Successful Use of Quality Improvement Methodology to Reduce Inpatient Length of Stay in Bronchiolitis Through Judicious Use of Intermittent Pulse Oximetry

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ABSTRACT

BACKGROUND AND OBJECTIVES: The American Academy of Pediatrics 2014 bronchiolitis guidelines recommend against the routine use of continuous pulse oximetry (CPO) because it has been implicated in prolonging the length of stay (LOS). At our institution, infants admitted with bronchiolitis were monitored by using CPO during the entire hospital stay and intermittent desaturations, 90% appeared to delay discharge. This quality improvement initiative was designed to reduce the LOS by decreasing the use of CPO in stable infants with nonsevere bronchiolitis.

METHODS: The quality improvement project was implemented on the inpatient units of 2 community hospitals during the 2016 and 2017 bronchiolitis seasons. In cycle 1 (January 2016 to April 2016), the bronchiolitis pathway from the associated quaternary children’s hospital was used to (1) limit the use of CPO to patients with severe bronchiolitis and those at high risk for apnea or severe disease, (2) discontinue CPO as patients improved and stabilized, and (3) standardize discharge criteria. In cycle 2 (November 2016 to April 2017), the clinical pathway was adopted. The main outcome measure was LOS, measured from the time of the admission order to the time of the discharge order. Process measures included compliance with the interventions.

RESULTS: The project included 373 patients, 180 preintervention and 193 postintervention. The average LOS decreased by 20 hours, from 53 hours at baseline to 33 hours in cycle 2. No adverse events were noted, and there was no significant change in the number of emergency department revisits and readmissions within 7 days.

CONCLUSIONS: In our study, LOS was successfully reduced in bronchiolitis patients by using a clinical pathway that limited CPO to patients with severe bronchiolitis and those at risk for severe disease or apnea.
Bronchiolitis is the most common cause of hospitalization among children <2 years of age, accounting for 16% of admissions in this age group. Approximately 130,000 infants are admitted with bronchiolitis in the United States each year, with estimated annual hospital charges of $1.73 billion. Oxygen saturation <90% is known to occur regularly in healthy infants as well as in infants with mild bronchiolitis. In a study of 118 infants with mild bronchiolitis that met criteria for discharge from the emergency department (ED), sustained desaturations lasting >1 minute <90% occurred in two-thirds of infants without causing any increase in unscheduled medical visits or readmissions. The 2014 American Academy of Pediatrics clinical practice guideline for the care of patients with bronchiolitis discourages routine use of continuous pulse oximetry (CPO) to prevent overdiagnosis of hypoxemia and recommends permissive hypoxemia with a target sustained pulse oximetry reading (SpO2) of 90% or higher. A randomized controlled superiority trial in which intermittent pulse oximetry (IPO) was initiated in bronchiolitis patients showing clinical improvement revealed no difference in rate of adverse events or need for treatment interventions.

The perceived need for supplemental oxygen based on pulse oximetry readings is a primary driver of prolonged length of stay (LOS) in admitted bronchiolitis patients. Although previous studies have not revealed a reduction in hospital LOS for bronchiolitis or time to readiness for discharge in a heterogeneous group of wheezing patients, judicious use of IPO in nonhypoxicem patients has been shown to be safe and with no detectable difference in the need for care escalation or the rate of adverse events.

Bronchiolitis is a common reason for hospitalization to our inpatient unit, accounting for almost half of our admissions in the winter. Historically, providers at our institution preferred to monitor these infants using CPO during the entire hospital stay, and mild hypoxemia (intermittent desaturations <90%) appeared to increase the LOS. We adapted an inpatient bronchiolitis clinical pathway developed at our affiliated quaternary care children’s hospital to our community hospital setting to limit use of CPO. We undertook this quality improvement (QI) project with the goal of reducing the LOS by 12 hours for patients aged <2 years admitted with bronchiolitis to our community pediatric inpatient program over the 2016 and 2017 bronchiolitis seasons.

**METHODS**

This study was conducted at 2 community hospitals affiliated with a children’s hospital in a suburban, mid-Atlantic community health system. One hospital has a 16-bed inpatient unit, a 6-bed PICU, and a pediatric ED staffed by pediatric emergency medicine physicians, general pediatricians, and pediatric hospitalists. The second hospital has a pediatric hybrid unit with 5 inpatient beds attached to a pediatric ED staffed by pediatric hospitalists.

The QI intervention was implemented at both hospitals simultaneously by a multidisciplinary team that included hospitalists, nurses, nurse managers, and nurse educators at each hospital. All patients <2 years with bronchiolitis admitted to either inpatient unit were included in the project. Patients directly admitted or transferred from the general inpatient unit to the PICU were not part of this study or analysis.

Baseline data, including patient demographics, LOS, CPO or IPO use, and return visits or adverse events, were collected for the November 2014 to April 2015 and November 2015 to December 2015 periods. The Institute for Healthcare Improvement’s Model for Improvement was used to design an interrupted time series QI project with new interventions in cycle 1 and cycle 2 spanning 10 months over the 2016 and 2017 bronchiolitis seasons. We defined hypoxemia as a SpO2 of <90% despite patient repositioning and suctioning. In cycle 1 (January 2016 to April 2016), we defined set criteria for use of CPO versus IPO using the bronchiolitis clinical pathway at the affiliated quaternary care hospital as a reference. The physicians and nurses agreed to limit orders for CPO to patients with severe bronchiolitis (Fig 1) and high-risk bronchiolitis patients. High-risk patients were defined as: (1) those at high risk for apnea or severe disease (age <1 month, ex-preterm <2 months corrected gestational age), (2) those with history of apnea, (3) those with underlying problems (complex, chronic medical conditions; chronic lung disease; cardiac defect; airway defects; immunodeficiency; Fig 1). We agreed to discontinue CPO when patients no longer satisfied criteria for severe bronchiolitis for 4 hours, including patients on <1.5 L/minute supplemental oxygen. Discharge criteria (SpO2 ≥90% in room air for 3 consecutive spot checks 4 hours apart) were also defined on the basis of the pathway to aid a safe and timely discharge.

In cycle 2, during the next bronchiolitis season (November 2016 to April 2017), we expanded efforts to standardize the care of bronchiolitis patients by adopting a modified version of the bronchiolitis pathway from the affiliated quaternary care hospital. Per pathway, high-risk patients were placed on CPO on the severe pathway. For all other patients, bronchiolitis severity was assessed as mild, moderate, or severe, and the appropriate pathway was ordered (Fig 1). Patients on the severe arm of the pathway were placed on CPO, and respiratory status was assessed at hourly intervals. Once they received 5 consecutive moderate assessments over 4 hours, CPO was discontinued, and they were transitioned to the moderate pathway. On the moderate pathway, IPO and respiratory assessments were performed every 2 hours. When 3 consecutive assessments over 4 hours were in the mild range, and they were no longer needing supplemental oxygen, they were advanced to the mild pathway. IPO and respiratory assessments were performed every 4 hours on the mild pathway.

At each assessment, the nurses were required to document the following in the electronic medical record (EMR): bronchiolitis severity, pathway position (Fig 1; mild, moderate, or severe), CPO or IPO, and type of suctioning (nasopharyngeal catheter, nasal aspirator, or none). Patients...
were discharged from the hospital when the oxygen saturation was maintained >90% for 8 hours over 3 IPO checks, performed at 4-hour intervals, provided they were tolerating feeds, and not requiring nasopharyngeal catheter suction for >8 hours.

Driver diagrams were used to study drivers of current practices and plan interventions. A PowerPoint with the rationale and details of the QI project was shared with all staff members. The lead physicians introduced the pathway to the physician group and the nurses at staff meetings. The team members, nurse managers, and nurse educators provided ongoing education. Nurse champions were recruited at both hospitals to provide additional bedside support during each shift. We displayed several point-of-care reminders, including posters with project details and laminated pathway cards at each workstation. Individual laminated pocket-size reference cards were distributed to each physician and nurse. EMR order sets were created for severe, moderate, and mild bronchiolitis pathways and contained a prechecked default order to discontinue CPO in patients transitioning from the severe pathway to the moderate pathway (Fig 2). Data were shared with the group at bimonthly intervals at scheduled meetings to promote continued engagement.

All data were collected by manual chart review. The baseline period spanned 8 months from November 2014 to April 2015 and November 2015 to December 2015. The intervention period encompassed 10 months, cycle 1 from January 2016 to April 2016 and cycle 2 from November 2016 to April 2107. In accordance with institutional review board standards at our institution, this study was considered QI and therefore exempt from institutional review board review.

**FIGURE 1** Inpatient bronchiolitis pathway. a High-risk patient criteria include the following: (1) high risk for apnea or severe disease, age <1 month, or former preterm <2 months old (corrected gestational age); (2) history of apnea; and (3) underlying medical problems, including complex chronic medical conditions, chronic lung disease, cardiac defects, airway defects, and immunodeficiency. b Any need for supplemental oxygen precludes mild classification. CR, cardiorespiratory monitoring; RR, respiratory rate; WOB, work of breathing.
In the preintervention baseline period and during the entire intervention period, LOS was measured from the time of the admission order to the time of the discharge order to eliminate the impact of nonmedical reasons for delay in patient discharge, such as waiting for transportation. Average monthly LOS was plotted on a statistical process control chart, and special cause rules were used to identify significant changes. All eligible patients, including those with mild, moderate, and severe disease severity (except those admitted to the PICU), were included in this analysis throughout the baseline and intervention cycles.

In cycle 1, the process measures were (1) proportion of infants with nonsevere bronchiolitis for whom IPO was ordered and (2) proportion of patients for whom CPO was discontinued after improvement in clinical classification from severe to nonsevere. In cycle 2, the process measures were (1) proportion of patients for whom the bronchiolitis pathway was ordered and (2) proportion of patients for whom nurses documented pathway position and severity assessment. Balancing measures included 7-day ED revisits and hospital readmissions within 7 days of discharge.

RESULTS

A total of 240 patients under the age of 2 years were admitted with bronchiolitis in the baseline period. Sixty patients were excluded from the analysis because of admission or transfer to the PICU for some part of their stay, and the remaining 180 were included in the analysis (Fig 3). During cycle 1, a total of 117 patients were seen; 23 were excluded because of admission or transfer to the PICU. In cycle 2, there were a total of 127 patients; 28 were excluded because of admission or transfer to the PICU, and the remaining 99 were included in the analysis.

The percentage of patients with a history of prematurity (<37 weeks’ gestational age) was 13.3% in the baseline period and 21.2% during both intervention cycles (P = .025).

In cycle 1, there was an increase in percentage of patients with nonsevere bronchiolitis for whom IPO was ordered from 20% to 75%. An order to discontinue CPO after improvement in clinical classification from severe to nonsevere was placed in ∼25% of patients. In cycle 2, the bronchiolitis pathway was ordered in 84.9% (84 out of 99) of patients eligible for analysis, and the nurses documented pathway position and severity assessment in 73.3% of patients.

Average LOS was 53.3 hours (2.22 days) in the baseline period, decreasing to 44.9 hours (1.87 days) during cycle 1 and to 33.2 hours (1.38 days) during cycle 2 for a total reduction of 20 hours from the baseline period (Fig 4). Seven-day ED revisit rate was 3.3% at baseline, 3.2% in cycle 1, and 5% in cycle 2. Corresponding 7-day readmission rates were 3.3%, 2.1%, and 5%.

DISCUSSION

We demonstrate that iterative QI initiatives targeting CPO over a 2-year period were associated with a reduction in average LOS by >20 hours for inpatient bronchiolitis patients. We achieved an average LOS of 33 hours (1.4 days) in cycle 2, which is significantly shorter than the LOS of 2.412 or 3.3 days13 previously reported in the literature.

In 2 previous studies, in which IPO was initiated after patients were completely weaned off oxygen, researchers did not detect a difference in need for transfer to a higher level of care in nonhypoxic patients; however, these studies did not reveal a decrease in LOS.6,9 In a recent review of pulse oximetry in bronchiolitis, Quinonez et al14 point to extensive evidence of “overdiagnosis of hypoxemia” in infants with bronchiolitis and list several potential harms from this overdiagnosis, including prolongation of hospital stay. These authors speculate that previous studies did not...
reveal a decrease in LOS with the use of IPO because the “intervention was not initiated until children were weaned off oxygen.”

In our cohort, use of IPO in patients with mild and moderate bronchiolitis, including sicker patients with moderate bronchiolitis on <1.5 L/minute supplemental oxygen, likely contributed to reduction in LOS. We believe that the use of IPO in this subset of moderately ill patients on <1.5 L/minute supplemental oxygen prevented the detection of clinically unimportant transient hypoxemia. This permitted more rapid weaning of oxygen supplementation in patients with mild hypoxemia and allowed early discharge of stable patients on room air.

Additional factors contributing to reduction in LOS included clear benchmarks for pathway progression based on scheduled respiratory assessments, which prevented delays in transitioning children to lower acuity levels of care and discharge criteria that allowed discharge after 3 consecutive pulse oximeter readings >90% in room air at 0, 4, and 8 hours. Before the QI intervention, it was common practice to monitor patients with CPO for 12 to 24 hours off oxygen, including documentation of a pulse oximeter reading >90% during sleep. During the intervention period, most patients who weaned to room air in the morning were discharged from the hospital on the same evening.

Factors contributing to the success of the QI intervention include collaboration among a multidisciplinary team (including hospitalists, nursing leadership, nurse educators, and bedside nurse champions), point-of-care reminders of pathway metrics and protocols visible at the bedside, and EMR order sets, which are associated with decreased variation in ordering practices. Use of bedside nurse champions and repeated bedside discussions on rounds helped in adoption of the change. Despite the above measures, a barrier to early adoption was encountered in cycle 1, in which many physicians were hesitant to omit CPO, and the nursing staff placed patients on continuous monitors despite orders for IPO, likely reflecting the historical practice of close monitoring. In cycle 2, to mitigate a low CPO discontinuation rate of 25% in cycle 1, the EMR order set included a prechecked default order to discontinue CPO for patients on the moderate pathway, which served as an automated reminder to nurses to discontinue CPO as a patient’s respiratory status improved. Default preselections in an EHR order set have been shown to influence ordering practices.

There are several limitations that must be recognized. Our average LOS of 33 hours (1.37 days) during cycle 2 was much shorter than the LOS of 2.2 to 3.3 days reported in previous studies. This may be related to lower severity of illness at a community hospital compared with that at children’s hospitals. It may also be related to the exclusion of sicker PICU patients with longer LOS; however, this population was excluded in both the baseline and intervention periods. Furthermore, we defined LOS up until the placement of the discharge order, which may have contributed to a shorter calculated LOS as compared with previous studies. In terms of the decline in LOS, the effect of variation in severity of bronchiolitis from year to year on the decline cannot be ruled out. Also, average LOS was already trending down before the 2 interventions were made, and the possibility that this trend may have continued downward along that trajectory without the interventions cannot be ruled out. Not adjusting for patient factors that may have been different pre- or postintervention (severity of illness, comorbidities, etc) is also a limitation of this study. However, the decrease in LOS during both intervention cycles was seen despite a higher proportion of patients born prematurely (<37 weeks) with a potential for more severe illness.

Our balancing measures, ED revisits and readmissions, showed a slight increase from 3.3% at baseline to 5% in cycle 2. This was likely unrelated to the decrease in use of CPO, as most readmissions seemed to be related to natural disease progression after patients were discharged from the hospital in stable condition early in the illness. Also, we did not account for patients who may have visited or been admitted to a different hospital. Additionally, we did not track codes or rapid responses that could have resulted from the intervention, but no events were brought to the attention of our performance improvement committee, which reviews all such occurrences.

**CONCLUSIONS**

Our intervention, a clinical pathway implemented to use IPO in nonsevere
bronchiolitis, was associated with a reduction in LOS in bronchiolitis patients by 20 hours over a 2-year period. The clinical pathway has become integrated into the workflow, and its use is encouraged by clinical decision support in the EMR. Together, these tools should help sustain this QI intervention over time.

As a next step, we plan to collaborate with our ED colleagues in efforts to use CPO more judiciously. Unwarranted CPO in a patient with mild bronchiolitis can detect clinically irrelevant hypoxemia and result in an otherwise avoidable admission. Moreover, care happens in a continuum, and actions taken in the ED can set the tone for the inpatient management. Families introduced to CPO in the ED may become anxious, and this can make it difficult to discontinue CPO after admission.

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