Trends in the presentation, surgical treatment, and outcomes of tethered cord syndrome: A nationwide study from 2001 to 2010

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ABSTRACT

Objective: This is a nationwide query into surgical management techniques for tethered cord syndrome, focusing on patient demographic, hospital characteristics, and treatment outcomes. Our hypothesis is that detethering vs. fusion for TCS results in different in-hospital complications.
Materials and methods: Retrospective review of the Nationwide Inpatient Sample 2001–2010. Inclusion: TCS discharges undergoing detethering or fusion. Sub-analysis compared TCS cases by age (pediatric [≤9 years] vs. adolescent [10–18 year]). Independent *t*-tests identified differences between fusion and detethering for hospital-related and surgical factors; multivariate analysis investigated procedure as a risk factor for complications/mortality.
Results: 6457 TCS discharges: 5844 detetherings, 613 fusions. Fusion TCS had higher baseline Deyo Index (0.16 vs. 0.06), procedure-related complications (21.3% vs. 7.63%), and mortality (0.33% vs. 0.09%) than detethering, all $p < 0.001$. Detethering for TCS was a significant factor for reducing mortality (OR 0.195, $p < 0.001$), cardiac (OR 0.27, $p < 0.001$), respiratory (OR 0.26, $p < 0.001$), digestive system (OR 0.32, $p < 0.001$), puncture nerve/vessel (OR 0.56, $p = 0.009$), wound (OR 0.25, $p < 0.001$), infection (OR 0.29, $p < 0.001$), posthemorrhagic anemia (OR 0.04, $p = 0.002$), ARDS (OR 0.13, $p < 0.001$), and venous thrombotic (OR 0.53, $p = 0.043$) complications. Detethering increased nervous system (OR 1.34, $p = 0.049$) and urinary (OR 2.60, $p < 0.001$) complications. Adolescent TCS had higher Deyo score (0.08 vs. 0.03, $p < 0.001$), LOS (5.77 vs. 4.13 days, $p < 0.001$), and charges ($54,592.28 vs. $33,043.83, $p < 0.001$), but similar mortality. Adolescent TCS discharges had increased prevalence of all procedure-related complications, and higher overall complication rate (11.10% vs. 5.08%, $p < 0.001$) than pediatric.
Conclusions: With fusion identified as a significant risk factor for mortality and multiple procedure-related complications in TCS surgical patients, this study could aid surgeons in counseling TCS patients to optimize outcomes.

1. Introduction

Tethered cord syndrome (TCS) is a clinical condition that has been well described in the literature. The characteristic features of TCS include neurological, musculoskeletal, and gastrointestinal abnormalities, due to an affixed conus medullaris to the sacrum, often the result of an enlarged filum terminale. Widely understood as a congenital condition, the pathophysiology of TCS has been well-established in pediatric patients, but less so in adult cases, wherein the etiology is less certain. Multiple reports of primary and secondary conditions have been associated with TCS. These include myelomeningocele (32% TCS prevalence), scoliosis (20% TCS prevalence), genetic associations (22q11.2 deletion syndrome & TBX1 mutations), Rubinstein-Taybi syndrome, and VACTERL association (39% TCS prevalence) [1–6].

The management of TCS is similarly uncertain, with reports advocating both for the effectiveness of conservative treatment in symptom improvement, and surgical benefits of detethering [7,8]. Recent searches of the National Guidelines Clearing House yielded no consensus guidelines for the treatment of TCS [1]. The presence of the aforementioned primary and secondary conditions with TCS lends itself to multiple modalities of surgically correcting the underlying causes. Given conflicting reports in current, this analysis was a nationwide query into the surgical management techniques for TCS, with a focus on patient demographics, hospital characteristics, and treatment outcomes.

Detethering techniques can generally be approached through an L5 laminectomy with occasional S1 laminectomy for further exposure of the filum terminale [9]. Using this approach, access to the spinal cord is achieved and detethering can occur. Recent reports of complications using detethering techniques have ranged from 17.0% to 27.5% with 5% to 50% of patients experiencing retethering, thus requiring additional surgical intervention [10–12]. Because TCS has been concurrently associated with scoliosis, there has been an increased interest in utilizing spinal fusion in the treatment of these patients. Mehta et al. retrospectively reviewed patients undergoing simultaneous spinal cord untethering and deformity correction with fusion for scoliosis and/or kyphosis and compared these patients with a cohort that underwent a 2-staged untethering followed by fusion. Their results revealed the 2-staged cohort experiencing longer operative times; greater blood loss; longer hospitalizations; and greater incidences of dural tears, wound infection, and retethering [13]. These results raise the question of whether or not to pursue spinal fusion as a primary approach.

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To the best of our knowledge, no studies have analyzed outcome differences between detethering and fusion techniques in TCS patients. While there have been reports looking into the complications of TCS detethering, these studies have been limited to single-institutions and have been geographically-limited in terms of its sample, thus reducing the generalizability of their results [1,9–13]. By utilizing the Nationwide Inpatient Sample (NIS) database, a more representative sample could be achieved, thus achieving a greater statistical power. The goal of this study is to comprehensively evaluate detethering and fusion approaches to TCS with the hope of guiding decision-making when choosing between surgical approaches.

2. Materials and methods

2.1. Data sample

This study was a retrospective review of the Nationwide Inpatient Sample (NIS) from 2001 to 2010. The NIS is the largest all-payer database available in the United States, containing approximately 8 million annual discharges. The database draws data from about 1000 hospitals in 45 states, representing an approximate 20% stratified sample of community hospitals [15]. The NIS database provides 100 data elements, with diagnoses and procedural data available in *International Classification of Disease, Ninth Revision, Clinical Modification (ICD-9-CM)* format. National estimated are calculated using annual discharge weight files. A detailed design overview of the NIS is available at http://www.hcup-us.ahrq.gov/db/nation/nis/NIS_Introduction_2010.jsp [14].

2.2. Inclusion criteria

Inclusion criteria were discharges diagnosed with TCS (ICD-9-CM code 742.59). The detethering cohort included TCS patients who underwent laminectomies: decompression of the spinal canal (03.09), excision of an intervertebral disc (80.51), excision of spinal cord or meninges lesion (03.4), or repair of spinal cord structures (03.59). The detethering cohort excluded patients who underwent spinal fusion, insertion of recombinant bone morphogenetic protein, or insertion of an interbody spinal fusion device in order to restrict fusion patients from this group (81.00–81.09, 84.52, and 84.51, respectively). The fusion cohort included TCS patients who underwent spinal fusion (81.00–81.09).

2.3. Analysis of variables

Demographic and comorbidity data, as well as hospital characteristics were collected for each included discharge.

TCS age sub-analysis compared TCS patients based upon age group between a pediatric population (≤9 years old) and an adolescent population (ages 10–18).

2.4. Statistical analysis

Statistical analysis was performed using R software. Multiple logistic regression models were developed to identify demographic, comorbidity, and surgical parameters associated with increased morbidity and mortality, adjusting for race as a covariate. The individual predictors were age, gender, individual comorbidities, revision status, levels fused (4–8 vs. 9+), and diagnosis subgroup (degenerative vs. congenital vs. idiopathic vs. other).

3. Results

3.1. Patient population

6,457 TCS discharges were identified from 2001 to 2010 (5844 underwent detethering, while 613 had fusions) (Table 1). Fusion TCS patients were on average older (32.65 vs. 16.17 years, $p < 0.001$) though a greater percentage of discharges ages 0–44 received detetherings (88.79% vs. 67.21%, $p < 0.001$). Males underwent detethering more readily (40.64% vs. 37.52%, $p < 0.001$) while females were fused more often (62.48% vs. 59.36%, $p < 0.001$). Fusion TCS cases also presented with greater overall Deyo Index at baseline (0.16 vs. 0.06, $p < 0.001$). TCS patients differed signifi-

Table 1
Patient demographics and healthcare system-related characteristics between patients with TCS undergoing detethering or fusion spinal surgery.

Spine surgery type	Detethering	Fusion	*P*-value
N (sample size)	5844	613	
	% of Total	% of Total	
Age (years)			<0.0001
Mean age	16.17	32.65	
0–44	88.79	67.21	
45–64	9.72	24.63	
65–74	0.98	5.38	
75+	0.52	2.77	
Gender			<0.0001
Male	40.64	37.52	
Female	59.36	62.48	
Race			<0.0001
White	68.59	72.35	
Black	5.31	7.69	
Hispanic	16.15	10.81	
Other	9.95	9.15	
Insurance			<0.0001
Medicare	5.45	15.88	
Medicaid	27.55	22.09	
Private/HMO	59.76	54.66	
Other	7.24	7.36	
Discharge status			<0.0001
Routine	92.06	80.69	
Short term hospital	0.36	0.33	
Other transfers	3.56	11.62	
Home health care	3.90	7.04	
Against medical advice	0.02	0.00	
Died in hospital	0.09	0.33	
Alive, destination unknown	0.02	0.00	
Small hospital size			<0.0001
Small rural nonteaching	0.05	0.00	
Small rural teaching	0.00	0.00	
Small urban nonteaching	1.13	3.11	
Small urban teaching	14.93	9.00	
Total	16.11	12.11	
Medium hospital size			<0.0001
Medium rural nonteaching	0.00	0.00	
Medium rural teaching	0.00	0.00	
Medium urban nonteaching	1.10	3.93	
Medium urban teaching	17.31	19.64	
Total	18.41	23.57	
Large hospital size			<0.0001
Large rural nonteaching	0.21	1.15	
Large rural teaching	1.42	0.98	
Large urban nonteaching	6.99	8.35	
Large urban teaching	56.86	53.85	
Total	65.48	64.32	
Admission status			<0.0001
Emergency	2.90	5.55	
Urgent	8.88	7.02	
Elective	87.76	87.25	
Newborn	0.45	0.00	
Trauma center	0.02	0.18	