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30-day outcomes analysis of NSQIP-pediatric for surgical management of head and neck lymphatic malformations in children

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Abstract

Objective: Identify adverse events associated with surgical management of head and neck lymphatic malformations in children by investigating a US national database. Data source: Pediatric American College of Surgeons (ACS) National Surgical Quality Improvement Program[®] (ACS NSQIP[®] - pediatric), years 2012 – 2016.

Methods: Subjects included children under 18 years with a postoperative diagnosis of International Classification of Diseases (ICD), 9th revision code: 228.1 – lymphangioma, any site or ICD-10 code D18.1.

Results: 163 patients were identified. 67 (41.1%) were female and 96 (58.9%) were male. The median age was 4.2 years (interquartile range [IQR] 1.6 to 11.3 years). Sixty-five (39.9%) underwent head and neck procedures. 19 (11.7%) patients with 30-day adverse events were identified, with unplanned reoperation being the most common; in the head and neck surgery group, there were 5 (7.7%). There was no significant difference in the occurrence of adverse events between head and neck surgery and the non-head and neck surgery group ($p = 0.2238$).

Conclusions: No individual patient clinical factors were identified to be associated with increased rates of 30-day adverse event rates for surgical management of lymphatic malformations in children. Our investigation highlights the need for quality improvement to help decrease 30-day adverse events for surgery for this group, as the rate was quite high overall (11.7%). The wound complication rate was very low, but we observed a non-negligible number of reoperations and readmissions. Improving quality of care for surgical management of lymphatic malformations in children should focus future investigations on limiting reoperations and readmissions within the first 30 days postoperatively.

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Keywords

lymphatic malformations; NSQIP; pediatric; vascular anomalies; risk factors; complications; head and neck

Introduction

Vascular malformations are congenital lesions affecting development of vascular and lymphatic channels, which may often present in children. One of the more commonly encountered vascular malformations is lymphatic malformations. Current treatment of these lesions has shifted dramatically over the past two decades with improvements in diagnostic and interventional radiology tools. Histologically, lymphatic malformations are benign, but given their proclivity to be large, diffuse, and span across multiple tissue planes, they have been historically difficult to manage. Even though lymphatic malformations are histologically benign, they often may result in clinically malignant symptoms, including airway compromise, tracheostomy dependence, and functional limitations, such as ambulation difficulties, dysphagia, and impairment of other activities of daily living. Current approaches often are focused on control of symptoms as opposed to curative therapy to ablate or remove all of the affected tissues.^{1,2}

Improvements in surgical techniques with facial neurophysiologic monitoring and more experience with sclerotherapy techniques have been described and have allowed greater control of symptoms related to head and neck lymphatic malformations in children.^{1,3} Given that these lesions, affect multiple different organ systems and areas of the body and may present with clinically complex management problems, there has been growth in the development of multidisciplinary vascular anomalies teams all over the country.^{4,5} A recent investigation looking at national resource utilization and trends over time from 2000 to 2009 in the US demonstrated that hospital admission rates and resource utilization related to total charges appears to remain stable for pediatric inpatients with lymphatic malformations from 2000 to 2009. Early on in the history of lymphatic malformations treatment in children, surgery was a mainstay and the most commonly performed procedure, but the trend has shifted away from operative intervention. Mortality rates, while low, experienced a rise in 2009.⁶ These lesions have been found to most commonly affect kids aged 3 years and younger and pediatric patients in urban areas, as well as in the South and West regions of the country. No significant effects based on season or change in age of children or the distribution of their age were noted from year to year for inpatient hospitalizations.⁷ As we continue to expand and develop our understanding of how best to manage lymphatic malformations in children with regards to specific treatment modalities, it is important to identify adverse events for surgical management to potentially aid in identification of areas for quality improvement.

Methods

The American College of Surgeons (ACS) has developed a hospital based reporting system called the ACS National Surgical Quality Improvement Program® (ACS NSQIP®). This database was created to enhance identification of surgical morbidity and mortality and

potentially preventable complications. Data are collected from the patient's medical chart, not insurance claims; risk-adjusted; case-mix adjusted; and reports 30-day patient outcomes. Starting in 2012, children's hospitals began using this database and reporting results in the ACS NSQIP-pediatric[®] database. This data repository includes 101,887 observations from 101 participating sites in 2016; 84,056 observations from 80 sites in 2015; 68,838 observations from 64 sites in 2014; 63,387 observations from 56 sites in 2013; and 51,008 observations from 50 sites in 2012. This database presents a unique opportunity to examine clinical factors that may be associated with 30-day postsurgical adverse events in children to identify and highlight areas for quality improvement. Duke University Institutional Review Board (IRB) approval exemption was obtained prior to initiating this investigation.

Patients aged under 18 years and had the postoperative diagnosis (PODIAG and PODIAG10 variables in NSQIP-pediatric) of lymphatic malformation were identified using ICD9 code 228.1 or ICD-10 code D18.1. 2017 current procedural terminology (CPT) codes were used to identify head and neck procedures and non-head and neck procedures.

Adverse events were defined as surgical site infection (SSI), superficial wound disruption, pneumonia, reintubation, unplanned reoperations (related and not related), unplanned readmission, nerve injury, sepsis, bleeding with subsequent transfusion, prolonged length of stay (> 30 days), and mortality. Clinical factors examined and assessed for association can be found in Table 1. Categorical variables were summarized with frequency counts and percentages. A Fisher's exact tests was used to determine if there was an association between the variables and adverse events. Continuous variables are summarized with median, interquartile range (Q1 and Q3), and range (minimum and maximum). Statistical significance was assessed at $\alpha = 0.05$. Analysis was performed using SAS 9.4 (SAS Institute Inc., Cary, NC).

Results

From 2012 – 2016, a total of 163 patients were identified with a postoperative diagnosis of lymphatic malformations. 67 (41.1%) were female and 96 (58.9%) were male. The median age was 4.2 years (IQR 1.6 to 11.3 years). Almost two-thirds were white. Sixty-five (39.9%) underwent head and neck procedures, while the remaining 98 (60.1%) had non-head and neck related surgery. Very few patients, 5 (3.1%), underwent upper airway endoscopy procedures. 64 (39.3%) were performed on inpatients, and 99 (60.7%) were outpatients. Demographic information for these patients is summarized in Table 2.

There were 19 (11.7%) patients with adverse events identified; in the head and neck surgery group, there were 5 patients (7.7%). (Table 3) The most common adverse event were wound complications (including superficial/deep/organ/space SSI and superficial wound disruption; 9 patients, 5.5%). Five (3.1%) patients had unplanned reoperation, 4 (2.5%) had unplanned readmission, two (1.2%) had bleeding and transfusion needs, and 4 (2.5%) had length of stay greater than 30 days. In the head and neck group, the most common adverse event was unplanned reoperation (3 patients, 4.6%), and no mortalities or cases of nerve injury were identified. There was no significant difference in the occurrence of adverse events between head and neck surgery and the non-head and neck surgery group ($p = 0.2238$). Some of the

patients experienced multiple adverse events, which included: superficial incisional SSI (1), superficial wound disruption (1), unplanned reoperation (3), readmission (1), prolonged hospitalization > 30 days (1), and bleeding/transfusion (1). Description of clinical risk factors are displayed in Table 4.

Compared to those without adverse events, patients who had adverse events had lower percentage of premature birth (5.9% vs. 9.7%), higher percentage of tracheotomy (10.5% vs. 1.4%), structural pulmonary/airway abnormality (26.3% vs. 5.6%), cardiac risk factors (21.0% vs. 3.5%), developmental delay/impaired cognitive status (10.5% vs. 1.4%), nutritional support (21.1% vs. 1.4%), hematologic disorder (5.3% vs. 0.7%), congenital malformation (47.4% vs. 29.9%), emergent/urgent status (15.8% vs. 9.8%), contaminated wound (42.2% vs. 22.2%), and ASA 2–4 groups (68.4% vs. 62.2%). The number of adverse events and patients was insufficient to perform any further statistical analysis.

Discussion

As we strive to improve quality of care and management of lymphatic malformations in children, it may be helpful to understand where our shortcomings currently lie and which children are at greatest risks for adverse events, so that we may target those areas for quality improvement. In the past, it has been well established that the anatomic location and extent of lymphatic malformations in the head and neck was strongly associated with rates of complications.⁸ There are no prior similar investigations, using a national database, investigating clinical factors that may contribute to adverse events for surgical management of lymphatic malformations in children, as most other reports are institutional or author consecutive case series. Given the high rate of adverse events (11.7% overall and 7.7% head and neck), our results suggest that there may be room for quality improvement. Khanwalkar et al also noted significantly high rates of seroma and transient facial nerve weakness in at least one-quarter of their 46 patient cohort who underwent surgery for head and neck lymphatic malformations.⁹

We were able to identify some reassuring short-term surgical results. No mortalities were identified. Furthermore, in the head and neck area, one of the primary surgery concerns is nerve injury, but fortunately, we did not identify any cases. Bajaj et al also reported on cohort of 53 pediatric patients who underwent surgical treatment of lymphatic malformations and found no permanent nerve weakness, with almost 80% complete or near complete resolution of disease. In this investigation, all (23) patients with disease localized to the head and neck had complete or near complete resolution of disease.¹⁰ Our findings may be the result of surgical case selection, evolving surgical procedures, and/or improved treatment outcomes from interventional radiology approaches.

No prior comparisons have been made investigating head and neck location alone, as a risk factor for surgical complications, in children with lymphatic malformations. We noted no significant difference in adverse events between head and neck and non-head and neck surgical procedures. We did find that compared to those without adverse events, patients with adverse events had lower percentage of premature birth, higher percentage of tracheotomies, structural pulmonary/airway abnormality, cardiac risk factors, developmental

delay/impaired cognitive status, nutritional support, hematologic disorder, congenital malformation, emergent/urgent status, contaminated wound, and ASA 2 – 4 groups. Logically, this seems to suggest that children who were more medically fragile were more susceptible to adverse events.

As the number of adverse events and the sample size of our cohort was insufficient to perform a multivariate analysis, our investigation is significantly limited in our ability to make any interpretations regarding clinical risk factors for adverse events related to surgery for lymphatic malformations in children. Still, our investigation highlights the need for quality improvement to help decrease 30-day adverse events for surgery for this group, as the rate was quite high overall (11.7%). The wound complication rate was very low, but we observed a non-negligible number of reoperations and readmissions. Two of the unplanned reoperations in our cohort underwent drainage of a hematoma or seroma, with one other significant unplanned reoperation for tracheostomy placement. Unplanned reoperations were the most common adverse event in the head and neck surgery group, and this may be an opportune area to target for quality improvement. Further investigations may help to identify interventions to limit or significantly reduce the risk of hematoma or seroma development postoperatively, along with provide guidelines for clinical considerations for airway assessment to determine if tracheostomy placement is beneficial at the time of surgery. It may be important to note that no single or group of clinical factors seemed to have significantly high incidence of adverse events. Our investigation may have been potentially underpowered; however, given the relatively infrequent prevalence of lymphatic malformations in children and the number of included cases, it may not be practically possible or clinically relevant to study a large enough cohort to determine statistically significant thresholds for adverse events.

Significant limitations exist in our study. Lacking, is an ability to track individual patient outcomes to help develop recommendations for patient selection, along with limited follow up and outcome measures for treatment effectiveness. Lymphatic malformations can vary greatly depending on the involved area and extent. Our cohort included very few children with lymphatic malformations who had airway endoscopy procedures, so the group likely does not reflect the entire spectrum of disease. A subset of these children will have primarily laryngeal and/or upper airway involvement.¹¹ Severity of disease and clinical presentation for individual cases could not be ascertained using this database approach; thus, it is not possible to determine which patients were selected for surgery. Given that the adverse event rate was fairly low, this is encouraging, as it is possible that interventional radiology techniques are being utilized more and the role for surgical case selection appears to be able to select for those with better chances of avoiding adverse events. Prior investigations have not demonstrated any decline in hospital admissions for lymphatic malformations in children, so lower adverse event rates probably cannot be explained by decreasing prevalence.⁶ We were also limited by the 30 day postprocedure tracking time window, as well as lack of any clinical measures of treatment outcomes.

We were not able to identify any specific clinical factors associated with increased rates of adverse events. It is likely that any single or group of patient factors is not as clinically important for treatment success and/or avoidance of adverse events; moreover, given the

significant variability in the presentation of this disease in children, it is more likely that the type and extent of disease is the primary driving factor. Approaches to quality improvement may likely have the most impact when focusing on individual patient selection for surgical management, based on specific disease extent, type, and affected area, in an attempt to limit reoperations and readmissions within 30 days postoperatively.

Conclusions

Based on our investigation of a national database in the US, adverse event rates for surgical management of lymphatic malformations in children appear to be relatively high with areas for quality improvement, specifically limiting reoperations and readmissions. Head and neck location does not seem to confer increased risk of adverse events related to surgery in children with lymphatic malformations. Appropriate case selection, based on extent of disease and individual characteristics of the lymphatic malformation, for surgical management may be a key factor in limiting adverse events and optimizing treatment outcomes.

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Table 1.

Related clinical factors examined for impact on adverse events.

Age
Gender
Race (American Indian, Asian, Black or African American, Native Hawaiian, White, Unknown)
Case status (inpatient/outpatient)
Premature birth
Asthma
History of chronic lung disease or prematurity/bronchopulmonary dysplasia
Tracheostomy (yes/no)
Structural pulmonary/airway abnormalities
Cardiac risk factors
Developmental delay/impaired cognitive status
Seizure disorder
Cerebral palsy
Structural central nervous system abnormality
Neuromuscular disorder
Steroid use
Nutritional support
Hematologic disorder
Sepsis/septic shock within 48 hours prior to surgery
Congenital malformation
Case type (elective, emergent, or urgent)
Wound classification
American Society of Anesthesiologists (ASA) classification

Table 2.

Demographic information for pediatric patients with lymphatic malformations.

	Head and neck surgery (N=65)	Non-head and neck surgery (N=98)	Total (N=163)
Gender			
Female	27 (41.5%)	40 (40.8%)	67 (41.1%)
Male	38 (58.5%)	58 (59.2%)	96 (58.9%)
Race			
White	44 (67.7%)	62 (63.3%)	106 (65.0%)
Black or African American	13 (20.0%)	17 (17.3%)	30 (18.4%)
Others	8 (12.3%)	19 (19.4%)	27 (16.6%)
Age in Year			
Mean (SD)	6.2 (5.5)	6.5 (5.8)	6.4 (5.7)
Median	4.2	4.2	4.2
Q1, Q3	1.8, 9.9	1.4, 11.5	1.6, 11.3
Range	(0.0–17.5)	(0.0–17.9)	(0.0–17.9)
Inpatient/outpatient			
Inpatient	23 (35.4%)	41 (41.8%)	64 (39.3%)
Outpatient	42 (64.6%)	57 (58.2%)	99 (60.7%)

Table 3.

Adverse events associated with lymphatic malformation surgery in children.

	Head and Neck (N=65)	Others (N=98)	Total (N=163)
Adverse Events	5 (7.7%)	14 (14.3%)	19 (11.7%)
Occurrences Superficial Incisional SSI	1 (1.5%)	3 (3.1%)	4 (2.5%)
Occurrences Deep Incisional SSI	0 (0.0%)	2 (2.0%)	2 (1.2%)
Occurrences Organ/Space SSI	0 (0.0%)	1 (1.0%)	1 (0.6%)
Occurrences Superficial Wound Disruption	1 (1.9%)	1 (1.3%)	2 (1.6%)
Occurrences Wound Disruption	0 (0.0%)	0 (0.0%)	0 (0.0%)
Occurrences Pneumonia	0 (0.0%)	0 (0.0%)	0 (0.0%)
Occurrences Unplanned Intubation	0 (0.0%)	0 (0.0%)	0 (0.0%)
Unplanned Reoperation	3 (4.6%)	2 (2.0%)	5 (3.1%)
Readmission 1	1 (1.5%)	3 (3.1%)	4 (2.5%)
Nerve Injury	0 (0.0%)	0 (0.0%)	0 (0.0%)
Still in Hospital > 30 Days	1 (1.5%)	3 (3.1%)	4 (2.5%)
Death in 30 days	0 (0.0%)	0 (0.0%)	0 (0.0%)
Occurrences Sepsis	0 (0.0%)	0 (0.0%)	0 (0.0%)
Occurrences Septic Shock	0 (0.0%)	0 (0.0%)	0 (0.0%)
Occurrences Bleeding/Transfusion	1 (1.5%)	1 (1.0%)	2 (1.2%)
Occurrences CL Associated Bloodstream Infection	0 (0.0%)	0 (0.0%)	0 (0.0%)

Table 4.

Clinical risk factors

	Head and Neck (N=65)	Others (N=98)	Total (N=163)
Premature Birth			
31–32 completed weeks gestation	1 (1.8%)	0 (0.0%)	1 (0.7%)
33–34 completed weeks gestation	3 (5.3%)	2 (2.4%)	5 (3.5%)
35–36 completed weeks gestation	4 (7.0%)	3 (3.6%)	7 (5.0%)
History Asthma	4 (6.2%)	2 (2.0%)	6 (3.7%)
Bronchopulmonary Dysplasia/Chronic Lung disease	0 (0.0 %)	0 (0.0 %)	0 (0.0 %)
Tracheostomy	2 (3.1%)	2 (2.0%)	4 (2.5%)
Structural pulmonary/airway abnormality	7 (10.8%)	6 (6.1%)	13 (8.0%)
Cardiac risk factors			
Major cardiac risk factors	1 (1.5%)	2 (2.0%)	3 (1.8%)
Minor cardiac risk factors	4 (6.2%)	2 (2.0%)	6 (3.7%)
Developmental delay/impaired cognitive status	1 (1.5%)	3 (3.1%)	4 (2.5%)
Seizure Disorder	0 (0.0%)	2 (2.0%)	2 (1.2%)
Cerebral Palsy	0 (0.0%)	1 (1.0%)	1 (0.6%)
Structural CNS Abnormality	0 (0.0%)	2 (2.0%)	2 (1.2%)
Neuromuscular Disorder	0 (0.0%)	1 (1.0%)	1 (0.6%)
Steroid use (within 30 days)	2 (3.1%)	1 (1.0%)	3 (1.8%)
Nutritional support	2 (3.1%)	4 (4.1%)	6 (3.7%)
Hematologic Disorder	0 (0.0%)	2 (2.0%)	2 (1.2%)
Sepsis/Septic Shock w/I 48 hrs prior to surgery	0 (0.0%)	2 (2.0%)	2 (1.2%)
Congenital Malformation	23 (35.4%)	29 (29.6%)	52 (31.9%)
Yes, Neonate >=1500 grams at the time of surgery or infant/child/teenager with a history of a congenital defect at the time of surgery			
Case Status			
Elective	62 (95.4%)	84 (85.7%)	146 (89.6%)
Emergent	2 (3.1%)	6 (6.1%)	8 (4.9%)
Urgent	1 (1.5%)	8 (8.2%)	9 (5.5%)
Wound classification			
Clean	54 (83.1%)	69 (70.4%)	123 (75.5%)
Clean/Contaminated	10 (15.4%)	24 (24.5%)	34 (20.9%)
Contaminated	0 (0.0%)	3 (3.1%)	3 (1.8%)
Dirty/Infected	1 (1.5%)	2 (2.0%)	3 (1.8%)
ASA classification			
ASA 1 - No Disturb	29 (44.6%)	31 (32.0%)	60 (37.0%)
ASA 2 - Mild Disturb	27 (41.5%)	52 (53.6%)	79 (48.8%)
ASA 3 - Severe Disturb	7 (10.8%)	11 (11.3%)	18 (11.1%)
ASA 4 - Life Threat	2 (3.1%)	3 (3.1%)	5 (3.1%)