The Footprint of Multiple Surgeries: Assessing Outcomes and Surgical Strategies for Patients with Charcot Neuroarthropathy

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INTRODUCTION:
Charcot neuroarthropathy (CN) is a progressive degenerative disease that most commonly manifests in the foot and ankle as a result of peripheral neuroarthropathy. Primary treatment is typically management of disease progression, however, surgical procedures including arthrodesis, exostectomy, and amputation may be indicated for more refractory cases. Our prior research analyzed a subset of the current sample to evaluate patients who underwent multiple surgical procedures to manage their CN, identifying amputation to be associated with the highest all-cause mortality rate. The purpose of this study is to analyze demographic data and mortality rates from a larger sample of patients with an emphasis on the mortality associated with procedure order and type in patients who underwent multiple procedures in the management of their CN.
METHODS:
Following IRB approval, a database of all patients at a single institution from 1/1/2000 to 1/31/2022 with CPT and ICD codes indicating a diagnosis of Charcot foot of the lower extremity who underwent amputation, exostectomy, and/or arthrodesis was created from the electronic health record. Only patients who underwent multiple procedures in the treatment of their CN were included in the study. Amputation was further classified as major (transmetatarsal amputation or above) or minor (below the metatarsal level or a single toe at the metatarsal level). Demographics including age, sex, race, and insurance status were recorded in addition to all-cause mortality rates for each procedure type and all-cause mortality rates relative to procedure order. Descriptive statistics and chi-square tests for homogeneity were conducted for analysis. One patient, identified as an outlier, had 13 procedures, and was excluded so as to not distort the statistical analysis.
RESULTS: A total of 700 individual patients who underwent at least 2 procedures were included in this study, with a total of 1,902 procedures performed of which 363, 651, 459, and 429 were completed for major amputation, minor amputation, exostectomy, and arthrodesis respectively. Figure 1A describes the baseline characteristics of patients who underwent each procedure. The all-cause mortality rate remained the lowest in arthrodesis patients, regardless of the order in which it was performed. Furthermore, patients who underwent either arthrodesis or exostectomy at any point in their procedure sequence had an absolute risk reduction in all-cause mortality of 42.5% and 21.1% respectively, while both amputation groups had an absolute risk increase in all-cause mortality of 46.0% (minor) and 48.3% (major).
DISCUSSION AND CONCLUSION: For patients who underwent multiple procedures to manage their CN, those who underwent arthrodesis at any point during their procedure sequence showed the trend of having the lowest all-cause mortality rates (Figure 1D). This may indicate that early anatomic correction through arthrodesis could lead to improved mortality in Charcot patients. Figure 1E describes the significantly increased ($p < 0.001$) mortality rates associated with both amputation groups, which further highlights the importance of early intervention and management of disease progression. Future research should aim to develop surgical treatment guidelines based on disease progression to continue to minimize mortality rates.

Figure 1A: Demographic Data for Each Procedure

VARIABLE	MAJOR AMPUTATION	MINOR AMPUTATION	EXOSTECTOMY	ARTHRODESIS	TOTAL
Procedure Total	363	651	459	429	1902
Average Age at Time of Procedure (yrs)	60.04	61.17	56.18	54.76	58.28
Race					
White	315	572	404	388	1679
Black or African American	21	31	16	12	80
His/Lat White	2	2	1	0	5
Two or More Races	6	18	14	11	49
Other	19	28	24	18	89
Sex					
M	267	431	244	161	1103
F	96	220	215	268	799
Insurance					
Medicare	167	276	151	137	731
Medicaid	35	55	43	35	168
Self-Pay	3	9	6	9	27
Commercial	22	49	45	64	180
PPO	1	2	1	1	5
Blue Cross	73	146	114	81	414
Blue Shield	7	10	19	17	53
HMO	37	60	45	46	188
Special Billing No Claims	14	35	28	29	106
Government Programs	5	9	6	2	22
Worker's Comp/Liability	0	0	1	7	8
Procedure Order					
1st	58	280	156	206	700
2nd	134	218	187	161	700
3rd	97	87	73	40	297
4th	38	36	28	17	119
5th	22	15	10	5	52
6th	9	9	3	0	21
7th	2	6	1	0	9
8th	3	0	1	0	4
Total	363	651	459	429	1902

Figure 1C: All Cause Mortality Rates by Procedure Type and Order

Procedure Order	Major Amputation	Minor Amputation	Exostectomy	Arthrodesis
1st	0.310	0.404	0.141	0.131
2nd	0.433	0.344	0.187	0.081
3rd	0.443	0.368	0.205	0.125
4th	0.395	0.472	0.286	0.059
5th	0.545	0.333	0.300	0
6th	0.222	0.444	0.333	-
7th	0.500	0.333	0	-
8th	0.333	-	0	-

Figure 1B: Number of Surgical Procedures in Each Category Relative to Order of Procedure

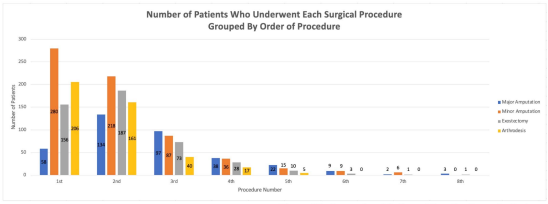


Figure 1D: All Cause Mortality Rates by Procedure Type and Order

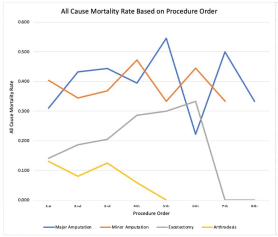
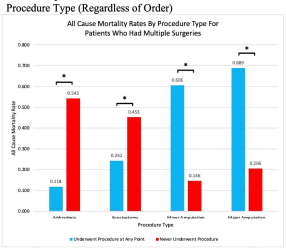


Figure 1E: Comparing All Cause Mortality Rates for Patients With Multiple Procedures Who Had vs. Did Not Have Each Procedure Type (Regardless of Order)



*Mortality rates were compared within each procedure type using a chi-square test of homogeneity (*denotes significance, p-value < 0.001)