.3)	45 (51.7)	5 (11.1)	6 (13.3)	5 (11.1)
Total	84 (100)	31 (36.9)	16 (19.0)	17 (20.2)	87 (100)	15 (17.2)	15 (17.2)	13 (14.9)

FN: Flap necrosis, RA: re-amputation, WBD: wound breakdown.

For those that had amputation level selection based on doppler based assessment, 45 had below knee amputation, amongst which 5 patients had flap necro-

sis, 6 patients had re-amputation and 5 patients had wound breakdown. Forty-two patients had above knee amputation based on doppler level assessment amongst which, 10 patients had flap necrosis, 9 patients had re-amputation and 7 had wound breakdown (**Table 3**).

30% of the patient had primary education, 27% had tertiary level of education, 20% had secondary school leaving education and about 8% had none. The duration of disease was less than 10 years in 13%, 10 - 20 years in 50% of the patients and greater than 20 years in 37%. Sixty seven percent (67%) of the patients are on oral antidiabetic agents while 33% are on insulin. Fifty percent of the patients had no knowledge of foot care in diabetics, 33% are informed on foot care while 17% are very well informed.

4. Discussion

Diabetes mellitus has been described by Shaban et al as a growing global epidemic [10]. It has been predicted by WHO that there will be over 300 million people that will be living with diabetes mellitus by 2025. The prevalence of diabetes mellitus is four times higher than all cancers combined [11] one of the major complications of diabetes mellitus is diabetic foot syndrome which is also a major cause of amputation contributing more than 90% of non-traumatic cause of lower limb amputation [12]-[14]. The increasing burden of patient with diabetes mellitus will invariably increase the number of diabetic amputation [15] [16]. Worldwide every 30 second a limb is lost to diabetes [17]. Thus, increasing the financial, emotional and psychologic burden of management of this condition. In 2001, it was estimated that diabetes foot ulcers and amputations cost U.S health care payers 11 billion dollars [18].

An optimal choice of the level of amputation ensures early healing and recovery of the patient whereas wrong choice of amputation level can increase hospital stay, wound healing time cause by varying level of wound failure which can even lead to the death of the patient. In this study, we compare the outcomes between the use of clinical assessment in determining the level of amputation with that obtain when doppler ultrasound is used to determine the level of amputation.

For clinical level assessment, **Table 1** shows the different clinical features presented by the patient, Paraesthesia is the commonest presenting complain among these patients, as much as 42.8% of our patients presenting with advance diabetic foot syndrome has Paraesthesia, which is one of the early features of diabetic neuropathy and if not handled early will lead to ulcers [18]. The next common clinical feature is superficial ulcer which was seen in 39.3% of our patients. Other studies also have similar statistics, with high incidence of ulceration among diabetic patients with diabetic foot syndrome [19] [20]. Other features include absent dorsalis pedis pulsation (35.7%), faint or absent popliteal artery pulsation (34.5%) gangrene of the toes (27.4%), forefoot gangrene (20.2%) and whole foot gangrene (17.9%).

Eighty-four patients (84) had amputation level chosen based on clinical level assessment, among which 41 (48.8%) had below knee amputation and 43 (51.2%)

had above knee amputation. Clinical features noted and use for determining level of amputation are shown in **Table 1**. Eighty-seven (87) patients had level of lower limb amputation determined by doppler ultrasonography features, among which 45 (51.7%) had below knee amputation while 42 (48.7%) had above knee amputation. **Table 2** shows the various findings during doppler for diabetic patients with foot syndrome going for amputation and dorsalis pedis artery is the most commonly affected vessels, followed by popliteal artery and very rare in femoral artery. This is also similar to other reports [21].

Table 3 showed the comparison between the patients that had doppler level assessment and those that had clinical level assessment using the outcome measures of flap necrosis, complete wound breakdown and re-amputation rate. Using chi-square at 95% confidence interval to calculate relationships of the variables, we found a statistically significant relationship between the method of assessment/choice of level of amputation and clinical outcome ($P = 0.003$). More patients who had clinical level assessment for choice of amputation level came down with flap necrosis, wound breakdown and re-amputation than those patients that had doppler base assessment for choice of level of amputation.

There were 103 (60.2%) males and 68 (39.8%) females who had lower limb amputation during the period of study, giving a male to female ratio of 1.5:1. This is in keeping with other studies that shows higher risk of lower limb amputation among male diabetic patients than their female counterpart [22]-[24]. Other risk factors also include cigarette smoking, peripheral vascular disease, proteinuria, hypertension [25].

There is no statistically significant relationship between sex or age of patient with the choice of the level of amputation $P = 0.77, 0.54$, respectively.

5. Conclusions

Diabetic foot syndrome presents a rising burden of amputation among diabetic patients.

From this study, doppler ultrasound was found to be superior to clinical level assessment in determining the level of amputation with regards to poor outcome measures of flap necrosis, wound breakdown and re-amputation.

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Ethical Approval

Ethical approval was obtained from the ethical board of Abubakar Tafawa-Balewa University Teaching hospital, Bauchi to conduct the study.

Author Contribution

All authors have been directly involved with the various aspects of the study. We

attest to the fact that all authors have participated in the research, read the manuscript, attest to the validity and legitimacy of the data.

Conflicts of Interest

The authors declare that they have no conflict of interest.

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