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ORIGINAL CLINICAL ARTICLE

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Do appreciable changes in the upper extremity motor capability to perform clean intermittent catheterization come about with time after traumatic spinal cord injury?

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Abstract

Introduction: Bladder dysfunction after spinal cord injury (SCI) often requires clean intermittent catheterization (CIC) or other management strategies. A common dilemma in those desiring to perform CIC independently but lacking the appropriate upper extremity (UE) motor function is the timing of reconstructive surgery.

Methods: We assessed the National Spinal Cord Injury Data Set for the years 2000-2016. Our cohort consisted of persons with cervical SCI, who underwent complete motor examination upon discharge from rehabilitation and at 1-year follow-up. Using a previously published algorithm, UE motor scores were transformed to predict a patient's ability to independently perform CIC. Improvements in the predicted ability to self-catheterize were evaluated.

Results: Of the 1428 individuals meeting the inclusion criteria, improvements in the predicted UE motor function necessary to independently self-catheterize were observed in 39%, 42%, and 38% of those deemed possibly able, only able with surgical assistance, or unable to self-catheterize at rehabilitation discharge, respectively. On multivariate analysis, only increasing Association Impairment Scale (AIS) classification and AIS classification improvement over the first year were associated with an increased odds of improving predicted CIC ability (odds ratio [OR] = 1.44 for AIS C and 1.97 for AIS D compared with AIS A, and OR = 1.90 for AIS classification improvement versus stable AIS classification, $P < 0.05$ for each).

Conclusion: Improvements in UE motor function to independently perform CIC occur in approximately 40% of persons with cervical SCI in the first year after rehabilitation discharge. Those with incomplete injuries are more likely to improve. These findings should enhance patient bladder management counseling and guide surgeons in determining an appropriate timeline for offering reconstruction.

KEYWORDS

clean intermittent catheterization, reconstructive surgery, spinal cord injury, upper extremity motor function

1 | INTRODUCTION

Annually, more than 17 000 traumatic spinal cord injuries (SCIs) occur in the United States. Of those injured, ~70% (12 000 persons) will not regain volitional bladder function.[1] Since Lapides et al[2] published his seminal work in 1972, clean intermittent catheterization (CIC) has been championed as the "gold standard" bladder management for those with bladder dysfunction after SCI. Compared with indwelling catheters, condom catheters, and reflex voiding, there are significantly fewer complications in persons performing CIC.[3,4]

One of the most important predictors of one's ability to perform CIC after SCI is adequate upper extremity (UE) motor function.[4–8] Unfortunately, many persons who sustain a SCI lack the motor function necessary to independently perform CIC.[9] In these instances, however, reconstructive surgery on either the UE (tendon transfer) or the bladder (catheterizable stoma) can be used to facilitate independent CIC.[10,11]

A common dilemma in those who desire to perform CIC independently but lack the requisite UE motor function is the timing of reconstructive surgery. Some advocate a period of a year to see if neurologic recovery might occur.[12] However, while neurologic recovery may take place in the first year after SCI, the extent to which recovery occurs specifically for a task such as self-catheterization has not been examined.[13–15] The purpose of this study is to evaluate UE motor changes in SCI patients, as it relates to independently performing CIC in the first year after discharge from acute rehabilitation.

2 | METHODS

We assessed data for the years 2000-2016 from Forms I and II of The National Spinal Cord Injury Database (NSCID), a data set that includes information on persons with traumatic SCI in designated Spinal Cord Injury Model System centers in the United States.[16] Form I is administered before a patient's discharge from their initial inpatient rehabilitation and includes a complete neurologic motor examination, patient demographics, patient health information, and bladder management method at the time of discharge. Form II contains similar data (including neurologic examination) and is a follow-up questionnaire that is administered 1 year after injury and every 5 years thereafter.

Using the NSCID, participant UE motor function was evaluated at the time of discharge from inpatient rehabilitation and at 1-year follow-up. As UE motor function is only impaired in those with cervical SCI, we excluded individuals with thoracic, lumbar, or sacral levels of injury. Other exclusion criteria were a lack of motor examination before discharge, a lack of motor examination at 1-year follow-up, the ability to void volitionally at the time of discharge, release from rehabilitation more than 180 days from injury or if a patient was younger than 13 years.

An algorithm previously published by our group was used to characterize the ability to perform CIC on the basis of UE function alone. Specifically, neurologic motor scores for C5 through C8 (involved in the control of UE movement) were transformed and classified as: (a) able to catheterize; (b) possibly able to catheterize; (c) able to catheterize only with reconstructive surgical intervention (eg, catheterizable stoma construction or tendon transfer surgery); and (d) unable to catheterize even with reconstructive surgical intervention (Figure 1).[5,9]

Cross-sectional comparisons among demographic characteristics, neurologic examination, and UE motor function scores between those included in the study versus those excluded from the study were compared. The variables examined included age, sex, time from injury to discharge from rehabilitation, American Spinal Injury Association Impairment Scale (AIS), and UE motor function. All data manipulation and statistics were performed using Stata version 12.1 (StataCorp, College Station, TX).

3 | RESULTS

After exclusions, a total of 3492 persons with cervical SCI who were unable to volitionally void and had a documented motor examination at the time of discharge were identified. Of this cohort, 1428 (40.0%) had a

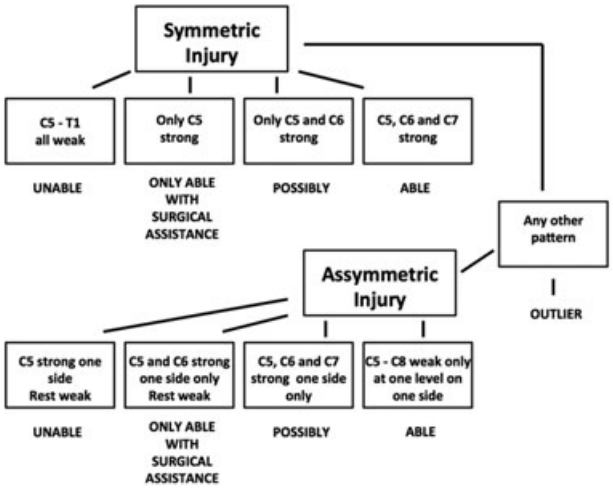

FIGURE 1 Algorithm for the Predicted Ability to Self-Catheterize Based on Upper Extremity Motor Strength Scores

TABLE 1 Baseline Characteristics of Cervical Spine Injury Patients With and Without 1-Year Follow-up of Upper Extremity Motor Function

Variable	1-Year Follow-Up Available (n = 1428)	No Follow-Up (n = 2064)
Mean Age	39.6 (SD 16.8)	42.0 (18.0 SD)
Gender		
Male	1128 (79.0%)	1673 (81.1%)
Female	300 (20.9%)	391 (19.9%)
Mean Days From Injury to D/C from Rehab	88.2 (36.1 SD)	84.4 (35.6 SD)
Race/Ethnicity		
White	1050 (73.5%)	1473 (71.4%)
Black	319 (22.3%)	441 (21.4%)
Asian	20 (1.4%)	47 (2.3%)
Other	39 (2.7%)	103 (4.9%)
AIS Class		
A	566 (38.9%)	711 (34.5%)
B	257 (18.0%)	413 (20.0%)
C	349 (24.4%)	361 (17.5%)
D	349 (24.4%)	566 (27.4%)
Miss	12 (0.9%)	13 (0.6%)
Ability to Cath		
Able	409 (28.6%)	529 (25.6%)
Possibly Able	331 (23.2%)	484 (23.5%)
Only With Surgical Assistance	293 (20.5%)	412 (20.0%)
No	371 (26.0%)	587 (28.4%)
Outlier	24 (1.7%)	52 (2.5%)

follow-up motor examination at their 1-year follow-up and were included in our final study cohort. The cohort was young (mean age, 39.6 years), predominantly male (79%) and of white race/ethnicity (73.5%). The median time from injury to discharge from rehabilitation was 85 days. The AIS classification was mixed with about half being AIS A/B and the other half AIS C/D. Improvement in AIS classification over the first year after rehabilitation discharge was seen in 233 (16.3%) of individuals. There were no significant baseline differences between the portion of the cohort that did and did not have a motor examination performed at 1-year follow-up (Table 1).

Overall, the cohorts predicted ability to independently self-catheterize at the time of discharge from rehabilitation was evenly distributed (29% Able, 23% Possibly Able, 21% with Surgical Assistance Only, and 26% Unable). This appreciably improved at 1-year follow-up (41% Able, 23% Possibly Able, 17% with Surgical Assistance Only, and 17% Unable). The improvements in UE motor function to perform the task of independent CIC was not appreciably affected by an individual's initial motor examination as improvement was seen in 39%, 42%, and 38% of those deemed possibly able, only able with surgical assistance, or unable to self-catheterize at the time of discharge from rehabilitation. Of those improving in the unable to catheterize or only with surgical assistance groups, a conversion to being fully able to independently catheterize was seen in only 8.6% and 10.9%, respectively. Worsening of UE motor function was rare (Figure 2).

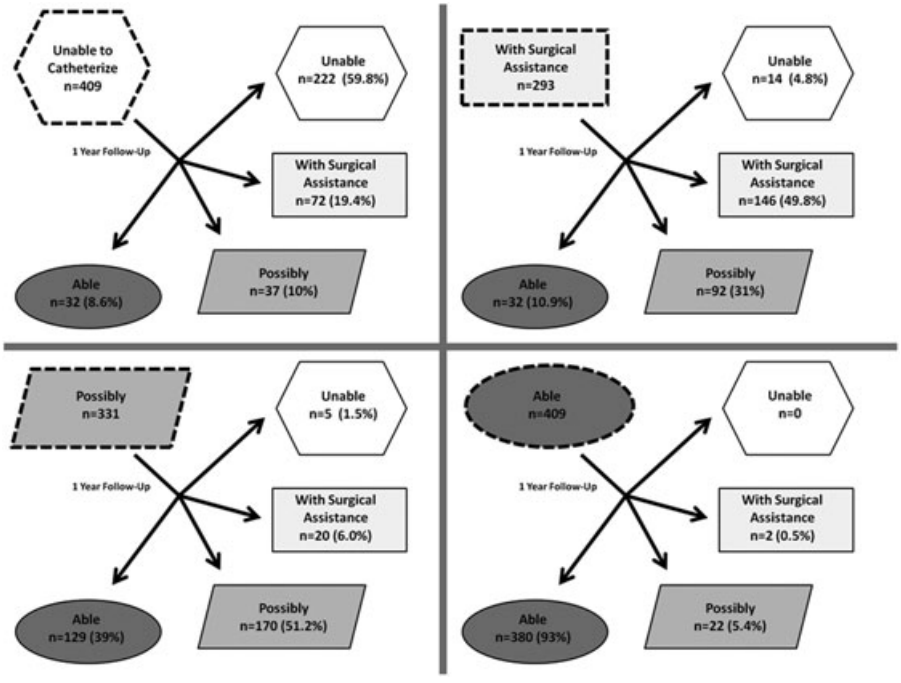

FIGURE 2 Changes observed in upper extremity motor function as it pertains to predicted ability to independently self-catheterize upon discharge from rehabilitation to 1-year follow-up

When evaluating characteristics associated with improvements in UE motor function, an increased degree of neurologic sparing and improvement in AIS classification during the first year of follow-up were found to be significant predictors. In particular, when evaluating the rate of conversion from less than able UE motor function to being able to independently self-catheterize, there appeared to be a stepwise progression with degree of preserved neurologic function (AIS A = 8.1%, AIS B = 13.8%, AIS C = 20.8%, and AIS D = 48.7%; $P < 0.001$). This was similarly seen in those with an improved AIS classification over the first year of follow-up, though to a lesser degree (18.2% improvement in those not changing AIS classification versus 25.1% in those with improvement; $P < 0.04$). These trends continued to be present on multivariate modeling (odds ratio [OR] = 1.44 for AIS C and OR = 1.97 for AIS D compared with AIS A and OR = 1.90 for AIS classification improvement versus stable AIS classification; $P < 0.05$ for each; Table 2). Interestingly, when focusing on those predicted to possibly be able to independently catheterize at the time of discharge (the group most like to convert to being able to independently self-catheterize over the first year), the only variable predictive of a conversion to "able to independently catheterize" was AIS classification at the time of rehabilitation discharge.

4 | DISCUSSION

Overall, we find that improvements in UE motor function, as it pertains to the ability to independently self-catheterize, occur in ~40% of those with SCI during the first year after rehabilitation discharge. The end predicted ability to independently perform CIC is often predicated by the initial degree of UE motor function and the extent of improvement varies by AIS classification. Improvements in AIS classification over time also slightly modify the degree of recovery.

Our work accomplishes our aim of enhancing reconstructive counseling with regard to bladder management after SCI. Specifically, in those desiring to independently perform CIC but with unfavorable UE motor function and more neurologically complete SCI, waiting up to a year after injury before considering reconstructive procedures to improve CIC accessibility (tendon transfer, catheterizable stoma creation) may be unnecessary. On the other hand, in those with more favorable UE motor function and incomplete neurological injuries at the time of discharge from rehabilitation, a more extended "wait-and-see" approach might serve to avoid unnecessary procedures.

The study findings are also useful when considering nonsurgical bladder management strategies in the newly injured SCI population who cannot volitionally void, especially in the setting of trying to clinically estimate the potential for improvement in UE motor function to independently perform the task of intermittent catheterization. Specifically, in someone with UE motor function deemed possibly able to perform CIC, our data would suggest that 40% will improve in the first year of recovery and convert to the "able" category. Conversely, in those with UE motor function predicted to be unable to catheterize or only to able to catheterize with surgical assistance, as few as 10% might be expected to improve to the "able" category. Further information such as AIS classification would also assist the decision-making process, as those with AIS C/D SCI are more likely to improve over the first year after injury compared with AIS A and B cohorts.

Our work builds upon prior studies suggesting that at least one motor level of improvement will occur in most persons with SCI and that this will occur more often in those with incomplete injury.[12–15] Furthermore, we augment the work of Kalsi-Ryan et al[13] who demonstrated specific improvements in UE motor function over the first year of injury in a small SCI cohort ($n = 53$) with the Graded Redefined Assessment of Strength, Sensibility and Prehension (GRASSP), Capabilities of Upper Extremity Questionnaire (CUE-Q), and Spinal Cord Independence Measure (SCIM-III) instruments. Specifically, however, we focus on the performance of a single, albeit important task in the daily management of someone with SCI (bladder management) rather than using motor level alone or task nonspecific tools as a primary endpoint.

TABLE 2 Multivariate logistic regression modeling of factors likely to predict an improvement in upper extremity motor function needed to independently self-catheterize 1 year after discharge from rehabilitation

Variables	OR (95% CI)	*P*
Age	1.00 (0.99-1.00)	0.964
Sex		
Male	Reference	…
Female	1.17 (0.88-1.56)	0.268
Race/ethnicity		
White	Reference	…
Black	0.87 (0.65-1.15)	0.322
Asian	1.59 (0.63-3.98)	0.325
Other	1.32 (0.55-3.13)	0.534
AIS Class		
A	Reference	…
B	1.18 (0.83-1.66)	0.359
C	1.44 (1.01-2.04)	0.042
D	1.97 (1.42-2.74)	<0.001
AIS Class improvement	1.91 (1.39-2.62)	<0.001

Abbreviations: AIS, Association Impairment Scale; CI, confidence interval; OR, odds ratio.

Several limitations to our work exist, the most important being that our algorithm to predict the ability to independently perform CIC based on UE motor function examination is based on expert opinion and not previously validated. In addition, the fact that only 40% of the participants in the NSCID cohort underwent a motor examination at their 1-year follow-up could potentially bias our findings, though no appreciable differences in demographic or injury characteristics appear to exist between the two groups. Furthermore, we must acknowledge that UE motor strength is only one of many features contributing to one's choice of bladder management after SCI and may not be relevant for certain individuals. Finally, our prior research has suggested that any UE motor classification less than able to independently perform CIC is associated with a lack of CIC adoption in the long term.[5] Thus, small increases in UE motor function to an ability less than "able" may not be clinically significant with regard to bladder management.

Despite these limitations, our findings provide a unique insight into neurologic improvements that may change the predicted ability to perform CIC in the first year after SCI. Given the findings of others, specifically that most improvements in motor function occur during the first year after SCI, our ability to follow standardized motor function over the first year after injury likely captures the vast amount of neurologic recovery that will occur.[12] Our use of the NSCID also affords us the ability to follow a large number of persons (>1000) with new-onset cervical SCI over the first year after their injury, something that would be quite difficult to do in any single institution series. Additionally, as the NSCID comprises approximately 15% of the national SCI population, our study cohort is highly representative.[1] Finally, our use of a specific task (the ability to perform CIC), allows us to focus on a patient-centric goal, provides insight into expected improvements in its performance over time and is likely more intuitive to understand than trying to grasp the significance of improving motor levels alone (ie, C5 to C6).

5 | CONCLUSION

Improvements in UE motor function necessary to independently perform CIC are observed in approximately 40% of persons with cervical spine injury within the first year after discharge from inpatient rehabilitation. At 1-year follow-up, those with higher baseline levels of UE motor function are more likely to be classified as independently able to catheterize. The degree of recovery in the predicted ability to perform CIC is modified by the completeness of injury, with those sustaining incomplete injuries more likely to improve. These findings should help enhance patient counseling in terms of appropriate bladder management strategies and further guide surgeons on an appropriate timeline for offering reconstructive surgery.

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