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Operative Utilization of Balloon Versus Traditional Endoscopic Sinus Surgery

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Objectives/Hypothesis: To study the utilization of balloon catheter dilation (BCD) compared to traditional endoscopic sinus surgery (ESS)

Study Design: Cross-sectional analysis

Methods: Cases identified by Current Procedural Terminology codes as BCD (2,717) or traditional ESS (31,059) were extracted from the State Ambulatory Surgery Databases 2011 for California, Florida, Maryland, and New York. Patient demographics, surgical center and surgeon volume, mean charge, and operating room (OR) time were compared.

Results: There were 33,776 patients who underwent sinus surgery in the included states in 2011. Of these, 4.6% of maxillary, 5.6% of sphenoid, and 13.9% of frontal procedures were performed using BCD. Adjusted analyses found increased use of BCD in patients with chronic diseases($P < .001$). Patients who had limited sinus surgery were less likely to have BCD compared to patients who had all four sinuses instrumented ($P < .001$). Surgeons who performed a medium (odds ratio 1.38 [1.14–1.65]) or high (odds ratio 1.71 [1.42–2.07]) volume of ESSs were more likely to use BCD compared to those who performed a low volume ($P < .001$). However, among surgeons who utilized BCD, there was a minimal relationship between the percentage of surgeries performed with BCD and the surgeon's total number of cases ($R^2 = 0.055$). Compared to traditional ESS, the median charges for maxillary/ethmoid procedures (mini-ESS) involving BCD were approximately \$4,500 ($P < .001$) and maxillary/ethmoid/sphenoid/frontal procedures (pan-ESS) were approximately \$2,950 ($P = .003$) greater, whereas the median OR time involving BCD was 8 minutes less for mini-ESS procedures($P = .01$) but not statistically different for pan-ESS procedures ($P = .58$).

Conclusions: In the study sample, balloon technology was used in 8.0% of ESS cases in 2011. Procedures using BCD were on average more expensive compared to traditional ESS procedures, with minimal decrease in OR time.

Key Words: State Ambulatory Surgery Databases, balloon sinus dilation, sinus surgery, cost.

Level of Evidence: 2c

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INTRODUCTION

The current literature suggests that balloon catheter dilation (BCD) can safely dilate the frontal, sphenoid and maxillary sinuses with ostial patency in a large number of cases for up to two years. However, limitations to the current evidence preclude conclusive recommendations on how to apply BCD in the treatment of rhinosinusitis.[1,2] There have been few rigorous trials comparing its risks and benefits to traditional endoscopic sinus surgery (ESS), and as a result of this limited evidence the 2012 European Position Paper on Rhinosinusitis and Nasal Polyps guidelines conclude, "Overall, the place of these systems in the sinus surgeon's armamentarium remains unclear (Evidence Level IV)."[1–4] BCD technology appears to have widespread adoption by surgeons across the United States,[3] but the prevalence of use has not previously been described.

The application of balloon catheters for sinus dilation was initially described by Lanza[5] in 1993, and balloon catheter technology was approved by the US Food and Drug Administration (FDA) in April 2005. However, BCD was not assigned specific Current Procedural Terminology (CPT) codes until January 1, 2011. Previously, BCD was assigned CPT code 31299 (unlisted procedure,

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accessory sinus),[6] limiting the ability to specifically study BCD adoption on a national level.

The objectives of this study were to: 1) quantify how often BCD versus traditional ESS is being performed, 2) describe the demographics of the patient population undergoing BCD compared to traditional ESS, 3) determine how the utilization of the technology differs based on surgical volume, and 4) calculate the orbital complications, mean charges, and mean operating room (OR) times for the two surgical techniques.

MATERIALS AND METHODS

Data Source and Subjects

We used the State Ambulatory Surgery Database (SASD) of California, Florida, Maryland, and New York for 2011, the first year that CPT codes for BCD were available. SASD is a product of the Healthcare Cost and Utilization Project (HCUP), conducted by the federal Agency for Healthcare Research and Quality.[7] These states were selected to gain a wide geographic distribution. The databases capture all hospital-based ambulatory surgery encounters, and additionally, freestanding ambulatory surgery center encounters for Florida, California, and New York.[7]

Compilation of Analytic Dataset

We defined the study cohort from the state data files using CPT codes. We extracted all patients with CPT codes for endoscopic sinus surgery (CPT 31233, 31235, 31254, 31255, 31256, 31267, 31276, 31287, 31288) and/or BCD (CPT 31295, 31296, 31297). We excluded patients <18 years of age, leaving 33,776 observations for demographic analysis.

To evaluate the effect of balloon use on total charges and OR time, we further subset the dataset to exclude patients who underwent procedures in addition to traditional ESS and/or BCD other than inferior turbinate, septoplasty, polypectomy, or concha bullosa procedures. These criteria left 19,592 observations for total charge analysis and 9,165 observations for OR time analysis. Patients with OR times >500 minutes (n = 54) were excluded from the OR time analysis, as these OR times are unlikely for routine ESS.[8] χ^2 analyses was performed to determine whether coprocedures were distributed evenly between the comparison groups.

Covariate Factors

We obtained patient demographic information including age (categorized based on quintile), gender, race (white, black, Hispanic, Asian/Pacific Islander, or other), number of chronic diseases (0, 1–3, or ≥4), median income quartile of the patient's Zip code, and primary expected payer (private, Medicare, Medicaid, or other). We obtained surgery center information including urban versus rural location and hospital-based versus freestanding ambulatory surgery center. We calculated the volume of procedures performed at each surgical site and determined terciles for low (≤62 procedures annually), medium (63–138 procedures annually), and high (≥139 procedures annually) volume surgery centers. Only Maryland and Florida included data regarding surgeon identifiers, and so for these states we also calculated the volume of procedures performed by individual surgeons and determined surgical volume terciles with equal number of surgeons: low (≤30 procedures annually), medium (31–60 procedures annually) and high (≥60 procedures annually).

We also defined a variable for the count of types of sinus procedures performed for each patient discharge.[9] We defined the number of sinuses procedures per case as the count of sinuses operated upon (range, 1–4).[9] The SASD dataset does not distinguish between unilateral versus bilateral sinus procedures.[9] For this reason, paired procedures (e.g., bilateral maxillary procedures) were only counted as a single-procedure type.

Outcome Measures

Despite being used by some otolaryngologists as a standalone device, balloon instrumentation is most frequently used in the operating room in conjunction with endoscopic sinus instrumentation.[4,8] The CPT codes 31295–31297 are explicitly meant for balloon-only sinus procedures, whereas the use of balloon and endoscopic instrumentation for any given sinus must be coded by the standard endoscopic codes. Therefore, the dataset does not differentiate between cases where a single sinus is opened with both balloon and traditional instrumentation, but does allow for the differentiation of cases where some sinuses were opened with BCD and others with ESS (for example, traditional maxillary antrostomy and ethmoidectomy combined with BCD of the frontal sinuses). Therefore, for our analysis we compared patients who underwent traditional ESS without BCD ("traditional ESS") versus patients who underwent combined surgery using balloon catheter technology for at least one sinus, with or without traditional ESS ("BCD").

Outcomes of length of stay and death during admission were obtained from the dataset. For identification of orbital injury, patients were searched for CPT codes for canthotomy, canthoplasty or orbital decompression and International Classification of Diseases, 9th Revision (ICD-9) codes for diplopia, retrobulbar hematoma, orbital hemorrhage, or blindness.[10]

To facilitate comparison of total charge and OR time, we created variables for maxillary sinus only, mini-ESS (defined as maxillary antrostomy either via endoscopic or balloon techniques and ethmoidectomy), and for pan-ESS (defined as maxillary, sphenoid, and frontal sinuplasty via endoscopic or balloon techniques and ethmoidectomy). Other combinations of sinus procedures that would fall between mini-ESS and pan-ESS were included in an overall comparison. Of note, only the dataset for New York contained information regarding OR time, defined as the total time actually in the operating room exclusive of preoperative (preparation) and postoperative (recovery) time.

Maryland, New York, and Florida datasets included data on total charges. The total charges do not include professional fees and noncovered charges, and professional fees are removed from the total charge during HCUP processing.[7] A single total charge value was reported by the surgical center without further itemization.

Statistical Analysis

We used *t* tests for continuous variables and χ^2 or Fisher exact tests for categorical variables to perform bivariate analyses of patient factors; surgery center factors and volume; surgeon case volume; and outcomes between the groups of patients who underwent traditional ESS or BCD procedures. We performed multiple logistic regression to compare patient factors and volume between patients undergoing ESS or BCD procedures. Covariates were based on significance in prior studies or statistical significance in the bivariate analyses. Variables with significance at the $P < 0.1$ level were included in the model per convention.

The normality of the distribution for total charges and OR time was tested by use of the Kolmogorov-Smirnov test statistic. Because the total charge and OR time data (and the log of both)

TABLE I.
Patient and Surgery Center Data for Endoscopic Versus Balloon/Combined Endoscopic Sinus Surgery.

	Endoscopic Only		Balloon/Combined			Total	
	No.	%	No.	%	*P* Value	No.	%
Mean age, yr	48.90 ± 15.73		48.27 ± 15.40		*t* test .044	48.85 ± 15.71	
Age quintiles, yr							
<34	6,041	19.45%	537	19.76%	χ^2 .19	6,578	19.48%
34–44	6,301	20.29%	560	20.61%		6,861	20.31%
45–52	5,862	18.87%	539	19.84%		6,401	18.95%
53–62	6,334	20.39%	563	20.72%		6,897	20.42%
>62	6,521	21.99%	518	19.07%		7,039	20.84%
Sex							
Female	15,301	49.69%	1,424	52.74%	χ^2 .002	16,725	49.93%
Male	15,493	50.31%	1,276	47.26%		16,769	50.07%
Race							
White	21,852	74.16%	2,098	79.95%	χ^2 <.001	23,950	74.63%
Black	1,877	6.37%	119	4.54%		1,996	6.22%
Hispanic	3,105	10.54%	260	9.91%		3,365	10.49%
Asian/Pacific Islander	1,154	3.92%	56	2.13%		1,210	3.77%
Other	1,478	5.02%	91	3.47%		1,569	4.89%
No. of chronic diseases							
0	1109	3.57%	44	1.62%	χ^2 <.001	1,153	3.41%
1–3	25,325	81.54%	2,186	80.46%		27,511	81.45%
>4	4,625	14.89%	487	17.92%		5,112	15.14%
Payer							
Private	21,733	69.97%	1,968	72.43%	χ^2 <.001	23,701	70.17%
Medicare	5,764	18.56%	482	17.74%		6,246	18.49%
Medicaid	1,895	6.10%	178	6.55%		2,073	6.14%
Other	1,667	5.37%	89	3.28%		1,756	5.20%
Median household state income quartile for patient Zip code							
1	5,149	16.85%	414	15.49%	χ^2 <.001	5,563	16.74%
2	7,247	23.72%	698	26.11%		7,945	23.91%
3	8,093	26.49%	776	29.03%		8,869	26.70%
4	10,061	32.93%	785	29.37%		10,846	32.65%
Urban/rural							
Large metropolitan (>1 million)	22,245	71.81%	1,767	65.13%	χ^2 <.001	24,012	71.27%
Small metropolitan (<1 million)	6,956	22.45%	739	27.24%		7,695	22.84%
Micropolitan/rural	1,778	5.74%	207	7.63%		1,985	5.89%
Ambulatory surgery center*							
Hospital based	25,497	82.09%	2,250	82.81%	χ^2 .35	27,747	82.15%
Freestanding	5,562	17.91%	467	17.19%		6,029	17.85%
Hospital volume							
Low	10,320	33.23%	904	33.27%	χ^2 <.001	11,224	33.23%
Medium	10,425	33.57%	1,082	39.82%		11,507	34.07%
High	10,314	33.21%	731	26.90%		11,045	32.70%
Surgeon volume†							
Low	4,081	34.17%	241	27.29%	χ^2 <.001	4,322	33.69%
Medium	3,718	31.13%	314	35.67%		4,033	31.44%
High	4,145	34.70%	327	37.035		4,472	34.86%
No. of operated sinus types							
1	7,187	23.14%	451	16.60%	χ^2 <.001	7,638	22.61%

TABLE I.
(*Continued*)

	Endoscopic Only		Balloon/Combined			Total	
	No.	%	No.	%	*P* Value	No.	%
2	10,778	34.70%	598	22.01%		11,376	33.68%
3	7,351	23.67%	1,051	38.68%		8,402	24.88%
4	5,743	18.49%	617	22.71%		6,360	18.83%
State							
California	9,375	30.18%	656	24.14 %	χ^2 <.001	10,031	29.70%
Maryland	2,242	7.22%	122	4.49%		2,364	7.00%
New York	9,723	31.30%	1,178	43.36%		10,901	32.27%
Florida	9,719	31.29%	761	28.01%		10,480	31.03%

*Data from Maryland only include hospital-based surgery centers.
†Surgeon volume data are only available for Maryland and Florida.

were not normally distributed, we used the Wilcoxon rank sum nonparametric test for bivariate analyses assessing cost and OR time between the group of patients who underwent BCD or traditional ESS during maxillary-only, mini-ESS, pan-ESS, or any sinus procedure. A multivariate generalized linear model was created using a gamma distribution and logarithmic transformation for the dependent variable.[11,12] We also performed a matched cohort analysis of patients who underwent a maxillary sinus-only procedure to compare results to the generalized linear model. One hundred fifty-five of the patients who underwent endoscopic maxillary antrostomy only were randomly sampled from the available 2,085 patients and matched to the 155 patients in the maxillary balloon dilation-only group using SAS PROC SURVEYSELECT (SAS Institute Inc., Cary, NC). The cohort was analyzed by an adjusted random effects Poisson regression in Stata (StataCorp LP, College Station, TX) using xtpoisson.

We performed all other data management and analyses with SAS (SAS Institute Inc.). Statistical significance was determined at a two-tailed level of $P < .05$. The Northwestern University Institutional Review Board deemed this study of publicly available de-identified information exempt from human subjects reviews.

RESULTS

In 2011 in California, Florida, Maryland, and New York, 33,776 balloon or endoscopic sinus surgeries were performed (Table I) at 738 facilities. Within the subset of patients from Florida and Maryland who had unique surgeon identifier codes, 581 surgeons performed 12,827 sinus surgeries.

Table II contains the patient, surgical center, and surgeon demographic data among traditional ESS versus combined procedure groups. Adjusted analysis found that black and Asian patients and patients who identified as "other" were less likely than white patients to have a balloon procedure ($P < .001$) (Table III). Men had lower odds of having BCD compared to women ($P < .001$). Patients with chronic diseases were more likely to undergo BCD compared to patients with none ($P < .001$). Patients who were self-pay or had free care were less likely to have BCD compared to patients with private insurance ($P < .001$). Patients in New York were more likely to have a balloon procedure compared to patients in California ($P < .001$). Patients who had a limited sinus surgery were less likely to have BCD compared to patients who had all four sinuses instrumented ($P < .001$). Surgical centers that performed a high volume of ESSs were less likely to utilize BCD compared to those who performed a low volume ($P < .001$).

Individual surgeon identifier variables were only available for the states of Florida and Maryland. For these two states, a variable regarding surgeon volume was added to the model, which found that surgeons who performed a medium or high volume of ESS had greater odds of utilizing BCD compared to those who performed a low volume of sinus surgery (medium odds ratio (OR) 1.38 [1.14-1.65], high OR 1.71 [1.42-2.07], $P < .001$]. Among surgeons who utilized BCD, there was no correlation between the percentage of surgeries performed with BCD and the total number of surgeries ($\beta = -0.088$, $t = -18.08$, $P < .001$, $R^2 = 0.055$). Similarly, among surgeons who performed frontal sinus BCD, there was no correlation between percentage of frontal sinus procedures performed with BCD and total number of frontal procedures performed ($\beta = -0.059$, $t = -1.33$, $P = .18$, $R^2 = 0.0027$).

There was no difference in length of stay for patients undergoing traditional versus combined procedures (χ^2 $P = .32$). No patient in the sample died during their ambulatory surgery admission. There was no difference in the rates of orbital surgery for possible diagnoses of orbital complications between patients undergoing traditional versus combined procedures (endoscopic 0.05%, combined 0.05%, Fisher $P = 1.00$). In the comparison group for cost and operating room time, 87.8% of patients had a coprocedure. There was no significant difference between the endoscopic and balloon patient groups in terms of rates of coprocedures (maxillary sinus only $P = .11$, mini-ESS $P = .18$, pan-ESS $P = .66$, and all ESS procedures $P = .82$).

The Wilcoxon rank sum test found that the median charges for maxillary sinus-only, mini-ESS, and pan-ESS procedures involving BCD were \$1,864, \$4,504, and \$2,953.50 greater, respectively, compared to traditional ESS alone (maxillary sinus only $P < .001$, mini-ESS $P < .001$, Pan-ESS $P = .003$) (Table IV). The median OR time was 8 minutes less for mini-ESS

TABLE II.
Total Number of Sinus Procedures Performed During Endoscopic-Only, Balloon-Only, and Combined ESS in Hospital-Based or Freestanding Ambulatory Surgery Centers in California, Florida, Maryland, and New York in 2011.

	No. of Procedures							
	Maxillary		Ethmoid	Sphenoid		Frontal		
Type of ESS	Traditional	Balloon	Traditional	Traditional	Balloon	Traditional	Balloon	No. of Patients (% of Patients)
Endoscopic technology only	26,532	—	25,242	10,063	—	11,931	—	31,059 (91.96%)
Balloon technology only	—	580	—	—	217	—	398	746 (2.21%)
Combined*	1,112	761	1805	467	403	177	1,550	1,971 (5.84%)
Total	27,644	1,341	27,047	10,530	620	12,108	1,948	33,776
% of procedures	95.37%	4.63%	NA	94.44%	5.56%	86.14%	13.86%	
Overall total	28,985		NA	11,150		14,056		

*Combined cases defined as those in which some sinuses are operated on using endoscopic technology, whereas other sinuses undergo balloon catheter dilation (e.g., endoscopic maxillary antrostomy and ethmoidectomy with frontal sinus balloon dilation).
ESS = endoscopic sinus surgery.

procedures using BCD but not statistically different for maxillary-only or pan-ESS procedures (mini-ESS $P = .01$, maxillary only $P = 1.0$, pan-ESS $P = .58$) (Table V). Controlling for gender, age, race, number of chronic diseases, primary payer, median income of patient's Zip code, urban versus rural location of surgical center, state (in the model for charge but not OR time), surgical center volume, and freestanding versus hospital surgery center, BCD during maxillary sinus-only surgery resulted in a 37.3% percent increase in the total charge ($P < .001$), and no significant difference in OR time compared to a procedure utilizing only traditional ESS technology ($P = .84$). The generalized linear model found that BCD during mini-ESS and pan-ESS resulted in a 31.4% and 18.5% increase, respectively, in the total charge ($P < .001$, $P < .001$), and a 14.7% decrease in OR time ($P = .002$) for mini-ESS OR time but no statistically significant difference in pan-ESS OR time ($P = .46$).

The matched cohort Poisson regression analysis of patients who underwent only maxillary antrostomy yielded an incident rate ratio of 1.43 (1.26-1.63, $P < .001$), which is within the confidence interval of the generalized linear model (GLM) results (Table IV). Because the Poisson regression of the matched cohort uses data from only a sample of the patients who underwent an endoscopic maxillary antrostomy, GLM was used for the remainder of the analysis.

DISCUSSION

This cross-sectional study examined data from four states, California, Florida, Maryland, and New York, for patients $\geq$18 years old who underwent endoscopic or balloon sinus surgery in 2011, the first year CPT codes were available for BCD. Overall, 33,776 patients underwent paranasal sinus surgery in the included states, and 4.6% of maxillary, 5.6% of sphenoid, and 13.9% of frontal procedures were performed utilizing BCD. We found racial and provider-dependent differences in the use of BCD. Surgeons who performed a medium or high volume of ESS were more likely to utilize BCD compared to those who performed a low volume. However, among surgeons who utilized BCD, there was a minimal relationship between the percentage of surgeries performed with BCD and the surgeon's total number of cases. Procedures using balloon technology were on average more expensive compared to procedures that utilized only endoscopic techniques with minimal decrease in operating room time.

Proponents of BCD emphasize that BCD is less invasive in terms of less distortion of the original anatomy and less mucosal disruption, thereby minimizing potential for synechiae formation and ostial stenosis.[13,14] Case series, nonrandomized retrospective comparative trials, and one small randomized clinical trial have reported sinus patency rates and durability of clinically significant symptomatic improvement for up to 2 years after BCD for both systems.[8,15–20] BCD may be advantageous in the setting of anatomic variants such as obstructing type III or IV frontal cells that are less accessible to current endoscopic instrumentation,[4] or in the management of immunocompromised and critically ill patients with acute rhinosinusitis.[21] BCD also may be used in the office setting, with minimal or no local anesthesia requirements.[22,23]

A potential drawback of BCD is that the instrumentation is not reusable between patients, and the cost of the disposable instrumentation may increase the total cost of the procedure, as we suggest in this report.[3,14] Proponents of BCD have argued that the cost of the technology may be offset by reduced operating room time, decreasing charges from the operating facility and the anesthesia team, but this analysis does not support that idea.[14] Another limitation of BCD is that complex frontal recess pneumatization patterns and significant osteoneogenesis may make BCD challenging or impossible.[24] Therefore, a surgeon attempting BCD should be able to perform endoscopic procedures if BCD is unable to achieve the desired results.[1,4,24,25] Additionally, patients with extensive mucosal disease, such as polyps, are generally not candidates for the current generation of catheters, because the goal of treatment in such cases is resection of edematous, inflamed mucosa.[1,4,26] Moreover, current

TABLE III.
Logistic Regression for Odds of Combined Procedure Compared to Endoscopic Procedure.

	Odds Ratio	95% Confidence Interval	Analysis of Effects *P* Value
Gender			
Female	—	—	<.001
Male	0.87	0.80-0.94	
Age			
<34 years	—	—	.29
34–44 years	0.98	0.86-1.12	
45–52 years	1.00	0.88-1.14	
53–62 years	0.94	0.82-1.07	
≥63 years	0.84	0.71-1.00	
Race			
White	—	—	<.001
Black	0.69	0.56-0.84	
Hispanic	0.98	0.85-1.13	
Asian	0.56	0.42-0.74	
Other	0.55	0.44-0.69	
No. of chronic diseases			
0	—	—	<.001
1–3	1.71	1.24-2.36	
>4	2.00	1.43-2.80	
Primary payer			
Private	—	—	<.001
Medicare	1.00	0.86-1.17	
Medicaid	0.96	0.80-1.14	
Self/free care	0.58	0.46-0.73	
Median household state income quartile for patient Zip code			
1	—	—	.005
2	1.12	0.98-1.28	
3	1.18	1.03-1.35	
4	0.99	0.86-1.13	
Urban/rural			
Large metropolitan (>1 million)	—	—	.058
Small metropolitan (<1 million)	1.13	1.02-1.25	
Micropolitan/rural	1.11	0.93-1.32	
State			
California	—	—	<.001
Florida	1.05	0.92-1.17	
Maryland	0.88	0.71-1.08	
New York	1.84	1.65-2.06	
Volume			
Low	—	—	<.001
Medium	1.10	1.00–1.21	
High	0.71	0.64-0.80	
No. of sinus types			
1	0.58	0.51-0.66	<.001
2	0.50	0.45-0.57	
3	1.30	1.16-1.45	
4	—	—	

literature provides little guidance regarding what risk factors may make patients better candidates for BCD versus traditional ESS.[27]

Because our study is limited to data from only four states, it is difficult to know how generalizable the results are. However, the demographic profile of patients in our sample undergoing endoscopic only or combined procedures is similar to the constructed demographic profile of patients undergoing sinus surgery for chronic rhinosinusitis created by Martin et al.[28] Our study had a similar percentage of females, racial/ethnic groups, and private insurance.[28] Moreover, Martin et al. found that 93.5% of sinus surgery is performed on an outpatient basis, so although our study sample includes only sinus surgery performed at ambulatory surgery centers, it most likely represents the majority of sinus surgery performed in an operating room in these states during 2011.[28]

We found that a greater percentage of patients who underwent combined procedures had frontal sinusotomy: 38.4% of cases involving ESS only included frontal sinus instrumentation, whereas 63.6% of combined cases involved frontal sinus instrumentation. Although our percentage of procedures utilizing BCD only is similar to that of Levine et al., a larger percentage of patients in our sample underwent frontal sinusotomy, and the average operating room time was longer.[8] In Levine et al.'s registry, the average surgery time was 73.0 minutes (median, 60 minutes; range, 6–230 minutes).[8] Our results showed a mean time for BCD cases of 104.9 minutes (median, 93.5 minutes; interquartile range, 69–129 minutes). The discrepancy could be partially explained by the fact that a higher percentage of patients in our data from 2011 had instrumentation of their frontal sinus compared to those in the registry, which included data from 2005 to 2007. Pynnonen and Davis found that the population-adjusted rates of sinus surgery increased during the 10-year period from 2000 to 2009 in the state of Florida, and the number of procedures per case also increased, with rates of frontal sinus procedures more than doubling, and rates of cases for which all four sinuses were treated tripling during the same time period.[9] It is not possible to determine the extent to which BCD contributed to the observed increases.[9] Further studies are necessary to determine if balloon technology influences rates of surgery, especially of the frontal sinus and procedures involving all four sinuses.

In contrast to Friedman et al., we found that at ambulatory surgery centers, the total charge associated with BCD procedures was greater than that of traditional ESS procedures. Friedman et al. evaluated cost for 70 patients with chronic rhinosinusitis who underwent BCD or traditional ESS.[16] They found that equipment charges were higher for BCD, and a significantly decreased cost of revision procedures using BCD contributed to difference seen in overall cost.[16] We are unable to determine if procedures in our dataset were primary or revision surgeries. Our findings are difficult to further compare to Friedman et al.'s because their article does not indicate the extent of surgery performed.[16]

Although the non-normality of our total charge and OR time data made statistical analysis difficult, the

TABLE IV.
Comparison of Median Charge Between Endoscopic and Balloon/Combined Maxillary Sinus Only, Mini-ESS, Pan-ESS, and All ESS Procedures.

	Total Charge*								
	Endoscopic			Balloon/Combined				Generalized Linear Model	
Procedure	No.	Median	Interquartile Range	No.	Median	Interquartile Range	Wilcoxon Rank Sum *P* Value	Estimate of Coefficient	*P* Value
Maxillary sinus only	2,085	$9,827.00	$4961.00–$16,000.00	155	$11,691.00	$7,928.00–$16,768.00	<.001	0.37	<.001
Mini-ESS	5,668	$12,231.00	$7,998.50–$19,516.00	151	$16,735.00	$9,670.00–$20,724.00	<.001	0.31	<.001
Pan-ESS	3,560	$17,398.50	$11,116.50–$29,291.50	409	$20,352.00	$11,369.00–$34,104.00	.003	0.19	<.001
All ESS	17,887	$13,680.00	$8,367.00–$22,778.00	1,705	$16,615.00	$10,519.00–$26,304.00	<.001	0.22	<.001

*Total charge data in dollars were available for Florida, Maryland, and New York.
ESS = endoscopic sinus surgery; Mini-ESS = maxillary/ethmoid sinus surgery; Pan-ESS = maxillary/ethmoid/sphenoid/frontal sinus surgery.

issue of nonparametric data is common in econometric analysis and has been studied extensively.[11] We followed standard statistical practice by performing nonparametric comparison of means testing and analyzing our data with models that did not necessitate normality in their assumptions.[11,12]

Our study faces many of the challenges associated with analyzing administrative data. There is a disparity in the collected variables across states. There are limitations with using CPT codes to identify cases, as procedures that utilize both balloon and endoscopic technology to open a single sinus should be reported using endoscopic codes, and these hybrid procedures would be missed by our analysis. This may lead to an underestimation of the true extent of the utilization of balloon technology and may miscategorize some procedures that used balloon technology as only ESS, which would be expected to lead to an underestimation of the true difference in charges between procedure types. The inability to distinguish unilateral from bilateral procedures may be perceived as a limitation, and although we recognize this perspective, we believe that the salient information is the extent of surgical dissection performed.[9] Due to the nature of the dataset, it is not possible to know the indications for surgery. This is especially important for the identification of orbital complications, which we searched for using both the ICD-9 code for diagnosis and CPT code for procedure.[10] It is not possible to know if these diagnoses were preexisting or a complication of the sinus procedure. However, the rate of orbital complication identified by this method is in keeping with prior estimates of the rate of orbital complications during sinus surgery.[10]

Finally, our data do not capture in-office BCD, as our dataset only includes procedures in ambulatory surgery centers. Prior studies have shown that BCD technology can be safely used in the office setting under local anesthesia for patients with or without a prior history of ESS, with high patient satisfaction and sustained symptom improvement.[22,23,29–34] In-office BCD may prove to be cost-effective and time-efficient,[35] but further studies are necessary to compare the costs of in-office BCD to resource utilization of surgical management in the operating room.

CONCLUSION

Balloon technology was used in 8.0% of ESSs in ambulatory surgery centers in the sampled states in

TABLE V.
Comparison of Median OR Time Between Endoscopic and Balloon/Combined Maxillary Sinus Only, Mini-ESS, Pan-ESS, and All ESS Procedures.

	OR Time, min*								
	Endoscopic			Balloon/Combined				Generalized Linear Model	
Procedure	No.	Median	Interquartile Range	No.	Median	Interquartile Range	Wilcoxon Rank Sum *P* Value	Estimate of Coefficient	*P* Value
Maxillary sinus only	788	76	55–110	79	75	55–107	1.0	−0.012	.84
Mini-ESS	2,807	90	62–120	125	82	60–101	.01	−0.15	.002
Pan-ESS	1,681	111	74–152	222	117	82–146	.58	0.036	.46
All ESS	8,185	92	64–130	980	93.5	60–69	.36	−0.017	.35

*OR time data in minutes were available for New York.
ESS = endoscopic sinus surgery; Mini-ESS = maxillary/ethmoid sinus surgery; OR = operating room; Pan-ESS = xillary/ethmoid/sphenoid/frontal sinus surgery.

2011. Surgeons who performed a medium or high volume of sinus surgeries were more likely to utilize balloon technology compared to surgeons who performed a low volume of procedures. The association of procedural patterns with specific surgeons in sinusitis care highlights the importance of future investigations to examine training, technological, and reimbursement factors that may influence surgeon's clinical decision making. Procedures using balloon technology in the operating room were on average more expensive compared to procedures that utilized only endoscopic techniques, with minimal decrease in operating room time. This study does not capture in-office BCD, which may prove to be cost-effective and time-efficient.

BIBLIOGRAPHY

1. Batra PS. Evidence-based practice: balloon catheter dilation in rhinology. *Otolaryngol Clin North Am* 2012;45:993–1004.
2. Fokkens WJ, Lund VJ, Mullol J, et al. European position paper on rhinosinusitis and nasal polyps 2012. *Rhinol Suppl* 2012:3 p preceding table of contents, 1–298.
3. BlueCross BlueShield Association. Balloon sinus ostial dilation for treatment of chronic rhinosinusitis. *Technol Eval Cent Assess Program Exec Summ* 2013;27:1–3.
4. Stewart AE, Vaughan WC. Balloon sinuplasty versus surgical management of chronic rhinosinusitis. *Curr Allergy Asthma Rep* 2010;10:181–187.
5. Lanza D. Postoperative care and avoiding frontal recess stenosis. Paper presented at: The International Advanced Sinus Symposium; 1993; Philadelphia, PA.
6. Finally, a balloon sinuplasty payment code. MD Buyline Blog website. Available at: http://blogsitemdbuyline.wordpress.com/2011/4/25/finally-a-balloon-sinuplasty-payment-code/. Published April 25, 2011. Accessed May 6, 2014.
7. Agency for Healthcare Research and Quality. State Ambulatory Surgery Databases (SASD). Available at: http://www.hcup-us.ahrq.gov/db/state/sasddbdocumentation.jsp. Accessed January 15, 2014.
8. Levine HL, Sertich AP II, Hoisington DR, Weiss RL, Pritikin J. Multicenter registry of balloon catheter sinusotomy outcomes for 1,036 patients. *Ann Otol Rhinol Laryngol* 2008;117:263–270.
9. Pynnonen MA, Davis MM. Extent of sinus surgery, 2000 to 2009: a population-based study. *Laryngoscope* 2014;124:820–825.
10. Ramakrishnan VR, Kingdom TT, Nayak JV, Hwang PH, Orlandi RR. Nationwide incidence of major complications in endoscopic sinus surgery. *Int Forum Allergy Rhinol* 2012;2:34–39.
11. Manning WG, Mullahy J. Estimating log models: to transform or not to transform? *J Health Econ* 2001;20:461–494.
12. Mauldin PD, Salgado CD, Hansen IS, Durup DT, Bosso JA. Attributable hospital cost and length of stay associated with health care-associated infections caused by antibiotic-resistant gram-negative bacteria. *Antimicrob Agents Chemother* 2010;54:109–115.
13. Ahmed J, Pal S, Hopkins C, Jayaraj S. Functional endoscopic balloon dilation of sinus ostia for chronic rhinosinusitis. *Cochrane Database Syst Rev* 2011(7):CD008515.
14. Melroy CT. The balloon dilating catheter as an instrument in sinus surgery. *Otolaryngol Head Neck Surg* 2008;139(3 suppl 3):S23–S26.
15. Thottam PJ, Haupert M, Saraiya S, Dworkin J, Sirigiri R, Belenky WM. Functional endoscopic sinus surgery (FESS) alone versus balloon catheter sinuplasty (BCS) and ethmoidectomy: a comparative outcome analysis in pediatric chronic rhinosinusitis. *Int J Pediatr Otorhinolaryngol* 2012;76:1355–1360.
16. Friedman M, Schalch P, Lin HC, Mazloom N, Neidich M, Joseph NJ. Functional endoscopic dilatation of the sinuses: patient satisfaction, postoperative pain, and cost. *Am J Rhinol* 2008;22:204–209.
17. Plaza G, Eisenberg G, Montojo J, Onrubia T, Urbasos M, O'Connor C. Balloon dilation of the frontal recess: a randomized clinical trial. *Ann Otol Rhinol Laryngol* 2011;120:511–518.
18. Ramadan HH, Terrell AM. Balloon catheter sinuplasty and adenoidectomy in children with chronic rhinosinusitis. *Ann Otol Rhinol Laryngol* 2010; 119:578–582.
19. Stankiewicz J, Truitt T, Atkins J, et al. Two-year results: transantral balloon dilation of the ethmoid infundibulum. *Int Forum Allergy Rhinol* 2012;2:199–206.
20. Weiss RL, Church CA, Kuhn FA, Levine HL, Sillers MJ, Vaughan WC. Long-term outcome analysis of balloon catheter sinusotomy: two-year follow-up. *Otolaryngol Head Neck Surg* 2008;139(3 suppl 3):S38–S46.
21. Wittkopf ML, Becker SS, Duncavage JA, Russell PT. Balloon sinuplasty for the surgical management of immunocompromised and critically ill patients with acute rhinosinusitis. *Otolaryngol Head Neck Surg* 2009; 140:596–598.
22. Levine SB, Truitt T, Schwartz M, Atkins J. In-office stand-alone balloon dilation of maxillary sinus ostia and ethmoid infundibula in adults with chronic or recurrent acute rhinosinusitis: a prospective, multi-institutional study with-1-year follow-up. *Ann Otol Rhinol Laryngol* 2013;122:665–671.
23. Luong A, Batra PS, Fakhri S, Citardi MJ. Balloon catheter dilatation for frontal sinus ostium stenosis in the office setting. *Am J Rhinol* 2008;22: 621–624.
24. Heimgartner S, Eckardt J, Simmen D, Briner HR, Leunig A, Caversaccio MD. Limitations of balloon sinuplasty in frontal sinus surgery. *Eur Arch Otorhinolaryngol* 2011;268:1463–1467.
25. Tomazic PV, Stammberger H, Braun H, et al. Feasibility of balloon sinuplasty in patients with chronic rhinosinusitis: the Graz experience. *Rhinology* 2013;51:120–127.
26. Catalano PJ, Payne SC. Balloon dilation of the frontal recess in patients with chronic frontal sinusitis and advanced sinus disease: an initial report. *Ann Otol Rhinol Laryngol* 2009;118:107–112.
27. Koskinen A, Penttila M, Myller J, et al. Endoscopic sinus surgery might reduce exacerbations and symptoms more than balloon sinuplasty. *Am J Rhinol Allergy* 2012;26:e150–e156.
28. Martin TJ, Yauck JS, Smith TL. Patients undergoing sinus surgery: constructing a demographic profile. *Laryngoscope* 2006;116:1185–1191.
29. Cutler J, Truitt T, Atkins J, et al. First clinic experience: patient selection and outcomes for ostial dilation for chronic rhinosinusitis. *Int Forum Allergy Rhinol* 2011;1:460–465.
30. Eloy JA, Friedel ME, Eloy JD, Govindaraj S, Folbe AJ. In-office balloon dilation of the failed frontal sinusotomy. *Otolaryngol Head Neck Surg* 2012;146:320–322.
31. Gould J, Alexander I, Tomkin E, Brodner D. In-office, multisinus balloon dilation: 1-Year outcomes from a prospective, multicenter, open label trial. *Am J Rhinol Allergy* 2014;28:156–163.
32. Karanfilov B, Silvers S, Pasha R, Sikand A, Shikani A, Sillers M. Office-based balloon sinus dilation: a prospective, multicenter study of 203 patients. *Int Forum Allergy Rhinol* 2013;3:404–411.
33. Albritton FDt, Casiano RR, Sillers MJ. Feasibility of in-office endoscopic sinus surgery with balloon sinus dilation. *Am J Rhinol Allergy* 2012;26: 243–248.
34. Stankiewicz J, Tami T, Truitt T, Atkins J, Liepert D, Winegar B. Transantral, endoscopically guided balloon dilatation of the ostiomeatal complex for chronic rhinosinusitis under local anesthesia. *Am J Rhinol Allergy* 2009;23:321–327.
35. Prickett KK, Wise SK, DelGaudio JM. Cost analysis of office-based and operating room procedures in rhinology. *Int Forum Allergy Rhinol* 2012; 2:207–211.