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Postnatal Steroids Use for Bronchopulmonary Dysplasia in a Quaternary Care NICU

Uthayakumaran Kanagaraj, MD[1] Jason Tan, BSc(Pharm)[1] Amuchou Soraisham, MD[2] Abhay Lodha, MD[2] Prakesh Shah, MD[3] Tapas Kulkarni, MD[1] Sandesh Shivananda, MD[1]

[1] Department of Pediatrics, Neonatal Division, University of British Columbia, Vancouver, British Columbia, Canada
[2] Department of Pediatrics, Neonatal Division, University of Calgary, Calgary, Alberta, Canada
[3] Department of Pediatrics, Neonatal Division, University of Toronto, Toronto, Ontario, Canada

Address for correspondence Sandesh Shivananda, MD, FRCPC, MSc (Health Informatics), Department of Pediatrics, University of British Columbia, Room 1N24, 4500 Oak Street, Vancouver, BC V6H 3V4, Canada (e-mail: sandesh.shivananda@cw.bc.ca).

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Abstract

Objective Intercenter variation and trends in postnatal steroids (PNS) use among preterm infants for prevention or treatment of bronchopulmonary dysplasia (BPD) is known. Understanding intracenter PNS use patterns facilitate implementation of center-specific change interventions to optimize outcomes.

This study aimed to (i) quantify the proportion of infants who received PNS, and describe the timing, type, trends over time, regimen used, and deviations, and (2) describe the clinical characteristics and unadjusted outcomes of infants who received PNS.

Study Design This was a cohort study in a quaternary neonatal intensive care unit including infants born at less than 33 weeks, and who received PNS for prevention or treatment of BPD between 2011 and 2021. Following data were included: proportion of babies who received PNS; type of PNS; age at initiation and duration; trends over time; deviation from published regimen; morbidity, mortality, and cointerventions.

Results One hundred and eighty four infants (8% of <33 week' infants) received PNS. The median (interquartile range [IQR]) gestational age and birth weight were 25 (24–26) weeks and 720 (625–841) grams, respectively. The median (IQR) day of initiation and duration of PNS use were 29 (19–38) and 10 (10–22) days, respectively. One hundred and fifty-seven (85%) infants received dexamethasone (DX) and 22 (12%) received hydrocortisone as the first PNS course, and 71 (39%) infants received multiple courses. The proportion of infants receiving PNS remained unchanged, but the cumulative median dose received for BPD per patient increased by 56%. Nearly one-third of cumulative PNS dose came from PNS used for non-BPD indications. Forty-six percent infants had a deviation from published regimen (±20% deviation in duration or ±10% deviation in dose). Survival, survival without major morbidity, moderate-to-severe BPD, and technology dependence at discharge were 87, 2, 91, and 67%, respectively.

Conclusion Increased variation in PNS use, deviation from published regimen, and concurrent PNS exposure from non-BPD indication offer insights into implementing interventions to improve processes.

Keywords
- bronchopulmonary dysplasia
- postnatal steroids
- neonatal intensive care
- variation

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Key Points

- In this quaternary NICU, 8% of infants born before 33 weeks were administered postnatal steroids (PNS).
- The percentage of infants given PNS remained stable; however, the cumulative dose per patient for BPD rose.
- The study identified targeted interventions to minimize clinical practice variations at the center.

Bronchopulmonary dysplasia (BPD) is the most common morbidity in extreme preterm infants with an incidence of 44 to 54% among infants admitted to Canadian neonatal intensive care units (NICUs) between 2013 and 2021.[1] Post-NICU discharge, these infants have repeated hospitalization, compromised lung function, and adverse neurodevelopmental outcome with significant health care costs.[2–6] The anti-inflammatory effect of glucocorticoids is used to treat the underlying inflammation in BPD. Three large, placebo-controlled, randomized controlled trials (RCTs)[7–9] and many cohort studies[10–12] have investigated the effects of dexamethasone (DX) and hydrocortisone (HC) on lung and neurodevelopmental outcome in past 15 years. However, the meta-analysis and practice guidelines highlight inconsistent quality of evidence and challenges in identifying infants where postnatal steroids' (PNS) benefits clearly outweigh risks.[13–17] Thus, PNS for BPD in individual units is prone to variation, with decision-making being strongly influenced by medical opinion. Identifying opportunities for improvement in a given hospital is unlikely to come from research trials, national guidelines or network analysis, as they do not provide granular details on magnitude and type of suboptimal practices related to PNS from an individual center.[12,14,18–20]

At British Columbia Women's Hospital (BCWH) NICU, the incidence of BPD in less than 29-week infants remains high (48–68%) despite multiple improvement efforts between 2013 and 2021.[1] The decision on PNS use, an important strategy to reduce BPD, is at the discretion of attending neonatologists' and there is no unit level guideline that specifies indications, type, and timing for PNS. The local neonatal lung health quality improvement (QI) team members suspected suboptimal use of PNS may be a major contributor to high BPD rates. Identifying and quantifying practice deficiencies in PNS use and gathering information outcomes are key preliminary steps in motivating local stakeholders to take action, and in designing change interventions to optimize care practices. Our primary aim is to describe the use of PNS for prevention or treatment of BPD over an 11-year-period in infants of less than 33 weeks from a single quaternary care NICU.

Objectives

This study aimed to (i) quantify the proportion of infants who received PNS, timing, type, and regimen used, deviation from established regimen and usage trends, and (ii) describe the clinical characteristics and unadjusted outcomes of infants who received PNS.

Methods

We conducted this retrospective, single-center, observational study in a 60-bedded quaternary care perinatal NICU for infants admitted between January 2011 and December 2021. We included infants with a gestational age of less than 33 weeks at birth and received steroids for prevention or treatment of BPD. Infants with major congenital anomalies like congenital diaphragmatic hernia, chromosomal abnormalities like Trisomy 21, and infants who received steroids only for non-BPD indications, such as hypotension, suspected adrenal insufficiency, laryngeal edema, or malignancy, were excluded.

Data Sources and Definitions

We collected data from NICU's pharmacy database, Canadian Neonatal Network (CNN) database, discharge summaries in electronic health record, and occasionally from individual patient charts. CNN has standard data definitions, collection, and reporting for its database.[1,21] To identify PNS use for indications other than BPD, and to facilitate calculation of cumulative steroid dose exposure, we used the following pragmatic definitions: (i) DX used in peri-extubation period, less than 3 consecutive days and/or doses consistent with airway edema, (ii) HC used concurrently with inotropes, for less than 7 days and/or doses consistent with pressor-resistant hypotension, (iii) HC started with inotropes and used for over 7 days at a fixed low physiologic replacement dose. We used the previously published categorical time points for initiation of the first steroid course to classify infants; early (E <7 days of life), early evolving (EE: 7–28 days of life), late evolving (LE: 29 days of life to $36^{6/7}$ weeks' postmenstrual age [PMA]), and established (Est ≥37 weeks' PMA).[22] We defined the repeat course of steroid as a course started 48 hours after stopping the previous one for the same type of PNS or no defined time gap for a different type of PNS. For calculating cumulative systemic steroid exposure, we converted DX to HC equivalents (Eq) by the multiplication factor 26.67.[21] For example, 20 mg of HC is equivalent to 0.75 mg of DX, so 1 mg of DX = 20/0.75 = 26.67 of HC Eq, mg/kg. This translates Dexamethasone–A Randomized controlled Trial (DART) protocol's total dose of 0.89 mg/kg of DX, to 23.7 HC Eq in mg/kg. Cumulative dose did not include inhaled steroids.[22] We defined the deviation in steroid use from a published regimen and approved for use in the unit (►**Supplementary Table S1**, available in the online version), if the infant received at least one steroid course with 20 and 10% deviance for the duration and the dose, respectively. For example, in DART regimen—deviation is—if the total duration of treatment was less than 8 or over 12 days (±20%), or the dose received was less than 0.81 mg or over 0.98 mg (±10%), or when the PNS got started at less than 7 days of life.[7] Similarly, for 22-day tapering doses of HC Systemic Hydrocortisone To Prevent Bronchopulmonary Dysplasia in preterm infants (SToP-BPD) regimen, deviation is—if the total duration of treatment was less than 18 or over 26 days (±20%), or the dose received was less than 65 or over 79 mg (±10%), or when the course got started at less than 7 or after 14 days of life, or when variable doses were used.[15] We inferred

providers' short-term intention at the initiation of PNS from reviewing summaries and progress notes and categorized into one of the predefined categories; rescue from high ventilatory or supplementary oxygen requirements, facilitate successful extubation, that is, break the vicious cycle of ongoing invasive ventilation associated lung injury, and prevention of reintubation when noninvasive ventilation setting is maximal or near maximal. If unclear, two investigators assigned the most likely intention by mutual agreement (S.S. and U.K.). We defined BPD as receiving any respiratory or ventilatory support or supplemental oxygen at 36 weeks' PMA.[21] Other major morbidities' (intraventricular hemorrhage $\geq$ grade 3, necrotizing enterocolitis $\geq$ stage 2, nosocomial infection, retinopathy of prematurity $\geq$ stage 3) definitions are as per CNN.[21]

Analysis

We report baseline characteristics, interventions, resource use, and outcome measures as proportion, median, and interquartile range (IQR). We set statistical significance at p-value of <0.05. Chi-square, Student's t-test, and Mann–Whitney U tests were used to compare differences between patient groups categorized based on the first course of PNS for parametric and nonparametric distribution of variables, respectively. We used SPSS statistical software (IBM Corp. Released 2023. IBM SPSS Statistics for Macintosh, version 29.0, Armonk, NY) for analysis. We analyzed the change in the type of PNS use and cumulative dose exposure over time using C- and X-charts (created using QI Macros for Excel 2022, KnowWare International, Inc., Denver, CO) by plotting data quarterly and identifying special cause variation using standard rules.[23,24] To determine center-level outcomes for providers' use during pre-PNS initiation discussion with parents, we performed a subgroup analysis; in other words, EE versus LE timing of first course, single versus multiple course, DX versus HC as the initial course, and determinants of nonsurvivors. The Research Ethics Board approved this study (H21-03933).

Results

Proportion of Infants who Received Postnatal Steroids for Bronchopulmonary Dysplasia, Timing and Type of Postnatal Steroids

We identified 430 infants who received PNS during the study period from 2,273 infant admissions of less than 33 weeks of gestation at birth. Of them, we included 184 infants (8%) who received PNS for BPD. Seventy-seven (42%) of these infants had received PNS for non-BPD indications prior to the initiation of the first course of PNS for BPD (►Fig. 1) and 71 (39%) received multiple courses of steroids. PNS use among less than 29-week infants was 17%. We provide the proportion of infants receiving various types of steroids based on timing of initiation of first and subsequent courses in ►Fig. 1.

Clinical Characteristics of Infants at Admission

Ninety-seven percent of infants were less than 29 weeks of gestational age at birth, and 164 (89.1%) infants had a severe illness at admission with a Score for Neonatal Acute Physiology with Perinatal Extension-II of over 20 (►Table 1).

Cointerventions

Almost all study infants received intubation and ventilation (99.5%), supplemental oxygen (100%), and antibiotics (100%) during the NICU stay. Over 85% of infants received one or more central venous catheters (►Table 1). The median (IQR) for ventilator, oxygen, and parenteral nutrition among study infants were 105 (83–141), 81 (60–114) and 40 (27–52) days, respectively.

Postnatal Steroids Duration and Dose

Majority of infants received the first course of PNS in EE (51%) and LE (46%) periods (►Fig. 1). Infants received 1.6 times the median cumulative dose of PNS from combined indications of BPD and non-BPD compared with the median cumulative dose received selectively for BPD. Increased variation in the day of initiation of first course of PNS, total duration, and cumulative dose received by infants was noted (►Fig. 2, ►Table 2).

Providers' Short-term Intention at Postnatal Steroids Initiation, Regimen Used, and Deviations from Published Regimen

The most common provider's short-term intention at initiation for the first course of PNS was to facilitate extubation (57.6%; ►Table 2). The only two PNS regimens used during the study period for BPD were SToP-BPD for HC and DART for DX. Overall, 45.7% of study infants had a deviation from published regimen with PNS use for BPD in at least one of their courses. Protocol deviation associated with HC (66.7%) usage was higher than DX (33.3%).

Postnatal Steroids Use Trends over Time

The number of infants receiving DX or HC as the first course of PNS treatment, or multiple courses of steroids per quarter, did not change. Similarly, the cumulative steroid dose received for the combined BPD and non-BPD indications per patient per quarter did not change over time (mean of 40.54 HC Eq., mg/kg). The cumulative steroid dose received for the BPD indication per patient per quarter increased from a mean of 30.6 to 46.78 HC Eq., mg/kg) with the centerline shift in 2017 (►Fig. 3). There was no concurrent change in the annual proportion of less than 29 weeks or, <25 weeks' infants, outborn admission or infants' severity of illness score at admission with median (IQR) of 14% (13–16), 3% (2–3), 33% (33–37), and 44 (31–56), respectively, over the study period. There was no change in the indication for PNS (rescue, facilitate extubation, or prevent reintubation) over time.

Outcomes

The mortality rate in the study infants was 13%. Survival without major morbidity was 1.6%. The median (IQR) length of stay was 127 (102–164) days (►Table 1).

Subgroup Analysis

Early Evolving versus Late Evolving Groups

On comparing the proportion of infants in EE with LE group, the maternal antibiotic received during labor was higher

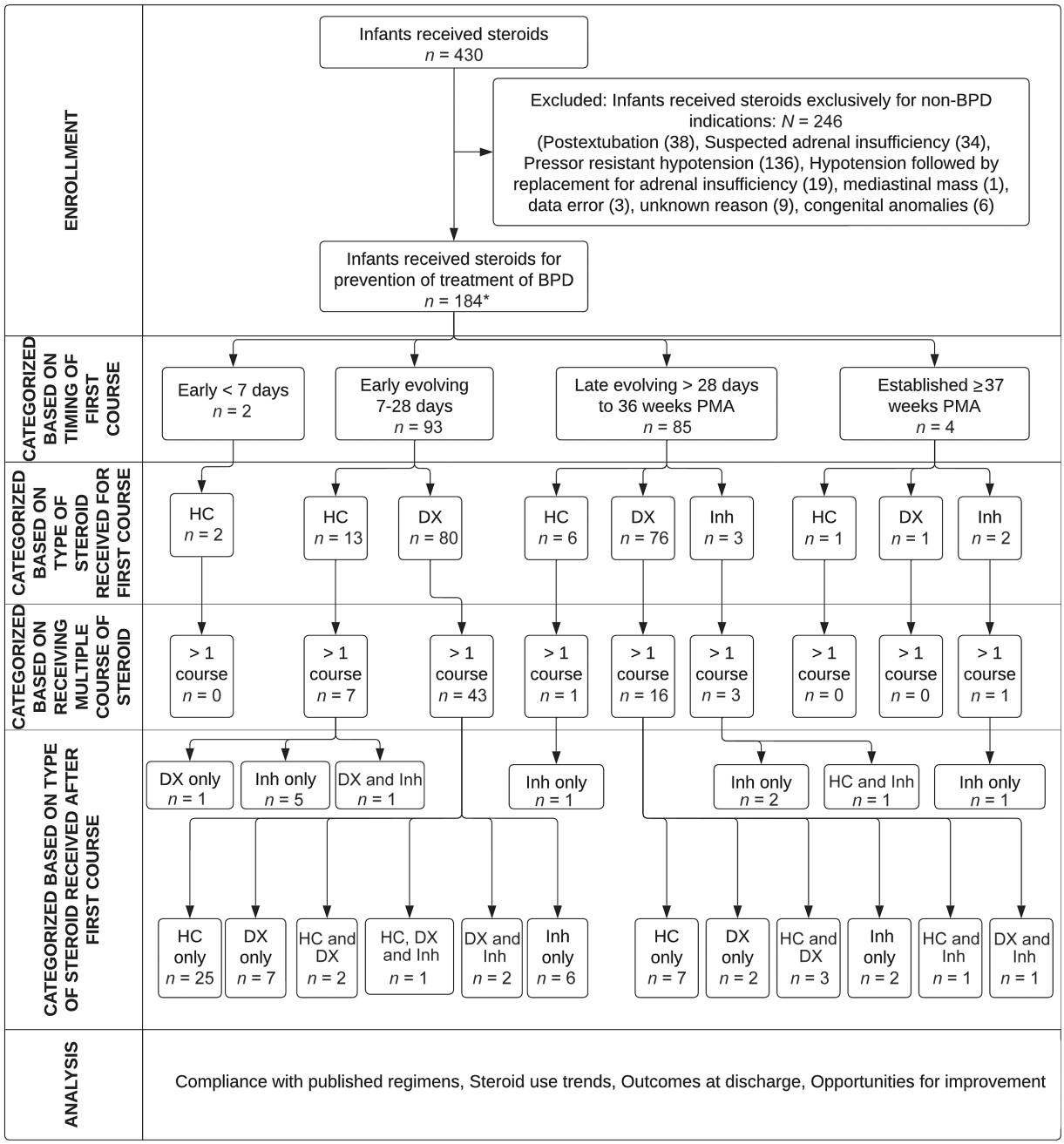

Fig. 1 Study flow diagram. *Seventy-seven infants had received steroids prior to initiation of first course of steroids for BPD for non-BPD indications. BPD, bronchopulmonary dysplasia; HC, hydrocortisone; DX, dexamethasone; Inh, inhaled steroid; PMA, postmenstrual age.

(81.2 vs. 62.9%, $p = 0.01$), and antenatal steroid received within 7 days of delivery was lower (35.5 vs. 50.6%, $p = 0.04$), respectively (►**Supplementary Table S2**, available in the online version). The proportion of infants receiving sedatives and muscle relaxants in the EE group was higher when compared with the LE (91.4 vs. 77.6%; $p = 0.01$ and 26.8 vs. 14.1%; $p = 0.04$, respectively). The proportion of infants receiving multiple courses and the duration of steroids received were higher in the EE group when compared with the LE group. Infants in the EE group, when compared with the LE had higher mortality rate (17.2 vs. 7.1%, $p = 0.04$), higher gavage feeding dependency at discharge (40.9 vs. 28.2%, $p = 0.01$), lower BPD rates (86.0 vs. 96.5%, $p = 0.01$), and no difference in BPD/mortality (100 vs. 96.5%, $p = 0.16$; ►**Supplementary Table S2**, available in the online version).

Single versus Multiple Courses

On comparing the characteristics of infants who received single versus multiple courses of PNS, we observed no differences in infant characteristics, resuscitation interventions at birth, or severity of illness at admission, except later median day of initiation of first course of PNS (34 vs. 22 d, $p = 0.001$). The length of NICU stay, the proportion of infants discharged

Table 1 Infant characteristics, interventions, and outcomes

	Total, $n = 184$
Infant characteristics	
Gestational age in weeks, Med (IQR)	25.0 (24.0–26.0)
Birth weight in grams, Med (IQR)	720 (625–841)
Female	63 (34.2)
Outborn	62 (33.7)
Antenatal steroids received (partial or complete)	167 (90.8)
Suspected chorioamnionitis[a]	57 (65.5)
C-section delivery	131 (71.2)
Intubation and ventilation during resuscitation	159 (86.4)
SNAPPE-II >20	164 (89.1)
APGAR 5 minutes, Med (IQR)	6 (4–7)
SNAPPE-II, Med (IQR)	44 (31–56)
Interventions received[b]	
Peripheral arterial line	90 (48.9)
Parenteral nutrition	184 (100.0)
High-frequency ventilation	162 (88.0)
Surfactant	184 (100.0)
Surfactant (>1 dose)	73 (39.7)
Narcotic infusion	181 (98.4)
Sedatives	155 (84.2)
Muscle relaxants	40 (21.7)
Inhaled nitric oxide	43 (23.4)
Inotropes	124 (67.4)
Caffeine	178 (96.7)
Transfusion	168 (91.3)
Outcomes	
Mortality	24 (13.0)
BPD at 36 weeks' PMA	167 (90.8)
Moderate	101 (54.9)
Severe	66 (35.9)
Mortality or mod/severe BPD	181 (98.4)
Retinopathy of prematurity, stage ≥ 3	17 (9.2)
Retinopathy of prematurity treated among survivors	42 (22.8)
Patent ductus arteriosus treated medically or surgically	123 (66.8)
Pneumothorax	19 (10.3)
Necrotizing enterocolitis, stage ≥ 2	14 (7.6)
Intraventricular hemorrhage, grade ≥ 3	44 (23.9)
Periventricular leukomalacia	17 (9.2)
Culture positive sepsis	93 (50.5)
Spontaneous intestinal perforation	11 (6)
Survival without major morbidity	3 (1.6)
Discharge oxygen[c]	41 (25.6)
Discharge gavage feeding[c]	64 (40.0)
Discharge tracheostomy[c]	8 (5.0)
Discharge gastrostomy[c]	19 (11.9)
Discharge ventilation[c]	9 (5.6)
Discharge CPAP[c]	33 (20.6)
Discharge technology dependency[c]	107 (66.9)

Abbreviations: BPD, bronchopulmonary dysplasia; CPAP, continuous positive airway pressure; IQR, interquartile range; PMA, postmenstrual age; SNAPPE-II, Score for Neonatal Acute Physiology with Perinatal Extension.
Values in each cell represent *n* (%), unless specified.
[a]Denominator is number of infants with available data.
[b]Anytime during hospital stay.
[c]Among survivors.

home on oxygen, and gastrostomy were significantly higher in multiple courses group (►**Supplementary Table S3**, available in the online version).

Dexamethasone versus Hydrocortisone as the First Course of Postnatal Steroids

On comparing the characteristics of infants who received DX versus HC as the first course of PNS, we found no difference in the infant characteristics, resuscitation interventions at birth, severity of illness at admission, or median day of initiation of steroids. However, the duration of steroids received for BPD, combined BPD and non-BPD indications, and a cumulative dose of steroids were significantly lower in the DX group. Apart from the lower proportion of infants treated for retinopathy of prematurity (ROP) in the DX group, the other morbidities, length of stay, and mortality were like HC group (►**Supplementary Table S4**, available in the online version).

Nonsurvivors versus Survivors

Nonsurvivors, when compared with survivors, had lower birth weight, higher severity of illness score at admission and exposure to inhaled nitric oxide. There was no difference in the day of initiation of PNS, type of first PNS course, duration, or cumulative dose exposure between the groups. More infants had necrotizing enterocolitis (NEC) and spontaneous intestinal perforation among nonsurvivors (►**Supplementary Table S5**, available in the online version). Technology dependency, respiratory support, and supplementary oxygen at discharge among survivors were 67, 24, and 25%, respectively.

Discussion

Eight percent of infants admitted to NICU received PNS, most commonly DX, at a postnatal age around third to sixth week of life. HC was the second common steroid used, followed by inhaled budesonide, consistent with previous surveillance reports.[12,19,20] Though the proportion of infants receiving PNS did not increase over time, the cumulative dose received

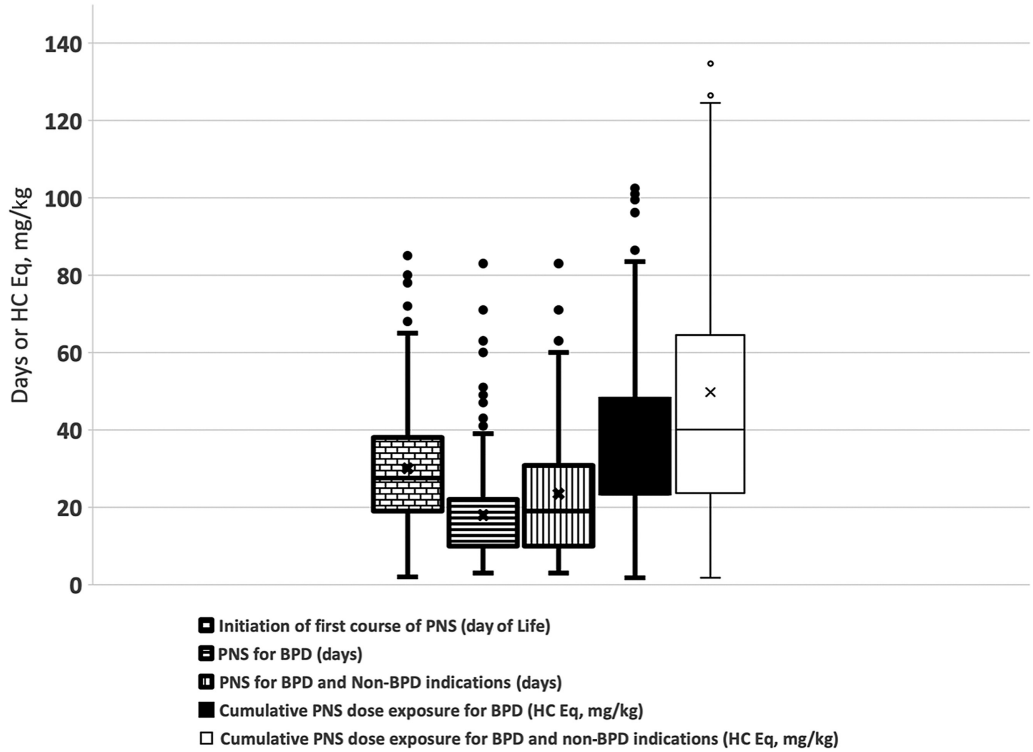

Fig. 2 Box and whisker plot showing the spread and variability of postnatal steroid timing, duration, and cumulative dose. BPD, bronchopulmonary dysplasia; Eq, equivalent; HC, hydrocortisone; PNS, postnatal steroid.

Table 2 Providers' intention at the initiation of postnatal steroids, timing, dose, duration, and deviation from published regimen

Timing, dose, and duration	
Total number of course used, Med (IQR)	1 (1–2)
Steroids day of life at initiation, Med (IQR) days	28 (19–38)
Repeat course used	71 (38.6)
Steroid used for BPD, Med (IQR) days	10 (10–22)
Steroid used for BPD and non-BPD indications, Med (IQR) days	19 (10–31)
Cumulative steroid dose exposure due to BPD indication, Med (IQR) Hydrocortisone Eq, mg/kg	24 (24–48)
Cumulative steroid dose exposure due to BPD and non-BPD indications, Med (IQR) Hydrocortisone Eq, mg/kg	38 (24–65)
Providers' intention at initiation of first course of PNS	
Facilitate extubation	106 (57.6)
Decrease ventilatory pressure and/or oxygen requirements	57 (30.9)
Prevention of reintubation	21 (11.4)
Deviation from published regimen	
Overall deviation in at least one steroid course from published regimen	84 (45.7)
Based on duration	52 (28.3)
Based on dosing	16 (8.7)
Based on timing	12 (6.5)
Unclear indication	4 (2.2)

Abbreviations: BPD, bronchopulmonary dysplasia; Eq, equivalent; Med, Median; IQR, interquartile range; PNS, postnatal steroid.
Values in each cell represent *n* (%), unless otherwise specified.

for BPD per patient increased by 56%. Nearly one-third of cumulative PNS dose came from PNS used for non-BPD indications. Some concerning findings were the proportion of infants exposed to PNS for non-BPD indications prior to the first course, deviations from published regimen, and intracenter variation in the timing, type, and dosing of PNS.

Unlike previous reports of an increase in proportion of infants receiving PNS over time,[12,19,20] we found an increase

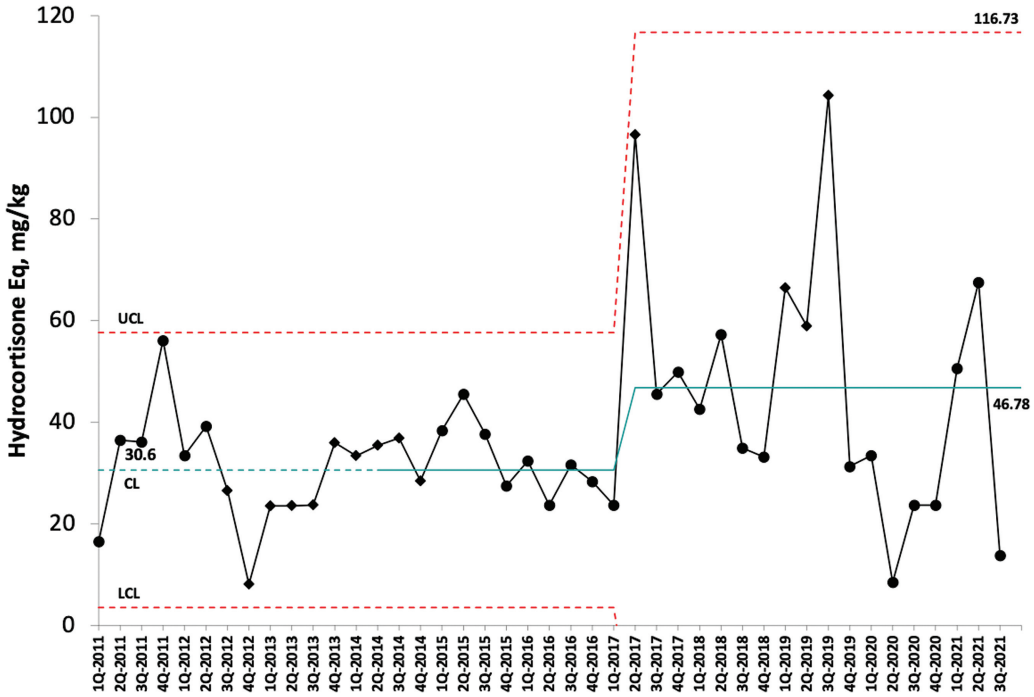

Fig. 3 Cumulative dose of postnatal steroid received per patient per quarter for BPD. X-chart, each dot represents the mean cumulative steroid dose received per patient per quarter for BPD. Diamond-and circle-shaped dots represent unstable points (out-of-control process) and stable points, respectively. Dotted lines show upper and lower control limits. Centerline shift shown conformed to significant standard process control rules, that is, 8 points in a row above the baseline central line. Unstable points identified by QI macros such as one point above or below UCL, or 2 points one above and below 2 sigma were possibly secondary to patient factors (more severe illness) rather than process changes. CL, central line; LCL, lower control limit; UCL, upper control limit.

in the cumulative dose of PNS received by infants that is not explained by an increase in the proportion of extreme preterm infants, their severity of illness, or outborn status.

We speculate that introducing the 22-day HC regimen (72.5 HC Eq; mg/kg per course) in 2016 and its frequent use may have contributed to this increment, whereas Canadian Pediatric Society recommends a cumulative DX dose of 1 to 2 mg/kg (27–54 HC Eq, mg/kg),[14] recent meta-analysis[17] suggested that DX with a medium cumulative dose (2–4 mg/kg or 54–108 HC Eq, mg/kg) is most effective for decreasing BPD and mortality. Though the median (IQR) cumulative dose used in this study for BPD alone or combined BPD and non-BPD indications is within the published acceptable limits, an increment in cumulative dose exposure without concurrent decrease in the BPD rate raises concerns for possible unwarranted use.[25,26] We believe that (i) center-specific guidelines for using PNS for BPD and non-BPD indications[27]; (ii) order sets to influence providers prescribing practices that standardize initiation, duration, and dose consistent with established regimens; (iii) standardizing PNS weaning when used for suspected adrenal insufficiency[22] might address unwarranted variation in PNS use.

Our observed single-center variation in timing of initial course of PNS and choice of PNS is consistent with reports involving multiple centers.[12,19,20] Nonusage of early HC for BPD in this study is consistent with an absence of this regimen in the unit formulary. The proportion of infants receiving a multiple course of PNS is similar to a study on DX (25–34%),[20] but higher when compared with a study involving all forms of PNS (1.4%).[12] This observed variation could be secondary to differences in the inclusion criteria, a priori risk of BPD, definitions used, and proportion of missing cases.[15]

The proportion of infants with a deviation in PNS use from published regimen, in this study is comparable with RCTs and meta-analysis (46 vs. 27–57%).[7,9,15,17,28] This magnitude of deviation may reflect one or more of patient diversity at risk of disease, responsiveness to treatment, or guidelines being lenient, equivocal, and incongruent,[13,15] or variation in providers' decision-making.[26]

The day of PNS initiation among EE group (IQR 14–24 d) is later than the optimal recommended time of 8 to 14 days for effectively decreasing BPD and mortality.[17] Since the inflammatory cascade for BPD may start during the perinatal period and start developing shortly after birth, PNS may have to be used earlier.[8,13,29] We believe using calculators to identify infants at relatively high risk of BPD may facilitate screening of infants eligible for PNS, prompt team conversation and reduce unwarranted variation in the selection of patients and timing of initiation.[13,30]

The strengths of the study include granularity of data arising from a typical quaternary care NICU for 11 years, insights into providers' practice patterns, and actionable opportunities for improvement. The pragmatic definitions used in this study, though unvalidated, may facilitate classification of PNS intervention in a real-world setting. The key limitation is that our center's experience and practice may or may not apply to other centers. Other limitations include (i) ascertainment and selection bias associated with

retrospective study, (ii) lack of comparison with another center, (iii) inability to determine any association between PNS open-label use, deviations, or cumulative dose exposure with outcomes because of small sample size, (iv) lack of BPD risk estimation at the beginning of PNS and data to assess response to every course, (v) insufficient details to differentiate warranted from unwarranted variation in practice, and (vi) indications for PNS were inferred and not documented consistently in the medical records.

We show variation in screening infants for PNS, initiation, and selection of type of PNS and supportive care practices, inline with inconsistent scientific evidence, and practice shaped by social context and practitioners' values.[26] The study findings are likely to facilitate our center's (i) QI planning and prioritization of contextually relevant and impactful practices for adoption such as online clinical tool to estimate risk of BPD,[30] and decision aids with information on PNS options with benefits and harms to facilitate contextual value-based decision-making, (ii) counselling of parents with local outcome data at the initiation of first or multiple course of PNS, (iii) resource planning by administrators, and (iv) internal benchmarking of type, timing, and deviations and impact of ongoing improvement efforts. However, other centers may consider using this study's methodological approach to identify opportunities for improvement in PNS use.

Conclusion

Eight percent of infants born less than 33 weeks and admitted to NICU received PNS, most commonly DX, at a postnatal age around third and sixth week of life. The proportion of infants receiving PNS did not increase over time, but the cumulative dose received for BPD per patient increased. Nearly half of the infants had protocol deviations. The mortality rate, death/BPD, and technology dependency at discharge were significant. We identified center-specific potential change interventions to reduce unwarranted variation in practice and optimize outcomes.

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Conflict of Interest
None declared.

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