

Original Investigation

Interdisciplinary Pediatric Aerodigestive Care and Reduction in Health Care Costs and Burden

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IMPORTANCE Children with complex respiratory and gastrointestinal disorders frequently require care from multiple pediatric subspecialists. Interdisciplinary pediatric aerodigestive clinic centers have been established at several pediatric tertiary care centers in the United States. Their effectiveness is unknown.

OBJECTIVE To determine whether an interdisciplinary approach to pediatric aerodigestive disorders reduces health care costs and burden.

DESIGN, SETTING, AND PARTICIPANTS Retrospective medical record review for the first 125 unique pediatric patients (median age, 1.51 years) seen at the Pediatric Aerodigestive Center (PAC) for aerodigestive disorders between June 2010 and August 2013 for a total of 163 outpatient clinical encounters. The PAC is an academic pediatric tertiary care center where specialists in gastroenterology, otolaryngology, pulmonology, and speech-language pathology provide interdisciplinary evaluation during a single clinic encounter and combined operative management when indicated.

INTERVENTIONS Interdisciplinary evaluation and treatment of pediatric aerodigestive disorders.

MAIN OUTCOMES AND MEASURES Number of operative procedures and estimated hospital charges related to combining clinic encounters and operative procedures.

RESULTS During the initial visit, each of the 125 patients received a mean (SD) of 2.9 (0.8) of a potential 4 services. Estimating per-encounter visit costs for gas, parking, and facility fees, we found that the average cost savings per family per PAC visit was \$182. Evaluation under anesthesia was recommended for 85 patients (68%), resulting in 267 operative procedures performed by participating services during 158 encounters with general anesthesia. Thus, 109 episodes of anesthesia were avoided (41% reduction), reducing the risks of anesthesia and related care costs (\$1985 per avoided episode).

CONCLUSIONS AND RELEVANCE Coordination of interdisciplinary care in the PAC resulted in a reduction of hospital charges realized through reduction in clinic- and anesthesia-related visits. Reductions in episodes of anesthesia may also reduce neurocognitive risks associated with multiple anesthetic exposures. Other nontangible benefits associated with the coordination of care, such as caregiver satisfaction, warrant further study.

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Children with complex respiratory and gastrointestinal symptoms, also known as aerodigestive disorders, can present with a variety of diagnoses, including sleep apnea, asthma, congenital airway or esophageal anomalies, dysphagia, feeding disorders, gastroesophageal reflux, esophagitis, and/or airway malacia. The burden of disease is unknown because no estimates of the prevalence of these complex aerodigestive disorders exist, but these conditions may be more common than previously realized. One common presentation of a pediatric aerodigestive disorder is infant feeding disorder: in 2010 2.6% of sick newborns discharged from short hospital stays in the United States had feeding disorders (*International Classification of Diseases, Ninth Revision [ICD-9] code 779.3*).¹ These disorders, even as comorbidities, can lead to increased mortality and morbidity; for example, comorbid dysphagia in hospitalized patients has been associated with longer hospital stays and increased mortality.² These children frequently require care from multiple pediatric subspecialists, including gastroenterologists, dietitians and/or nutritionists, otolaryngologists, pulmonologists, respiratory therapists, and speech-language pathologists. Over the past decade, a number of pediatric tertiary care hospitals have established interdisciplinary clinics to coordinate care,^{3,4} including at least 35 centers in the United States as of May 2014 (found via systematic web search for pediatric aerodigestive center websites, May 16, 2014).

The primary goal of pediatric interdisciplinary coordination of care is to improve outcomes. Benefits of interdisciplinary approaches for children have been observed in the management of obesity,^{5,6} asthma,^{7,8} diabetes,^{9,10} and cystic fibrosis.^{11,12} Compared with conventional subspecialty care where clinicians are seen on separate occasions, coordinated care of aerodigestive disorders may result in a more rapid reduction in symptoms owing to earlier diagnoses and thereby improve patient and family quality of life. In addition, although some pediatric interdisciplinary clinics have demonstrated a reduction of costs to the family and society for nonaerodigestive disorders,¹³⁻¹⁵ others have not.¹⁶ Finally, in a number of cases medical management fails to improve aerodigestive disorders,³ and examination under anesthesia may be warranted, including flexible and rigid bronchoscopy and esophagogastroduodenoscopy. An interdisciplinary approach may reduce the number of separate episodes of anesthesia and thus reduce the risks associated with anesthesia. We have been unable to locate any published studies quantifying the potential benefits of an interdisciplinary approach to pediatric aerodigestive disorders.

In 2010, the Pediatric Aerodigestive Center (PAC) was established at our pediatric tertiary care center to coordinate care by specialists in gastroenterology, otolaryngology, pulmonology, and speech-language pathology. The goals of this joint effort were to provide interdisciplinary evaluation during a single clinic encounter and combine operative management, when warranted, with the goal of reducing anesthesia exposure. The purpose of the present investigation was to determine the effect of interdisciplinary coordination on health care costs and anesthesia-related risks. We hypothesized that clinical coordination between pediatric subspecialties would lead to reduced estimated hospital charges and number of episodes of general anesthesia, with the primary assumption that all care

coordinated through the PAC would have been achieved through separate clinic visits and operative encounters if the patient were not seen in PAC.

Methods

This retrospective medical record review was approved by the Johns Hopkins institutional review board, which waived written informed consent.

Study Sample

All participants (n = 125) attended the Johns Hopkins PAC between June 2010 and August 2013. Patients were internally referred to the PAC by pediatric subspecialty faculty at Johns Hopkins as well outside referrals from area pediatricians. There were no specific criteria for clinic attendance; but patients typically had multisystem symptoms and/or diagnoses.

Demographic Characteristics

Race and/or ethnicity was self-reported. Driving distance to clinic was calculated from residential zip code using Google Maps.

Clinic Encounters

Dates of clinical encounters in the PAC were obtained through medical record review. A subject was defined as having seen a particular specialty service on the basis of a dictated note in the electronic medical record. Subjects had the potential to be seen by as many as 4 services on a single clinic visit, including gastroenterology, otolaryngology, pulmonology, and speech-language pathology. The PAC clinicians determined which participants needed which consulting services in a pre-clinic meeting.

Operative Encounters

Decisions to proceed with operative procedures were based on clinician judgment. Dates of operative procedures were obtained through medical record review. A participant was defined as having a procedure on the basis of a dictated note in the electronic medical record. An *operative encounter* for a specific service encompassed all procedures performed by that service on a single day. For example, a laryngeal cleft repair and tonsillectomy performed by otolaryngology on a single day would be tabulated as a single operative encounter for otolaryngology, although 2 separate procedures were performed. In contrast, multiple services performing procedures on the same day would be tabulated as separate operative encounters; a laryngeal cleft repair and tonsillectomy performed by otolaryngology and a flexible bronchoscopy performed by pulmonology would be tabulated as 2 separate operative encounters because 2 specialty services completed procedures.

A *missed opportunity* for coordination of care was arbitrarily defined as a specialty service performing an elective procedure within 90 days of a different PAC specialty service performing a procedure on the same patient after the initial PAC visit. For example, gastroenterology performing a diagnostic esophagogastroduodenoscopy 60 days after otolaryngology performed an adenoidectomy would be coded as a missed opportunity.

Table 1. Participant Demographic Characteristics

Characteristic	Patients Seen in the PAC (n = 125)
Sex, No. (%)	
Male	78 (62.4)
Female	47 (31.8)
Race/ethnicity, No. (%)	
White	82 (65.6)
Black	26 (20.8)
Hispanic	5 (4.0)
Other	12 (9.6)
Age, median (range), y	1.51 (0.08-21.26)
Distance to clinic, median (range), miles	25.3 (0.60-2099.00)

Abbreviation: PAC, Pediatric Aerodigestive Center at Johns Hopkins.

Table 2. Clinic Encounter Characteristics

Characteristic	Patients Seen in the PAC, No. (%) (n = 125)
Specialty services involved	
1	5 (4.0)
2	32 (25.6)
3	56 (44.8)
4	32 (25.6)
Particular service involved	
Gastroenterology	91 (72.8)
Otolaryngology	121 (96.8)
Pulmonology	90 (72.0)
Speech-language pathology	63 (50.4)

Abbreviation: PAC, Pediatric Aerodigestive Center at Johns Hopkins.

Hospital Charge Estimates

Publicly available 2014 charge rates for our institution for preoperative and postoperative care are \$11.41 per minute; for anesthesia time, \$6.65 per minute; and for operating room time, \$24.17 per minute (<http://www.hsrc.state.md.us>).

Statistical Methods

Demographic frequencies and clinical outcomes were tabulated and summarized using STATA IC 11 software (StataCorp LP). Only descriptive statistics were performed.

Results

Demographics

There were a total of 163 outpatient clinical encounters in the interdisciplinary PAC for 125 unique participants: 97 participants were seen once; 20 had 2 visits; 6 had 3 visits; and 1 had 4 visits to the PAC. Of the 125 participants, 62.4% were boys, and 65.6% were white (Table 1). The median age at the initial clinic visit was 1.51 years (age range, 0.08-21.26 years). During the initial clinic visit, participants were seen by an average (SD) of 2.9 (0.8) of 4 possible consulting services (Table 2). Specifically, 72.8% of participants were seen by gastroenterology, 96.8% by otolaryngology, 72.0% by pulmonology, and 50.4% by speech-language pathology.

Table 3. Operative Encounter Characteristics

Characteristic	Patients Seen in the PAC, No. (%) (n = 125)
Anesthesia encounters involving gastroenterology, otolaryngology, or pulmonology	
0	40 (32.0)
1	43 (34.4)
2	26 (20.8)
3	9 (7.2)
4	3 (2.4)
5	2 (1.6)
6	0
7	2 (1.6)
More than 1 operative encounter with a specific service	
Gastroenterology	69 (55.2)
Otolaryngology	76 (60.8)
Pulmonology	42 (33.6)

Abbreviation: PAC, Pediatric Aerodigestive Center at Johns Hopkins.

Clinic Costs

Estimated costs for a trip to the clinic independent of clinician fees include facility fees (\$80 per clinic visit) and parking (\$10). Based on residential zip code, families resided a median of 25.3 miles from the clinic location (range, 0.60-2099.00 miles). Estimated costs for gas for a clinic round trip using median mileage for the calculations were \$5.90. Thus, for every additional clinic clinician seen in the PAC at a single visit, a total of \$96 was saved. In a single PAC visit, families saw a mean of 2.9 clinicians; thus, on average, 1.9 additional trips to clinic were avoided, resulting in mean savings of \$182 per participant. Costs related to child care, meals, and missed time from work were not calculated.

Reduction in Anesthesia Encounters

Of the 125 participants, 85 (68%) underwent a total of 267 operative encounters by participating services in the operating room after the initial PAC visit (Table 3). This included 99 encounters with gastroenterology, 117 with otolaryngology, and 51 with pulmonology. At least 60.8% of participants had at least 1 procedure performed by otolaryngology; 55.8% had at least 1 procedure performed by gastroenterology; and 33.6% had at least 1 procedure performed by pulmonology. These 267 encounters with the participating services required a total of 158 episodes of general anesthesia. Thus, by services coordinating to combine procedures, a total of 109 episodes of anesthesia were avoided (41% reduction). Of note, only 32 participants (26%) underwent "triple endoscopy" (bronchoscopy, esophagogastroduodenoscopy, and laryngoscopy).

Missed Opportunities for Joint Procedures

There were 2 occurrences of a service performing a procedure within 90 days of a different service performing a procedure. On both of these occasions, a procedure was emergently required (one for gastrostomy tube replacement, the other for pulmonary infiltrate); thus, there were no missed opportunities for coordinating elective procedures to minimize anesthesia exposure.

Operative Costs

There are several components of charges for operative encounters, including the operating clinician's fee, the anesthesiologist's fee, and the facility fee. The facility fee encompasses preoperative care, operating room costs, and postoperative observation. We assume that if operative encounters are combined, the operating clinician's fees, anesthesiologist's fees, and operating room costs for the procedure remain similar to those if the procedures were performed separately. However, some savings may be realized from reduced anesthesia costs, reduced operating room time, and fewer episodes of preoperative and postoperative care. For each combined procedure, an estimated 2 hours of preoperative and postoperative care was avoided in addition to a reduction of 20 minutes of induction and emergence time, which is typically conducted in the operating room at our facility. Based on publically available 2014 charge rates for our institution, \$1369 was saved in preoperative and postoperative charges, \$133 saved in anesthesia charges, and \$483 saved in operating room charges, for a total of \$1985 per avoided anesthetic encounter. Thus, in avoiding 109 anesthetic encounters, participants realized an estimated \$216 365 reduction in hospital charges, or an average of \$3490 for each of the 62 participants who underwent combined procedures or \$1731 per participant when averaged over the entire clinic population.

Discussion

This is the first investigation to our knowledge to report on the potential reduction in hospital charges associated with an interdisciplinary approach for children with aerodigestive disorders. Our model of care also meets 1 of the goals (care coordination) of the Patient Protection and Affordable Care Act signed into US law in 2010. Coordination of care has been defined by the Agency for Quality Healthcare and Research (AHQR) as "the deliberate organization of patient care activities between two or more participants (including the patient) involved in a patient's care to facilitate the appropriate delivery of health care services."^{17(p41)} Furthermore, organization of care can be defined as "the marshaling of personnel and other resources needed to carry out all required patient care activities and is often managed by the exchange of information among participants responsible for different aspects of care."^{18(p41)} We found that coordination of interdisciplinary care in the PAC resulted in a theoretical hospital charge reduction and clinic costs of nearly \$2000 per participant realized through reduction in clinic- and anesthesia-related visits as well as a reduction in the number of episodes of anesthesia.

In our interdisciplinary approach to pediatric aerodigestive disorders, we estimate a savings of \$182 for the initial clinic visit and \$1731 per participant for operative encounters, yielding a total reduction of hospital charges and clinic costs of \$1913 per participant. It is also possible that further reductions in health care burden were realized through decreased lost time from work and family responsibilities and a reduction in acute care utilization through coordination of care.

However, it should be recognized that while interdisciplinary coordination of care for children and a subsequent es-

timated reduction in hospital charges results in a theoretical cost savings, this assumption of cost savings may not be true for all stakeholders. For example, all clinicians and/or hospitals may not find this model financially viable. A 2004 study¹⁹ in a pediatric endocrinology practice observed that clinician expenses were covered in a single specialty clinic for diabetes but not in an interdisciplinary one. In terms of insurers' costs, it is possible that attending an interdisciplinary aerodigestive clinic leads to more operative procedures. A 2005 study¹⁶ of 175 medically complex children enrolled in an interdisciplinary primary care clinic reported decreased lengths of stay for hospital admissions but increased use of surgical services after enrollment in the clinic. Finally, depending on the deductible amount of their insurance coverage, families may still face the same out-of-pocket expenses even with our estimated reduction of hospital costs.

We found that through coordination of care, the number of anesthesia episodes experienced by medically complex children was reduced by 41%. Such a reduction may have only marginal reduction in cumulative anesthesia duration, but it substantially reduces the number of inductions and emergences a patient experiences. This has implications for patient safety because anesthesia-related critical events may disproportionately occur during induction and emergence.²⁰⁻²²

In addition, recent reports have highlighted the potential association between multiple episodes of anesthesia and learning disabilities and other poor neurocognitive outcomes.²³⁻²⁷ However, this observed association in retrospective populations is not seen in all populations.²⁸ In the absence of more definitive data from pending prospective studies of anesthesia and neurocognitive outcomes,²⁹ we cannot speculate that the participants who underwent combined operative encounters had better developmental outcomes than if they had undergone the encounters separately.

Furthermore, it is unclear whether cumulative anesthesia duration or number of episodes of anesthesia is the true risk factor.³⁰ This is a key distinction because our interdisciplinary approach may or may not have marginal reduction in cumulative anesthesia duration.

Conclusions

Although the present report is one of the first to describe some of the potential benefits of an interdisciplinary approach to pediatric aerodigestive disorders, our study does have limitations. The most significant limitation is our assumption that all care provided through the PAC would have occurred even if the participant had not attended the PAC. It is possible that not attending the PAC could lead to lower hospital charges because clinic visits and procedures by some subspecialists might not have occurred. However, it is also possible that not attending the PAC might have led to higher costs through poorly coordinated care.

In terms of generalizability, our patients are internally referred, and consequently our case mix, both in terms of severity of symptoms and frequency of specific diagnoses, may be different than that seen in other pediatric institutions where self-

referral occurs; thus, the cost savings and anesthetic reduction may differ from other centers. Additionally, although it is possible that coordination of care leads to a reduction in acute care utilization, we were not able to capture costs related to admissions or clinic visits for acute exacerbations of the participants' chronic aerodigestive conditions. Our institution is located in a dense urban area and not necessarily the closest institution for acute care admissions for most of our participants.

Although we observed a reduction in potential charges for medical care and a reduction in the number of episodes of an-

esthesia, there are certainly other nontangible benefits associated with the coordination of care that our study did not capture. Specifically, such potential benefits may include direct medical benefits of more rapid diagnoses and treatment, better communication between clinicians, decreased wait times for families to receive a coordinated plan of care, and indirect benefits such as improved caregiver satisfaction. Prospective longitudinal studies are needed to capture the benefits and improved outcomes that interdisciplinary pediatric aerodigestive clinics can potentially offer.

ARTICLE INFORMATION

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REFERENCES

- Centers for Disease Control and Prevention. Number of all-listed diagnoses for sick newborn infants discharged from short-stay hospitals. http://www.cdc.gov/nchs/data/nhds/8newsborns/2010new8_numbersick.pdf. Accessed June 3, 2014.
- Altman KW, Yu GP, Schaefer SD. Consequence of dysphagia in the hospitalized patient: impact on prognosis and hospital resources. *Arch Otolaryngol Head Neck Surg*. 2010;136(8):784-789.
- Hill CA, Ramakrishna J, Fracchia MS, et al. Prevalence of eosinophilic esophagitis in children with refractory aerodigestive symptoms. *JAMA Otolaryngol Head Neck Surg*. 2013;139(9):903-906.
- Maturo SC, Braun N, Brown DJ, Chong PS, Kerschner JE, Hartnick CJ. Intraoperative laryngeal electromyography in children with vocal fold immobility: results of a multicenter longitudinal study. *Arch Otolaryngol Head Neck Surg*. 2011;137(12):1251-1257.
- Bocca G, Corpeleijn E, van den Heuvel ER, Stolk RP, Sauer PJ. Three-year follow-up of 3-year-old to 5-year-old children after participation in a multidisciplinary or a usual-care obesity treatment program. *Clin Nutr*. 2013;32(12):1251-1257.
- Nemet D, Ben-Haim I, Pantanowitz M, Eliakim A. Effects of a combined intervention for treating severely obese prepubertal children. *J Pediatr Endocrinol Metab*. 2013;26(1-2):91-96.

- Condren M, Boger JA. Impact of a pediatric clinic-based multidisciplinary asthma education and management program. *J Pediatr Pharmacol Ther*. 2005;10(4):254-258.
- Chan DS, Callahan CW, Moreno C. Multidisciplinary education and management program for children with asthma. *Am J Health Syst Pharm*. 2001;58(15):1413-1417.
- Goss PW, Paterson MA, Renelson J. A 'radical' new rural model for pediatric diabetes care. *Pediatr Diabetes*. 2010;11(5):296-304.
- Sworen BM, Butler D, Levine BS, Anderson BJ, Laffel LM. Reducing acute adverse outcomes in youths with type 1 diabetes: a randomized, controlled trial. *Pediatrics*. 2003;112(4):914-922.
- Lebecque P, Leonard A, De Boeck K, et al. Early referral to cystic fibrosis specialist centre impacts on respiratory outcome. *J Cyst Fibros*. 2009;8(1):26-30.
- Mahadeva R, Webb K, Westerbeek RC, et al. Clinical outcome in relation to care in centres specialising in cystic fibrosis: cross sectional study. *BMJ*. 1998;316(7147):1771-1775.
- Casey PH, Lyle RE, Bird TM, et al. Effect of hospital-based comprehensive care clinic on health costs for Medicaid-insured medically complex children. *Arch Pediatr Adolesc Med*. 2011;165(5):392-398.
- Bhaumik U, Norris K, Charron G, et al. A cost analysis for a community-based case management intervention program for pediatric asthma. *J Asthma*. 2013;50(3):310-317.
- Bratton DL, Price M, Gavin L, et al. Impact of a multidisciplinary day program on disease and healthcare costs in children and adolescents with severe asthma: a two-year follow-up study. *Pediatr Pulmonol*. 2001;31(3):177-189.
- Berman S, Rannie M, Moore L, Elias E, Dryer LJ, Jones MD Jr. Utilization and costs for children who have special health care needs and are enrolled in a hospital-based comprehensive primary care clinic. *Pediatrics*. 2005;115(6):e637-e642.
- McDonald KM, Sundaram V, Bravata DM, et al. *Closing the Quality Gap: A Critical Analysis of Quality Improvement Strategies*. Vol 7. Rockville, MD: Care Coordination; 2007.
- Weeks DL, Polello JM, Hansen DT, Keeney BJ, Conrad DA. Measuring primary care organizational capacity for diabetes care coordination: the Diabetes Care Coordination Readiness Assessment. *J Gen Intern Med*. 2014;29(1):98-103.
- Melzer SM, Richards GE, Covington ML. Reimbursement and costs of pediatric ambulatory

diabetes care by using the resource-based relative value scale: is multidisciplinary care financially viable? *Pediatr Diabetes*. 2004;5(3):133-142.

20. Gupta S, Naithani U, Brajesh SK, Pathania VS, Gupta A. Critical incident reporting in anaesthesia: a prospective internal audit. *Indian J Anaesth*. 2009;53(4):425-433.

21. Klanarong S, Suksompong S, Hintong T, Chau-In W, Jantorn P, Werawatganon T. Perioperative pulmonary aspiration: an analysis of 28 reports from the Thai Anesthesia Incident Monitoring Study (Thai AIMS). *J Med Assoc Thai*. 2011;94(4):457-464.

22. Khan FA, Hoda MQ. A prospective survey of intra-operative critical incidents in a teaching hospital in a developing country. *Anaesthesia*. 2001;56(2):177-182.

23. Wilder RT, Flick RP, Sprung J, et al. Early exposure to anesthesia and learning disabilities in a population-based birth cohort. *Anesthesiology*. 2009;110(4):796-804.

24. Flick RP, Katusic SK, Colligan RC, et al. Cognitive and behavioral outcomes after early exposure to anesthesia and surgery. *Pediatrics*. 2011;128(5):e1053-e1061.

25. Ing C, DiMaggio C, Whitehouse A, et al. Long-term differences in language and cognitive function after childhood exposure to anesthesia. *Pediatrics*. 2012;130(3):e476-e485.

26. DiMaggio C, Sun LS, Kakavouli A, Byrne MW, Li G. A retrospective cohort study of the association of anesthesia and hernia repair surgery with behavioral and developmental disorders in young children. *J Neurosurg Anesthesiol*. 2009;21(4):286-291.

27. Kalkman CJ, Peelen L, Moons KG, et al. Behavior and development in children and age at the time of first anesthetic exposure. *Anesthesiology*. 2009;110(4):805-812.

28. Bartels M, Rietveld MJ, Van Baal GC, Boomsma DI. Heritability of educational achievement in 12-year-olds and the overlap with cognitive ability. *Twin Res*. 2002;5(6):544-553.

29. Sun L. Early childhood general anaesthesia exposure and neurocognitive development. *Br J Anaesth*. 2010;105(suppl 1):i61-i68.

30. Slacon J. Cumulative duration of anesthesia as a risk factor for learning disabilities. http://pediatrics.aapublications.org/content/early/2011/09/28/peds.2011-0351.abstract/reply#pediatrics_el51721. Accessed January 30, 2014.