



Demonstrating the Benefits of a Multidisciplinary Aerodigestive Program

Amanda G. Ruiz, BA; Jay M. Bhatt, MD; Emily M. DeBoer, MD; Joel Friedlander, DO; Norah Janosy, MD;
Melissa Brooks Peterson, MD; Todd Wine, MD; Robin Deterding, MD; Jeremy D. Prager, MD, MBA

Objectives/Hypothesis: The Aerodigestive Program (the Aero Program) at Children’s Hospital Colorado is a multidisciplinary program focused on airway, digestive, and lung disorders in complex children, involving collaboration between gastroenterology, pulmonology, anesthesiology, and otolaryngology in clinic and operating room. These programs have proliferated as institutions focus on providing greater care coordination and family satisfaction. However, few cost, charge, and satisfaction data exist to support these resource-intensive programs. The goal of this study was to investigate the value of combined triple endoscopy delivered by the Aero Program through analysis of institutional charges, direct costs, operating room efficiency metrics, and parent satisfaction.

Study Design: Program evaluation.

Methods: Finance, satisfaction, efficiency, and quality-of-care metrics were evaluated within and outside of the Aero Program through retrospective queries of electronic health records, administrative databases, and parent surveys at our institution.

Results: Mean anesthesia time in the Aero Program was 54 minutes (49–60; 95% confidence interval), which was significantly less ($P < .0001$) than the estimated 89 minutes of having the three procedures done separately. Average charges and average direct costs for triple endoscopy were 38.8% and 41.9% less than the sum of the averages for separate procedures, respectively. Parent satisfaction was high for the Aero Program care.

Conclusions: As organizations move toward greater coordination of care for complex patients, multidisciplinary programs must demonstrate their value by delivering cost-effective care. Aerodigestive programs have the potential to provide satisfying care that is less costly to the organization, insurer, and family. These programs represent a step in the evolution toward higher value care and value-based payment methodology.

Key Words: Pediatric, interdisciplinary care, aerodigestive program, care coordination, cost-effectiveness.

Level of Evidence: 4

Laryngoscope, 9999:1–5, 2019

Additional Supporting Information may be found in the online version of this article.

From the Department of Pediatric Otolaryngology (A.G.R., J.M.B., T.W., J.D.P.), Department of Pediatrics–Section of Pulmonary Medicine (E.M.D., R.D.), Department of Pediatrics–Section of Gastroenterology, Hepatology, and Nutrition (J.F.), and Department of Pediatric Anesthesiology (N.J., M.B.P.), University of Colorado School of Medicine and Children’s Hospital Colorado, Aurora, Colorado, U.S.A.

Editor’s Note: This Manuscript was accepted for publication on February 27, 2019.

Presented at the American Society of Pediatric Otolaryngology Meeting, Austin, Texas, U.S.A., May 18–21, 2017.

Dr. DeBoer discloses founders stock, board membership, and ownership of Triple Endoscopy, Inc. Dr. Friedlander is President and Cofounder/Owner of Triple Endoscopy, Inc. and coinventor on patent pending US PCT 15/850,939, CIP 15/853,521, CON 15/887,438, CA PCT 2,990,182, AU 2016283112 EP PCT 16815420.1 JP PCT 2017-566710 and WO PCT/US2016/039352 related to endoscopic methods and technologies. Dr. Friedlander was a consultant to QOL Medical during the time frame of the manuscript that has now ceased. Dr. Prager discloses founders stock, board membership, and ownership of Triple Endoscopy, Inc. Dr. Prager is also supported by Surgery Research Partnership grant PGO100481. Dr. Deterding discloses founders stock, board membership, and ownership of Triple Endoscopy, Inc.

This work was funded by the Clinical Effectiveness and Patient Safety Small Grants Program, University of Colorado School of Medicine.

The authors have no other funding, financial relationships, or conflicts of interest to disclose.

Send correspondence to Jeremy D. Prager, MD, MBA, Department of Pediatric Otolaryngology, Children’s Hospital Colorado, B-455, 13123 East 16th Avenue, Aurora, CO 80045. E-mail: jeremy.prager@childrenscolorado.org

DOI: 10.1002/lary.27939

INTRODUCTION

Children with complex disorders of the aerodigestive tract often require evaluation and management from multiple disciplines. Families spend a great deal of time being seen by multiple specialties in different settings and undergoing diagnostic procedures, ancillary studies, and therapies. Thus, the potential exists for communication and collaboration issues. In addition, the patients and their families as well as the payers and healthcare organizations have concerns regarding the cost of delivering care in this fashion. These costs can be a source of frustration and anxiety and include time and opportunity costs for families.

Academic organizations have begun to address the need for comprehensive aerodigestive care of children through the development of multidisciplinary programs. Aerodigestive programs focus on children with complex breathing and feeding disorders and offer a team of specialists including pulmonology (Pulm), gastroenterology (GI), otolaryngology (ENT), speech pathology, and others in a single visit. The goal is to provide comprehensive and coordinated care and to decrease the time-cost and financial burden on the families.

The Aerodigestive Program (the Aero Program) at Children’s Hospital Colorado (CHCO) began in 2010 and offers a single clinic visit with multiple providers as well

as combined procedures in a single operating room (OR) encounter. These programs offer improved coordination of care for patients including less travel, time, and opportunity costs. For providers and healthcare organizations, these are resource-intensive programs, requiring multiple providers to coordinate their schedules, that often lead to less patients being seen in a specified amount of time than could be seen outside of a multidisciplinary program. In addition, operative resources are not insignificant, given the coordination and time required to place these specialties in the same location with regularity. The literature exploring the cost and charge data, safety, and family satisfaction of multidisciplinary aerodigestive programs is nascent and often involves evaluation of the clinic process. Recent consensus statements have been published to help direct the structure and function of pediatric aerodigestive programs, but additional evidence-based outcomes with regard to their structure and function are needed to help develop uniform guidelines.¹

The aim of the project was to assess the direct costs, charges, family satisfaction, and time under anesthesia of patients undergoing diagnostic operative evaluation through a multidisciplinary aerodigestive program and compare to single-specialty care of pediatric aerodigestive tract disorders.

MATERIALS AND METHODS

This study was carried out as a 2-year (2014–2015), single-institution retrospective quality-improvement study. It did not meet the definition of human subject research per the Department of Health and Human Services and the Food and Drug Administration regulations. The study was approved by the CHCO Organizational Research Risk and Quality Improvement Review Panel. It did not require interaction with patients, and the review panel did not require a consent process.

Procedures were identified by a clinical informatics data analyst via a query of the electronic medical record. An aero triple scope procedure was defined as a combination procedure of a microlaryngoscopy/bronchoscopy (MLB), pulmonary flexible bronchoscopy (Flex Bronch), and upper endoscopy (EGD), coordinated so all providers (ENT, Pulm, GI) were present together in the OR and it was completed under the Aero Program service name. All identified procedures underwent quality control by two-pass verification. Two different research assistants reviewed patient charts to ensure no ancillary procedures were performed and to account for comorbidities. Aero triple scopes with ancillary procedures or comorbidities with anesthetic precautions, such as malignant hyperthermia, were excluded from the data set.

For statistical comparison, the electronic medical record was queried for the three procedures defined under aero triple scope as separate, stand-alone procedures. An ENT MLB was identified by procedure name (MLB) and service name (ENT). Similarly, a Pulm Flex Bronch and GI EGD were identified by procedure name (Flex Bronch, EGD) and service name (Pulm, GI). For quality control, two different research assistants reviewed patient charts to ensure the patients underwent only one of the three procedures without any ancillary procedures and that the procedure was completed by its respective service. Patients who underwent a stand-alone procedure with any ancillary procedures, had comorbidities with anesthetic precautions, or were assigned to a service other than ENT, Pulm, or GI were excluded from the data set.

Time Under Anesthesia

Total anesthesia time in minutes was calculated for all included procedures. An estimate of average anesthesia time should a patient undergo the three procedures as stand-alone procedures was calculated by summing the averages of the stand-alone procedures. A one-sample *t* test was used to compare this summed average with the average anesthesia time for the aero triple scope. Significance was set at .05. R version 3.1.1 software (R Foundation for Statistical Computing, Vienna, Austria, <http://www.R-project.org/>) was used.

Direct Cost and Charge Data

Direct costs are those expenses incurred that are directly related to the treatment and care of a patient. These costs are calculated based on standard cost accounting methodologies that include relative value units and ratio of cost-to-charge allocations. Examples of direct costs include but are not limited to nursing labor, lab supplies, pharmaceuticals and diagnostic imaging.

Direct cost and charge data were collected for our identified procedures. The Hospital Account Record, a unique identifier that groups charges on the encounter level, was used to query a CHCO financial database for direct cost and charges per visit. Encounters with emergency department, urgent care visit, and inpatient and intensive care unit stays were excluded from the cost and charge data analysis.

All identified aero triple scopes were included in the analysis. Ten ENT MLBs and 25 Pulm Flex Bronchs were excluded from the financial analysis. Two-hundred of the 846 GI EGDs were randomly selected for query in the CHCO financial database. Of the 200, 195 GI EGDs met the criteria for inclusion in the financial analysis.

The average direct cost and charge for patients receiving all three scopes separately were estimated by summing the averages of the three stand-alone procedures (ENT MLB, GI EGD, and Pulm Flex Bronch). Charge reduction percentage (direct cost non-aero/direct cost reduction in aero) was used to compare the charge and cost of an aero triple scope with the charge and cost of the three scopes as separate procedures outside of the Aero Program.

Family Satisfaction Data

Prospective patient satisfaction survey (see Supporting Information, Appendix 1, in the online version of this article) was administered via Research Electronic Data Capture (REDCap) tools hosted at University of Colorado, Denver.² REDCap is a secure, Web-based application designed to support data capture for research studies that provides 1) an interface for validated data entry; 2) audit trails for tracking data manipulation; 3) automated data downloads to common statistical packages; and 4) procedures for importing data from external sources. In particular, the family satisfaction survey was developed by the study

TABLE I.
Average Procedure Time.

Procedure	N	Mean ± SD, min	Range, min
Aero triple scope	32	54 ± 15	32–95
ENT MLB	41	26 ± 14	13–84
GI EGD	846	23 ± 9	6–82
Pulmonary flexible bronchoscopy	32	39 ± 19	14–98

EGD = upper endoscopy; ENT = otolaryngology; GI = gastroenterology; MLB = microlaryngoscopy/bronchoscopy; SD = standard deviation.

TABLE II.
Children's Hospital Colorado Fiscal Year 2014–2015 Aero Program Charge and Direct Cost Reduction (Average for Triple Endoscopy vs. the Sum of Averages for Separate Procedures).

	Aero Charge per Visit Reduction, %	Aero Direct Cost per Visit Reduction, %
Anesthesia related	42.0	39.0
Lab related	24.0	40.0
Medical/surgical supplies related	43.0	31.0
Pharmacy related	51.0	52.0
Surgery related	34.0	32.0
Treatment/recovery room related	53.0	50.0
Grand total	39.0	42.0

investigators using standardized survey development methodology. The survey was initially reviewed by the coinvestigators, and a 14-question survey was piloted with 10 families who also provided verbal feedback. The feedback was reviewed, and a Cronbach α test was completed to evaluate internal consistency between questions.

Following analysis, one question was removed from the survey due to low reliability. The final survey consisted of 13 discrete field questions using a Likert scale with two anchors: disagree very much and agree very much. A comment box was added so

parents could provide additional feedback. The questions aimed to determine parent satisfaction not only with the program but also with the multidisciplinary approach. Quantitative analysis was completed on the results of the survey.

RESULTS

Thirty-two aero triple scope procedures, 41 ENT MLBs, 846 GI EGDs, and 32 Pulm Flex Bronchs were identified over a 2-year period (2014–2015).

Time Under Anesthesia

Anesthesia data were retrospectively collected over a 2-year period for 951 patients who had one of four procedures: aero triple scope, ENT MLB alone, GI EGD alone, and Pulm Flex Bronch alone. The average mean anesthesia time for an aero triple scope of 54 minutes (95% confidence interval, 49–60 minutes) was significantly less than the estimated time of having all three procedures done separately, which was 89 minutes ($P < .0001$) (Table I).

Charge and Direct Cost Data

ENT MLB (N = 31), GI EGD (N = 195), and Pulm Flex Bronch (N = 7) direct cost and charge data were

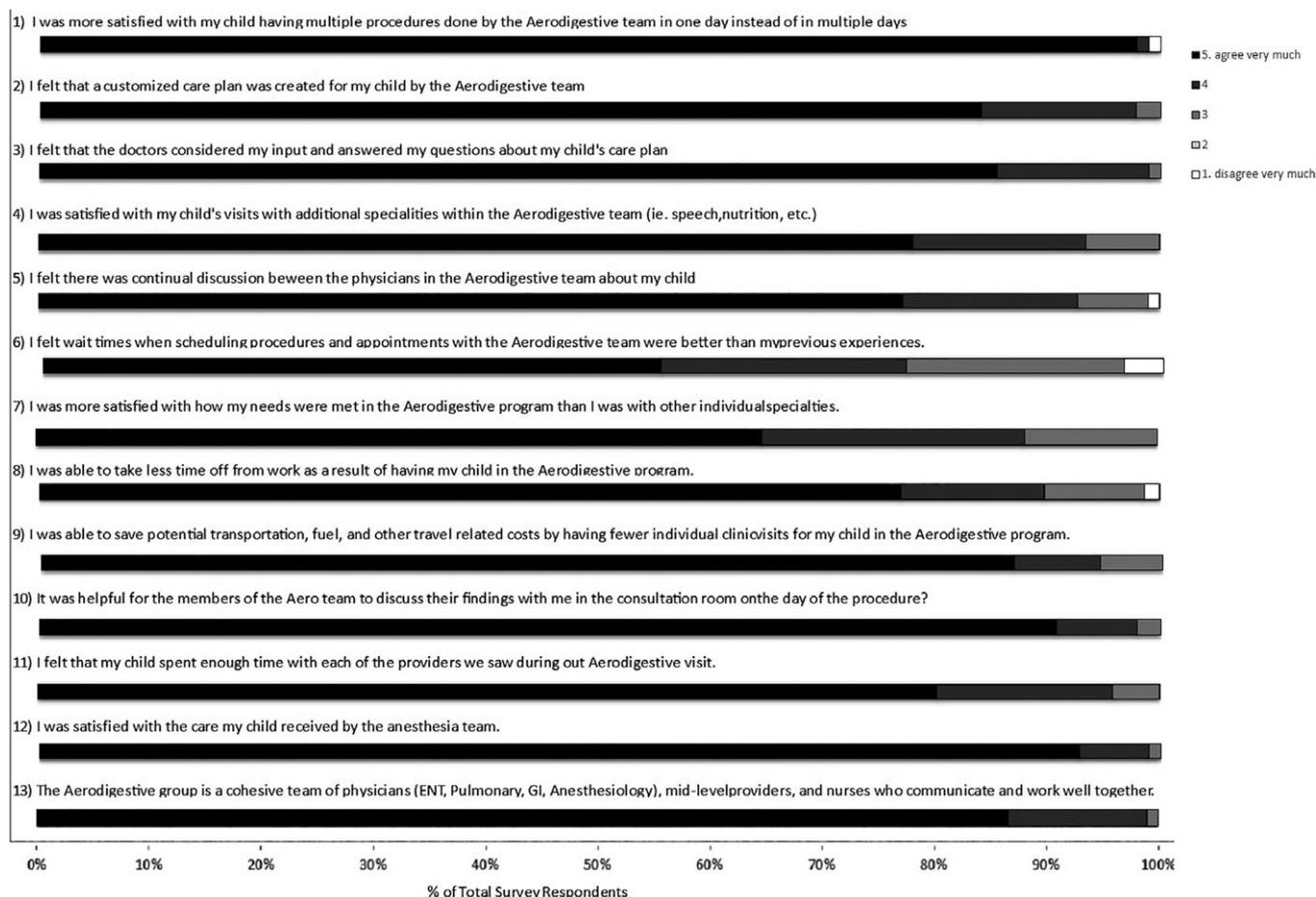


Fig. 1. Family satisfaction survey. ENT = otolaryngology; GI = gastroenterology.

collected for fiscal year 2014–2015. For data integrity and power, aero triple scope direct cost and charge data were collected over a 2-year period (N = 32 procedures). Average charges and average direct costs for aero triple scope were 38.8% and 41.9% less than the sum of the averages for separate procedures, respectively (Table II). Using the same methodology (average charges for triple endoscopy vs. the sum of averages for separate procedures) applied to CHCO revenue code buckets, we found that the greatest percentage charge reductions were in seen in the categories of treatment/recovery room, pharmacy, medical/surgical supplies, and anesthesia-related charges. The greatest percentage direct-cost reductions were seen in the categories of pharmacy, treatment/recovery room, lab, and anesthesia-related direct costs.

Family Satisfaction Data

A total of 97 families of patients within the Aero Program were surveyed to determine their satisfaction with the program and the multidisciplinary care approach beginning at the end of February 2015 and continuing for a period of approximately 6 months. Because all the questions used positive wording and had the same scale, responses were collapsed into a comprehensive representation of the survey results. Overall, 80.9% of responders were very satisfied with the quality of service, including the providers, wait times, communication, and packaged care plan. Survey respondents also believed the Aero Program reduced financial and time burdens for their family (e.g., parents felt they did not need to take as much time off from work with their child being in the program compared to seeing the specialties individually) (Fig. 1).

DISCUSSION

Multidisciplinary clinics offer providers, patients and their families, and payers several opportunities for improving the value of healthcare by improving outcomes and reducing the cost of that achievement.³ A growing body of literature exists examining value delivered through multidisciplinary management of complex medical conditions. Investigations have demonstrated value enhancement in the management of pediatric asthma, cystic fibrosis, and diabetes.^{4–6} Few data exist investigating pediatric aerodigestive disorders. The first investigation of the value of this care was conducted by Collaco et al. in 2015.⁷ The authors reviewed their aerodigestive clinic and operative experience and demonstrated the potential clinic cost reductions for families from reduced facility fees, travel, and parking, as well as a 41% reduction in the number of individual anesthetic encounters. The authors also described reduced hospital charges stemming from less procedures, which were estimated using the decreased time component of anesthesia and facility charges. Potential safety benefits due to the reduction in anesthetic time as well as the reduction in induction and emergence were also described.^{8–10} This same group subsequently studied the population of patients before enrollment and after enrollment in their multidisciplinary clinic, noting a decrease in total charges after enrollment and a shift toward outpatient care.¹¹ Most

recently, Mudd et al. evaluated the revenue and direct costs of an aerodigestive program over a 14-month period, noting a positive contribution margin with the caveat that accounting for downstream encounters can impact this finding.¹²

In this study, we have collected reductions in the time components of operative care as well as reductions in charges to patients and direct costs to CHCO in our aerodigestive program. This is the first such study to quantify the reduction in time, charge, and direct cost for operative procedures within these programs to our knowledge. Not surprisingly, consolidating procedures into one anesthetic encounter significantly reduces the time under anesthetic. This is most certainly due in large part to the presence of only one induction and emergence. A confounding variable is the fact that in our program, the same core set of providers perform these procedures, and no doubt some amount of skill development and learning has occurred, leading to greater efficiency. The non-Aero Program procedures were not tracked by provider but likely were performed by many different people. Nevertheless, as concern regarding anesthetic exposure and cognitive development has increased within pediatric medicine as well as the public, interest in significantly reducing exposure encounter number and time has also grown.¹³

With regard to charges billed to the payer, time-sensitive charges were reduced by the greatest percentage in the treatment/recovery room, representing a reduction in the facility fee. Anesthesia-related charges (time-sensitive billing for physician services and medications) were also greatly reduced. Pharmacy (e.g., anxiolytic medications, antibiotics) and supply charges also decreased through consolidation of three procedures into one. The greatest percentage reductions in direct costs were seen in pharmacy costs as well as the time-sensitive categories of treatment/recovery room and anesthesia-related costs (in this case anesthetic medications). Supply costs decreased through consolidation of procedures. We speculate that lab charges and costs were reduced through improved communication among providers regarding what tests were necessary. We were not surprised to find that the service categories that are time-sensitive show reduction in both charges to the payer and direct costs to the hospital. The institution and the payer are particularly sensitive to space utilization, by way of time used, of the operating and recovery rooms, as well as anesthesia-related physician services and medications. Supply and pharmacy charges and costs are reduced primarily through the consolidation of three events into one event. Although each organization may categorize its charges and costs differently, these results provide greater details regarding specific areas in which to focus our efforts to improve the value of care delivered.

Although a reduction in charges through aerodigestive programs may decrease potential revenue in the fee for service model, this can be offset by greater case volume. Greater case volume may also be augmented by a competitive referral advantage from other physicians and choice advantage from patient customers gained from higher family satisfaction. Should the pendulum continue to swing toward value-based payment methodology and bundled payments, programs such as these represent the forefront of complex

pediatric care contracting. Developing an aerodigestive program represents an organizational decision to move toward higher efficiency, highly satisfying, higher value care. Finally, family satisfaction delivered in this fashion is high, as reflected in our survey.

In terms of outcomes, multidisciplinary aerodigestive programs offer the opportunity to improve safety by shortening procedural times and consolidating skills.^{7,14} In terms of costs, these programs can lower the opportunity costs to patients and families by combining visits and procedures. The charge to payers is also lowered because procedural elements that are associated with time under anesthetic, such as anesthesia medication and service charges as well as facility charges, are reduced when procedures are consolidated. Finally, the direct cost to the institution is also reduced. Unfortunately, reducing the direct costs to the organization does not always outweigh the reduction in revenue from reduced charges, which is the situation for our program. Consolidation of procedures brings in less net revenue at our hospital. However, the reduction in time required to perform the procedures together (35 minutes of operating time per combined Aero Program evaluation, Table II) has led to the opening of additional OR time for other services, and more cases have been completed as a result.

This investigation has several important limitations. We have assumed that all care delivered through the Aero Program would have been delivered outside of the program as well—that is, that a single patient would have had three scopes as three separate procedures. It is possible that this would not have occurred. As a result, the average anesthesia time we presented for having all three procedures done separately is an estimate and was compared to the true observed average of an aero triple scope. However, if all care had occurred as separate, independent visits, it would have taken longer due to scheduling wait times. It also would have incurred greater opportunity costs and out-of-pocket clinic and travel costs for families and would have required more time in the OR, entailing greater anesthetic exposure, and amassed greater charges to payers and direct costs to the institution as well. In addition, as noted previously, the individual procedures used to create the time averages as well as the direct cost and charge data were performed by a much larger group of providers than work in the Aero Program. It is possible that the Aero Program providers

have a significantly different workflow that is responsible for a portion of the difference seen in time, direct cost, and charge data.

CONCLUSION

Much can be learned from aerodigestive programs and other multidisciplinary methods of care delivery, particularly as reimbursement declines and care coordination and efficiency become more important. The current project demonstrated that these programs may deliver cost-effective, family-centered, and satisfying operative care for a particular population of complex children when compared to a traditional care-delivery method.

BIBLIOGRAPHY

1. Boesch RP, Balakrishnan K, Acra S, et al. Structure and functions of pediatric aerodigestive programs: a consensus statement. *Pediatrics* 2018;141.
2. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap) – a metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform* 2009;42:377–381.
3. Porter ME, Teisberg EO. *Redefining Health Care: Creating Value-Based Competition on Results*. Boston, MA: Harvard Business School; 2006.
4. Condren M, Boger JA. Impact of a pediatric clinic-based multidisciplinary asthma education and management program. *J Pediatr Pharmacol Ther* 2005;10:254–258.
5. Sawicki GS, Goss CH. Tackling the increasing complexity of CF care. *Pediatr Pulmonol* 2015;50(suppl 40):74–79.
6. 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: 26–30.
7. Collaco JM, Aherrera AD, Au Yeung KJ, et al. Interdisciplinary pediatric aerodigestive care and reduction in health care costs and burden. *JAMA Otolaryngol Head Neck Surg* 2015;141:101–105.
8. Gupta S, Naithani U, Brajesh SK, Pathania VS, Gupta A. Critical incident reporting in anaesthesia: a prospective internal audit. *Indian J Anaesth* 2009;53:425–433.
9. 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;94:457–464.
10. Khan FA, Hoda MQ. A prospective survey of intra-operative critical incidents in a teaching hospital in a developing country. *Anaesthesia* 2001;56: 177–182.
11. Skinner ML, Lee SK, Collaco JM, Lefton-Greif MA, Hoch J, Au Yeung KJ. Financial and health impacts of multidisciplinary aerodigestive care. *Otolaryngol Head Neck Surg* 2016;154:1064–1067.
12. Mudd PA, Silva AL, Callicott SS, et al. Cost analysis of a multidisciplinary aerodigestive clinic: are such clinics financially feasible? *Ann Otol Rhinol Laryngol* 2017;126:401–406.
13. Andropoulos DB, Greene MF. Anesthesia and developing brains - implications of the FDA warning. *N Engl J Med* 2017;376:905–907.
14. Garcia JA, Mistry B, Hardy S, et al. Time-driven activity-based costing to estimate cost of care at multidisciplinary aerodigestive centers. *Laryngoscope* 2017;127:2152–2158.