Research Article

Variables affecting functional improvement in chordoma patients admitted to an inpatient rehabilitation facility: A retrospective review

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Study Design: Retrospective chart review of patients after surgical resection of chordoma admitted to an inpatient rehabilitation facility.

Objective: To evaluate the characteristics associated with improving two or more functional levels and therefore classifying as a substantial responder after an inpatient rehabilitation facility stay in post-resection chordoma patients.

Setting: Acute inpatient rehabilitation facility in the United States.

Methods: A total of 40 patients were admitted to an inpatient rehabilitation facility from 2010–2015 after chordoma resection. Demographics, tumor management information, lengths of stay and functional independence measures on admission and discharge were collected. Substantial responders were identified as individuals who improved two or more functional levels based on total FIM score change. Logistic regression was used to analyze the available data for association of quantitative and categorical variables with being a substantial responder.

Results: The categorical variables analyzed in this study (sex, readmission to an acute hospital, Charlson Comorbidity Index, tumor level, nerve sacrifice, recurrent tumor and metastases) were not associated with being a substantial responder. The quantitative variables age and length of stay at the inpatient rehabilitation facility were individually associated with being a substantial responder, while length of stay at the acute hospital was not.

Conclusions: Patients who were younger were more likely to be classified as substantial responders. Patients with longer lengths of stay at the inpatient rehabilitation facility were also more likely to be classified as substantial responders.

Keywords: Chordoma, Rehabilitation, Activities of daily living

Introduction

Chordomas are slow growing tumors that account for almost 20% of bony tumors within the axial spine and are thought to develop from notochord remnants.^{1–3} These tumors present with vague symptoms such as pain, bladder or bowel incontinence, neurologic dysfunction or paresthesias in the fifth or sixth decade and can be visualized on MRI or CT.^{1,4–8} Surgical resection is the optimal treatment of these tumors, though targeted chemotherapy and radiation play a role.^{9–12}

Surgical resection can be extensive and result in neurologic dysfunction as the tumors can be quite locally aggressive and recur with incomplete removal.^{13–16}

Post-operatively, chordoma resection can result in complications such as dural tears and hardware failure, the latter of which can present years after resection.^{3,17} Wound complications, such as infection, drainage and dehiscence, occur in 30–50% of cases.^{5,18} Motor and sensory impairments in addition to bowel, bladder and sexual dysfunction are dependent on the level of tumor involvement and surgical resection.^{5,14,18–20} Close monitoring of the medical care of these patients is imperative to prevent complications

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and many are discharged to rehabilitation facilities post-operatively.

Rehabilitation of chordoma patients after resection at inpatient rehabilitation facilities (IRFs) aims to improve functional outcomes. Patients with chordomas are admitted to rehabilitation facilities to improve independence with activities of daily living (ADLs), bowel and bladder management, mobility, transfers and strength. The purpose of this study was to determine the characteristics of chordoma patients admitted to an IRF who experienced substantial functional improvement after a rehabilitation stay compared to those who did not improve as well. It will also ideally provide guidance based on individual patient characteristics on likelihood of functional improvement after an IRF stay for a patient after a chordoma resection. This comparative analysis will help health care providers form appropriate rehabilitative goals for chordoma patients upon admission to an IRF for optimal functional phenotyping.

Methods

Procedure

This study received approval from the institutional internal review board. Potential patients for inclusion in the study who were admitted to an academic inpatient rehabilitation facility with the diagnosis of chordoma from 2010–2015 were identified using ICD-9 codes 170.2 (malignant neoplasm of vertebral column, excluding sacrum and coccyx) and 170.6 (malignant neoplasm of pelvic bones, sacrum and coccyx) and ICD-10 codes C41.2 (malignant neoplasm of vertebral column, excluding sacrum and coccyx) and C41.4 (malignant neoplasm of pelvic bones, sacrum and coccyx). A total of 44 patients were identified using these diagnostic codes over the 6 year time period and 4 were excluded after review of the medical records as they did not have a diagnosis of chordoma. As a result, 40 patients with chordoma were included in this study. Demographic data including age, sex and prior medical history (interpreted using the Charlson Comorbidity Index)²¹ in addition to level of chordoma and other details of operative and post-operative care and complications were collected. This information was compared to an available chordoma database from a specialized chordoma center who referred many patients to the IRF.

The functional status of the individual chordoma patients was collected on admission and discharge from the IRF based on the Functional Independence Measures (FIM) scores. The FIM score is a reflection of the level of independence for mobility including transfers and locomotion, activities of daily living,

sphincter control and cognition. Each of these motor or cognitive domains is scored on a 1 to 7 scale, with 1 as completely dependent for the activity and 7 as completely independent for the activity. Total FIM scores can classify patients based on 7 levels: (1) dependent, score 18–35; (2) maximal assistance, score 36–53; (3) moderate assistance, score 54–71; (4) minimal contact assistance, score 72–89; (5) supervised/set up, score 90–107; (6) modified independence, score 108–125; (7) independence, score greater than 126.²²

After reviewing the admission and discharge functional independence measure (FIM) score changes, the patients were separated into one of two groups as either “substantial responders” or “limited responders” to an inpatient rehabilitation stay based using the scale above, which is based on a similar study classification using the change in FIM score.²² The purpose of this distinction was to determine if there are any patient-specific, medical, surgical or rehabilitative characteristics of those who made substantial functional gains while at an IRF after surgical resection. Substantial responders were classified as patients who experienced functional improvement by achieving a change in the above FIM classification based on their total score by 2 or more levels, such as transitioning from a (3) moderate assistance level to a (5) supervised/set up level.²² Limited responders were classified as patients who did not experience as much functional improvement, as they did not experience a change in total FIM scores by 2 or more levels.²² The characteristics of these two groups were examined to determine what, if any, demographic, medical, surgical or rehabilitative details contributed to the level of functional improvement at IRF. Investigated variables for influencing whether someone was a substantial responder included categorical and quantitative variables. Categorical variables analyzed included female sex, readmission to an acute hospital during IRF stay, CCI, level of chordoma (cervical/thoracic, lumbar, sacral/coccygeal), surgical nerve sacrifice, recurrent tumor and metastatic disease on admission to the IRF. Quantitative variables were age, length of stay (LOS) at the acute hospital, and LOS at the IRF. Accurate details for bowel and bladder function were absent for some patients, and so this information was excluded from analysis.

Statistical analysis

Descriptive statistics were used for substantial and limited responder characteristics. T-tests were used for quantitative variables while χ^2 tests were used for categorical variables. For ease of statistical analysis based on limited numbers, cervical and thoracic chordomas were

considered one category, sacral and coccygeal chordomas were considered a second category, and lumbar chordomas were considered in a third separate category for chordoma levels. Logistic regression was used to determine whether each categorical or quantitative variable predicted the designation of a substantial responder or a limited responder. Given the small number of participants in the analysis, the analysis was performed by looking at the potential predictors one variable at a time. A model including each predictor that had a P-value <0.2 was included, and then these were narrowed down based upon a P-value cutoff of 0.05. Once a final model was constructed, the c-statistic was used to determine the discriminatory capability of the model while the calibration was assessed with the Hosmer-Lemeshow test. The final model also had internal validity assessed using bootstrap resampling with 1,000 replications.²³ Linearity was checked for each of the quantitative variables.

Results

There were 40 patients included for analysis in this study as the other four initially identified patients were excluded because they did not have a diagnosis of chordoma. The average age of the study population was 52.5 ± 15.2 years and there were 57.5% men and 42.5% women. The majority of the primary tumor sites were the sacral (18 cases) and lumbar (15 cases) regions. Other tumor sites included the thoracic region (4 cases), coccygeal region (2 cases) and cervical region (1 case). As there was only one case of cervical chordoma in this study population, this case was included in the thoracic group for statistical analysis. Most cases admitted to IRF were of primary tumor resection (33 cases) and all patients except for one functioned independently prior to tumor resection. A total of eight patients had metastatic disease when admitted to the IRF; metastases were located in the lung, liver, bone or lymph nodes. A comprehensive collection of demographic data is listed in Table 1 for substantial responders and limited responders. Table 2 demonstrates the number of individuals who had a change in FIM category, with 0 representing those who did not change category, 1 representing those who increased one category, 2 representing those that increased two FIM categories, and so on from admission to discharge.

We were able to evaluate the response capacity for functional change because all 40 patients had the potential to become a substantial responder, as the highest total FIM score on admission was 87, corresponding to a (4) minimal contact assistance level. In total, 29 patients (or 72.5% of this study group) were ruled to

Table 1 Demographic data.

	Substantial Responder	Limited Responder	P-value
Number of subjects	29	11	
Mean age (years)	49.8 ± 15.1	59.5 ± 13.6	0.07
Female	14	3	0.23
LOS at acute hospital (days)	26.7 ± 23.9	22.0 ± 13.2	0.55
LOS at the IRF (days)	42.9 ± 27.5	17.6 ± 10.4	0.01
Readmitted to acute hospital	9	4	0.75
Charlson Comorbidity Index			
0	16	7	0.74
1	4	1	
2	6	1	
3+	3	2	
Nerve sacrificed	14	4	0.50
Recurrent tumor	5	2	0.94
Metastatic disease	6	2	0.86

be substantial responders and 11 patients (27.5%) were determined to be limited responders. Two of the individuals within the limited responder category did not change FIM categories.

Table 3 shows the odds ratio for each categorical and quantitative variable examined by logistic regression based upon one variable at a time. The odds ratio for a female was 2.49 ± 1.92 . The odds ratio of those readmitted to an acute hospital during the IRF stay was 0.79 ± 0.59 . For the CCI, a score of 1 had a corresponding odds ratio of 1.75 ± 2.11 , a score of 2 had an odds ratio of 2.63 ± 3.07 and a score of 3 or more had an odds ratio of 0.66 ± 0.67 . The cervical/thoracic chordomas were used as the control for determining the odds ratio for substantial and limited responders for the lumbar and sacral/coccygeal group. The odds ratio for the lumbar tumor level was 4.13 ± 4.47 and the odds ratio for the sacral/coccygeal tumor level was 6.00 ± 6.42 . For nerve sacrifice, the odds ratio was 1.63 ± 1.19 . The odds ratio for recurrent tumor (versus primary tumor) was 0.94 ± 0.87 . The odds ratio for metastases was 1.17 ± 1.06 . Substantial responders

Table 2 Change in FIM categories, based on total FIM scores, from admission to discharge.

Number of categories moved	Number of individuals	Percentage
0	2	5.0%
1	9	22.5%
2	20	50.0%
3	8	20.0%
4	1	2.5%

Table 3 Odds ratio for categorical and quantitative variables in models estimated with just one predictor or covariate at a time.

Variable	Odds Ratio	95% Confidence Interval	c-statistic	P-value
Female	2.49 ± 1.92	0.55–11.31	0.61	0.24
Readmitted to acute hospital	0.79 ± 0.59	0.18–3.39	0.53	0.75
CCI (0 as base)				
1	1.75 ± 2.11	0.16–18.62	0.60	0.64
2	2.63 ± 3.07	0.26–26.07		0.41
3	0.66 ± 0.67	0.09–4.84		0.68
Tumor level				
Lumbar	4.13 ± 4.47	0.49–34.50	0.63	0.19
Sacral/coccygeal	6.00 ± 6.42	0.74–48.90		0.09
Presence of nerve sacrifice	1.63 ± 1.19	0.39–6.81	0.56	0.50
Recurrent Tumor	0.94 ± 0.87	0.15–5.73	0.50	0.94
Metastases	1.17 ± 1.06	0.20–6.93	0.51	0.86
Age	0.95 ± 0.03	0.90–1.00	0.70	0.08
LOS acute hospital	1.01 ± 0.02	0.97–1.05	0.48	0.54
LOS at the IRF	1.09 ± 0.04	1.02–1.16	0.81	0.01

had metastases to bone, lung or lymph nodes, while limited responders had metastases to the liver or lung. As can be seen in Table 3, the low c-statistics for these categorical variables (which vary between 0.5–0.6) are minimally better than chance for the classification of a substantial responder.

For quantitative variables, age, length of stay at the acute hospital and length of stay at the IRF were examined. The odds ratio for age was 0.95 ± 0.03 with a c-statistic of 0.70, demonstrating that older individuals were less likely to be classified as substantial responders. A quadratic, non-linear relationship for age and substantial responders had a P-value greater than 0.5. For LOS at the acute hospital, the odds ratio was 1.01 ± 0.02 with a low c-statistic of 0.48, suggesting that LOS at the acute hospital is not related to being a substantial responder. The odds ratio for the LOS at the IRF was 1.09 ± 0.04 with a P-value of 0.01, which is statistically significant and also had a high c-statistic (0.81).

In the final logistic model, the odds ratio for age was 0.92 ± 0.04 and for LOS at the IRF was 1.11 ± 0.05 as can be seen in Table 4. Other categorical and quantitative variables such as level of chordoma and sex were not included as they were not statistically significant. In the final model, older individuals were found to less likely be substantial responders, with odds decreasing 8.3% for each additional year of age. The average age of substantial responders was 49.8 ± 15.1 and the average age of limited responders was 59.5 ± 13.6 . The odds of

being a substantial responder increased approximately 11% for each additional day at the IRF. The average length of stay for substantial responders was 42.9 ± 27.5 days and for limited responders was 17.6 ± 10.4 days. In the final model, the c-statistic was 0.89 and the goodness-of-fit test had a P-value of 0.94. Based on bootstrap analysis with 1,000 replications for internal validation, age and length of stay at the IRF were independently statistically significant.

Discussion

Improved survival in the chordoma population after surgical resection is an achievable goal as a result of improved disease treatment with surgery, targeted chemotherapy and radiation.^{9,11,24} Improved function in the chordoma population after surgical resection or other treatment should also be an achievable goal. Post-operative stays at inpatient rehabilitation facilities are meant to improve patient function in a multitude of dimensions. Based on logistic regression analysis, chordoma patients can anticipate becoming a substantial responder—in other words, achieve two or more levels of improved independence—after an inpatient rehabilitation stay if they have a longer length of stay at the IRF or if they are younger in age. Variables such as sex, readmission to the acute hospital, medical comorbidities, recurrent tumor, nerve sacrifice, presence of metastases, LOS at the acute hospital and location of chordoma in the cervical, thoracic, lumbar, sacral or coccygeal regions of the spine did not statistically affect whether an individual had substantial improvement while at an IRF. The variables that statistically affected substantial improvement at the IRF were either a younger age or a longer length of stay at the IRF.

Table 4 Final model for a substantial responder.

Variable	Odds Ratio	95% Confidence Interval	P-value
Age	0.92 ± 0.04	0.85–0.99	0.03
LOS at the IRF	1.11 ± 0.05	1.03–1.21	0.01

The results of this study demonstrate that patients who are younger or have longer stays at an IRF have more functional improvement after chordoma resection. Theoretically, younger patients have less comorbidities and are overall healthier with better fitness levels than older patients. Longer IRF stays result in more therapy, thereby improving overall function. Substantial responders had longer LOS at IRF compared to limited responders. Potentially, substantial responders had ongoing functional improvement and were allowed to continue at IRF for therapy compared to limited responders. Additionally, other factors not analyzed in this study may have influenced limited responders to have shorter LOS at IRF. While we did not evaluate whether being a substantial responder to an IRF stay was associated with longer survival, other studies have demonstrated that improved function after an IRF stay results in improved survival in cancer patients.^{22,25} The functional results from this study are important to chordoma patients and family members in addition to the health care provider team for appropriate goal-setting for an IRF stay. Future studies can investigate the outpatient therapy setting for achieving functional goals in the chordoma population and also investigate other cancer populations and rehabilitation settings.

The biggest limitations of this analysis include the lack of a control group, the small sample size, and the availability of only two time points for data collection. The change in FIM between substantial and limited responders may correlate with length of time from resection and overall healing from surgery alone rather than functional gains from an IRF stay. This study is unable to determine whether the FIM gains were the direct result of the IRF rehabilitation program or the result of time and normal recovery post-operatively based upon the retrospective study design. A prospective study evaluating FIM scores at predetermined times would be better to evaluate this limitation. As mentioned in the Results, only one case of cervical chordoma was included in our analysis. For purposes of statistical analysis, this case was included in the category of the thoracic chordomas as we did not want to exclude it from our study. Understandably, cervical chordomas would present with tetraplegia rather than paraplegia in the clinical setting and could potentially influence the designation of a substantial responder. However, given we only had one case of cervical chordoma and did not want to falsely influence the results, we included it for statistical purposes with the thoracic chordomas. Another limitation of the small data sample size influenced the LOS while at IRF; everyone with a LOS of

at least 40 days was identified as a substantial responder. Another limitation was the study design, as it was not blinded and had no long-term follow up. While all patients had the potential to become a substantial responder, ascending two levels may not have been equally feasible for all patients depending on the starting FIM at the time of admission. Because FIM can be a subjective measure, patients may have scored slightly differently and thus affected the classification. Lastly, a limitation of the study is the patient population, as it only investigated chordoma patients and not the general cancer population. The small sample size of 40 patients made the number of cofounders difficult to control and limited the statistical analysis. We also did not have data on all medical comorbidities such as the presence of deep vein thromboses or pressure ulcers, which could have influenced the shorter length of stay at the IRF for limited responders.

The results of this study should not be used to determine whether chordoma patients are admitted to an IRF based upon demographic factors. While the FIM scores for limited responders may not have improved as much as those for substantial responders, overall all chordoma patients admitted to the IRF in this study had improvement in function. Instead, the purpose of this study was to examine variables that were associated with more functional improvement after an IRF stay, with the intent to serve as assistance for appropriate goal-setting upon an IRF admission. Patient-specific factors such as prior and current functional status and the ability to participate in three hours of therapy per day rather than theoretical models should determine appropriateness for an IRF stay after chordoma resection, and patients should not be discriminated against based on the results of this study.

Despite the limitations of this study, the results are important for health care practitioners taking care of chordoma patients after surgical resection of tumor in order to consider realistic functional goals after an IRF stay. Future prospective study can investigate the significance of FIM change as a result of time from surgical healing compared to a rehabilitation program in an IRF setting. In conclusion, patients who were younger in age or who had longer inpatient rehabilitation facility lengths of stay were classified as substantial responders by improving two or more functional levels.

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