High Levels of Foot Ulceration and Amputation Risk in a Multiracial Cohort of Diabetic Patients on Dialysis Therapy

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OBJECTIVE — To evaluate the prevalence of lower-limb complications in a multiracial cohort of patients with diabetes receiving dialysis.

RESEARCH DESIGN AND METHODS — This work was a cross-sectional study of lower-limb complications in dialysis-treated patients with diabetes in the U.K. and U.S.

RESULTS — We studied 466 patients (139 U.K.; 327 U.S.). The prevalence of lower-limb complications was high (foot ulcers 12%, neuropathy 79%, peripheral arterial disease 57%, history of foot ulceration 34%, and prior amputation 18%), with no significant ethnic variation, except that foot ulcers were more common in whites than in patients of African descent ($P = 0.013$). Ninety-five percent of patients were at high risk of lower-limb complications. Prior amputation was related to foot ulcer history, peripheral arterial disease, and hemodialysis modality in multivariable analysis. Prevalent ulceration showed independent associations with foot ulcer history and peripheral arterial disease, but not with ethnicity.

CONCLUSIONS — All patients with diabetes receiving dialysis are at high risk of lower-limb complications independent of ethnic background.

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Among individuals with diabetes, significant ethnic differences in lower-limb complications have been identified in the U.K. (1) and the U.S. (2). Previous studies linking renal impairment or end-stage renal disease to lower-limb complications have been retrospective and have not considered ethnicity (3,4). We aimed to establish the prevalence of lower-limb complications by ethnic group in dialysis-treated diabetic patients.

RESEARCH DESIGN AND METHODS

— This was a prospectively designed cross-sectional study including patients with diabetes receiving dialysis therapy from centers in Manchester (U.K.) and Texas (U.S.). During routine clinic appointments, patients were interviewed and had a detailed foot examination including neurological (5,6) and peripheral arterial disease (PAD) assessment. Data were collected on diabetes and dialysis status, foot conditions, foot care, and footwear. Peripheral neuropathy was defined as vibration perception threshold >25 V (Neurothesiometer; Horwell Scientific Laboratory Supplies, Nottingham, U.K.) and/or a modified neuropathy disability score >3 (5,6). PAD was defined as follows: ankle/brachial pressure index (ABPI) <0.9 (7), a history of peripheral artery revascularization or angiography confirming PAD, noncompressible arteries (ABPI >1.4 with monophasic or biphasic waveforms) (8), or the absence of two or more foot pulses on palpation (9).

The International Working Group on the Diabetic Foot (IWGDF) risk classification was used to assign patients into four levels of increasing risk of lower-limb complications (9): no recognizable risk factor (risk category 0); neuropathy and no other risk factors (risk category 1); PAD with or without neuropathy (risk category 2); or prevalent foot ulceration, a history of foot ulcer, or prior amputation (risk category 3). Patients in risk categories 1, 2, or 3 were considered to be at high risk of lower-limb complications. Ethnicity was based on patient self-report. The study received prior approval from the relevant ethics committee and review boards.

Pearson's χ^2 and Fisher's exact tests were used for between-group comparisons of categorical data. ANOVA was used to assess the influence of ethnic group on lower-limb complications. Proportions of patients with lower-limb complications are presented with 95% CI estimated by the modified Wald method. Univariate analysis was performed to identify factors associated with prevalent foot ulceration or prior amputation, and variables with significant associations were included in multivariate logistic regression. $P < 0.05$ was considered statistically significant. Analyses were performed using SPSS version 15.0 (SPSS, Chicago, IL).

RESULTS

— We studied 466 patients (139 U.K., 327 U.S.). Eighty-eight percent were receiving hemodialysis; the remainder received peritoneal dialysis. Recruitment center (U.K. or U.S.) was not associated with prevalent foot ulcer or prior amputation in univariate analysis. We observed a high prevalence of PAD and peripheral neuropathy and a moderately high prevalence of past foot ulceration and amputation that did not vary by ethnicity (Table 1). The only foot complication that varied by ethnicity was current foot ulceration, which affected approximately one in eight patients, with whites having a higher prevalence than patients

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Table 1—*Prevalence of foot ulcers, amputations, and risk factors for developing lower-limb complications by ethnic groups*

	White	Hispanic	African	Asian	Total	*P* (ANOVA for ethnicity)
n	196	165	70	35	466	
Age (years)	61 ± 14	61 ± 12	59 ± 13	57 ± 12	60 ± 13	0.363
Sex (% male)	55	52	53	57	53	0.896
Diabetes (% type 1)	23	4	6	11	13	0.001
Time since diagnosis of diabetes (years)	21 ± 11	18 ± 10	21 ± 10	17 ± 9	20 ± 10	0.012
Glycated hemoglobin (%)	7.4 ± 1.7	6.9 ± 1.4	7.2 ± 1.8	7.6 ± 1.2	7.2 ± 1.6	0.005
Current foot ulcer* (%)	16 (12–22)	10 (6–15)	4 (1–12)	11 (4–27)	12 (9–15)	0.041
Past foot ulcer* (%)	36 (30–43)	34 (27–41)	30 (20–41)	20 (10–36)	33 (29–38)	0.277
Past or present foot ulcer* (%)	42 (35–49)	39 (32–46)	34 (24–46)	26 (14–42)	38 (34–43)	0.276
Amputation* (%)	15 (11–21)	20 (15–27)	21 (13–32)	9 (2–23)	18 (14–21)	0.286
PAD* (%)	54 (47–61)	58 (50–65)	63 (51–73)	54 (38–69)	57 (52–61)	0.672
Peripheral neuropathy* (%)	82 (76–87)	76 (69–82)	79 (68–87)	89 (73–96)	80 (76–83)	0.313
IWGDF risk category						
0: No risk factors (%)	5 (3–9)	5 (2–9)	3 (0.1–10)	0 (0–12)	4.5 (3–7)	0.208†
1: DPN only (%)	9 (6–13)	2 (0.4–5)	6 (2–14)	29 (16–45)	7 (5–10)	
2: PAD ± neuropathy (%)	44 (37–51)	55 (47–62)	57 (45–68)	46 (30–62)	50 (45–54)	
3: Present or past ulcer or amputation (%)	43 (36–50)	39 (32–46)	34 (24–46)	26 (14–42)	39 (34–43)	

Data are *n*, means ± SD, or % (95% CI). White includes all Europeans and similar white origins (U.K.) and non-Hispanic whites (U.S.). The only Native American ($n = 1$) was included in the white group. Hispanic includes Mexican Americans and similar Hispanic origins (U.S.). African includes people of African descent in the U.K. (African-Caribbeans) and U.S. (African Americans). Asian includes Indo-Asians or similar Asian origin (U.K. only). *95% CIs are calculated by the modified Wald method. †Multiple comparison test of variance (Bonferroni correction) confirmed there was no difference between the ethnic groups.

of African descent (16.4 vs. 4.5%, $P = 0.013$) but not significantly higher than Asians or Hispanics. Based on IWGDF risk categories, 95% of all patients were considered to be high risk.

Prevalent foot ulceration showed univariate associations with PAD (OR [95% CI]: 4.5 [2.1–9.4], $P < 0.0001$), foot ulcer history (3.1 [1.7–5.4], $P < 0.0001$), retinopathy (4.0 [1.9–8.3], $P < 0.0001$), white ethnicity (2.1 [1.2–3.7], $P = 0.008$), and failure to wear bespoke footwear (2.1 [1.2–3.6], $P = 0.010$). Prevalent foot ulceration remained independently associated with PAD (4.1 [1.9–8.6], $P < 0.0001$) and foot ulcer history (2.8 [1.6–5.1], $P = 0.001$) in multivariate analysis.

Prior amputation showed univariate associations with foot ulcer history (46 [19–110], $P < 0.0001$), PAD (3.8 [2.1–6.8], $P < 0.0001$), failure to wear bespoke footwear (3.8 [2.3–6.2], $P < 0.0001$), hemodialysis modality (2.9 [1.1–8.3], $P = 0.023$), peripheral neuropathy (2.3 [1.1–4.7], $P = 0.016$), male sex (1.7 [1.1–2.8], $P = 0.019$), and retinopathy (1.6 [1.0–2.7], $P = 0.043$). Prior amputation was independently associated with foot ulcer history (42 [17–100], $P < 0.0001$), PAD (4.1 [2.9–8.4], $P < 0.0001$), and hemodialysis modality (17 [2–132], $P = 0.008$) in multivariate analysis.

CONCLUSIONS — We report a high prevalence of lower-limb complications in a large ethnically diverse cohort of diabetic patients on dialysis, with up to 95% of them having at least one recognizable risk factor for foot ulceration. Contrary to previous reports of ethnic variations of foot complications in diabetes (1,2), we observed no ethnic variation in prevalent foot complications in our dialysis-treated cohort, except for prevalent foot ulceration. This may be due to these patients having a heavy burden of systemic end-stage microvascular and macrovascular disease, such that ethnic differences become relatively insignificant.

Diabetic patients with end-stage renal disease are likely to have falsely elevated ABPI levels (10,11), and ABPI measurements are less able to detect occlusion in arterial segments distal to the ankle, which might be detected by palpation of distal pedal pulses. Therefore, we used a combination of criteria to define subjects with PAD.

Our data confirm and extend previous reports on diabetic foot disease in the end-stage renal disease population (12,13). The strengths of our study include the following: the large multiethnic sample providing reliable prevalence data, the inclusion of U.K. and U.S. centers, and a comprehensive assessment of foot pathology. Our study is limited by the small number of patients receiving peritoneal dialysis and suboptimal information on preventative and therapeutic care.

Although this was not an intervention study, we believe that our findings have immediate implications for foot care delivery. Because we found that 95% of dialysis-treated diabetic patients are at high risk for foot problems, we suggest that all such patients should be considered to be high risk. Dialysis-treated patients may fail to attend for appropriate foot care, since they are too concerned with the demands of dialysis (14); therefore, scheduling foot evaluation, education, and interventions during or immediately after dialysis may be a key component of effective prevention (15).

In summary, diabetic patients treated with dialysis have a high prevalence of foot ulceration, amputation, and the "high-risk foot" that is similar across all ethnic groups. Comprehensive and multidisciplinary diabetic foot care should be offered to all patients and be integrated within dialysis services.

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