Charcot Foot and Amputation: The Interplay of Social Determinants, Comorbidities, and Living Situations

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INTRODUCTION: Charcot neuroarthropathy (CN) is a progressive, debilitating condition predominantly affecting patients with diabetes mellitus. Complications frequently result in the need for surgical intervention, including partial and extensive amputations. Drivers have been shown to be clinical severity as well as sociodemographic, economic, and behavioral influences. The aim of this study was to explore the role of social determinants of health (SDoH) and living situation on the rate of amputations in diabetic CN patients. Our hypothesis was that SDoH might influence the process of decision making towards amputation when indicated in these patients.

METHODS: A retrospective chart review of adults from 2020 to 2025 at a single multi-institution academic healthcare institution was conducted and a total of 134 diabetic patients with confirmed CN were identified. The following data were collected: sociodemographics (age, sex, race, language, marital status), clinical characteristics (type of diabetes, HbA1c, body mass index [BMI], Charlson Comorbidity Index [CCI], peripheral arterial disease [PAD], retinopathy, smoking status and alcohol use), and SDoH (education level, employment status, insurance status, Social Vulnerability Index [SVI; census tract and county], Housing Type and Transportation Index [county], Socioeconomic Status [SES; census tract and county], Area Deprivation Index [ADI; state and national], home value, square footage of home, number of bedrooms, square footage per room). Continuous variables were compared using independent T-tests or Mann-Whitney U-tests after normality testing. Chi-square tests or Fisher's Exact tests evaluated associations between categorical variables and amputation status. Logistic regression models were used to assess associations between SDoH, clinical risk factors, and living status for amputation with significance set at $P<0.05$. We developed a prediction formula based on our regression models for the risk of amputation in our patient population based on the factors that showed significant associations in our study.

RESULTS: Of the 134 patients, 27% (n=36) underwent amputation after diagnosis of CN. Type 2 diabetes was present in 86% (n=115) of the cohort. The overall average home value was $691,461, which is higher than both the state of care average ($658,231) and the national average ($367,711). The amputated cohort was educated with 89% attending college. Patients with amputations reported 58% current alcohol use versus 34% without ($P=0.01$), while no significant difference was found in the proportion of other comorbidities. All SVI, ADI, SES and living situation metrics showed no significant association between cohorts. From our multivariable regression, employment was strongly protective, with employed patients demonstrating lower odds of amputation (OR=0.15, 95% CI 0.04–0.55; $P=0.004$). Also, current alcohol use increased the odds of amputation nearly four-fold (OR=3.98, 95% CI 1.15–13.75; $P=0.03$). Our prediction algorithm based on the significantly correlated factors included in the current study showed an area under the receiver operating characteristic curve (AUROC) of 0.79 with a Youden's Index of 0.50 with sensitivity and specificity set to 70% and 80%, respectively.

DISCUSSION AND CONCLUSION: As shown in our outcomes, our cohort was relatively homogenous and was from an above average population in terms of SES and SDoH. Despite slight variations, SVI, ADI, SES, and living status were shown to be non-predictive for the risk of amputation. Active employment reduced amputation odds, whereas ongoing alcohol consumption significantly increased vulnerability. While our findings do not suggest any meaningful correlation between SDoH and the amputation rate, homogeneity of our population in terms of SES class might have led to a selection bias, or more specifically, restriction bias. We assumed that there could be a threshold for SES and SDoH that once crossed, these factors lose influence on the outcomes of such patient population. On the other hand, this can also show that more uniform access to care and correct policies can provide more equitable care. However, there is a need for further studies in larger, more diverse populations to better explore the role of SDoH and living situation on the outcomes of diabetic CN.

Table 1. Comparison of patient characteristics for diabetic patients with charcot neuroarthropathy between amputation and non-amputation groups (n=134)

Variables		Amputation (n=36)	Non-Amputation (n=98)	*P* Value
Age (years)		56.83 ± 11.36	58.83 ± 10.70	0.35*
Mortality (Alive/Dead)		80.56%/19.44% (n=29/n=7)	81.63%/18.37% (n=80/n=18)	0.89†
Sex (Female/Male)		13.89%/86.11% (n=5/n=31)	27.55%/72.45% (n=27/n=71)	0.10†
Race (Non-White/White)		11.11%/88.89% (n=4/n=32)	17.53%/82.47% (n=17, n=80)	0.37†
Diabetes (Type 1/Type 2)		11.11%/88.89% (n=4/n=32)	15.31%/84.69% (n=15/n=83)	0.54†
Language (Non-English/English)		0.00%/100.00% (n=0/n=36)	8.51%/91.49% (n=8/n=86)	0.07†
Education (College/High School)		88.89%/11.11% (n=8/n=1)	37.50%/62.50% (n=3/n=5)	0.05‡
Job (Employed/Unemployed)		50.00%/50.00% (n=14/n=14)	68.06%/31.94% (n=49/n=23)	0.09†
Marital Status (Married/Not Married)		57.69%/42.31% (n=15/n=11)	68.49%/31.51% (n=50/n=23)	0.32†
Smoking	**Current**	19.4% (n=7)	9.4% (n=9)	0.11†
	Not Current	80.6% (n=29)	90.6% (n=87)	
Alcohol	**Current**	38.3% (n=21)	33.7% (n=32)	**0.01**†
	Not Current	41.7% (n=15)	66.3% (n=63)	
Insurance	**Private**	36.67% (n=11)	47.56% (n=39)	0.12†
	Public	53.33% (n=16)	51.22% (n=42)	
	Both Public & Private	6.67% (n=2)	1.22% (n=1)	
	Uninsured	3.33% (n=1)	0.00% (n=0)	
BMI (kg/m²)		30.38 [26.83-35.26]	34.58 [30.12-37.49]	0.13**
Charlson Comorbidity Index		6.00 [4.75-6.25]	5.00 [3.00-6.00]	0.61**
HbA1c (%)		8.55 [5.85-10.40]	7.70 [6.90-8.50]	0.81**
Peripheral Arterial Disease (No/Yes)		75.76%/24.24% (n=25/n=8)	87.23%/12.77% (n=82/n=12)	0.12†
Retinopathy (No/Yes)		65.62%/34.38% (n=21/n=11)	69.15%/30.85% (n=65/n=29)	0.71†
Socioeconomic Status Census Tract		0.21 [0.13-0.38]	0.19 [0.07-0.40]	0.72**
Socioeconomic Status Counties		0.20 [0.12-0.34]	0.20 [0.14-0.34]	0.46**
SVI Census Tract		0.25 [0.20-0.36]	0.22 [0.11-0.46]	0.98**
SVI Counties		0.30 [0.29-0.61]	0.31 [0.29-0.51]	0.35**
SVI Housing Type and Transportation Index Counties		0.80 [0.73-0.83]	0.74 [0.47-0.74]	0.23**
ADI State		4.76 ± 2.18	5.23 ± 2.48	0.33*
ADI National		21.00 [5.50-26.75]	20.00 [13.00-26.00]	0.91**
Home Value at Diagnosis		488,350.00 [323,100.00–682,250.00]	397,900.00 [327,100.00–504,900.00]	0.22**
Home Value at Current Value		582,550.00 [490,725.00–893,650.00]	569,800.00 [478,600.00–667,200.00]	0.57**
Home Square Feet		2,035.50 [1,625.75–2,330.50]	1,890.00 [1,344.00–2,287.00]	0.32**
Home Bedrooms		3.00 [3.00-4.00]	3.00 [3.00-4.00]	0.84**
Square Feet/Rooms		540.88 [459.06–676.17]	536.40 [436.00-682.67]	0.48**

Abbreviations: y, yes; n, no; BMI, Body mass index; SVI, Social Vulnerability Index; ADI, Area Deprivation Index
* Independent T-Test; *P*<0.05 was considered significant
** Mann-Whitney U test; *P*<0.05 was considered significant
† Chi Square test; *P*<0.05 was considered significant
‡ Fisher's Exact test; *P*<0.05 was considered significant

Table 2. Multivariable regression using selected variables from univariate analysis in table 1

Variables	Coefficient	OR (95% CI)	*P* Value
Age	-0.04	(0.91-1.01)	0.15
Gender	0.48	(0.40-6.49)	0.50
Job	-1.88	(0.04-5.44)	**0.004**
Current Alcohol	1.38	(1.15-13.75)	**0.03**
BMI	-0.06	(0.87-1.02)	0.16
CCI at Risk	1.10	(0.65-13.82)	0.16
SVI Counties	-2.65	(0.003-1.59)	0.10
ADI State	-0.08	(0.73-1.17)	0.51

Abbreviations: BMI, Body mass index; OR, odds ratio; CI, confidence interval, CCI, Charlson Comorbidity Index; SVI, social vulnerability index; ADI, area deprivation index
Values shown in bold are significant.