Balloon Sinuplasty Utilization in the Pediatric Population: A National Database Perspective

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Abstract

Objective. Balloon sinuplasty (BS) is a surgical management option in the treatment of chronic rhinosinusitis. The purpose of this study was to examine BS utilization among children with a national database.

Study Design. Retrospective review.


Subjects and Methods. All cases of children aged ≤18 years who underwent BS or traditional endoscopic sinus surgery (ESS) 5 years before and after the introduction of BS billing codes were studied with the Pediatric Health Information System database. We evaluated overall trends, demographics, performing physicians, readmissions, and cost data.

Results. A total of 14,079 patients met inclusion criteria: 13,555 underwent traditional ESS and 524 had a BS procedure. There was no significant increase in BS rates between 2011 and 2016. BS was more commonly performed among younger children than ESS (median age [interquartile range], 6 years [4-10] vs 9 years [6-13]; P < .001). There were 23 (4.4%) readmissions within 30 days in the balloon cohort versus 474 (3.5%) in the ESS cohort. The median cost of balloon maxillary antrostomy (US $6560 [$5420-$8250]) was higher than that of traditional maxillary antrostomy (US $5630 [$4130-$7700], P < .001). Physicians who performed BS had a larger volume of ESS procedures when compared with those who did not perform BS.

Conclusion. Rates of BS performance in the pediatric population have not increased over time. Results showed no difference in readmission rates between BS and ESS. BS was associated with higher costs as compared with ESS. The role of BS in the pediatric chronic rhinosinusitis population remains unclear.

Keywords

sinusitis, rhinosinusitis, pediatric, endoscopic sinus surgery, balloon sinuplasty

The American Academy of Otolaryngology–Head and Neck Surgery Foundation clinical consensus statement with respect to the management of pediatric chronic rhinosinusitis (CRS) regards endoscopic sinus surgery (ESS) as an effective procedure for children and adolescents who have failed medical therapy, adenoidectomy, or both.1 Balloon sinuplasty (BS) has been shown to be a safe alternative to traditional ESS for children who have similarly failed medical therapy and adenoidectomy, or both.2-4 A prospective multicenter evaluation involving 50 patients undergoing 157 sinus dilations found pediatric BS to be safe and effective for patients with CRS aged ≥2 years, resulting in no serious complications and only 2 minor adverse events.3 Furthermore, in a nonrandomized controlled prospective review of 30 patients with pediatric CRS who underwent BS, 80% showed improvement based on the Sinus and Nasal Quality of Life Survey.2

The actual frequency of performance of BS as a treatment of CRS among children and adolescents, however, remains unclear. We therefore sought to document trends in BS in the pediatric population using a large administrative database. The Pediatric Health Information System (PHIS) is a comprehensive database developed by the Children’s Hospital Association (CHA) containing inpatient, ambulatory surgery, and emergency department data from 45 distinct children’s hospitals nationwide. Our primary objective was to determine if there has been any significant difference in the performance rate of this sinus surgical procedure

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since the introduction of billing codes for BS in 2011. We additionally sought to assess patient and billing provider demographics to determine who is receiving and performing pediatric BS in the United States. Finally, we wished to compare readmission rates and costs for traditional and balloon ESS.

Methods

The institutional review board of Boston Children’s Hospital deemed this protocol exempt from review, as it did not represent human subject research. The PHIS database was used to assess national trends in pediatric sinuplasty before and after the introduction of Current Procedural Terminology (CPT) codes for BS. All patients aged 0 to 18 years who underwent outpatient BS or traditional ESS at a CHA-affiliated hospital between January 1, 2006, and December 31, 2016, were included. The number of patients who underwent traditional ESS (CPT codes 31245-31256, 31267, 31276, 31287, 31288) was compared with the number of patients who underwent BS procedures (CPT codes 31295-31297). Patients were excluded from analysis if they underwent any other concomitant surgical intervention or if their procedure was performed on an inpatient basis. We included the 28 pediatric hospitals that joined PHIS before 2008 in this study.

Variables included hospital location, age, sex, presence of a complex chronic condition (CCC), type of procedure, year of procedure, performing physician, and readmission data. As defined in 2000 and updated in 2014, the CCC classification represents “any medical condition that can be reasonably expected to last at least 12 months (unless death intervenes) and to involve either several different organ systems or one organ system severely enough to require specialty pediatric care and probably some period of hospitalization in a tertiary care center.”4,5,6 Defining these conditions allows for assessment of population-level trends in morbidity and mortality, patterns of health care utilization, and individual-level risk adjustments of outcomes among patients with CCCs.6 Physicians were identified as having performed BS only, ESS only, or both. Trends were analyzed by patient age (<4, 5-11, or 12-18 years), year of procedure, and region of the United States (Midwest, Northeast, South, or West). Data were also collected regarding readmissions, and readmission was defined as any patient who had an unplanned return to the hospital within 30 days following surgery. We compared the cost of balloon versus traditional maxillary antrostomy based on the surgical procedures performed since 2011. Costs were based on the hospital-specific cost:charge ratios reported by the Centers for Medicare and Medicaid Services and adjusted for yearly price and wage index.

We compared the characteristics of patients by surgery using the chi-square test for categorical variables and the Wilcoxon rank sum test for continuous variables. To examine the yearly trend in the proportion of patients who received BS, we used the logistic regression model, adjusting for age and chronic condition. The generalized linear model with gamma distribution with a log link function was used to compare the cost by surgery. The generalized estimating equations approach was employed to account for within-hospital correlation. All analyses were conducted with SAS 9.4 (SAS Institute, Cary, North Carolina).

Results

During the study period, 15,216 pediatric patients underwent ESS. Patients who underwent a concomitant adenoidectomy were excluded from analysis given the added cost and risk of readmission associated with it. A total of 1019 patients who underwent adenoidectomy in conjunction with traditional ESS and 118 with BS were excluded. The final comparative cohorts included 13,555 patients who underwent traditional ESS and 524 who had a BS procedure (Table 1). BS was more likely to be performed among younger children than traditional ESS (median age [interquartile range]: 6 years [4-10] vs 9 years [6-13], P < .001). Alternatively, BS was less likely than traditional ESS to be performed among patients with a CCC, such as cystic fibrosis (18.3% vs 23.1%, P = .011). Among patients who underwent BS, 74% (n = 388) received maxillary dilation; 25% (n = 130) underwent frontal dilation; and 10% (n = 52) had sphenoid dilation.

Overall, approximately 6.4% (95% CI, 5.8%-6.9%) of patients who received sinus surgery between 2011 and 2016 underwent BS.
underwent a balloon procedure. The proportion of patients
who received BS was 4.9% in 2011, 8.2% in 2013, and
5.2% in 2016 (Table 2). There was no significant increase
in BS rates between 2011 and 2016 (P = .47). BS was per-
formed for 13.7% of children ≤4 years old. This rate like-
wise did not increase significantly over time (2011-2016).
The BS rate among children 5 to 11 years of age was
approximately half the rate (6.5%) of younger children and
even lower (3.3%) among children 12 to 18 years of age.

From 2011 to 2016, BS was performed more frequently
in pediatric hospitals in the Midwest (7.2% of all cases
undergoing sinus surgery) and South (6.6%) when compared
with the West (4.8%) and Northeast (3.1%).

There were 23 (4.4%) readmissions within 30 days in the
balloon cohort, with readmission defined as admission to
the inpatient hospital service. The readmission rate was
3.5% (n = 474) for patients who underwent traditional ESS
during the same period. The median cost of balloon maxil-
lary antrostomy (US $6560 [interquartile range: $5420-
8250]) was higher than the median cost of traditional maxil-
lary antrostomy (US $5630 [$4130-7700], P < .001).

Following introduction of the BS billing codes, patients
who required an ethmoid procedure were significantly more
likely to undergo traditional ESS than BS (40.7% vs 14.3%,
P < .0001). As patients who have ethmoid disease are more
likely to be those with a CCC, ESS may be favored in the
setting of more complex disease. At the physician level,
those who performed BS also performed a larger volume of
ESS procedures overall when compared with those who did
not perform BS (median traditional ESS: 12 vs 2 proce-
dures). Among 1130 physicians, 978 (86.6%) performed
only traditional ESS; 134 (11.9%) performed both ESS and
BS; and 18 (1.6%) performed only BS. Among physicians
who performed BS, a mean 3.4 (SD, 6.8) balloon procedures
were performed during the study period.

Discussion

This study examines a large pediatric cohort from 28 chil-
dren’s hospitals who underwent traditional ESS or BS over
a 10-year period. We identified 14,079 cases, of which
18.7% of patients were aged ≤4 years, 46.1% were aged 5
to 11 years, and 35.3% were aged 12 to 18 years. Of note,
approximately two-thirds of patients who underwent sinus
surgery during the study period were <12 years old. The
current clinical consensus statement regarding pediatric
CRS recognizes treatment of patients ≤12 years of age as
distinct from older pediatric patients, with adenoidectomy
advocated as a first-line surgical intervention for younger
patients.1 Clinical decision-making details cannot be
extracted from the PHIS database, precluding determination
of the indications for sinus surgery in this younger age
group.

Throughout the study period, the overall number of sinus
surgery procedures in the pediatric population remained rel-
atively stable, with 1133 cases in 2006 and 1369 performed
in 2016. Similarly, since billing codes for BS were intro-
duced in 2011, there has been no significant increase in the
rate of BS procedures being performed (4.9% of all cases in
2011 vs 5.2% in 2016, P = .47). These findings are similar
to a study documenting the overall proportion of BS proce-
dures in the pediatric population to be low (11.9% of all
sinus procedures).2 BS rates were highest among the young-
est patients, with 13.7% of cases being performed among
those ≤4 years of age versus 3.3% among those aged 12 to
18 years. Several previously published studies showed BS
to result in fewer complications for children and adults with
CRS.3,4 Such data perhaps resulted in BS being considered
a less aggressive treatment than traditional ESS in the pedia-
tric population, favoring BS for younger patients. There
were also regional differences, with BS being performed
most frequently in the Midwest (7.2% of all cases vs 3.1%

### Table 2. Balloon Sinuplasty Performance Trends.

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<tbody>
<tr>
<td>Traditional ESS, n</td>
<td>1133</td>
<td>1020</td>
<td>941</td>
<td>1389</td>
<td>1361</td>
<td>1266</td>
<td>1314</td>
<td>1270</td>
<td>1242</td>
<td>1321</td>
<td>1298</td>
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<tr>
<td>Balloon sinuplasty, n</td>
<td>65</td>
<td>76</td>
<td>113</td>
<td>94</td>
<td>105</td>
<td>71</td>
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<td>Cases that were balloon procedures, %</td>
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<tr>
<td>All patients</td>
<td>4.9%</td>
<td>5.5%</td>
<td>8.2%</td>
<td>7.0%</td>
<td>7.4%</td>
<td>5.2%</td>
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<td>Age category, y</td>
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<tr>
<td>≤4</td>
<td>10.5%</td>
<td>10.8%</td>
<td>13.9%</td>
<td>15.3%</td>
<td>21.8%</td>
<td>11.3%</td>
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<tr>
<td>5-11</td>
<td>4.6%</td>
<td>6.2%</td>
<td>8.8%</td>
<td>7.1%</td>
<td>7.2%</td>
<td>5.1%</td>
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<tr>
<td>12-18</td>
<td>2.4%</td>
<td>2.1%</td>
<td>4.9%</td>
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<tr>
<td>Midwest</td>
<td>7.2%</td>
<td>8.5%</td>
<td>12.0%</td>
<td>6.1%</td>
<td>5.9%</td>
<td>3.8%</td>
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<tr>
<td>Northeast</td>
<td>0.0%</td>
<td>2.6%</td>
<td>0.0%</td>
<td>3.4%</td>
<td>9.1%</td>
<td>1.5%</td>
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<tr>
<td>South</td>
<td>4.7%</td>
<td>5.1%</td>
<td>7.4%</td>
<td>8.1%</td>
<td>8.1%</td>
<td>6.0%</td>
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<tr>
<td>West</td>
<td>1.4%</td>
<td>1.1%</td>
<td>7.1%</td>
<td>6.2%</td>
<td>6.9%</td>
<td>6.2%</td>
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Abbreviation: ESS, endoscopic sinus surgery.
in the Northeast). This may simply reflect the incidence of pediatric CRS in these regions.10

In the adult literature, there has been a reported explosion in BS performance rates, with an annual increase of 59% between 2011 and 2014.8,11,12 This clearly has not been the case in the pediatric population. The most likely explanation for this age-based rate differential is that BS can be performed in the office setting for adults. Conversely, office BS is much less likely to be tolerated by pediatric patients due to a number of factors, including reduced ability to cooperate, management of procedural risks, need for associated personnel, and parental anxiety; hence, BS for children is typically an operating room procedure under anesthesia. As the Food and Drug Administration–approved indication for BS is for patients ≥18 years, the added complexity of obtaining authorization from insurance companies may have had some effect on the choice of procedure in the pediatric CRS population.

A recent study that examined trends in BS in the adult population demonstrated a large increase in providers who performed BS but not traditional ESS.11 The authors suggested that the office-based nature of BS lends itself to incorporation in the repertoire of nonrhinology fellowship–trained providers as their principal or sole surgical sinus intervention. This has not been the case in the pediatric population, with only 1.6% of all physicians in our study performing BS alone. In fact, those providers performing both ESS and BS tended to be physicians who performed a high volume of sinus surgery. It may be inferred that BS in the pediatric population is becoming another tool in the armamentarium of pediatric sinus surgeons.13

Although a prospective trial showed BS to be an effective surgical management option for pediatric CRS,3 there is no evidence in the existing literature indicating that BS is superior to traditional ESS in terms of outcomes or cost. We documented readmission rates in the BS and ESS groups to be similar at 4.4% and 3.5%, respectively. These findings are contrary to the perception of BS as a safer alternative to traditional ESS. This perception is based on several papers arguing that BS is mucosa sparing and inherently less invasive, demonstrating favorable outcomes for BS in terms of complications and need for revision surgery.8,14 In addition, the PHIS data indicate the median cost for BS to be significantly higher than traditional ESS, aligning with previous research showing BS to be difficult to justify from a cost-benefit standpoint.15 Taken together, these factors suggest that additional research is needed to support a role for this technology among pediatric patients.

Our results indicate that BS was 4 times more likely to be performed among those <4 years old than those 12 to 18 years old. The reason may be that very young children have relatively small nasal passages and limited access to the middle meatus. BS may cause less injury to the middle meatal mucosa and therefore less postoperative synchiae.16 Similarly, BS may be advantageous during frontal sinuplasty for the same reasons.13 If there is less circumferential mucosal injury within the nasofrontal outflow tract, then restenosis is less likely. Both these potential benefits to pediatric BS could be examined in future studies with a retrospective or prospective design.

We did not assess clinical data such as preoperative Lund-McKay score17 or symptoms used in the clinical decision-making process. Similarly, postoperative outcome measures such as SNOT-22 were not available,18 nor were the rates of complications. All conclusions made in this study are based on the assumption that the PHIS data are accurate, though subject to the miscoding errors associated with all databases. Community hospitals are not well represented in the CHA database, and any variation in practice in non-CHA environments may not be adequately reflected in our results. Thus, it is possible that these findings may not be fully generalizable to the pediatric population as a whole. These data, however, do provide insight into surgical activity in a large number of pediatric hospitals across the United States. It enables analysis of patient demographics, which has led to some interesting observations. Furthermore, it enables the analysis of case numbers over a long period, thus allowing the identification of trends within the pediatric CRS population.

**Conclusion**

The frequency of BS use in the adult population has increased dramatically, likely because this is an office-based alternative to traditional ESS. Our study alternatively demonstrates that rates of BS have remained static in the pediatric CRS population since the introduction of BS codes in 2011. Only 13.5% of pediatric sinus surgeons have adopted this technology, presumably because its comparative benefit is unclear at the present time. With no difference in readmission rates and higher median costs for BS, more studies are necessary to determine the comparative advantages of BS in the pediatric population.

**Author Contributions**

Gerard Thong, interpretation of data, drafting and revising, final approval, accountable for all aspects of work; Natasha D. Dombrowski, acquisition/interpretation of data, drafting and revising, final approval, accountable for all aspects of work; Kosuke Kawai, analysis/interpretation of data, drafting and revising, final approval, accountable for all aspects of work; Michael J. Cunningham, conception of work/interpretation of data, drafting and revising, final approval, accountable for all aspects of work; Elam A. Adil, conception and design of work/interpretation of data, drafting and revising, final approval, accountable for all aspects of work.

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