ORIGINAL ARTICLE

Orbital and Periorbital Infections

A National Perspective

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Objectives: To describe the epidemiologic features of pediatric orbital and periorbital infections from a national perspective and to identify predictors of surgery.

Design: Analysis of the Kids' Inpatient Database.

Setting: Administrative data set.

Patients: Pediatric inpatient admissions with an *International Classification of Diseases, Ninth Revision, Clinical Modification* diagnosis of orbital cellulitis.

Main Outcome Measures: Hospital admission, socioeconomic, and clinical variables were examined and predictors of surgical intervention were evaluated using logistic regression.

Results: A total 5440 hospital admissions was noted for pediatric orbital cellulitis; of these, 672 patients (12.4%) underwent surgical intervention. Mean length of stay for all patients was 3.8 days; 90.4% were routinely discharged. Patients who had surgery were older, with a mean (SE) age of 10.1 (0.29) years compared with 6.1 (0.10) years for nonsurgical patients ($P<.001$). Surgical patients had a significantly longer mean hospital stay (7.1 vs 3.4 days, $P<.001$) and a higher mean cost of care ($41 009 vs $13 008, $P<.001$) compared with nonsurgical patients. Demographic predictors of surgical intervention included male sex, admitting characteristics, and hospital location. Except for sex, these variables remained significant in a multivariate model. Clinically, diplopia is a predictor of surgical intervention (odds ratio, 6.3; 95% confidence interval, 3.4-11.7).

Conclusions: This study describes the medical and surgical management of pediatric orbital and periorbital infections from a national perspective. Predictors of surgical intervention include older age, presentation with diplopia, and hospital admission via the emergency department. Knowledge of these variables facilitates analysis of resource utilization for pediatric orbital cellulitis and can be used to optimally triage patients, ultimately reducing costs and lengths of stay while preserving quality of care.

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PEDIATRIC ORBITAL AND PERIorbital infections are often managed medically; however, the nature or severity of a patient's infection often progresses to the point that surgical intervention is imperative.[1] Despite the significant potential sequela and morbidity of orbital and periorbital infections, there are no national studies that help put pediatric orbital and periorbital infections into perspective regarding resource utilization and macro-level trends. There are several institutional series about the management of pediatric orbital and periorbital infections that have laid the foundation for the current knowledge and management of such infections.

Furthermore, in the management of pediatric orbital and periorbital infections, there remains controversy on the timing of and indications for surgical intervention.[2] Operative intervention is usually triggered by the identification of a periorbital or orbital abscess on sectional imaging. A scan is typically obtained after the diagnosis of significant or worsening visual impairment or a failure to improve after 24 to 48 hours of medical management.[2] Understandably, physicians vary in the precise application of these criteria and often trial medical management if the patient's clinical condition permits. However, because imaging procedures are not associated with a unique *International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)* diagnostic code, it was impossible to include their presence, absence, or timing in the analysis.[3]

Administrative data sets have recently emerged as a robust research tool to look at macro-level trends and provide a perspective on somewhat infrequently occurring disease processes that has previously been unattainable. Large national samples allow for the extraction of pertinent details

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Table 1. Demographic Characteristics of Pediatric Admissions With Orbital Cellulitis From KID 2006 (Weighted N=5440)

Characteristic	Value
Age, mean (SE), y	6.6 (0.10)
Sex, No. (%)	
Male	3191 (59.5)
Female	2173 (40.5)
LOS, mean (SE), d	3.9 (0.11)
Total charges, mean (SE), $	16 444 (805.40)
Race/ethnicity, No. (%)	
White	1993 (50.2)
Black	874 (22.0)
Hispanic	798 (20.1)
Asian/Pacific	104 (2.6)
Other	201 (5.1)

Abbreviations: KID, Kids' Inpatient Database; LOS, length of stay.

that may not be identified in smaller institutional series. The Kids' Inpatient Database (KID), published by the Agency for Healthcare Research and Quality, is one such database. KID facilitates the study of infrequent disease processes at a national or regional level to discern trends in the management and outcomes of pediatric patients and provides normative baseline data for comparison.

The objectives of this study were to use KID to report the demographic, admission, and socioeconomic characteristics of pediatric patients admitted with orbital and periorbital infections and to attempt to identify variables that may predict surgical intervention. Identification of normative data and demonstrating predictors of surgery may prove invaluable in reducing variances in care or possibly suggest avenues for targeted research to do so.

METHODS

Institutional review board approval was obtained from the Children's National Medical Center for this study. KID 2006 is a publicly available database of national inpatient data for pediatric patients, defined as those 20 years or younger. KID includes data from 38 states and more than 5100 hospitals and, as such, is a representative patient population for the purposes of studies such as this one.[4] The *ICD-9-CM* code 376.01, "orbital cellulitis," was used as the search variable (inclusion criteria) for this study. Entries in KID with orbital cellulitis as 1 of their first 15 diagnoses were included in the study sample; there were no a priori exclusion criteria.

The terms of use for KID prohibit reporting results for variables in which the sample is 10 data entries or fewer. This is done to protect the confidentiality of patients and providers and to prevent survey studies such as this one from revealing patient-level data. As such, some variables were unable to be expounded on in this study.

The study population was analyzed for the variables found in KID, including admission source and type, discharge status, length of stay, total charges, age, sex, and race/ethnicity. Concomitant diagnoses (on the basis of *ICD-9-CM* codes) were also examined.

The "total charges" variable represents the cost of treatment to the facility, rather than physician billing, and, as such, is used as a surrogate for resource utilization (operating room time, hospital beds, equipment, and others) in the course of a patient's admission.[5]

Patients with an admitting diagnosis of orbital cellulitis were classified as either surgical or nonsurgical by examining all procedures associated with each admission and creating a list of operative procedures to be used as inclusion criteria for the surgical group. Patients who had records of 1 or more of these surgical procedures in any of the 15 procedure codes were classified as surgical; all others were classified as nonsurgical.

Bivariate analysis was performed to evaluate surgical status in patients with orbital cellulitis. Variables associated with the surgical population with $P < .05$ were deemed significant predictors of surgery. These results were analyzed in a multivariate model. Weighted data are presented to provide national estimates.

RESULTS

PATIENTS ADMITTED WITH ORBITAL CELLULITIS

A weighted total of 5440 pediatric patients were admitted with a diagnosis of orbital cellulitis in 2006. Patients were 59.5% male and had a mean (SE) age of 6.6 (0.10) years. The mean (SE) length of stay was 3.9 (0.11) days, and the mean (SE) total charges associated with a patient were $16 444 ($805.40). Most patients (54.1%) were admitted through the emergency department, 39.9% were routinely admitted, and 5.9% were transferred from other facilities. Correspondingly, most admissions (85.9%) were classified as emergency (56.5%) or urgent (29.4%); 14.2% were elective. Almost all the patients (91.8%) were routinely discharged; the remainder required additional care: 3.7% at short-term facilities and 4.6% with home health care. There were fewer than 10 mortalities in the sample population, and, thus, they will not be discussed further per the data use agreement.[4] The demographics of pediatric patients admitted to the hospital with orbital cellulitis are given in **Table 1**.

CHARACTERISTICS OF PATIENTS REQUIRING SURGICAL INTERVENTION

Of the 5440 patients, 672 (SD, 46.4; 12.4%) were classified as surgical; the remaining patients were classified as nonsurgical. The surgical and nonsurgical categories were compared for to pertinent variables (**Table 2**).

Age was predictive of the need for surgery ($P < .001$); nonsurgical patients had a mean (SE) age of 6.1 (0.10) years compared with a mean (SE) of 10.1 (0.29) years in the surgical population ($P < .001$). Sex was also predictive ($P = .02$); 58.8% of nonsurgical patients were male compared with 64.7% of surgical patients. Unlike the other predictors identified in this study, patient sex was not a significant predictor of surgery in the multivariate model. Admission source ($P < .001$) was also predictive of being in the surgical group. Patients transferred from another hospital were 4.4 times as likely to be operated on compared with patients with routine admissions ($P < .001$); patients admitted through the emergency department were 1.4 times as likely to be surgical as routine admissions ($P < .001$).

A significant association was noted between surgical status and discharge status ($P < .001$). Surgical patients were discharged to home health care 3.8 times more frequently than were nonsurgical patients ($P < .001$).

Table 2. Bivariate Analyses and Predictors of Surgical Status in Patients Admitted With Orbital Cellulitis

Characteristic	Nonsurgical Weighted	Surgical Weighted	Odds Ratio (95% CI)	*P* Value
LOS, mean (SE), d	3.4 (0.11)	7.1 (0.38)	NA	<.001
Total charges, mean (SE), $	13 008 (716.8)	41 009 (2971.9)	NA	<.001
Age, mean (SE), y	6.1 (0.10)	10.1 (0.29)	NA	<.001
Sex, No. (%)				.02
Male	2761 (58.8)	430 (64.7)	1 [Reference]	
Female	1938 (41.2)	235 (35.3)	0.777 (0.624-0.968)	
Race/ethnicity, No. (%)				.27
White	1728 (49.6)	265 (54.2)	1 [Reference]	
Black	749 (21.5)	125 (25.6)	1.083 (0.781-1.501)	.63
Hispanic	719 (20.7)	79 (16.2)	0.720 (0.511-1.014)	.06
Asian/Pacific Islander	104 (3.0)	[a]	[a]	[a]
Other	181 (5.2)	20 (4.1)	0.711 (0.383-1.318)	.28
Admission source, No. (%)				<.006
Emergency department	2551 (54.1)	360 (54.5)	1.374 (1.097-1.721)	<.001
Other hospital	219 (4.6)	100 (15.2)	4.427 (3.081-6.363)	<.001
Routine birth/other	1947 (41.3)	200 (30.3)	1 [Reference]	
Admission type, No. (%)				<.001
Emergency	2358 (56.7)	313 (55.0)	1 [Reference]	
Urgent	1206 (29.0)	182 (32.0)	1.132 (0.872-1.47)	.35
Elective	595 (14.3)	74 (13.0)	0.93 (0.65-1.332)	.69
Other	[a]	[a]	[a]	[a]
Discharge, No. (%)				<.001
Routine	4362 (92.7)	564 (85.2)	1 [Reference]	
Short term	179 (3.8)	17 (2.6)	0.744 (0.398-1.388)	.35
Home health	166 (3.5)	81 (12.2)	3.766 (2.68-5.294)	<.001
Hospital region, No. (%)				.07
Northeast	1074 (22.5)	112 (16.6)	1 [Reference]	
Midwest	1055 (22.2)	147 (21.8)	1.334 (0.892-1.995)	.16
South	1668 (35.0)	248 (36.8)	1.422 (0.962-2.103)	.08
West	972 (20.4)	166 (24.7)	1.632 (1.126-2.367)	<.01
Primary payer, No. (%)				.09
Medicaid	1989 (42.0)	252 (37.7)	1 [Reference]	
Private/HMO	2359 (49.8)	367 (54.9)	1.226 (0.973-1.544)	.08
Self-pay	245 (5.2)	23 (3.4)	0.735 (0.407-1.327)	.31
Other	148 (3.1)	27 (4.0)	1.437 (0.866-2.385)	.16
Hospital location, No. (%)				.01
Rural	432 (9.4)	19 (2.9)	1 [Reference]	
Urban	41.75 (90.6)	637 (97.1)	0.842 (0.737-0.963)	
Median household income quartile, No. (%)				.91
1	1433 (30.7)	206 (31.5)	1 [Reference]	
2	1037 (22.2)	153 (23.4)	1.029 (0.767-1.38)	.85
3	1087 (23.3)	144 (22.0)	0.922 (0.693-1.225)	.57
4	1110 (23.8)	151 (23.1)	0.949 (0.711-1.267)	.72

Abbreviations: CI, confidence interval; HMO, health maintenance organization; LOS, length of stay; NA, not applicable.
[a]The variable has fewer than 10 admissions and per the data use agreement cannot be expounded on.

As expected, patients undergoing surgery had higher mean (SE) total charges vs nonsurgical patients ($41 009 [$2971.9] vs $13 008 [$716.8]; *P*<.001). Surgical patients had significantly longer mean (SE) lengths of stay than did nonsurgical patients (7.1 [0.38] days vs 3.4 [0.11] days; *P*<.001). Socioeconomic factors were not significant predictors of surgical intervention, including median household income (*P*=.91), primary payer (*P*=.09), and race/ethnicity (*P*=.27).

VARIATIONS IN CARE

Analysis using the "hospital region" variable showed that patients in the western geographic region were 1.6 times as likely to undergo surgery as patients admitted in the northeastern region (*P*<.001). Patients admitted to rural hospitals were operated on 0.842 times as frequently as were their urban counterparts (*P*=.01).

Large variations were noted between individual states regarding patient volume and the proportion of surgical patients. Two states accounted for nearly one-quarter of national admissions: California (12.1%) and New York (11.1%); 6 states (California, New York, Texas, Florida, New Jersey, and Illinois) accounted for more than half (51.6%) of all admissions among states reporting in KID 2006. Although New York had the second-highest number of admissions (n=603), it had the lowest proportion of surgical patients, with only 8.3% of patients classified as surgical. The state with the highest proportion of operative admissions was Tennessee, where 22.1% of the state's 136 admissions had surgery.

Concomitant diagnoses in patients admitted with orbital cellulitis and the association with surgical group

Table 3. Concomitant Diagnoses in the Overall Population of Patients With Orbital Cellulitis and Bivariate Analysis

Diagnosis (*ICD-9-CM* Code)	Weighted No. (%) Total	Nonsurgical	Surgical	Odds Ratio (95% CI)	*P* Value
Asthma (493.9)	**324** (6.0)	277 (5.8)	47 (7.0)	1.228 (0.834-1.807)	.30
Diplopia (368.2)	**70** (1.3)	38 (0.8)	32 (4.8)	6.289 (3.39-11.666)	<.001
Neutropenia (288)	**38** (0.7)	38 (0.8)	[a]	[a]	[a]
Ethmoidal sinusitis (461.2 or 473.2)	**846** (15.5)	578 (12.1)	268 (39.8)	4.799 (3.797-6.066)	<.001
Maxillary sinusitis (461.0 or 473.0)	**723** (13.3)	515 (10.8)	208 (31.0)	3.698 (2.9-4.714)	<.001

Abbreviations: CI, confidence interval; *ICD-9-CM*, *International Classification of Diseases, Ninth Revision, Clinical Modification*.
[a]The variable has fewer than 10 admissions and per the data use agreement cannot be expounded on.

analyses are given in **Table 3**. Many patients had asthma (6.0%), 0.7% were neutropenic, and 1.3% presented with diplopia. Several of these concomitant diagnoses proved to be significant clinical predictors of a patient's surgical status in the bivariate model. Patients who presented with diplopia (*ICD-9-CM* code 368.2) were 6.3 times (95% confidence interval, 3.4-11.7 times) as likely to be operated on as were other patients ($P < .001$).

COMMENT

The objectives of this study were to provide a macro-level description and analysis of pediatric inpatients with an orbital or periorbital infection and to identify predictors of surgical intervention. The significance of this study's results are discussed with respect to national demographics, surgical predictors, and variations in care of pediatric patients with orbital and periorbital infections.

NATIONAL DEMOGRAPHICS

Patients admitted with orbital and periorbital infections are, on average, 6.6 years old, predominantly male (59.5%), and stay in the hospital a mean of 3.9 days. The resource utilization for an admission resulted in mean total charges of $16 444. Surgical intervention was required in approximately 12% of admitted patients. Normative data such as these are invaluable in assisting individual physicians, hospitals, insurers, and regulatory agencies in benchmarking or evaluating outcomes between providers. There is a shifting onus on physicians to demonstrate the quality of the care they provide, and baseline data are imperative for such determinations.

Based on these normative data, there was significant state-to-state variation in patients admitted with orbital and periorbital infections and the associated proportion of patients who underwent surgical admission. It is interesting that a hospital in the western geographic region of the United States was predictive of higher surgical rates. Similarly, admission to a hospital in an urban location was found to be a significant predictor of surgery. The administrative data set does not allow us to research an individual patient's record, so we cannot tease out the nuances of care that lead to this discrepancy. The answer to this is best answered by a multi-institutional study from hospitals in this region or cohort compared with other institutions.

Several studies exist documenting the link between underinsurance and delayed care, especially in children,[6] and delays in care come at the risk of advanced infection in these cases. Disproportionate underinsurance, along with other factors, create disparities in care that extend to income classes and racial groups; the delay experienced by African American patients in seeking care has been well-documented.[7] From the present analysis of KID, in pediatric orbital and periorbital infections, there was no evidence that race/ethnicity, income quartile, or insurance status affects the likelihood of a patient needing surgery.

SURGICAL PREDICTORS

Several single-institution studies have found operative rates within a few percent of the rate reported herein of 12.4%.[2,8,9] Surgical patients in this study were significantly older than were nonsurgical patients, corroborating these single-institution studies.[10] A retrospective analysis[11] of pediatric inpatients with orbital cellulitis in Pittsburgh between 1971 and 1980 reported that the proportion of patients with severe orbital disease increased with increasing age. The role of sinus development may provide clarity on this finding.[12]

One of the main clinical indicators of surgery is imaging that demonstrates an abscess or potential compromise of critical structures, such as the eye or brain. However, owing to the limitations of an administrative data set, specific imaging characteristics for operative patients could not be extracted.

As expected, surgical patients had significantly longer lengths of stay. This is likely because patients who progress to surgery initially are treated with maximal medical therapy. Once medical management fails, surgery is the best option.

In the management of pediatric orbital and periorbital infections, one of the hardest decisions is to determine when to operate. In the present series, diplopia was the strongest clinical predictor of surgery; this is not surprising because diplopia is a well-known variable that is closely monitored in the management of pediatric orbital cellulitis. Chandler et al[11] cited a change in visual acuity as the single most certain indicator that surgery is necessary. This finding was corroborated by later studies, and visual disturbance remains a classic indicator of surgery in current practice.[9]

In patients with a diagnosis of sinusitis, the ethmoidal and maxillary sinuses were most commonly involved, as seen in previous studies.[2,8,11,13] Ethmoidal and maxillary sinusitis are well-known causes of orbital cellulitis because infections can spread from these sinuses to affect the orbit. Chandler et al[11] note the strong association between advanced orbital cellulitis and sinus disease, especially ethmoiditis. A recent retrospective review[2] of patients with orbital cellulitis (not all pediatric) at the University of Michigan hospitals found a strong association with sinusitis and noted that most cases involved more than 1 sinus, with maxillary and ethmoidal involvement being the most common. The present study mirrored these findings on a national scale.

Patients admitted via the hospital's emergency department were more likely to require surgery than were routine admissions. There exists literature demonstrating that emergency department admissions have been linked to delays in seeking care[14] and further delays in treatment.[15] Disease processes are managed differently, and for orbital and periorbital infections, this finding could be an indicator of the patient's access to primary care. Although an interesting finding, the implications for treating a patient with orbital and periorbital infections from this association are unclear.

Oftentimes, patients managed medically are given prolonged intravenous antibiotics and as such their disposition can include home health services or, rarely, short-term care at a step-down facility. However, from these national estimates, it seems that surgical patients were more likely to be discharged with home care than were nonsurgical patients. In attempts to reduce hospitalization charges, these patients may be preferentially managed in a more acute manner at home to complete their long-term antibiotic courses; or it may be that this finding represents a selection bias because the patients are more ill; hence, necessitating surgery, and, as such, need more care at home than those managed medically. Because this mode of care provision drives resource utilization, knowledge of why these patients require home health care services may reduce total charges.

The use of *ICD-9-CM* coding is the principal source of this study's limitations. The *ICD-9-CM* code 376.01 (orbital cellulitis) was used as the inclusion criteria. It is possible that some patients in the target population were coded incorrectly (eg, as facial abscess) and were missed in this study's sample. It is also possible that similar error caused patients to be included who ought not to have been.

This study also had no a priori exclusion criteria. It is possible that some of the patients included in the sample did not have isolated orbital or periorbital infections but rather were admitted for some other condition and had a concomitant diagnosis of orbital cellulitis. From an administrative data set, this source of error is difficult to eliminate. Finally, because KID does not include all 50 states, its generalizability, even with the use of appropriate data weighting, may be limited.

In conclusion, patients admitted to the hospital with a diagnosis of orbital cellulitis were, on average, 6.6 years old, predominantly male (59.5%), stayed a mean of 3.9 days, and had total charges of $16 444. Surgical intervention for pediatric orbital and periorbital infections was required in approximately 12% of admitted patients. Surgical patients were found to be older, to have higher total charges and longer lengths of stay, and to be more likely discharged with home health care services. Ethmoidal and maxillary sinusitis, along with diplopia, are significant clinical predictors of surgery. Knowledge of these normative data should assist in optimizing medical outcomes and minimizing resource utilization because variations in care can be studied in attempts to mitigate these occurrences.

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