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Does Perioperative Respiratory Event Increase Length of Hospital Stay and Hospital Cost in Pediatric Ambulatory Surgery?

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ABSTRACT

Objective: We examined the consequences of perioperative respiratory event (PRE) in terms of hospitalization and hospital cost in children who underwent ambulatory surgery.

Methods: Thissubgroup analysis of a prospective cohort study **(**ClinicalTrials.gov: NCT02036021**)** was conducted in children aged between 1 month and 14 years who underwent ambulatory surgery between November 2012 and December 2013. Exposure was the presence of PRE either intraoperatively or in the postanesthetic care unit or both. The primary outcome was length of stay after surgery. The secondary outcome was excess hospital cost excluding surgical cost. Financial information was also compared between PRE and non-PRE. Directed acyclic graphswere used to select the covariates to be included in the multivariate regression models. The predictors of length of stay and excess hospital cost between PRE and non-PRE children are presented as adjusted odds ratio (OR) and cost ratio (CR), respectivelywith 95% confidence interval (CI).

Results: Sixty-three PRE and 249 non-PRE patients were recruited. In the univariate analysis, PRE was associated with length of stay (p =0.004), postoperative oxygen requirement (p <0.001), and increased hospital charge (p =0.006). After adjustments for age, history of snoring, American Society of Anesthesiologists physical status, type of surgeryand type of payment, preoperative planned admission had an effect modification with PRE(p<0.001). The occurrence of PRE in the preoperative unplanned admission was associated with 24-fold increased odds of prolonged hospital stay (p <0.001). PRE was associated with higher excess hospital cost (CR =1.35, p=0.001). The mean differences in contribution margin for total procedure(per patient) (PRE vs non-PRE) differed significantly (mean =1,523; 95% CI: 387, 2,658 baht).

Conclusion: PRE with unplanned admissionwas significantly associated with prolonged length of stay whereas PRE regardless of unplanned admissionincreased hospital cost by 35% in pediatric ambulatory surgery.

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Objective and methodology

1 Objective

To examine if the occurrence of PRE is associated with prolonged the length of stay and increased hospital cost in pediatric ambulatory surgery.

2 Methods

This study was part of a larger research project (ClinicalTrials.gov: NCT02036021). Children aged between 1 month (term infants) and 14 years who underwent general anesthesia (GA) for ambulatory surgery between November 2012 and December 2013 were included. Written informed consent was obtained from all parents. The patients who developed PRE (PRE group) were compared with a control group who did not have any PRE (non-PRE group) in terms of length of hospital stay postoperatively and excess hospital cost. Excess hospital cost was defined as hospital direct cost that did not include surgical costs.

3

Hospital cost system and length of stay

Costs and length of hospitalization were retrieved from the hospital information system. Since there is no system of cost unit analysis in our hospital, the hospital charge was used to represent direct hospital cost (the hospital charge multiplied by cost-to-charge ratio) [8, 9]. Subsequently, a fixed cost-to-charge ratio eventually cancelled out when the hospital cost in PRE was divided by the hospital cost in non-PRE. Since we focused on direct hospital cost in pediatric ambulatory surgery, the indirect costs (the combination of transportation cost and parental loss of income) were omitted in the analysis. Participants Children were included if they fit the criteria for ambulatory surgery. They were excluded if a written informed consent could not be obtained from the parents.

Main exposure (PRE and non-PRE)

In our hospital, all patients are monitored under anesthesia surveillance using continuous pulse oximetry, capnography and electrocardiography incorporating the vital signs every 5 minutes. The PRE group was defined as children who had perioperative respiratory events such as laryngospasm, bronchospasm, upper airway obstruction [10], or reintubation either intraoperatively or in the PACU period with or without having desaturation. Desaturation was defined as oxygen saturation (SpO2) by pulse oxymetry that was <95% for more than 10 seconds [11]. The occurrence of PRE, causes of PRE, and the lowest SpO2 intraoperatively or at PACU were recorded immediately in the vital signs table and in the data record form by the anesthetist nurse in charge of each operating theater. The patients with PRE and the lowest recorded SpO2 were placed into 3 categories based on the occurrence/severity of perioperative desaturation (PD): no PD (SpO2 >94%), mild to moderate PD (SpO2 86–94%), and severe PD (SpO2 <86%). Patients in the non-PRE group were defined as children who did not develop any PRE intraoperatively or in the PACU period based on the recorded data form. Occurrence/severity of PRE was divided into 3 categories: non-PRE, mild to moderate PRE (SpO2 86–99%) and severe PRE (SpO2 <86%). Time to first PRE event and duration of PRE were also recorded to increase the accuracy of the main exposure.

Outcomes of interest

Prolonged hospitalization post-surgery

The primary outcome was length of stay post-surgery. Any hospital stay recorded by the PACU nurses followed approval by both the surgeon and anesthesiologist in charge. The number of days of hospitalization post-surgery as well as occurrence of postoperative complications were obtained from the hospital information system by the principal investigator (MO). In our hospital, 25% of ambulatory surgery cases are planned admissions, usually occurring from surgical concerns or parent's preference (insurance/difficult transportation[EM1] [A2]). An unplanned admission could arise from an anesthetic adverse event or surgical complication. Based on past data, the average length of stay for a planned admission is 1.0 day. [EM3] [A4] Therefore, prolonged length of stay post-surgery was defined as the number of hospitalization days more than 1 day for a planned admission and at least 1 day for an unplanned admission post-surgery. The duration of PACU stay and postoperative oxygenation were recorded by the PACU nurses.

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Excess hospital cost

The secondary outcome was excess hospital cost. Hospital charge was used instead of direct hospital cost for a comparison between PRE and non-PRE. Thus, excess hospital charge was defined as all hospital charges excluding the surgical charge in the PRE group minus those in the non-PRE groups. Hospital charges included the use of resources within the health sector, e.g. home medication, anesthesia charge, and hospitalization [12]. After the patient was discharged, total hospital charges were obtained from the hospital information system and recorded by the principal investigator (MO).

4 Financial information

In the area of hospital planning, financial information including net revenue, direct hospital costs, fixed costs, and variable costs need to be addressed. Gross revenue arises from the hospital charges of each outpatient, or inpatient if admitted. We used a cost-to-charge ratio of 0.4 based on our previous estimate of direct hospital costs [7], therefore, direct hospital costs were calculated from hospital charges multiplied by 0.4. Since fixed expenditures associated with buildings, salaries, equipment and other overhead were not obtained from our previous study [7], fixed cost was omitted in the present study. Thus, the variable costs included medication and supplies, which change based on the number and acuity [EM5] [A6] of patients treated would be obtained in our financial information [13]. [EM7] [A8] Therefore, direct hospital cost, e.g. accommodation, meals, medication, laboratory, and nursing care service, would represent the variable cost in our setting. Since contribution margin represents actual net cash flows for individual patients in terms of delivery of care [14], the contribution margin instead of total margin was calculated in this study. The contribution margin was obtained from gross revenue (hospital charges) minus variable costs (direct hospital cost). Therefore, the contribution margin in our setting was calculated from hospital charges multiplied by 0.6

Potential confounding variables

Patient-related characteristics and type of payment system were obtained at the preoperative period by the investigative team (BS, BS, KN) while surgical and anesthesia-related variables were obtained at the intraoperative period by the anesthetist nurse in charge of each operating theater. Patient-related characteristics included age, sex, body mass index (kg/m2), history of upper respiratory tract infection [7], obesity (>95 percentile weight for age), and history of snoring. Surgical and anesthesia-related data included type of surgery, American Society of Anesthesiologist (ASA) classification, choice of anesthesia, technique of anesthesia, induction agent, intubating agent, inhalation agent, gas mixed with oxygen, and narcotic use. Type of preoperative admission (planned vs unplanned), which was decided by the surgeon, was also included as a potential confounding variable.

5 **Model for prolonged hospitalized post-surgery**

The association between the main exposure (PRE vs non-PRE) and prolongedlength of hospital staypost-surgery was determined by cross-tabulation. A directed acyclic graph(DAG) was used to represent the potential causal relationships among the covariates (including PRE) and the outcomes using DAGitty software version 3.0. Potential confounding variables including hospital payment suggested by the DAG were then selected for a multivariate logistic regression model and were retained in the model irrespective of their statistical significance[15, 16]. The associationbetween prolonged length of hospital staypost-surgery and PREispresented as an adjusted odds ratio (OR) with95% confidence interval (CI).

Model for adjusted excess hospital cost

A DAG was also used to represent the potential causal relationships among covariates (including PRE) and excess hospital charge. To model the relationship between PRE and excess hospital cost, potential covariates indicated by the DAG, including preoperative planned admission and the type of hospital payment system, were included in a multiple linear regression model. To fit the residual of linear distribution assumption, the so-called adjusted excess charge obtained by the log of excess charge more than 2,000 bahtwas used for the final excess hospital cost parameter. The exponentials of their coefficients (cost ratio [CR] and 95% CI) were displayed and considered significant if the F test p values were <0.05.

To further determine the impact of the severity of PRE on hospital stay and hospital cost, PRE was replaced with a variable indicating severity of PRE after obtaining the final model. The effect modification between the potential predictors and PRE/severity of PRE on the outcomes were evaluated for each final model.

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