Can J Anesth/J Can Anesth (2017) 64:724–735
DOI 10.1007/s12630-017-0888-y

REPORTS OF ORIGINAL INVESTIGATIONS

Pediatric tonsillectomy is a resource-intensive procedure: a study of Canadian health administrative data

L'amygdalectomie pédiatrique est une procédure consommatrice de ressources : une étude des données administratives canadiennes

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Received: 22 August 2016 / Revised: 21 December 2016 / Accepted: 13 April 2017 / Published online: 21 April 2017
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Abstract

Background *The majority of pediatric surgeries are performed in a day surgery setting. The rate of adverse postoperative outcomes and the factors that influence them are poorly described in the Canadian setting. Concerns about the safety of adenotonsillectomy (AT) have been raised. The objective of this Ontario-based study was to determine the rates and risks of hospital readmission, emergency department (ED) visits, or deaths within 30 days following common pediatric surgeries, with an emphasis on AT.*

Methods *Inpatient and day surgery children who were < 18 yr of age and undergoing one of the ten most common surgeries in Ontario from 2002-2013 were identified by linking four provincial health administrative databases. Risk of each outcome was determined separately for all surgeries. Cox regression was used to measure the association of demographics, clinical factors, Ontario drug benefit (ODB) status, and prescribed opioids with adverse outcomes.*

Results *Among 364,629 children, AT accounted for 30.5% of all surgeries. The AT patient rates of readmission and ED visits compared with the full study cohort were 2.7% vs 1.5% and 12.4% vs 9.2%, respectively. The study cohort postoperative death rate was 0.27 per 10,000 children (95% confidence interval [CI], 0.18 to 0.39). For the study cohort, an increased risk of readmission was associated with previous urgent admission (hazard ratio [HR], 2.15; 95% CI, 1.75 to 2.63), length-of-stay ≥ four days (HR, 2.04; 95% CI, 1.57 to 2.65), Charlson comorbidity score ≥ 1 (HR, 1.61; 95% CI, 1.17 to 2.22), and age ≥ 14 yr (HR, 1.15; 95% CI, 1.02 to 1.19) or ≤ 3 yr (HR, 1.16; 95% CI, 1.15 to 1.17). Similar factors were associated with an increased risk of ED visits. Patients covered by ODB (11.8%), particularly those prescribed opioids, had an increased risk for readmission and ED visit.*

This article is accompanied by an editorial. Please see Can J Anesth 2017; 64: this issue.

Electronic supplementary material The online version of this article (doi:10.1007/s12630-017-0888-y) contains supplementary material, which is available to authorized users.

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Conclusions *Post-discharge readmissions and ED visits are relatively common after pediatric surgery, particularly for AT. Perioperative treatment algorithms that consider risk factors for hospital revisits are required in children.*

Résumé

Contexte *La majorité des interventions chirurgicales pédiatriques sont réalisées dans le cadre de la chirurgie d'un jour. Le taux d'événements secondaires postopératoires et les facteurs qui l'influencent sont peu décrits dans le contexte canadien. Des questions ont été soulevées à propos de la sécurité de l'adénoamygdalectomie (AA). L'objectif de cette étude ontarienne était de déterminer les taux et les risques de réhospitalisation, de visites aux services des urgences ou de décès dans les 30 jours suivant des chirurgies pédiatriques courantes, et plus particulièrement l'AA.*

Méthodes *Les enfants âgés de moins de 18 ans, hospitalisés ou en chirurgie d'un jour, ayant subi l'une des dix plus fréquentes interventions chirurgicales en Ontario entre 2002 et 2013 ont été identifiés par le regroupement de quatre bases de données administratives provinciales dans le domaine de la santé. Le risque concernant chaque critère d'évaluation a été déterminé séparément pour toutes les interventions chirurgicales. Une analyse de régression de Cox a permis de mesurer l'association entre les caractéristiques démographiques, les facteurs cliniques, le statut de bénéficiaire d'assurance médicaments de l'Ontario (ODB) et la prescription d'opioïdes, avec la survenue d'aboutissements délétères.*

Résultats *L'AA a représenté 30,5 % de toutes les interventions chirurgicales subies par 364 629 enfants. Les taux de réhospitalisations et de visites à l'urgence des patients AA comparés à ceux de l'ensemble de la cohorte ont été, respectivement, de 2,7 % contre 1,5 % et de 12,4 % contre 9,2 %. Le taux de décès postopératoires dans la cohorte de l'étude était de 0,27 pour 10 000 enfants (intervalle de confiance [IC] à 95 % : 0,18 contre 0,39). Dans la cohorte, une augmentation du taux de réhospitalisations a été associée à une admission antérieure en urgence (Rapport de risque [RR] : 2,15; IC à 95 % : 1,75 à 2,63), la durée de l'hospitalisation ≥ quatre jours (RR : 2,04; IC à 95 % : 1,57 à 2,65), un score de comorbidités de Charlson ≥ 1 (RR : 1,61; IC à 95 % : 1,17 à 2,22), et l'âge ≥ 14 ans (RR : 1,15; IC à 95 % : 1,02 à 1,19) ou ≤ 3 ans (RR : 1,16; IC à 95 % : 1,15 à 1,17). Des facteurs similaires ont été associés à une augmentation du risque de visite à l'urgence. Les patients couverts par l'ODB (11,8 %), en particulier ceux à qui des morphiniques avaient été prescrits, avaient un plus grand risque de réhospitalisation et de visites à l'urgence.*

Conclusions *Les réhospitalisations et les visites aux services d'urgence après un congé de l'hôpital sont relativement fréquentes à la suite d'une intervention chirurgicale pédiatrique, et notamment l'AA. Il est nécessaire d'avoir des algorithmes de traitement périopératoires qui prennent en compte les facteurs de risque de retour des enfants à l'hôpital.*

The quality of the perioperative care that children receive has recently come into question, with high rates of hospital readmissions and emergency department (ED) visits reported after common procedures such as adenotonsillectomy (AT).[1,2] Furthermore, United States and Canadian data would suggest that care for this surgical population is variable and does not always conform to published standards.[3,4] Care may be influenced by the level of socioeconomic status (SES),[5] but this does not appear to be a factor in Canadian or other healthcare systems with universal access.[6,7] United States data on pediatric surgical patient readmissions suggest that the majority of these are preventable.[8] While preliminary Canadian data support pain and dehydration as the main problems resulting in hospital visits following AT, [4] it is unclear how these revisit rates compare with other common surgeries. Furthermore, data similar to those developed for adult patients—i.e., identifying post-surgery discharge predictor variables for readmission, ED visits, and mortality—are lacking for pediatric patients.[9,10]

Beyond the quality of care for children undergoing surgery, questions about its safety, particularly in a day surgery setting, are being raised. Specifically, United States reports have raised concerns about home deaths following AT.[11,12] These children are vulnerable to adverse respiratory-related events[13] because of the surgery itself and the high prevalence of obstructive sleep apnea (OSA). Obstructive sleep apnea is the most common indication for AT in a pediatric setting[14] and is associated with increased sensitivity to opioid-related respiratory depression when used to manage post-surgical pain. Opioid-related adverse events (ORADEs), e.g., constipation, are common and have been shown to impact recovery, healthcare costs, length of stay (LOS) and readmission rates in adults.[15,16] More serious ORADEs (oversedation and respiratory depression) after surgery[17] may result in anoxic brain injury or death.[18] As opioids continue to be a cornerstone of pain management, it is important to understand the association between the post-discharge use of oral opioid analgesics and complications specific to AT and to surgeries in general.

The main objective of this population-based study was to estimate the rates of urgent readmission, emergency

department (ED) visits, and mortality within 30 days of commonly performed pediatric surgeries, with an emphasis on AT. A secondary objective was to identify factors associated with an increased risk of each of these outcomes. In exploratory analysis, we also sought to determine if post-discharge opioid dispensation increased the risk of these outcomes. We hypothesized that children undergoing AT would have a higher rate of postoperative complications, mortality, and risk of opioid-related outcomes compared with other common pediatric surgical populations.

Methods

Ethical

This study was approved by the Children's Hospital of Eastern Ontario Research Ethics Board and complies with the REporting of studies Conducted using Observational Routinely-collected health Data (RECORD) statement.[19]

Historical patient cohort

We identified all hospitalizations with valid Ontario Health Insurance Plan (OHIP) enrolment discharged from April 1, 2002 to March 1, 2013 for children < 18 yr of age with a least one procedure coded. We excluded admissions for neonates, patients undergoing an unplanned surgery within 30 days of a previous hospital admission, and those who were discharged to any location other than the community. From this cohort, we determined the ten most common *primary* procedures by using the first five alphanumerics of the Canadian Classification of Health Interventions codes. We included only those interventions that were operating room surgical procedures, with some similar procedures being clustered (Appendix A). The study cohort consisted of the first admission for each person for one of the top ten surgeries during the study period. Patients with another top ten procedure coded as a secondary procedure (e.g., AT with ear tube insertion/removal) were excluded.

Databases used in the study

Four provincial population-based health administrative databases in Ontario, Canada (2014 population, 13.6 million) were linked deterministically using encrypted healthcare numbers. Briefly, the Discharge Abstract Database (DAD) captures demographic, diagnostic, and procedural data for all hospital and day surgery encounters and has been determined by medical record re-abstraction studies to be accurate and reliable.[20,21] The Registered Persons Database (RPDB) provides basic demographic information (including date of death, neighbourhood, and date of last encounter with the healthcare system) on OHIP recipients. The National Ambulatory Care Reporting System (NACRS) captures all visits to emergency departments. Finally, the Ontario Drug Benefits (ODB) database records all drug prescriptions, including opioids, covered by the provincial drug plan.

Outcomes

Our study included three 30-day post-discharge outcomes: 1) urgent readmission (any unplanned admission in DAD), 2) unscheduled return to the emergency department (any emergency department visit in NACRS), and 3) all-cause death (as determined by RPDB). No data cells with numbers less than six were reported in detail to preserve confidentiality.

Covariates

We determined the following data from the DAD: patient age and sex; hospital setting (tertiary care or community hospital); whether or not the admission was urgent; time in an intensive care unit; hospital LOS; and discharge disposition (home without services, home with services, and against medical advice). Being in receipt of ODB, typical among families on social assistance, was also considered as a risk factor for adverse postoperative outcomes.[5] Diagnostic codes in DAD were used to calculate each patient's Charlson comorbidity index (American Society of Anesthesiologists physical status was unavailable) based on admissions within one year prior to the index admission and chronic diagnoses at the index admission and using category weights from Schneweiss.[22] We linked to the RPDB to determine residence (urban/rural) and the median household income quintile.

The capture of drug prescriptions among ODB patients, which represents approximately 20% of the general population,[23] provides a unique opportunity to evaluate the postoperative risk associated with opioid prescriptions in the AT population. The status of each patient's ODB coverage was determined by examining the ODB records during the one year preceding and 30 days following the index admission. Patients with claims were classified as having ODB coverage. Among ODB patients, those given opioids during the 30 days following discharge were classified as "ODB, opioids", and otherwise, they were categorized as "ODB, no opioids". Finally, in children who had undergone AT, the reason for each outcome was established based on ICD codes.

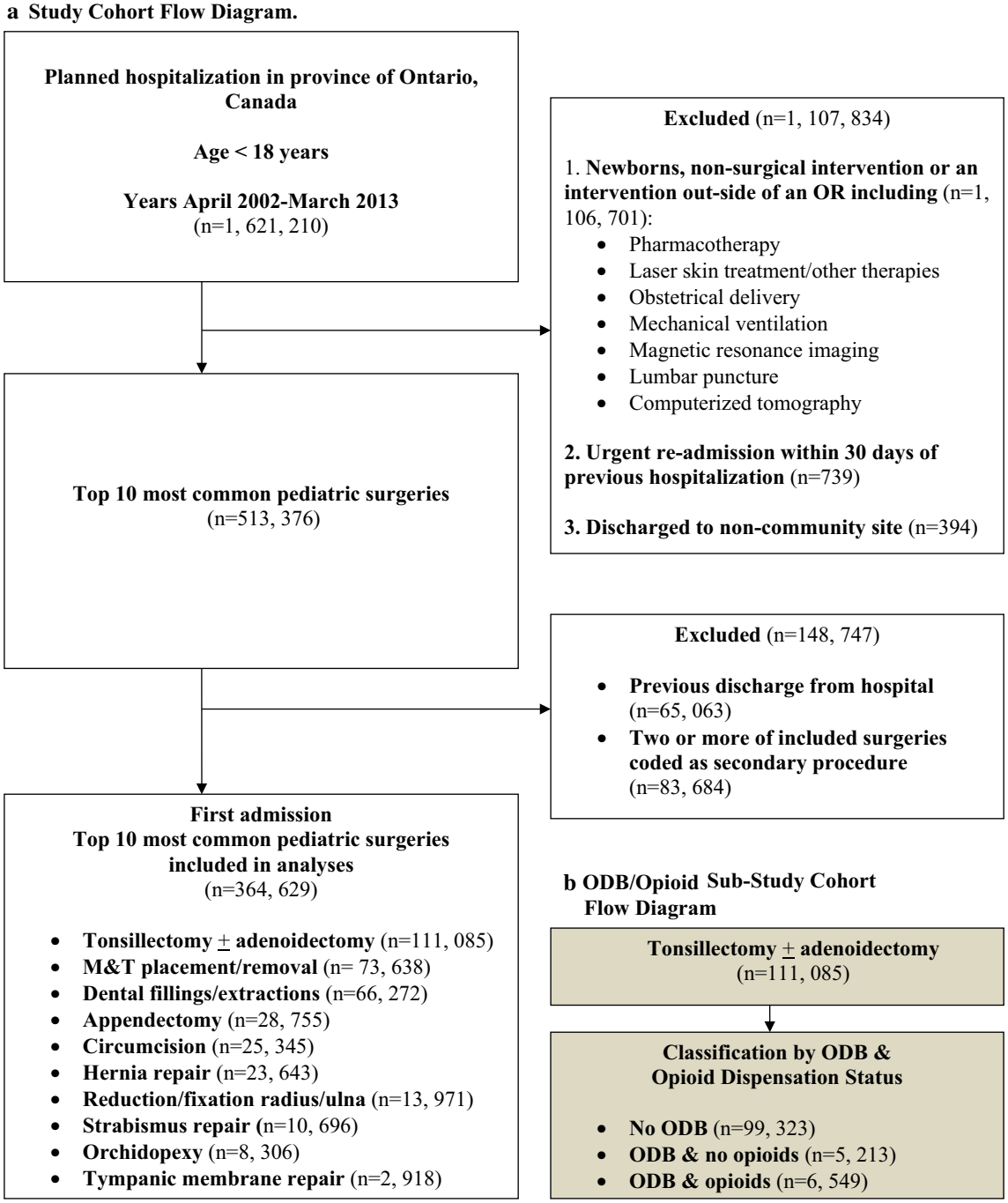

Fig. 1 A) Study cohort flow diagram. B) ODB/Opioid Substudy Cohort Flow Diagram. ODB = Ontario drug benefits. Note: M&T= myringotomy and tube; ODB=Ontario Drug Benefits

Statistical analyses

We determined outcome rates for ED visits, postoperative readmissions, and deaths for each of the top ten most common pediatric surgical procedures identified in the database. Because AT was the most common procedure, the reasons for patient outcomes were determined using the primary diagnoses, where possible. For each outcome, we first identified the 30 most common individual diagnoses. Because of their relevance to AT, respiratory-related individual diagnostic codes (abnormal breathing and asthma) and codes grouped together representing "upper airway infection" and "other respiratory" were also described. Diagnostic codes were grouped into nine AT-related categories (pain, upper airway infection, nausea/vomiting, volume depletion, bleeding, abnormal breathing,

Table 1 Demographics of pediatric Ontarians undergoing one of ten most common surgeries, years 2002-2013

Factor	Value	No ODB (%)* (n = 326,224)	ODB, no opioids (%)* (n = 26,632)	ODB, opioids (%)* (n = 11,773)	Overall, n (%)* (n = 364,629)
Age in yr	Mean (SD)	6.9 (4.9)	5.7 (4.3)	9.0 (4.9)	6.9 (4.9)
Female		131,324 (40.3)	10,829 (40.7)	5,020 (42.6)	147,173 (40.4)
Charlson Score	0	321,532 (98.6)	25,349 (95.2)	11,376 (96.6)	358,257 (98.3)
	1	657 (0.2)	203 (0.8)	83 (0.7)	943 (0.3)
	2	3,928 (1.2)	930 (3.5)	275 (2.3)	5,133 (1.4)
	3	107 (0.0)	150 (0.6)	39 (0.3)	296 (0.1)
Rural home		47,695 (14.6)	3,150 (11.8)	1,181 (10.0)	52,026 (14.3)
HHI quintile	Poorest	53,653 (16.4)	11,606 (43.6)	5,750 (48.8)	71,009 (19.5)
	2	59,346 (18.2)	5,853 (22.0)	2,608 (22.2)	67,807 (18.6)
	3	69,434 (21.3)	4,152 (15.6)	1,638 (13.9)	75,224 (20.6)
	4	74,426 (22.8)	2,990 (11.2)	1,062 (9.0)	78,478 (21.5)
	Richest	69,365 (21.3)	2,031 (7.6)	715 (6.1)	72,111 (19.8)
Operation	Tonsillectomy ± adenoidectomy	99,323 (30.4)	5,213 (19.6)	6,549 (55.6)	111,085 (30.5)
	Myringotomy & Tube	65,957 (20.2)	7,605 (28.6)	76 (0.6)	73,638 (20.2)
	Dental Fillings / Extractions	57,762 (17.7)	7,213 (27.1)	1,297 (11.0)	66,272 (18.2)
	Appendectomy	26,526 (8.1)	1,333 (5.0)	896 (7.6)	28,755 (7.9)
	Circumcision	21,719 (6.7)	1,344 (5.0)	580 (4.9)	25,345 (7.0)
	Hernia Repair	21,719 (6.7)	1,344 (5.0)	580 (4.9)	23,643 (6.5)
	Reduction/Fixation Radius/Ulna	13,059 (4.0)	414 (1.6)	498 (4.2)	13,971 (3.8)
	Strabismus Repair	9,400 (2.9)	1,255 (4.7)	41 (0.3)	10,696 (2.9)
	Orchidopexy	7,527 (2.3)	382 (1.4)	397 (3.4)	8,306 (2.3)
	Tympanic Membrane Repair	2,627 (0.8)	142 (0.5)	149 (1.3)	2,918 (0.8)
Admitted urgently		32,505 (10.0)	1,584 (5.9)	1,162 (9.9)	35,251 (9.7)
Same-day Surgery		275,452 (84.4)	23,538 (88.4)	9.506 (80.7)	308,496 (84.6)
Special care unit		345 (0.1)	95 (0.4)	39 (0.3)	479 (0.1)
Mean length of stay	Days, (SD); Range	0.33 (1.50); <1-156	0.39 (3.74); <1-254	0.34 (1.17); <1-50	0.34 (1.75); <1-156
Discharge disposition	Not Specified	240,640 (73.8)	20,601 (77.4)	8,551 (72.6)	269,792 (74.0)
	Home, no services	374 (0.1)	117 (0.4)	46 (0.4)	537 (0.1)
	Home, with services	85,172 (26.1)	5,910 (22.2)	3,176 (27.0)	94,258 (25.9)
	Against medical advice	38 (0.0)	≤5 (0.0)	0 (0.0)	42 (0.0)

HHI = household income; ODB = Ontario drug benefits; SD = standard deviation. * Unless otherwise indicated

asthma, follow-up care, and unspecified complication) or unrelated (other) and stratified by ODB/opioid status.

In exploratory analysis, we used multivariable proportional hazards regression to evaluate the risk of each outcome associated with prescribed opioid analgesia in ODB patients. In this analysis, patient factors were treated as fixed baseline covariates, with the exception of the factor, prescribed opioids, which was entered as a binomial time-dependent covariate. We used fractional polynomials to determine the best transformation for patient age and hospital LOS. In each model, we clustered patients together within hospitals to account for within-hospital similarity.

Adjusted proportional hazards models were created separately for each outcome for each type of surgery to calculate parameter estimates for the influence of prescribed opioids on outcome risks after accounting for ODB status. We compared these parameter estimates between types of operations using 83% confidence intervals (CI) to achieve estimates with an α error equal to 5%.

Results

Participants and surgical populations

During April 1, 2002 to March 1, 2013, 1,621,210 Ontarians (< 18 yr and > one month of age) with a valid OHIP card were discharged from hospital (Fig. 1a). The

Table 2 Province of Ontario raw outcome risk by pediatric surgical study group, years 2002-2013

Surgical Study Group (*n*)	Urgent readmission *n* (%)	Emergency room visit *n* (%)	Death from any cause* *n* (%)
Appendectomy (28,755)	1,102 (3.8)	3,687 (12.8)	0 (0.0)
Tonsillectomy ± Adenoidectomy (111,085)	2,947 (2.7)	13,782 (12.4)	≤ 5 (0.0)
Reduction/Fixation Radius/Ulna (13,971)	188 (1.3)	1,173 (8.4)	0 (0.0)
Circumcision (25,345)	256 (1.0)	2,929 (11.6)	≤ 5 (0.0)
Orchidopexy (8,306)	85 (1.0)	686 (8.3)	0 (0.0)
Hernia Repair (23,643)	222 (0.9)	1,486 (6.3)	≤ 5 (0.0)
Myringotomy & Tube (73,638)	393 (0.5)	5,837 (7.9)	≤ 5 (0.0)
Tympanic Membrane Repair (2,918)	12 (0.4)	168 (5.8)	≤ 5 (0.0)
Strabismus Repair (10,696)	43 (0.4)	529 (4.9)	0 (0.0)
Dental Fillings / Extractions (66,272)	227 (0.3)	3,195 (4.8)	≤ 5 (0.0)

*The term "≤ 5" indicates that the number of deaths ranged from1-5. The total number of deaths reported was 10 (0.27 deaths per 10,000 children), and they were relatively evenly distributed among the groups. Further details could not be disclosed due to a confidentiality agreement

following patients were excluded: 1,106,701 (68.3%) did not undergo one of the included procedures; 394 (0.02%) were discharged to locations other than the community; 739 (0.04%) were urgently readmitted within 30 days of a previous hospitalization; 83,684 (5.2%) patients underwent more than one of the included procedures; and 65,063 (4.0%) had a prior eligible surgery and were thus already enrolled in our patient-level analytic dataset. Thus, 364,629 patients (22.5% of all discharges) representing 165 distinct hospitals were involved in the study. Nine hospitals were classified as teaching hospitals and accounted for 74,839 (20.5%) of the patients. The ten most common procedures are listed in Appendix A. Tonsillectomy with or without adenoidectomy (AT) was the most common procedure. The AT cohort flow diagram related to ODB classification and opioid dispensation is shown in Fig. 1b.

Demographic characteristics for the full cohort are described in Table 1. The mean age was seven years and females represented 40% of the surgeries but varied by type of surgery (Appendix B, available as Electronic Supplementary Material). Patients rarely had any significant coded comorbidity (Charlson index = 0 in 98.3% of cases). Most patients (84.6%) underwent same-day surgery, and the mean hospital LOS was a third of a day (Table 1). The highest rates of postoperative admission to a special care unit (i.e., a medical, surgical, medical-surgical, or neurological intensive care unit) were for appendectomy (0.6%), hernia repair (0.4%), and AT patients (0.2%) (Appendix B, available as Electronic Supplementary Material). Most patients (89.5%) had no ODB coverage. Among patients receiving ODB (n = 38,405), most resided in the lowest household income quintile neighbourhoods, and the majority (69.4%) did not receive opioids after discharge. The ODB patients prescribed opioid analgesics were older and more likely to have undergone AT.

Outcomes

The overall risks of 30-day urgent readmission and emergency room visits were 1.5% (n = 5,475) and 9.2% (n = 33,472), respectively. Appendectomy patients (urgent readmission 3.8%; ED visit 12.8%) and AT patients (urgent readmission 2.7%; ED visit 12.4%) had the highest crude risks of postoperative complications, while circumcision patients had a high risk of ED visits (11.6%) (Table 2). Among AT patients, the most common diagnosis for readmission was related to volume depletion (7.7-10.6%), followed by pain (2.7-5.8%) and nausea/vomiting (0.7-3.9%). Among AT patients, the most common diagnoses

Table 3 Reasons for hospital visit within 30 days following adenotonsillectomy in children as per ODB / opioid substudy groups, years 2002 to 2013 (n = 111,085)

Diagnosis	Urgent Hospital Readmission (n = 2,947), n (%)			Emergency Department Visit (n = 13,782), n (%)		
	No ODB (n=2,538)	ODB & no opioid (n=151)	ODB & opioid (n=258)	No ODB (n=11,973)	ODB & no opioid (n=732)	ODB & opioid (n=1,077)
Pain*	90 (3.6)	4 (2.7)	15(5.8)	1,076 (9.0)	63 (8.6)	124 (11.5)
Upper Airway Infection†	37 (1.5)	7 (4.6)	4(1.6)	1,007 (8.4)	74 (10.1)	86 (8.0)
Nausea and vomiting	100 (3.9)	1 (0.7)	7 (2.7)	494 (4.1)	15 (2.1)	37 (3.4)
Volume Depletion	195 (7.7)	16 (10.6)	21 (8.1)	387 (3.2)	25 (3.4)	39 (3.6)
Bleeding	15 (0.6)	0 (0)	3 (1.2)	234 (2.0)	13 (1.8)	20 (1.9)
Abnormal breathing	7 (0.3)	4 (2.6)	1 (0.4)	0 (0)	0 (0)	0 (0)
Asthma	13 (0.5)	0 (0)	1(0.4)	101 (0.8)	12 (1.6)	7 (0.7)
Follow-up care‡	6 (0.2)	3 (2.0)	0 (0)	303 (2.5)	28 (3.8)	27 (2.5)
Complication not specified§	1,529 (60.2)	62 (41.1)	144 (55.8)	4,825 (40.3)	217 (29.6)	430 (40.0)
Other	546 (21.5)	54 (35.8)	62 (24.0)	3,446 (28.8)	285 (38.9)	307 (28.5)

*Pain includes otalgia. †Upper airway infection includes croup/epiglottitis, tonsillitis, pharyngitis, and unspecified upper respiratory infection. ‡Follow-up care includes examination after treatment and specifically related to surgery. §Complications include those related to procedure, surgical and medical care. ODB = Ontario drug benefits

for ED visits were pain and upper airway infection (8.0-11.5%), followed by nausea/vomiting (2.1-4.1%) and volume depletion (3.2-3.6%) (Table 3). In the entire study cohort, only ten deaths (0.27 deaths per 10,000 children) were reported within 30 days post discharge (95% confidence interval [CI], 0.18 to 0.39). Surgical populations reporting deaths ($n \leq 5$), in descending order of prevalence, were tympanic membrane repair, hernia repair, circumcision, dental restorations, myringotomy & tube (M&T), and AT, but a confidentiality agreement prevented any further analysis surrounding these deaths (Table 4).

Outcome-associated risk factors

Factors, besides type of surgery, associated with at least a modest increase in the risk (hazard ratio [HR] > 1.15) of readmission and ED visits included previous prolonged LOS ≥ four days, inpatient admission, associated comorbidities (Table 5), and extremes of age, with higher risks noted in the very young (age ≤ three years) and older (age ≥ 14 yr) patients (Fig. 2A and B, available as Electronic Supplementary Material). In addition, compared with children not covered by ODB, the risk of either readmission and/or ED visits was higher across most surgeries for ODB patients not prescribed opioid analgesia. The risk of ED visits was higher still for ODB patients prescribed opioids (Table 6). Compared with most other surgeries, AT generally had a lower outcome risk for ODB children, whether or not they were prescribed opioids. For the population cohort, ODB children had increased crude risks for urgent readmissions and ED visits—i.e., for ODB patients not prescribed opioids (relative risk increase, 28.3% and 26.5%, respectively) as well as for ODB patients prescribed opioids (relative risk increase, 109.5% and 60.5%, respectively) (Table 7, available as Electronic Supplementary Material).

Discussion

In the province of Ontario, Canada, elective AT was the most common pediatric surgical procedure during 2002-2013. Compared with other common day surgeries, AT patients had the highest risk for a postoperative urgent readmission and were comparable to circumcision patients in terms of risk for an ED visit. The majority of visits following AT were related to potentially preventable pain, nausea/vomiting, and dehydration. Fortunately, death within 30 days of surgery was rare for all surgeries. Prolonged LOS, comorbidities, previous inpatient admission, and age were found to increase the risk of readmission and ED visits following surgery. The ODB coverage was also a risk factor for postoperative hospital visits, particularly when opioids were dispensed.

Our findings are similar to pediatric and adult perioperative literature, with some notable exceptions. Our reported overall 30–day ED visit rate of 9.2% was higher than the overall 30-day postoperative complication

Table 4 Thirty-day mortality and associated urgent readmission for *"Abnormal Breathing"* rates by surgical study group, years 2002-2013 (n = 364, 629)

Surgical Study Group	Death Rate* (range per 10,000)	Urgent Readmission Rate for *"Abnormal Breathing"* (per 10,000)
Tympanic Membrane Repair	3.43-17.14	3.43†
Hernia Repair	0.42-2.11	3.81
Circumcision	0.40-1.97	4.28
Dental Restoration	0.15-0.75	0.45
Myringotomy & Tube	0.14-0.68	1.36
Adenotonsillectomy	0.09-0.45	1.08
Orchidopexy	0	2.41
Strabismus	0	0.94
Reduction/Fixation Radius/Ulna	0	0
Appendectomy	0	0

*Where reported, the actual number of deaths per surgical population ranged from 1-5. A confidentiality agreement did not allow for the actual number to be disclosed. The mortality rate for the study cohort was 10 (0.27 deaths per 10,000 children), and deaths were relatively evenly distributed among populations reporting it. †One patient was readmitted with a diagnosis of "somnolence, stupor, and coma" and classified as having abnormal breathing

rate of 7.4% reported for 2010 by the National Surgical Quality Improvement Program Pediatric® (NSQIP-P) database.[24] Nevertheless, the latter collects data only on 30-day readmissions and not on ED visit rates, and it considers only wound/organ system complications and not pain and nausea/vomiting. This may explain why they found otolaryngologic procedures to be among the lowest as regards complications; whereas, we found AT to have the highest rate of post-discharge complications and healthcare resource utilization among day surgeries. Inclusion of inpatient admissions or those considered to have chronic complex comorbidities,[25] as in the present study, may explain our higher rates compared with studies specific to the pediatric AT population.[3,26] Nevertheless, rates of post-AT hospital visits related to surgical complications, including upper airway infections and bleeding, were similar to other studies[3,4,25–27] and similar to the low (3.8%) NSQIP-P post-otolaryngology 30-day complication rate.[24] As with other United States[3,25–28] and one Canadian-based study,[4] pain, nausea/vomiting, and dehydration were among the most common reasons for a post-AT hospital visit/readmission. Capture of all types of associated adverse events following AT likely provides a more comprehensive picture and should be considered in efforts to improve outcomes following surgery.[29]

Our 30-day all-cause pediatric mortality rates among the top ten most common surgeries were lower than previous reports from 2003-2010, which ranged from 11.0-18.8 per 10,000 children.[24,30] This may reflect our predominantly day surgery case mix. Our data show that concerns about excessive postoperative deaths after AT,[11,12,26] when compared with other common surgeries, are unfounded in Ontario. This may be due to differences in the surgical setting, healthcare access, and a different population case mix than in the United States, with different comorbidities and associated risk factors. While all Canadian children undergo AT in hospital settings, in the United States, many children now routinely receive care in ambulatory surgery centres[25,31] where pressures to "efficiently operate and discharge patients" may negatively impact patient outcomes.[11] In addition, hospital co-payments and insurance deductibles in the United States may influence the willingness to seek medical attention. Further, a higher proportion of patients undergoing AT in the United States are African American, a known risk factor for OSA.[32] Finally, higher United States mortality rates may be attributed to the 2001 adoption of pain as the "fifth vital sign" by The Joint Commission, which may increase the postoperative complication rate in this at-risk population due to overzealous opioid administration.[33]

Based on our research, there are other factors beyond surgical procedure associated with the risk of readmission. Those related to prolonged LOS, associated comorbidities (Charlson score > 2), urgent inpatient surgery status, and age may all reflect associated medical complexity. Also, a prolonged LOS may be the result of an unmeasured complication, a known adult risk factor for postoperative morbidity.[34] These factors are consistent with hospital-based tools derived in Ontario to predict the risk of postoperative readmission in adults[9,10] and reflect experience in children.[3,4,35,36] The impact of SES on postoperative outcomes in Ontario requires further study;

Table 5 Influence of other patient and hospitalization factors on outcome risk in Ontario, years 2002-2013

Factor	Value	Outcome Hazard Ratio (95% CI)	
		Urgent Readmission	Emergency Room Visit
Female		1.11 (1.05 to 1.17)	1.02 (1.00 to 1.04)
Charlson Score	0	1	1
	1	1.61 (1.17 to 2.22)	1.03 (0.84 to 1.25)
	2	1.80 (1.53 to 2.12)	1.45 (1.34 to 1.56)
	3	3.22 (2.27 to 4.56)	1.52 (1.17 to 1.99)
Rural		0.97 (0.89 to 1.06)	1.26 (1.22 to 1.30)
Median HHI	Richest quintile	1	1
	4	1.05 (0.96 to 1.14)	1.06 (1.03 to 1.10)
	3	1.02 (0.94 to 1.11)	1.06 (1.02 to 1.10)
	2	1.06 (0.97 to 1.16)	1.11 (1.07 to 1.15)
	Poorest quintile	0.96 (0.88 to 1.05)	1.12 (1.08 to 1.17)
Admission type	Same-Day Surgery	1	1
	Inpatient, Elective	1.65 (1.34 to 2.04)	1.04 (0.94 to 1.14)
	Inpatient, Urgent	2.15 (1.75 to 2.63)	1.22 (1.11 to 1.33)
Special care unit		1.21 (0.87 to 1.67)	1.10 (0.89 to 1.35)
Length of Stay (days)	0	1	1
	1	0.66 (0.54 to 0.82)	0.91 (0.83 to 1.00)
	2	0.76 (0.60 to 0.96)	0.92 (1.03 to 2.22)
	3	1.12 (0.87 to 1.44)	1.08 (1.23 to 1.63)
	4+	2.04 (1.57 to 2.65)	1.59 (1.38 to 1.82)
Discharge disposition	Home, no services	1	1
	Home, services	0.97 (0.72 to 1.31)	1.20 (1.00 to 1.43)
	AMA	1.54 (0.38 to 6.18)	1.75 (0.91 to 3.37)

AMA = against medical advice; CI = confidence interval; HHI = household income

however, our findings suggest that neighbourhood income quintile does not significantly impact outcomes after pediatric surgery, which is similar to previous reports in universal access health systems.[6,7,37] Nevertheless, ODB status, which is a family-level (as opposed to geographic) measurement of low SES and a known risk factor for inferior surgical care and outcomes,[5,6,27,38] identified children who were particularly vulnerable to readmission or ED visits. This association may reflect children on ODB having procedures that required more complex care at home (e.g., urological surgeries) or were associated with conditions (e.g., upper airway infections most common following dental and M&T procedures—data not shown) that could not be managed in the community due to known limited access to primary care providers among lower SES families. Otherwise, this could reflect factors associated with a lower SES, such as lack of informal support networks or low household health literacy which can negatively impact recovery from illness. Either way, stratification of future risk and development of processes in pediatric surgery should include appropriate measurement and considerations of SES in the context of family-centred care.

The impact of opioids on outcomes also requires consideration. We were only able to assess the impact of dispensed opioids in ODB patients, which may limit the generalizability of our findings; however, similar associations between opioids and increased readmissions and ED visits have been reported in adults.[15] Not surprisingly, opioids were associated with increased nausea/vomiting among ODB AT patients, which could drive increased rates of return to the acute care setting. Furthermore, older ODB patients were dispensed opioids, a known risk factor for the increased pain experienced, which could be exacerbated in a setting like AT surgery where undertreatment of pain is well recognized.[4] Regardless of the causal pathway underlying the association between opioids and readmissions or ED visits, future care and research should address the role that opioids may play in promoting adverse outcomes in at-

Table 6 Outcome risk by Ontario drug benefits status with or without opioids for the ten most common pediatric surgeries in Ontario, years 2002-2013

Surgical Study Group (n=364,629)	Urgent Hospital Readmission Hazard Ratio (95% CI)			Emergency Department Visit Hazard Ratio (95% CI)		
	No ODB	ODB & no opioid	ODB & opioid	No ODB	ODB & no opioid	ODB & opioid
Overall	1	1.29 (1.17 to 1.43)	1.81 (1.61 to 2.03)	1	1.26 (1.21 to 1.31)	1.62 (1.54 to 1.71)
Tonsillectomy ± adenoidectomy	1	1.11 (0.95 to 1.31)	1.38 (1.20 to 1.58)	1	1.14 (1.06 to 1.23)	1.30 (1.21 to 1.38)
Myringotomy & tubes	1	1.91 (1.46 to 2.49)	-	1	1.42 (1.32 to 1.53)	4.79 (2.82 to 8.11)
Dental fillings/extractions	1	2.43 (1.75 to 3.36)	3.07 (1.74 to 5.40)	1	1.60 (1.45 to 1.76)	1.82 (1.49 to 2.24)
Appendectomy	1	1.63 (1.31 to 2.02)	1.13 (0.80 to 1.60)	1	1.39 (1.22 to 1.58)	1.44 (1.22 to 1.71)
Circumcision	1	2.32 (1.52 to 3.54)	1.90 (1.02 to 3.51)	1	1.27 (1.10 to 1.45)	1.32 (1.13 to 1.55)
Hernia repair	1	1.60 (1.03 to 2.49)	1.83 (0.78 to 4.29)	1	1.59 (1.33 to 1.90)	1.32 (0.97 to 1.80)
Reduction/fixation radius/ulna	1	1.45 (0.67 to 3.15)	1.72 (0.93 to 3.17)	1	2.13 (1.66 to 2.75)	1.52 (1.15 to 2.03
Strabismus repair	1	1.51 (0.68 to 3.37)	-	1	1.23 (0.96 to 1.59)	1.09 (0.27 to 4.46)
Orchidopexy	1	2.55 (1.22 to 5.32)	2.32 (1.00 to 5.38)	1	1.55 (1.14 to 2.11)	1.03 (0.71 to 1.50)
Tympanic Membrane Repair	1	1.66 (0.17 to 16.16)	-	1	1.00 (0.49 to 2.01)	0.63 (0.29 to 1.36)

CI = confidence interval; ODB = Ontario drug benefits

risk groups, including those on social assistance, to delineate their appropriate use.

Our results support ongoing initiatives to heighten the quality of perioperative AT in Ontario.[4] Future considerations for such initiatives should include appendectomy, M&T, circumcision, and dental surgical populations based on the absolute number and prevalence of postoperative adverse outcomes reported here. Simpler tools to predict the risks of adverse outcomes, including the prevalence of underlying OSA, are needed, and screening should occur in all surgical populations, not just those undergoing AT. An adaptation of the United States "Perioperative Surgical Home" model[39] with standardized interventions, including improved parental education, may reduce the incidence of preventable postoperative pain and dehydration following AT.[40] The ODB status and opioid dispensation should be included in a pediatric tool to identify at-risk patients. Finally, a provincial repository of AT cases is needed to allow for cross-referencing with health administrative databases to ensure all cases are accurately captured for research purposes.

The strengths of our study include accurate identification of all readmissions, ED visits, and deaths following the ten most common pediatric surgeries in a universal access healthcare system. As a province-wide study, our results are highly generalizable, as Ontario accounts for over one-third of the Canadian population. That said, our study has some limitations that deserve mention. There is no validated administrative database methodology to determine if all-cause 30-day death or unplanned hospital readmission/visits were related to the index surgery, but this is a standard outcome in the literature. A confidentiality agreement makes it unclear why tympanoplasty, among other surgical populations, was associated with a strikingly higher postoperative mortality rate compared with AT; a coincidence cannot be ruled out. Our databases included only children with a valid OHIP number; however, non-OHIP patients account for only a small fraction of children treated annually. The Charlson comorbidity index has not been validated in children,[41] and it is unknown how it correlates with the American Society of Anesthesiologists health status grade. Nevertheless, modest correlation has been shown in certain adult surgical populations.[42,43] Although the diagnoses for ED visits following AT were accurately identified, ICD-10 codes have variable accuracy. Nevertheless, the pattern of our results is similar to previous reports. By excluding patients who underwent combined same-day AT and M&T, it is possible that we may not have accounted for all outcomes of interest; however, the number is relatively small—only 10-15% of AT patients undergo M&T. We did not comment on the preventability of hospital visits following other procedures because it was beyond the scope of this paper. Further, we were not able to capture anoxic brain injuries *not* leading to death, but these are suggested to be low in number.[11,12,44] It is unknown whether prescribed opioids were actually ingested.[45]

To conclude, among children undergoing day surgery, AT is a healthcare resource-intensive procedure in Ontario's universal access healthcare system. Death after AT is fortunately rare and rates are lower than those reported in the United States, which may be a reflection of differences in surgical population, healthcare delivery, and postoperative procedures. Opioid dispensation in ODB surgical populations is generally associated with increased

postoperative hospital revisits; however, this was not unique to AT and therefore requires future study to determine whether a generalizable causal relationship exists. Quality improvement initiatives in the AT population and other surgical populations at high risk of postoperative complications are warranted.

Acknowledgments We sincerely thank Johanna Spaans for helping to edit the manuscript.

Financial disclosure The authors have indicated that they have no financial relationships relevant to this article to disclose.

Conflict of interest The authors have indicated they have no conflicts of interest to disclose.

Editorial responsibility This submission was handled by Dr. Philip M. Jones, Associate Editor, *Canadian Journal of Anesthesia.*

Author contributions *Kimmo Murto* conceptualized the study and helped design the study, supervised data collection and analysis, and drafted the initial manuscript. *Sherri Katz*, *Mathew Bromwich, Regis Vaillancourt,* and *Carl van Walraven* contributed to study conception. *Sherri Katz*, *Mathew Bromwich, Regis Vaillancourt, Daniel McIsaac,* and *Carl van Walraven* contributed to study design and reviewed and revised the manuscript. *Daniel McIsaac* contributed to data analyses. *Kimmo Murto* and *Daniel McIsaac* contributed to data interpretation. *Carl van Walraven* was responsible for data collection and carried out the initial analyses and interpretation.

Funding Dr. van Walraven was supported by a chair from the University of Ottawa Department of Medicine.

Appendix

Appendix A: Ten most common surgical procedures conducted in hospitalized children & youth in Ontario, years 2002-2013

Surgical Procedures	CCI Codes (1st five alphanumerics)
Tonsillectomy with/without Adenoidectomy	1FR89, 1FR87
Myringotomy & tube insertion or removal	1DF53
Dental Fillings and/or Extractions	1FE29, 1FE57, 1FE89
Appendectomy	1NV89
Circumcision	1QD89
Hernia Repair	1SY80
Reduction and/or Fixation of Radius/Ulna	1TV73, 1TV74
Strabismus Repair	1CQ74
Orchidopexy	1QM74
Tympanic Membrane Repair	1DF80

CCI = Canadian Classification of Interventions

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