Does High BMI Influence Hospital Charges in Children Undergoing Adenotonsillectomy?

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Background: Obesity is a highly prevalent chronic problem with health and fiscal consequences. Data from adults and nonsurgical pediatric patients suggest that obesity has serious implications for the US economy.
Objective: Our goal was to describe the impact of BMI on hospital charges in children undergoing adenotonsillectomy (AT).
Methods and Procedures: We carried out a retrospective comparative analysis of the electronic anesthesia record and the charges from billing data from a large tertiary institution on children aged 3–18 years who had AT during the year 2005–2007. The main outcome measures were mean total hospital charges, likelihood of admission, and length of hospital stay (LOS).
Results: Of 1,643 children, 68.9% were aged <10 years, 76% were whites, and 74.1% had private commercial insurance. Most (75.3%) children were discharged on the day of surgery. Obese and overweight children were more likely to be admitted than their normal-weight peers ($X^2 = 26.3$, $P < 0.001$). Among those admitted, BMI showed a positive correlation with LOS ($r = 0.20$, $P < 0.001$). Obese and overweight patients had significantly higher total hospital charges than their healthy-weight counterparts ($P = 0.001$). Anesthesia, postanesthesia care unit (PACU), and pharmacy and laboratory charges were also higher for obese than normal-weight children ($P < 0.05$).
Discussion: Overweight and obese children undergoing AT accrued higher hospital charges and had longer postoperative LOS than their healthy-weight peers. If these findings are extendable to other surgical procedures, they could have far-reaching implications for the US economy.

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INTRODUCTION

Childhood obesity is an increasingly prevalent, serious health problem with health and psychosocial consequences (1). Obesity, even in children, is a well-established independent risk factor for many chronic diseases including bronchial asthma, type 2 diabetes, obstructive sleep apnea (OSA), and hypertension (2). Very often, reports on the prevalence and health consequences of obesity have overshadowed the economical cost (direct and indirect) to the individual and to the society. Adult-derived data and many economic projections suggest that there are considerable economical consequences associated with obesity (1). In 1998, health-care expenditures attributable to obesity accounted for 9.1% of the total US health-care expenditures. This translated to $51.6 billion/year in direct costs and $100 billion/year in indirect costs (3). Additionally, annual health-care expenditures for an obese adult are $732 more than for a nonobese individual (4). Obesity in adults has also been shown to be associated with moderately increased hospital charges following total knee arthroplasty (5). Recently, Woolford *et al.* (6) showed among children hospitalized for common pediatric conditions that having obesity as a secondary diagnosis was associated with increased hospital charges. These authors, however, did not study a common surgical procedure and did not describe specific charges associated with the perioperative period. To the best of our knowledge, there are no data on the impact of childhood overweight and obesity on the health care cost of having a surgical procedure.

Adenotonsillectomy (AT) is one of the most common major surgical procedures performed in children (7). Conservative estimates are that ~300,000 ATs are performed annually in the United States (8). In addition, AT is the primary treatment for the symptomatic relief of OSA, a condition that is known to be prevalent in overweight and obese children (7,8). As the prevalence of obesity is increasing steadily in American children, it is reasonable to postulate that an increasing number of ATs will be performed in obese children, and these procedures would

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likely impact the health-care expenditures of the United States. AT is therefore a good surgical paradigm to use for studying the clinical and economical consequences of childhood obesity in the perioperative period. The degree to which overweight and obesity in childhood affects health-care charges following AT is presently unknown. This study aims to describe the association between childhood BMI and perioperative health-care charges following AT at a tertiary US children's hospital.

METHODS AND PROCEDURES

Following Institutional Review board approval, we reviewed our electronic perioperative clinical information system (Centricity; General Electric Healthcare, Waukesha, WI). We extracted the following demographic, anthropometric, and clinical data on all children aged 3–18 years who had AT, between January 2005 and June 2007: American Society of Anesthesiology classification, age, gender, race, insurance type, height and weight. It is a routine in our hospital to measure height and weight on all children prior to an elective surgical procedure. BMI was calculated as weight in kilograms divided by the square of the height in meters (BMI = kg/m^2). Children were classified as normal weight (BMI <85th percentile), overweight (BMI ≥85th and <95th percentile), or obese (BMI ≥95th percentile) using age- and gender-specific reference growth charts from the National Center for Health Statistics/Centers for Disease Control and Prevention (9). Clinical OSA was defined by history of snoring with or without observed cessation of breathing by the parents or caregivers. We excluded children aged <3 years because these are routinely admitted following AT, in our institution. Children with secondary causes of obesity such as Prader–Willi syndrome, Cushing's syndrome, nephrotic syndrome, or craniofacial abnormalities were also excluded, as well as those with missing height and weight data.

Charge data were obtained by linking the perioperative database with the University of Michigan Data Warehouse (TSI; Transition System, Boston, MA); TSI is a cost accounting system that incorporates all direct and indirect charges in dollars, both variable and fixed, for specific procedures.

We used total charges and length of stay (LOS) as dependent variables. The total charge was calculated from the bill forwarded by the University of Michigan Health System to the patient's insurance payer. Professional fee and the charges during outpatient preoperative and follow-up clinic visits were not included. In order to determine factors contributing to the total hospital charge, the total charge was subdivided into operating room charge, anesthesia charge, pharmacy charge, postanesthesia care unit (PACU) charge, laboratory charge, and routine nursing charge. All charges are in US dollars. LOS was measured in days; a value of zero was assigned to patients discharged on the day of surgery. We defined *a priori*, the following as potential confounders, age in years, gender, race, and insurance status.

Statistical analysis

Data analysis was carried out with SPSS v.14.0 (SPSS, Chicago, IL). Basic descriptive statistics, including means, s.d., and percentages were calculated for the demographic and anthropometric data. Pearson's χ^2-test was used for categorical variables while differences between continuous variables (hospital charges and LOS) in the three BMI groups were examined using one-way ANOVA. Where necessary, bivariate correlation coefficients were calculated to explore relationships between continuous variables. General linear models were created to determine factors associated with total charges and LOS. Because majority (75.3%) of patients were same-day discharges, we dichotomized LOS as "admitted or not." For similar reasons, insurance status was dichotomized into insured or uninsured. General linear models were conducted using age, gender, race, insurance status, use of laboratory services, LOS, and BMI as predictors of total charges. *A priori* statistical significance was defined as two-sided *P* value of <0.05.

RESULTS

A total of 1,685 children underwent AT during the study period, of which 42 were excluded because of missing height and weight data. **Table 1** shows the baseline demographic, anthropometric, and clinical characteristics of the study population. The mean age of the population was 7.2 ± 3.8 years while the mean BMI was 19.1 ± 7.5 kg/m^2. The overall prevalence of overweight was 13.1% and obesity was 7.4%. As expected, BMI showed a moderate positive correlation with age ($r = 0.527$, $P < 0.001$) in the entire cohort of patients.

Preoperative diagnosis of OSA was present in 22.7% of patients (**Table 1**). Diagnosis of OSA was slightly positively correlated with age indicating that older children were more likely to have a diagnosis of OSA ($n = 1,643$; $r = 0.18$, $P = 0.001$). At the same time, overweight and obese children were significantly more likely to have a preoperative diagnosis of OSA than their lean peers (normal weight = 13.7%, overweight = 49.4%, and obese = 64.3%; $X^2_{2df} = 202.8$; $P < 0.001$).

Table 1 Demographic, anthropometric, and clinical parameters of the study population

Parameter	Number (%) of patients (*n* = 1,643)
Age groups (year)	
<5	738 (44.9)
6–12	713 (43.4)
13–18	192 (11.7)
Gender	
Male	908 (55.3)
Female	735 (44.7)
Race/ethnic categories	
White	1,248 (76.0)
African American	180 (11.0)
Hispanic	92 (5.6)
Other[a]	123 (7.4)
Payer	
Private commercial	1,217 (74.1)
Medicaid	73 (4.4)
Uninsured	353 (21.5)
BMI categories	
Normal	1,306 (79.5)
Overweight	215 (13.1)
Obese	122 (7.4)
Baseline indication for surgery	
Recurrent tonsillitis	1,270 (77.3)
Obstructive sleep pattern	373 (22.7)
Postoperative disposition	
Same-day discharge	1,237 (75.3)
Admitted	406 (24.7)

[a]Asian, Pacific Islander, Native American, or unspecified.

Table 2 Mean hospital charges and LOS by BMI categories

	Normal weight	Overweight	Obese	All patients	
Charges	Mean (s.d.)	Mean (s.d.)	Mean (s.d.)	Mean (s.d.)	*P* value
Total hospital charge ($)*	4,023.9 (2,494.8)	4,468.8 (3,400.9)	5,031.9 (2,559.4)	4,056.2 (2,355.9)	0.001
Anesthesia charge ($)[a]	980.7 (109.8)	1,016.3 (211.3)	1,024.2 (142.9)	983.6 (120.3)	0.001
OR charge ($)[a]	1,601.5 (813.9)	1,776.8 (919.2)	1,888.8 (854.5)	1,633.5 (851.2)	0.008
PACU charge ($)[a]	642.5 (366.7)	817.51 (234.6)	846.8 (302.4)	664.3 (361.7)	0.001
Pharmacy charge ($)*[b]	234.4 (192.0)	256.4 (207.8)	310.1 (251.0)	193.0 (124, 281)	0.027
Laboratory charge ($)[a,b]	144.2 (36.9)	148.7 (33.0)	299.4 (53.4)	46.0 (0, 92.0)	0.001
Nursing charge ($)	272.5 (727.5)	257.2 (988.2)	286.4 (622.4)	271.9 (737.8)	0.972
LOS (days)[a,b]	0.25 (0.64)	0.39 (0.75)	0.63 (0.83)	0 (0,0)	0.001

LOS, length of hospital stay; OR, operating room; PACU, postanesthesia care unit.
[a]Charges greater in obese than overweight than normal weight ($P < 0.001$). [b]Distribution of these parameters in the total patient column given as median (interquartile ranges; 25, 75% respectively). All other values are mean (s.d.). **P* value < 0.05 for overweight vs. normal weight.

The majority (75.3%) of patients were discharged on the day of surgery. However, obese and overweight children were more likely to be admitted than normal weight children ($F = 14.04$, df = 2, $P < 0.001$). Among those admitted, BMI showed a slight positive correlation with LOS ($r = 0.20$, $P < 0.001$). Patients with a preoperative diagnosis of OSA were also more likely to be admitted than those without a history of OSA (30.0% vs. 21.2%, $X^2_{1df} = 9.4$, $P = 0.003$). In addition, overweight/obese patients with OSA were more likely to be admitted than overweight/obese patients without OSA (15.6% vs. 9.3%, $X^2_{1df} = 9.4$, $P = 0.004$).

The majority (74.1%) of patients had private commercial insurance, although 21.5% of children were uninsured. Of the normal weight children ($n = 1,306$), 16.5% were uninsured compared to 20.2% of overweight ($n = 215$) and 8.3% of obese ($n = 122$) children. The χ^2-test revealed that being uninsured was statistically significantly associated with high BMI category ($X^2_{2df} = 5.78$, $P = 0.05$). The charges associated with AT for the entire group and for each BMI category are shown in **Table 2**.

Within each of the BMI categories, overweight and obese patients had higher mean anesthesia, operating room, PACU, pharmacy, laboratory, and total hospital charges (**Table 2**). Relative to the normal weight children, the mean total charge for obese children was $1,008 higher, while the mean difference between overweight and obese children was not so large ($445) suggesting a "dose–effect relationship" for BMI and total hospital charges. There was no significant difference in the routine nursing, hospital supplies, and respiratory therapy charges. Insurance status was slightly predictive of total hospital charges. The mean total charge for the uninsured patients ($n = 353$) was $1,078.79 ± 414.9 compared to $1,158.9 ± 416.4 for the insured patients ($P = 0.01$).

Recognizing the potential interaction between OSA diagnosis and BMI, we examined the effect of preoperative OSA diagnosis on accrued charges. The mean total charge for the patients with OSA diagnosis ($n = 373$) was $4,090.22 ± 2,211.57 compared to $4,049.90 ± 2,382.45 for the non-OSA patients ($P = 0.825$). A similar relationship was observed with all the other charge categories.

Table 3 General linear model predicting total charges following adenotonsillectomy

Source	df	Type III SS	*F* value	*P* value
BMI category	2	33439774.2	3.860	0.021
Age group (<5 years, 6–12, >12)	1	250738.7	0.085	0.771
Gender (Male, female)	1	1096739.9	0.253	0.615
OSA diagnosis (yes or no)	1	698295.9	0.161	0.688
Race (white, nonwhite)	1	3505056.2	0.809	0.369
Insured (yes or no)	1	481645966.3	4.855	0.011
LOS (admitted or not)	1	15587810.5	3.598	0.058
LAB use (yes or no)	1	1397243290.2	322.55	0.001

For entire model $P < 0.0001$, $R^2 = 0.529$.
df, degrees of freedom; LAB, laboratory; LOS, length of hospital stay; OSA, obstructive sleep apnea; SS, sum of squares.

Multivariate analysis

The general linear model-predicting factors contributing to total hospital charges (**Table 3**) achieved statistical significance ($P < 0.001$). The predictors significantly associated with higher total charges include insurance status ($P = 0.01$), LOS ($P = 0.05$), and use of laboratory services ($P = 0.001$). After adjusting for other parameters that could contribute to total hospital charges (age group, gender, race, OSA diagnosis, and use of laboratory services), the impact of BMI on the total hospital charges decreased but remained statistically significant ($P = 0.02$). The other parameters (such as age group, gender, OSA diagnosis, and race) did not appear to contribute significantly to total charges (**Table 3**).

DISCUSSION

The prevalence of overweight and obesity in children is increasing steadily in the United States. We recently showed that this secular trend is reflected in the pediatric surgical population (10). To date, no study has examined the impact of childhood BMI on perioperative health-care expenditures. We have demonstrated that overweight and obese children undergoing

AT accrued ~$1,000 higher total hospital charges than their normal-weight peers. Higher total charges were due to higher charges in anesthesia, operating room, PACU, laboratory, and pharmacy charges. Our results agree with those of Hampl *et al.*, who showed increased health-care utilization and charges in overweight and obese compared to normal weight children seen at a primary care center (11). In the adult surgical population, Vincent *et al.* (5) recently studied obese and normal-weight orthopedic patients and found a modest positive relationship between hospital charges and the magnitude of obesity. After controlling for age, gender, presence or absence of OSA, overweight and obese children still had significantly higher total hospital charges than their normal-weight peers (**Table 3**).

Our study sheds light on the sources of higher charges among obese children undergoing AT. However, we were not able to determine exactly why charges are higher in some of the categories examined. For example, it is not entirely clear why overweight and obese children accrued higher anesthesia charges than their lean peers. However, as anesthesia charges are usually billed as base units plus total time required for the procedure (12), it is possible that obese patients had longer anesthesia time units (related to longer induction time because of difficult venipuncture, difficult airway (13), and possibly slower emergence from anesthesia). The longer duration of anesthesia care would contribute to higher overall accrued charges. Unfortunately, we do not have data on the anesthesia times in these patients. In addition, as anesthesia time has been shown to correlate closely with surgical time (12), it is also possible that longer surgical duration had a role to play. Although there are no published data, it is very plausible that AT in obese children would be technically more difficult than in normal-weight children.

We were not surprised to find that obese children had higher PACU charges. We had previously shown that the incidence of upper airway obstruction, prolonged PACU stay and requirement of multiple antiemetics was significantly higher in overweight and obese compared to their lean peers (13). All these complications would be associated with higher PACU resource utilization and consequently higher charges. There is a need for more data to define which aspect of PACU care contributes to increased overall charges following AT.

Consistent with the observation by Hampl *et al.* (11), we found a significantly higher rate of utilization of laboratory services (measured by higher laboratory charges) in overweight and obese compared to the normal-weight children. The higher charges remained significant even after controlling for the effect of age, gender, and presence or absence of OSA diagnosis (**Table 3**). We speculate that this may be a reflection of increased incidence of postoperative complications in obese children (13) that could increase the likelihood of request for laboratory tests. In addition, presence of preoperative comorbid conditions such as bronchial asthma, diabetes, and hypertension in overweight and obese children may likely trigger request for laboratory studies.

The contribution of insurance status to total charges is quite interesting. The proportion of American children with partial or no health-care coverage continues to increase (14). It has been suggested that lack or insufficient health insurance could result in inferior health outcome for children (15). We found a higher proportion of uninsured children in the overweight/obese group compared to the healthy-weight group. This is consistent with the established observation that obesity is more prevalent in the low socioeconomic group—a group that is more likely to have partial or no insurance (15). We were surprised to find that uninsured children accrued slightly lower charges than their insured peers despite the higher prevalence of overweight and obesity in the uninsured group. Probably only the most essential diagnostic procedures were undertaken in uninsured patients. These explanations can only be speculative from a retrospective study, and it will be interesting to examine the subject prospectively.

We were somewhat surprised that clinical diagnosis of OSA was not a statistically significant predictor of charges on univariate and multivariate analysis. OSA is increasingly becoming the commonest indication for pediatric AT (16), and it also appears to be closely associated with overweight and obesity (17). One possible explanation for the lack of effect of OSA diagnosis on the observed charges could be that we excluded preoperative clinic and laboratory charges (which would include polysomnography) from the analysis. Our institution and others (18) do not routinely perform sleep studies on all children with OSA prior to AT. We also do not routinely admit all children with a preoperative diagnosis of OSA. The practice of routine admission following adenotonsillar hypertrophy for children with OSA remains controversial (19). Some reports have shown increased odds of residual features of OSA in obese children following AT, presumably due to parapharyngeal fat deposition in obese children (20). In order to determine the contribution of OSA to hospital resource utilization, future prospective studies should consider the cost of preoperative investigations such as polysomnography and use of noninvasive respiratory support in children with OS, with or without obesity as a secondary diagnosis.

In conclusion, we confirmed our study hypothesis that overweight and obese children incurred substantially higher charges in the perioperative period for AT than their normal-weight peers. If generalizable to other childhood surgeries, these findings have major public health and economic implications in the United States. It seems that the economic burden of obesity in the perioperative period is consistent between children and adults in that those with higher BMIs have higher hospital charges. A clear understanding of factors contributing to increased health care expenditure is of vital importance, and obesity may be a modifiable risk factor for some of these expenses. There is a need for primary prevention of obesity in children so that the economic burden of excessive BMI can be reduced. In addition, since a high proportion of obese children become obese adults (21,22), the health-care costs associated with obesity in the society is likely to continue to rise, if primary and secondary preventive measures are not instituted to curb the rising epidemic.

Study limitations

Since this was a retrospective database analysis, mechanisms used to explain the charge differences between overweight, obese, and normal-weight children can only be speculative. This is an inherent limitation of our technique and of other published data in adults (3,5) and children (6,11). Also, we did not have data on all the preoperative comorbidities in these patients which may have influenced total perioperative charges. In addition, we used hospital charges as a marker of resource utilization, and although this is co mmon practice, it does have some limitations, most important of which is the fact that charges are generally higher than costs or true reimbursement/payment (23). However, we have no reason to believe that the relationship between cost and charges varies based on BMI. Thus, our finding of higher charges for overweight and obese children likely also reflects higher costs. Future prospective studies should attempt to examine the impact of secondary diagnoses on hospital charges and should also attempt to measure anesthesia, surgical, and PACU times.

Despite these limitations, our study is noteworthy for the following reasons. First, it is one of the first to support with data what many practitioners have suspected for some time—that overweight and obese children utilize more hospital resources. Second, we studied a large sample of a commonly performed pediatric surgical procedure (AT) and used economically relevant data (hospital charges) to show the significant discrepancy in charges accrued by children based on their BMI.

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DISCLOSURE

The authors declared no conflict of interest.

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