Clinical Study

Impact of Sinus Surgery on Hospital Utilization for Complications of Sinusitis

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Abstract

Background: Sinusitis complications are potentially lethal conditions that generally require extensive treatment and thus place a significant burden on the health-care system. The purpose of this study was to assess the impact of surgery on hospital utilization associated with treatment of sinusitis complications. Methods: Retrospective cohort study using a national hospital database. The 2012 to 2013 National Inpatient Sample was queried for adult patients with sinusitis and complications. Patients were grouped based upon the presence or absence of sinus procedures. Patient demographics and health status, hospital characteristics, length of stay (LOS), and charges were determined. Results: Of 1645 patients with sinusitis and associated complications, 232 (14%) underwent sinus procedures. These patients had higher LOS (8.0 ± 7.3 days vs 4.3 ± 5.2 days; P < .001) and charges (US$96 107 ± 108 089 vs US$30 661 ± 47 138; P < .001) than nonprocedure patients. Increased time to procedure in one operation patients (n = 209) of more than 2 days increased total LOS (11.4 ± 9.3 days vs 6.2 ± 5.5 days; P < .001) and charges (US$120 306 ± 112 748 vs US$76 923 ± 81 185; P = .005). Patients with multiple sinus procedures (n = 23) versus one had increased LOS and charges, despite no time difference from admission to first procedure (P = .35). On regression analysis, sinus procedure patients had excess LOS of 0.827 days and charges of US$36 949. Conclusion: Although often necessary, sinus surgery has proven to be cost-effective compared to medical management alone in patients with chronic rhinosinusitis who elect surgery, and further certain situations involving sinusitis complications may warrant proceeding directly to surgery.10-12

Keywords

sinusitis, sinusitis complications, sinus surgery, outcomes, costs

Introduction

Acute rhinosinusitis is a common infection, typically with a rather benign course. However in some cases, a variety of potentially devastating complications may occur. Such sequelae, which may develop from either direct or hematogenous spread of infection, include preseptal cellulitis, orbital cellulitis or abscess, subperiosteal abscess, intracranial abscess, meningitis, cavernous sinus thrombosis, and facial cellulitis or abscess.1-5 Due to high morbidity and potential mortality of these complications, hospital admission for aggressive medical or surgical intervention is frequently required, leading to significant resource utilization including inpatient and intensive care unit (ICU) stays, extensive and repeated imaging studies, surgical interventions, and pharmacy costs.5 Further, the proportion of individuals undergoing surgical management for sinusitis complications is also increasing, which may be contributing to rising health-care costs.6,7

In selected cases of sinusitis complications, medical therapy can be successful and can avoid potential additional morbidity and costs of surgery.8 However, sinus surgery has proven to be cost-effective compared to medical management alone in patients with chronic rhinosinusitis who elect surgery, and further certain situations involving sinusitis complications may warrant proceeding directly to surgery.9 Specifically, several authors have suggested sinus surgery as initial management in cases of intracranial complications from sinusitis.10-12

Given the uncertainty over optimal treatment of sinusitis complications and over the timing of surgical intervention, as well as the need to seek the most cost-effective treatment strategies, further examination of the management of sinusitis complications is warranted. The primary aim of this study was thus to examine the impact of sinus surgery in the treatment of patients with sinusitis complications, using analyses of hospital utilization as outcome measures. Such data may guide further efforts to reduce health-care costs, create management guidelines, and improve patient outcomes.

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Patients and Methods

Utilization of the National Inpatient Sample and Patient Characteristics

A retrospective cohort study was performed using the 2012 and 2013 National Inpatient Sample (NIS) databases, available from the Healthcare Cost and Utilization Project (HCUP) of the Agency for Healthcare Research and Quality (HCUP Central Distributor, Rockville, Maryland). The NIS database contains more than 7 million hospital stays each year, representing a stratified sample of 20% of US hospitals. Data elements provided include patient demographics, hospital characteristics, diagnosis codes, procedure codes, lengths of stay (LOS), disposition, total hospital charges (THC), and severity measures. National Inpatient Sample records were screened first to identify patients with a diagnosis of acute or chronic sinusitis, and then further screened to identify adult patients with a primary diagnosis of acute sinusitis, chronic sinusitis, or a complication of sinusitis using International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes. This was done to restrict our study population to patients admitted for sinusitis and its complications, and thus avoid patients admitted for other diagnoses who happened to have or develop sinusitis or its complications secondarily.

Patients with acute or chronic sinusitis were identified using ICD-9-CM codes 461–461.9 and 473–473.9, respectively. Sinusitis complications were identified using ICD-9-CM codes for preseptal cellulitis (373.13), orbital cellulitis, abscess, or subperiosteal abscess (376.01), intracranial abscess (324.0 and 324.9), cavernous sinus thrombosis (325), bacterial meningitis (320 and 320.9), and facial cellulitis or abscess (682.0). Patients were then stratified into 2 groups based upon whether or not they underwent sinus procedures during the admission, using ICD-9 procedure codes for open or endoscopic sinus surgical procedures (222, 223.0–9, 224.0–2, 225.0–3, 226.0–4, 227.0–9, and 229). Patient demographics recorded were age, sex, and race. Hospital data recorded included discharge quarter, census division of hospital, primary expected payer, median household income quartile for ZIP code, patient location, hospital type, hospital size, and day of sinus procedure. Diagnoses and comorbidities were identified using Clinical Classification Software codes for diabetes mellitus (49, 50), cardiovascular disease (98, 101), respiratory disease (127, 128), renal disease (157, 158) and immunosuppressive conditions including human immunodeficiency virus (5), lymphoma (37 and 38), leukemia (39), cystic fibrosis (56), immune disorders (57), and diseases of white blood cells (63). Clinical Classification Software codes were also used to determine which patients underwent intracranial procedures (1, 9). Outcome measures included disposition, LOS, and THC. Time to first sinus procedure was recorded and stratified to determine the impact on hospital costs. Disposition status included routine, short-term hospital, another facility which included skilled nursing facilities, and home health care.

As this data set contains no patient identifiers, this study required no approval from the institutional review board of Virginia Commonwealth University.

Statistical Analysis

Statistical data analyses were performed using IBM SPSS Statistics for Windows, version 24 (IBM Corp, Armonk, New York). Categorical variables were analyzed using χ² tests, and continuous variables were analyzed using independent samples t tests. Linear regression was performed for univariate variables with a P value less than or equal to 0.1. P values were the result of 2-sided tests and all regression outcomes with a Β value less than .05 were determined to be statistically significant.

Results

Out of 4957 patients admitted for acute or chronic sinusitis requiring hospitalization, 1645 (33%) had infectious complications. Patient demographics and characteristics are shown in Table 1. The majority of patients were age 45 or older, male, white, presented to an urban or large hospital, had a diagnosis of chronic sinusitis, and had a diagnosis of facial cellulitis or abscess. Two-hundred and thirty-two (14%) patients with sinusitis complications underwent sinus procedures. On comparing this group to patients who did not undergo sinus procedures, these patients were more likely to be male, live in a medium metropolitan area, present to an urban or large hospital, and have a diagnosis of acute sinusitis. Preseptal cellulitis, meningitis, and facial cellulitis or abscess were the 3 complications least likely to undergo sinus procedures. Patients who underwent sinus procedures are also more likely to undergo intracranial procedures.

Outcomes of patients with complications of sinusitis by procedure status are shown in Table 2. There were no differences in mortality between the 2 groups (P = .89). Post-discharge dispositions differed, with sinus procedure patients more likely to be discharged to a short-term hospital, a skilled nursing facility, or with home health care, whereas those without procedures were more likely to be discharged as routine. Sinus procedure patients had a higher total LOS (8.0 ± 7.3 days vs 4.3 ± 5.2 days; P < .001) and charges (US$96 107 ± 108 089 vs US$30 661 ± 47 138; P < .001) than patients without sinus procedures. Patients undergoing sinus procedures had a mean hospital day of the first procedure of 1.8 ± 2.7 days. Length of stay from the first procedure to discharge (6.3 ± 6.7 days) was longer than total LOS for those without sinus procedures (4.3 ± 5.2 days; P < .001).

We next examined the effect of type of complication on outcomes. Patients were grouped as those with facial cellulitis or abscess, those with orbital complications (preseptal cellulitis, orbital cellulitis, orbital abscess, or subperiosteal abscess), those with intracranial complications (intracranial abscess, cavernous sinus thrombosis, or meningitis), or those with multiple complications (Table 3). All patients with complications who underwent sinus procedures had higher total LOS and...
Table 1. Patient Demographics and Admitting Hospital Data of Patients With Sinusitis and Complications.

| All Patients | Sinus Procedure | No Procedure | P Value |
|--------------|-----------------|--------------|---------|
| Number of cases | 1645 | 252 | 1413 | 0.17 |
| Age (n = 1645; mean [STD]; years) >45 | 981 (60) | 126 (54) | 855 (61) | 0.07 |
| Gender (n = 1645; male) | 829 (50) | 141 (61) | 688 (49) | <0.001 |
| Race (n = 1571) White | 1136 (72) | 159 (73) | 977 (72) | 0.92 |
| Black | 197 (13) | 35 (16) | 162 (12) | 1.1 |
| Other | 238 (15) | 25 (11) | 213 (16) | 1.1 |
| Discharge quarter (n = 1640) 1 (Jan-Mar) | 483 (29) | 77 (33) | 406 (29) | 0.16 |
| 2 (Apr-Jun) | 405 (25) | 58 (25) | 347 (25) | 0.88 |
| 3 (Jul-Sep) | 366 (22) | 44 (19) | 322 (23) | 2.2 |
| 4 (Oct-Dec) | 386 (24) | 52 (22) | 334 (24) | 0.69 |
| Census division of hospital (n = 1645) Northeast | 301 (18) | 39 (17) | 262 (19) | 0.53 |
| South | 652 (40) | 90 (39) | 562 (40) | 0.77 |
| Midwest | 376 (23) | 54 (23) | 322 (23) | 0.87 |
| West | 316 (19) | 49 (21) | 267 (19) | 0.43 |
| Primary expected payer (n = 1537) Medicare | 476 (31) | 60 (29) | 416 (31) | 0.37 |
| Medicaid | 260 (17) | 18 (18) | 222 (17) | 0.67 |
| Private insurance | 578 (38) | 86 (41) | 492 (37) | 0.34 |
| Self-pay | 223 (15) | 28 (13) | 195 (15) | 0.56 |
| Median household income national quartile for patient Zip Code (n = 1596) 0-25th | 494 (31) | 69 (31) | 425 (31) | 0.96 |
| 25-50th | 403 (25) | 60 (25) | 343 (25) | 0.57 |
| 50th-75th | 366 (23) | 44 (20) | 322 (24) | 0.2 |
| 75th-100th | 333 (21) | 51 (23) | 282 (21) | 0.45 |
| Patient location (n = 1633) Large central metropolitan | 455 (28) | 61 (26) | 394 (28) | 0.59 |
| Large fringe metropolitan | 435 (27) | 47 (20) | 388 (28) | 0.02 |
| Medium metropolitan | 275 (17) | 53 (23) | 222 (16) | 0.007 |
| Small metropolitan | 147 (9) | 28 (12) | 119 (9) | 0.07 |
| Micropolitan | 195 (12) | 26 (11) | 169 (12) | 0.73 |
| Other | 126 (8) | 16 (7) | 110 (8) | 0.63 |
| Hospital type (n = 1644) Urban (vs rural) | 1449 (88) | 223 (96) | 1226 (87) | <0.001 |
| Hospital size (n = 1644) Large (vs small) | 1428 (87) | 215 (93) | 1213 (86) | 0.005 |
| Comorbidity conditions (n = 1645) Immunosuppressive conditions | 209 (13) | 29 (13) | 180 (13) | 0.92 |
| Diabetes mellitus | 389 (24) | 41 (18) | 348 (25) | 0.021 |
| Cardiovascular disease | 642 (39) | 77 (33) | 565 (40) | 0.05 |
| Respiratory disease | 277 (17) | 33 (14) | 244 (17) | 0.25 |
| Renal disease | 152 (9) | 24 (10) | 128 (9) | 0.53 |
| Acute sinusitis | 519 (32) | 135 (58) | 384 (27) | <0.001 |
| Chronic sinusitis | 1126 (68) | 97 (42) | 1029 (73) | 0.001 |
| Complications Preseptal cellulitis | 121 (7) | 14 (6) | 107 (8) | 0.41 |
| Orbital cellulitis, abscess, or subperiosteal abscess | 433 (26) | 134 (58) | 299 (21) | <0.001 |
| Intracranial abscess | 121 (7) | 55 (24) | 66 (5) | <0.001 |
| cavernous sinus thrombosis | 42 (3) | 14 (6) | 28 (2) | <0.001 |
| Meningitis | 87 (5) | 11 (5) | 76 (5) | 0.69 |
| Facial cellulitis or abscess | 999 (61) | 59 (25) | 940 (67) | <0.001 |
| Multiple (>1) | 146 (9) | 47 (20) | 99 (7) | <0.001 |
| Intracranial procedure | 96 (6) | 53 (23) | 43 (3) | <0.001 |

*Significant at P value ≤ 0.1. Age is expressed as mean (standard deviation), with the P value obtained using an independent samples t test. All other variables are expressed as n (%) and compared using χ² tests. Percentages for variables were calculated after omitting missing values. All statistical comparisons are between the sinus procedure and no procedure groups.

hospital charges except those with intracranial complications, who had no difference in LOS but significantly higher charges. However, there was no difference between LOS after the first sinus procedure in the procedure group and the total LOS of patients without sinus procedures across all complications. Further, patients with intracranial complications were more likely to undergo intracranial procedures than those without intracranial complications (84% vs 8%; P < .001). Patients with intracranial complications who underwent intracranial procedures had both increased LOS (14.2 ± 10.5 days vs 8 ± 9.8 days; P < .001) and THC (US$169 201 ± 152 621 vs US$76 316 ± 68 837; P < .001) compared to those without intracranial procedures.

To increase homogeneity of our sinus procedure patient group, we examined outcomes in patients who underwent only one sinus operation (n = 209). Among these patients, time to sinus procedure of more than 2 days was associated with increased charges (US$120 306 ± 112 748 vs US$76 923 ± 81 185; P = .005) and total LOS (11.4 ± 9.3 days vs 6.2 ± 5.5 days; P < .001), without increasing LOS after procedure (6.2 ± 8 days vs 5.4 ± 5.5 days; P = .45). Further, patients undergoing one procedure had greater LOS from procedure to discharge compared to total LOS of patients without sinus procedures (5.6 ± 6.2 days vs 4.3 ± 5.2 days; P = .001), as well as greater total LOS (7.4 ± 6.9 days vs 4.3 ± 5.2 days; P < .001) and THC (US$85 626 ± 89 722 vs US$30 661 ± 47 138; P < .001).

Patients who underwent repeat sinus procedures (n = 23) were compared to patients who underwent only one sinus procedure. There was no difference in mean hospital day of first sinus procedure between the 2 groups (1.3 ± 1.3 days vs 1.8 ± 2.8 days; P = .35). However LOS after first procedure (12 ± 8.7 days vs 5.6 ± 6.2 days; P < .001), total LOS (13.4 ± 8.7 days vs 7.4 ± 6.9 days; P < .001), and charges (US$193 300 ± 190 779 vs US$85 626 ± 89 722; P < .001) were all significantly higher in the repeat sinus procedure group. These patients were also more likely to have intracranial complications (48% vs 21%; P = .004), have multiple complications (39% vs 18%; P = .018), and undergo intracranial procedures (52% vs 20%; P < .001) than one-procedure patients. Finally, repeat procedure patients were more likely to be discharged to a skilled nursing facility (30% vs 10%; P = .007), while one-procedure patients were more likely to be discharged as routine (68% vs 45%; P = .04).

Statistically significant univariate variables were included in a regression analysis to assess risk factors associated with LOS and THC (Table 4). Intracranial abscess had both the highest excess LOS of 7.23 days and charges of US$65 734 of all the complications. Patients with sinus procedures had an excess LOS of 0.827 days and cost of US$36 949.

**Discussion**

Sinusitis is common disease usually treated in the outpatient setting with relatively minor costs and morbidity. However, severe cases and complications may occur, which although
Table 2. Outcomes of Patients With Sinusitis Complications by Procedure Status.

| Complications                              | Sinus Procedure (n = 232) | No Procedure (n = 1413) | P Value |
|--------------------------------------------|---------------------------|-------------------------|---------|
| Patient disposition (n = 1571)             |                           |                         |         |
| Routine                                    | 135 (66)                  | 1142 (84)               | <.001*  |
| Transferred to short-term hospital         | 13 (6)                    | 43 (3)                  | .023*   |
| Transferred to another facility            | 24 (12)                   | 85 (6)                  | .004*   |
| Home health care                           | 34 (17)                   | 95 (7)                  | <.001*  |
| LOS (n = 1644; days)                       | 8.0 ± 7.3                 | 4.3 ± 5.2               | <.001*  |
| LOS after first sinus procedure vs total LOS (n = 1644; days) | 6.3 ± 6.7                 | 4.3 ± 5.2               | <.001*  |
| THC (n = 1616; US$)                        | 96107 ± 108089            | 30661 ± 47138           | <.001*  |

Abbreviations: LOS, length of stay; THC, total hospital charges.
*Significant at P value < .05. Length of stay and THC are expressed as mean (standard deviation), with P values obtained using independent samples t tests. Patient disposition is expressed as n (%) and compared using χ² tests. Percentages for variables were calculated after omitting missing values.

Table 3. Outcomes of Sinusitis Patients With Complications With and Without Sinus Procedures.

| Complications                              | Sinus Procedure (n = 904) | No Procedure (n = 117) | P Value |
|--------------------------------------------|---------------------------|------------------------|---------|
| Facial cellulitis or abscess (n = 904)     |                           | 968 (96)               |         |
| LOS (days)                                 | 5.2 ± 3.4                 | 3.4 ± 2.7              | <.001*  |
| LOS after first sinus procedure (days)     | 2.9 ± 2.7                 | 3.4 ± 2.7              | .25     |
| THC (US$)                                  | 57597 ± 60144             | 21457 ± 25603          | <.001*  |
| Orbital complications (n = 413)            |                           | 308 (75)               |         |
| LOS (days)                                 | 5.7 ± 4.3                 | 3.9 ± 2.6              | <.001*  |
| LOS after first sinus procedure (days)     | 4.3 ± 3.5                 | 3.9 ± 2.6              | .15     |
| THC (US$)                                  | 55922 ± 43903             | 26607 ± 27936          | <.001*  |
| Intracranial complications (n = 211)      |                           | 156 (74)               |         |
| LOS (days)                                 | 12.6 ± 8.6                | 9.6 ± 11               | .06     |
| LOS after first sinus procedure (days)     | 10.6 ± 8.7                | 9.6 ± 11               | .5      |
| THC (US$)                                  | 178598 ± 146479           | 88846 ± 96016          | <.001*  |
| Multiple complications (n = 117)           |                           | 81 (69)                |         |
| LOS (days)                                 | 10.1 ± 10.2               | 5.1 ± 8.9              | .008*   |
| LOS after first sinus procedure (days)     | 8.5 ± 9                   | 5.1 ± 8.9              | .06     |
| THC (US$)                                  | 130083 ± 131625           | 33250 ± 61073          | <.001*  |

Abbreviations: LOS, length of stay; THC, total hospital charges.
*Significant P value < .05. Length of stay and THC are expressed as mean (standard deviation). Number of patients with each complication are expressed as n (%).

rare, may require hospitalization and surgical intervention with associated major costs and morbidity. Given this potential for substantial health-care resource utilization for such cases, we sought to better understand determinants of hospital outcomes in patients with complications of sinusitis. In our study of hospital data from 2012 to 13, we found that 14% of patients with sinusitis complications underwent surgical intervention. Additionally, 25% of patients in our study with orbital complications underwent sinus procedures, in agreement with previous data showing increasing rates of surgical intervention in management of orbital complications of sinusitis. As expected, our data corroborated that total LOS and THC were higher in patients undergoing sinus procedures than those who did not. We felt comparison of LOS after surgery for those undergoing procedures with total LOS for those who did not was a more meaningful comparison of LOS associated with each treatment modality. This difference in LOS of 2 days in favor of those not undergoing surgery may have several potential contributing factors. First, the operative and recovery times for the surgery may add at least part of a day to LOS. Second, the more complex dispositions noted for these patients, such as to short-term facilities, skilled nursing facilities, or with home health care, may require additional time sorting out insurance and logistic issues. Interestingly in our population there was no difference in procedure status of patients with immunosuppressive conditions. Patients with diabetes were also less likely to undergo sinus procedures but were independently associated with increased hospital stay and charges. Lastly, data available in NIS do not provide any information about severity of complication (for example size of abscesses) or prior treatment which might lead to bacterial antimicrobial resistance. Thus, it can be argued that cases undergoing surgery may represent more severe cases, as these had presumably already proven refractory to medical therapy alone. As such it is possible that for cases of similar severity, surgical intervention may even lead to shorter LOS than medical therapy alone. Longer delay to surgical intervention was further associated with increased hospital charges as well as total LOS. Additional preoperative days in these patients thus may be increasing costs. Padia et al reported the mean cost to the hospital per patient hospitalized...
with sinusitis complications to be US$20 748. Inpatient floor costs were the largest expenditure accounting for 32% of costs, and decreasing LOS by 1 day was found to possibly reduce cost per patient by US$4453.5

Previous authors have examined indications for earlier surgical intervention in management of orbital complications of sinusitis. Studies of pediatric subperiosteal abscesses have led some to advocate surgical intervention based upon age as conservative medical management may be of greater success in younger patients, while others have suggested using clinical features including poor response to early antibiotics.3,16-19 Peña et al noted an increase in more virulent organisms causing sinusitis complications since introduction of the heptavalent pneumococcal vaccine.20 Thus, both older age of patient and changing microbiologic data may influence the decision to operate sooner. In the management of orbital sinusitis complications, other factors have been suggested to contribute to increasing costs. Mahalingam-Dhingra et al found surgical patients had greater LOS of 7 days versus 3 days and higher costs of US$41 009 versus US$13 008 for medically managed patients. Patients admitted through the emergency department were also more likely to require surgery, which they suggest may be in response to delay in seeking care or obtaining treatment.15

In our study, nearly one-half of patients with intracranial abscesses had sinus procedures, a far higher percentage than any other complications. These were associated with the highest LOS and charges of all complications. Patients with intracranial complications were also more likely to undergo neurosurgical procedures, with increased costs of around US$169 000 versus US$76 000. This may be due to the charges associated with the procedure itself (surgeon fees, anesthesia, equipment, operating room charges, postanesthesia care unit charges) and may also reflect other associated charges such as increased ICU stays and imaging needed for following intracranial processes postoperatively that may be driving up costs in these patients. Padia et al identified intracranial complications in approximately 30% of pediatric patients hospitalized for sinusitis complications. They noted that intracranial complications may include more severe conditions and represent the highest health-care burden, as these require more intensive care and have the highest use of imaging before and after surgical intervention.5 Kou et al assessed sinus surgery for intracranial complications in pediatric patients and found 86% of patients had sinus procedures within 4 days of admission. They indicated that size of intracranial collections may impact clinical decision-making as larger collections are usually considered an indication for neurosurgical drainage, while smaller collections may be managed with antibiotics and sinus surgery.11 While some suggest sinus surgery does not prevent neurosurgical drainage and should only be used in specific

### Table 4. Risk Factors Associated With LOS and Hospital Charges.

|                          | LOS (days) | THC (US$) |
|--------------------------|-----------|-----------|
|                          | Change    | Std. Error| Change    | Std. Error |
| Gender (male)            | -.992³    | .248      | 5401³     | 2532       |
| Age (≥45 vs <45)         | .899³     | .271      | 2242      | 2761       |
| Race                     |           |           |           |            |
| Black                    | .799³     | .382      | 5745      | 3900       |
| Other                    | .64       | .352      | 14 612²   | 3613       |
| Patient location         |           |           |           |            |
| Large fringe metropolitan| .143      | .31       | -.526     | 3157       |
| Medium metropolitan      | .544      | .361      | -.13 809² | 3687       |
| Small metropolitan       | -.253     | .464      | -.10 490² | 4707       |
| Hospital type            |           |           |           |            |
| Urban (vs rural)         | .551      | .413      | 14 484³   | 4186       |
| Hospital size            |           |           |           |            |
| Large (vs small)         | .742³     | .372      | 9038³     | 3781       |
| Comorbid conditions      |           |           |           |            |
| Diabetes mellitus        | .613³     | .301      | 7567³     | 3.066      |
| Cardiovascular disease   | .086      | .278      | 2958      | 2839       |
| Acute sinusitis (vs chronic) | .566³   | .271      | 2001      | 2765       |
| Complications            |           |           |           |            |
| Orbital cellulitis, abscess, or subperiosteal abscess | -.239 | .45 | -8557 | 4588 |
| Intracranial abscess     | 7.23²     | .801      | 65 734²   | 8434       |
| Cavernous sinus thrombosis | 4.328²    | .828      | 24 937²   | 8482       |
| Facial cellulitis or abscess | -.775 | .5 | -12 999² | 4072 |
| Multiple                 | 1.946³    | .54       | 12 200²   | 5544       |
| Intracranial procedure   | 3.008³    | .849      | 60 405³   | 8883       |
| Sinus procedure          | .827³     | .402      | 36 949³   | 4127       |

Abbreviations: LOS, length of stay; THC, total hospital charges.

³Significant at P value < .05.
situations including recurrent intracranial complications after neurosurgical drainage, others recommend sinus surgery as routine management due to general low morbidity and possible contribution to clinical improvement. Sinus surgery has been shown to reduce requirement for neurosurgical procedures in these patients and, at times, such as for small epidural abscesses, may be the only procedure necessary. Pandrangi and Reiter found that among patients with orbital complications 27% required more than 1 sinus procedure. Erickson et al. found that only about 10% of surgical patients in our population required more than 1 sinus procedure. Erickson et al. found that among patients with orbital complications 27% required reoperation. Gitomer et al. reviewed pediatric patients with intracranial complications and found that 97% of patients had surgery. In their cohort, nearly 40% underwent sinus surgery alone, of which 41% underwent revision procedures. Schupper et al. assessed outcomes with combined surgical management of intracranial complications including drainage and concomitant sinus surgery in all patients, finding that 19% required revision sinus procedures. In our population, there was no difference in mean hospital day of the first sinus procedure between patients undergoing one procedure compared to those undergoing revision procedures, with a mean time to procedure of about 2 days. This suggests that patients requiring revision procedures did not have a greater delay in surgical treatment causing poorer outcomes that may account for needing multiple operations. However, patients with repeat procedures had increased LOS and charges. Thus, further examination of factors leading to need for revision surgery, such as abscess location, size, and culture results, may allow delineation of evidence-based management guidelines to help avoid repeated procedures, thereby improving patient care and reducing costs.

Our study has several limitations, some of which are inherent to any study reliant on a large database such as the NIS. Coding errors may exist leading to misdiagnoses being entered, as well as sampling bias, due to the fact that the NIS represents only a 20% sampling of US hospitals. In addition, we sought to create a subject population consisting only of patients admitted for complications of sinusitis. To do so, we restricted our population to patients with a primary diagnosis of sinusitis or one of the complications of interest. This was intended to avoid inclusion of patients admitted for an unrelated condition who then experienced sinusitis and a complication of sinusitis. However, although all patients had a diagnosis of sinusitis and a potential complication of sinusitis, we have no way to directly link the causality of the complication to sinusitis. Thus, some patients may have had, for example, a brain abscess caused by sepsis or otitis media and also coincidentally had sinusitis. On the other hand, it is plausible that some patients with potential sinusitis complications did not have adequate evaluation to render a diagnosis of sinusitis, thus leading these patients to be excluded from our analysis. In addition, we have no way to assess a number of important factors that could impact the decision for medical or surgical therapy or the outcome of treatment. These include the extent of sinusitis, specific sinususes involved, causative organisms, previous treatment, or the severity of complications such as size of abscesses or vision loss associated with orbital complications. Lastly, although we sought to utilize the readily available and real-world outcomes of LOS and hospital charges, both of these are imperfect as outcome measures. Length of stay may be impacted by such nonmedical factors as insurance coverage affecting disposition, patient family or support issues, and physician preference. Hospital charges also suffer from extensive inter-institutional and regional variabilities and thus may not accurately reflect the true cost of care.

Conclusion

Surgical management of sinusitis complications places a significant economic burden on the health-care system, most notably for intracranial complications. Among patients who underwent one sinus operation, prolonged time to surgery more than 2 days increased hospital charges but did not impact the duration of postoperative hospitalization. Patients who required revision sinus procedures also incurred significant health-care expenditures. These patients did not have a delay in surgical treatment compared to single procedure patients, but were more likely to have intracranial complications and undergo intracranial procedures. Further exploration of shorter trials of medical therapy prior to surgery as well as earlier intervention with sinus surgery for intracranial or medically refractory cases may improve outcomes and reduce health-care costs.

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