Standardizing Nasal Cannula Oxygen Administration in the Neonatal Intensive Care Unit

Jodi K. Jackson, MD, Susannah P. Ford, MD, Kerri A. Meinert, BHS, RRT, Mary Kay Leick-Rude, RN, MSN, Betsi Anderson, BSN, RN, CPHQ, Michael B. Sheehan, MD, Barbara M. Haney, RNC, MSN, CPNP, Sherri R. Leeks, MSN, CNNP, RNC, Stephen D. Simon, PhD

Section of Neonatology, Department of Pediatrics, Children’s Mercy Hospitals and Clinics, University of Missouri, Kansas City School of Medicine, Kansas City, Missouri

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

ABSTRACT

OBJECTIVE. A multicycle, quality improvement method was used to standardize nasal cannula O2 administration and weaning in the NICU.

METHODS. A 2-armed nasal cannula standardized order form (nasal cannula for stable O2 arm and nasal cannula for stable flow arm) was developed after review of the literature, surveying of the practice of NICU physicians and nurse practitioners, and development of consensus among these providers. Outcomes were measured by tracking the distribution of protocol arm chosen, days on O2, weeks on nasal cannula, and disposition of infants who were supported by nasal cannula. Data were collected in an SPSS statistical data set.

RESULTS. Of the 90 infants evaluated, 12 were supported on the stable O2 arm and 53 on the stable flow arm for their entire nasal cannula course. Twenty-five infants switched between arms of support. Patients who were on the stable flow arm of the standard order set for their entire nasal cannula course experienced fewer O2 days but more days on nasal cannula. A subpopulation of infants were supported on nasal cannula flow 0.5 to 1.0 L, with fraction of inspired O2 of 21%. When data from the first 10 weeks of observation were compared with that of the second 10 weeks, the rate of discharge on O2 had decreased from 13 (30%) of 44 to 3 (7%) of 39.

CONCLUSIONS. The multiple steps of literature review, practice surveys, and consensus-building resulted in enthusiastic reception of the nasal cannula standardized order form. The 2-armed nasal cannula protocol forced caregivers to consider which method of support was most beneficial for each infant who was on nasal cannula and allowed a subpopulation of NICU patients to be supported with a lower fraction of inspired O2 than previously used in the NICU.
THROUGH THE VERMONT Oxford Network, a hospital-based neonatal respiratory care committee joined with multiple other centers. A focus of this collaborative group was targeting O₂ saturation levels. Initially, the hospital-based committee developed a unit-based O₂ saturation protocol to avoid hyperoxia.1 However, the focus on O₂ saturation targeting revealed difficulty in maintaining infants who were on nasal cannula (NC) within their goal saturation ranges. This objective finding, along with the long-standing frustration of nurses and doctors concerning varied “methods of weaning” NC O₂, directed the committee’s attention toward development of NC weaning guidelines and standard orders.

The literature provided evidence for the clinical practice of NC use2–10; however, obstacles still remained when introducing this practice into the clinical service. The process of developing and introducing standard NC orders was approached using a quality improvement (QI) model.11 When any new practice is implemented, close monitoring is required to ensure that the proposed changes take place. Involvement of many disciplines and distribution of information throughout the process allow for modifications and ultimately facilitate acceptance of the new process. The purpose of rigorous QI monitoring is to document the evolution of practice and outcomes in relation to proposed changes.

METHODS
This QI project was reviewed by the Children’s Mercy Pediatric Institutional Review Board before submission for publication. A structured QI method using the plan-do-study-act cycle11 was applied. This model was used to implement and test changes. The “plan” step consisted of evaluating the evidence, developing theories, and creating a plan. The “do” step implemented those plans. During the “study” step, results of actions that were taken in the “do” step were evaluated. In the “act” step, actions were taken on the basis of results of the “study” step, thereby leading to subsequent cycles in response to new objectives. Details of these cycles are presented in Table 1.

Data were gathered from information that was documented and stored in Quantitative Sentinel, a computer-based charting system. Data that were obtained from this documentation then was hand-entered into an SPSS database. All analyses were done using SPSS software (SPSS Inc, Chicago, IL). Statistical analysis was performed by using Pearson χ² test and associated 95% confidence intervals (CIs) for differences between 2 independent proportions. For the analysis of trends over time, a simple linear regression model was used. Comparison of time on NC and O₂ days used a simple analysis of variance model with a Tukey follow-up test.

Overall Project Aims
The overall aims of the project were (1) to form a consensus among practitioners regarding the use of NC O₂ in the NICU and to obtain 100% acceptance and adherence to a standard order form reflecting that consensus and (2) to monitor disposition in relation to implementation of the standard order form.

RESULTS
The results section is composed of the “study” component of the plan-do-study-act cycle for the 4 cycles described within this article (Table 1). These are reported in the following subsections.

Study Cycle 1: Results of Initial Literature Exploration, Use of Delphi Technique Questionnaire for Consensus Formation, and Identification of the Amount of O₂ Received Through NC
Results from the literature survey revealed that when a stable O₂ delivery is the primary goal in supporting a nonintubated infant, there is a choice between hood O₂ and NC. The advantage of hood O₂ is that it provides the most stable O₂ delivery because it minimizes entrainment of room air (RA). Hood O₂ also is easy to wean because the only variable is fraction of inspired O₂ (FIO₂).

When prolonged O₂ delivery is required, hood O₂ can interfere with feeding, developmental care, and parental interaction.2 For this reason, the practice of many NICUs has evolved into using NC to deliver supplemental O₂.

When stable O₂ delivery is the goal, the literature supports using low-flow NC with 100% FIO₂. The amount of O₂ that actually reaches the infant can be measured using a hypopharyngeal probe. Hypopharyngeal oxygen concentration (FHO₂) is affected by multiple factors, including fractional nasal breathing (amount of nose compared with mouth breathing), tidal volume, and inspiratory time.3 Because changes in fractional nasal breathing are more likely to be larger and of greater consequence than changes in tidal volume and inspiratory time, stability of FHO₂ can be maximized by avoiding conditions under which nasal breathing fractions affect FHO₂, by using the lowest possible cannula flow with high O₂ concentration.3,4 In addition, using the lowest flow possible minimizes irritation from drying of the nasal passage.3 The literature also guided the development of a chart to calculate the O₂ level delivered to the hypopharynx (FHO₂) from patient weight, NC flow, and FIO₂.3,4,6,8 Using a number of assumptions, the mathematical calculation can be simplified to (0.21 + [flow/weight] × [FNCO₂ – 0.21]), where FNCO₂ is the FIO₂ set to be delivered via the NC (Appendix 1).1 This calculation produces values that correlate to the oxygenation grid used by the National Institute of Child Health and Human Development in recent studies.12,13

A staff questionnaire was constructed using the Delphi technique and focused on the use of NC to deliver a stable O₂ supply/dose.14 There was 100% compliance in
TABLE 1  PDSA Approach to Standardization of NC Use

Cycle 1 (June 2003 to September 2003)

Objectives
1. Identify standard methods of weaning infants who are on NC
2. Begin to explore a standard approach to NC O2 management among the neonatologists and NNPs who care for infants in the NICU
3. Identify amount of O2 that infants receive via NC based on O2 liter flow and FIO2

Plan
1. Perform a literature search regarding administration of NC O2 to neonates
2. Develop a conversion chart to assist in identifying the level of O2 exposure based on flow and FIO2
3. Develop a questionnaire tool based on knowledge gained from the literature related to NC O2 delivery using the Delphi technique

Do
1. Completed literature search and distributed to members of the committee to construct questionnaire
2. Constructed and distributed first questionnaire to assess NC use; included summaries of evidence from literature review
3. Completed conversion chart identifying the level of O2 exposure and provided for physician and NNP staff review (Appendix 1)

Study: see “Results”

Act
1. Disseminated information gathered from first questionnaire
2. Went back to the literature to search evidence for the use of NC to deliver flow/pressure
3. Created a follow-up questionnaire to focus better on a consensus to practice in regard to use of NC

Cycle 2 (September 2003 to December 2003)

Objectives
1. Work toward a consensus regarding NC use in the NICU
2. Finalize a consensus statement regarding NC use in the NICU

Plan
1. Complete a second literature search focused on neonatal NC administration with the goal of delivering flow/pressure
2. Discuss standard practice of other centers within VON
3. Develop of a follow-up questionnaire regarding NC use on the basis of the results of the second literature search and information learned from other centers, using the Delphi technique
4. Create a consensus statement based on results from the above

Do
1. Literature search completed and distributed to members of the committee to construct a follow-up questionnaire
2. Discussed at the biannual VON meeting
3. Developed and distributed follow-up questionnaire to refine further the ideas regarding NC use; included summaries of evidence from both literature reviews with the questionnaire
4. Consensus statement created

Study: see “Results”

Act
1. Disseminated information gathered from the second questionnaire
2. Formulated a standardized approach to initiating and weaning NC O2 through development of standard orders that offer 2 sets of weaning guidelines; one set of orders provided guidelines for NC use to provide stable O2 delivery (the stable O2 arm), and the other set of orders provided guidelines for NC use to deliver flow/pressure, with O2 administration being the secondary goal (the stable flow arm); flow diagrams were printed on the back of the order forms to guide the providers’ thought process when choosing an order set (Appendix 2)
3. Clearly define arms of standard orders
   a. Stable O2 arm: NC used with the intent to give as stable and reliable O2 support as possible, which is done with low NC flow (<0.5 L) and 100% FIO2, with the goal to wean the flow to 0.1 L and then the FIO2 (Appendix 2)
   b. Stable flow arm: NC used with the intent to deliver flow/pressure, which is done by setting a higher flow (0.5–1.0 L) and weaning the FIO2 only until it is deemed clinically indicated to wean the flow (Appendix 2)

Cycle 3 (January 2004 to April 2004)

Objective: The objective of this cycle was to create and implement a standard NC order form with the intention of improving
1. Education through encouraging each physician and NNP to communicate for each patient whether NC O2 is selected primarily for stable O2 delivery or primarily for flow or distending pressure
2. Communication of the plan of care for weaning FIO2 and flow parameters
3. Documentation of the reason for NC use to measure the effects of standard and varied approaches

Plan
1. Develop standard orders and guidelines
2. Gain approval of the standard order form by all neonatologists and NNPs
3. Educate NNPs, bedside nurses, and RTs regarding use of order form
4. Identify methods to track use of the standardized NC orders
5. Identify methods to track outcomes of patients who are on NC

Do
1. The NC order form was completed and submitted to forms committee
2. A public presentation was made to all neonatologists; those who were not present were approached individually; with small revisions, there was 100% acceptance of the standard order form by the neonatologists
3. Presentations were made to the bedside nurses at 3 strategically timed mandatory meetings to accommodate all shifts; 90% of the 121 nursing staff were present at 1 of these updates
4. Presentations were made to the 51 float pool nurses, where there was 78% attendance
completing the questionnaire as a result of creative persistence of the committee members. The results from the first NC questionnaire revealed that the idea of a “standard approach” was acceptable, but many were concerned that written guidelines would compromise flexibility and ability to respond to specific clinical situations. The underlying theme was that O2 by NC should be managed differently depending on the reason that it is needed. Most agreed that if the goal is to provide stable O2 delivery, then high FIO2 and low flow would be preferable. The questionnaire also revealed that many use NC as a means of providing flow/pressure (continuous positive airway pressure [CPAP]). It was proposed that if microatelectasis is the predominant factor in the disease process, then pressure, not O2, may be the treatment of choice.

Study Cycle 2: Results of Second Literature Search and Generation of Consensus Statement Regarding NC Use

The second literature survey focused on delivery of NC for flow/pressure. Infants often need some type of pressure support after extubation, but there is no consensus about the best means by which this can be achieved. There is literature to support the use of NC as CPAP. However, there also is literature that discourages it, supporting nasal CPAP (NCPAP) as the most reliable way to deliver positive end-expiratory pressure (PEEP). The literature varied in estimation of PEEP that is generated by NC. Factors that affect the amount of pressure administered include infant weight, prong size, ratio of the diameter of the nares to the diameter of the NC prongs, and flow. The relationship of the size of the cannula to the infant’s anatomy, not the absolute size of the cannula, can lead to an uncontrolled and significant delivery of PEEP.

When discussing with other centers within the Vermont Oxford Network collaborative group, some centers reported using NCPAP until an infant was on RA and then switched to NC. These centers expressed that they experienced lower chronic lung disease (CLD) rates by following this practice. Other centers reported moving from NCPAP to 2-L flow NC and expressed that this practice had beneficially affected their CLD rates.

The second questionnaire was focused on reasons for NC delivery and included scenarios that identified patient disease, chronological age, and size. Again, there was 100% compliance with completion of the questionnaire. On the basis of information obtained in the 2 rounds of questionnaires, the conclusion was to formulate a 2-armed approach to NC O2 therapy. One set of orders provided guidelines for NC use to provide stable O2 delivery (the stable O2 arm). The other set of orders provided guidelines for NC use to deliver flow/pressure, with O2 administration being the secondary goal (the stable flow arm). Flow diagrams were printed on the back of the order forms to guide the providers’ thought process when choosing an order set (Appendix 2).

Study Cycle 3: Results of Formation of Standard NC Order Form

Feedback from all presentations was very positive. All disciplines were excited about the prospect of having a systematic method of weaning NC and to have the reasons communicated to them. They appreciated being
Study Cycle 4: Data Collected Regarding Use on Standard NC Orders and Associated Disposition

Accuracy of NC Order Form Use
Data are presented for the first 20 weeks after implementation of the standard NC order form. Accurate use of the standard NC order form occurred 78% of the time for the stable O₂ arm and 91% of the time for the stable flow arm of the order set. Initially, more caregivers chose the stable O₂ arm. As the weeks progressed, caregivers began preferentially to choose the stable flow arm. A significant linear trend was seen ($r^2 = 0.41$, $P = .002$; Fig 1).

Definition of Disposition
Disposition was defined by the type of support needed at the time of data analysis. Data were collected for each infant from the initiation of NC support until the patient was on RA, discharged on O₂, or placed on increased support (hood, NCPAP, or ventilator). Data are reported for the 90 infants who have reached 1 of these 3 dispositions (levels of support) and is ongoing for those who remain on NC. When patients were placed on increased support, data collection was suspended until they returned to NC and then continued until they reached 1 of the final end points (RA or discharge on O₂). Data were categorized by support type. Patients who were supported on the stable O₂ arm for the whole course of NC use were labeled “stable O₂ only.” Twelve infants were labeled as “stable O₂ only,” all of whom reached a final end point of data collection at the time of this data analysis. Those who were supported on the stable flow arm for the whole course of NC use were labeled “stable flow only.” There were 53 infants in this group; only 47 reached a final end point, and 6 had moved to increased support at the time of this data analysis. Those who switched between arms of support (order sets) were labeled “switched.” There were 25 infants in this group: 24 reached a final end point, and 1 had moved to increased support at the time of this analysis. Analysis revealed that a trend in weight was associated with support type ($P = .02$; Table 2). No infants who weighed <2 kg were supported by “stable O₂ only.” Sixty-seven of the 90 infants evaluated where discharged on RA; 3 (60%) of 5 were <1.0 kg, 7 (64%) of 11 were 1.0 to 1.5 kg, 5 (71%) of 7 were 1.5 to 2.0 kg, 11 (73%) of 15 were 2.0 to 2.5 kg, 11 (65%) of 17 were 2.5 to 3.0 kg, and 30 (86%) of 35 were >3.0 kg. Weight ranges reflect weight at the time the infant initially was placed on NC. Although there was some variation in these percentages, it was not large enough to be statically significant ($P = .193$).

Disposition in Relation to Support Type
Of the 83 infants who had reached a final end point (RA or home on O₂) at the time of this report, 8 (67%) of 12 of the infants in the “stable O₂ only” group, 45 (96%) of 47 in the “stable flow only” group, and 14 (58%) of 24 in the “switched” group had moved to RA (Fig 2). The final end point disposition was significantly associated with the type of NC support used ($P < .001$). A significantly greater proportion of infants were discharged from the hospital on RA in the “stable flow only” group in comparison with the “stable O₂ only” group ($P = .003$; 95% CI: 2%-56%) and in comparison with the

FIGURE 1
Percentage of patients who were treated on each order set. Initially, more caregivers chose the stable O₂ arm, but as the weeks progressed, caregivers began preferentially to choose the stable flow arm ($r^2 = 0.41$, $P = .002$). A stable amount of infants switched between order sets during each week of data collection.
“switched” group \((P < .001; 95\% \text{ CI}: 17\%–58\%)\). When the analysis was restricted to only infants who weighed >2 kg at the time of NC initiation, the same pattern held: 37 \((97\%)\) of 38 infants who were labeled as “stable flow only” were discharged on RA, whereas 8 \((67\%)\) of 12 infants who were labeled as “stable O2 only” were discharged on RA \((P = .003; 95\% \text{ CI}: 10\%–57\%)\).

Of the infants in the “stable flow only” group, increased support after the initiation of NC was required in 11 \((21\%)\) of 53; 5 \((9\%)\) of 53 of these were placed on NCPAP, 5 \((9\%)\) of 53 moved to the ventilator, and 1 \((2\%)\) of 53 went to NCPAP and then to the ventilator; 6 of the 11 described remained on the ventilator at the time of this report. Of the infants in the “switched” group, increased support after the initiation of NC was required in 4 \((16\%)\) of 25, 3 \((12\%)\) of 25 were placed on NCPAP, and 1 \((4\%)\) of 25 went to NCPAP and then to the ventilator; 1 of the 4 described remained on the ventilator at the time of this report (Fig 2). None of the patients in the “stable O2 only” group required increased support in the form of NCPAP or the ventilator after the initiation of NC support. This likely is confounded by the fact that if increased support were needed, then infants in the stable O2 arm would be switched to the NC for stable flow arm of the orders and then be classified in the “switched” group.

Days on O2 in Relation to Support Type
In comparison with the “stable O2 only” group, patients in the “stable flow only” group had fewer O2 days \((9.4 \pm 14 \text{ vs } 36.7 \pm 45 \text{ days}; P = .008; 95\% \text{ CI}: 6\%–49\%)\) and a trend but no significant difference toward more weeks on NC \((2.1 \pm 1.4 \text{ vs } 1.33 \pm 0.5; P = .34; 95\% \text{ CI}: –2.1 \text{ to } 0.5\%). This trend toward more time on NC but fewer O2 days appeared because many patients were supported by NC with flows of 0.5 to 1.0 L but with an FIO2 of 21% (no supplemental O2; Table 3). In fact, 23 of the infants who reached a final end point \((17 \text{ of } 47 \text{ from the “stable flow group” and } 6 \text{ of } 24 \text{ from the “switched” group})\) were maintained on NC with a maximum FIO2 of 21% for more than an entire week. This represents an evolution of a new practice in the local NICU evaluated. When data from the first 10 weeks of observation were compared with those of the second 10 weeks, the rate of discharge on O2 decreased from 13 \((30\%)\) of 44 to 3 \((7\%)\) of 39 \((P = .013; 95\% \text{ CI}: 6\%–38\%)\).

**DISCUSSION**
NC support was identified as an area that was in need of standardization through objective data that were ob-

<table>
<thead>
<tr>
<th>Weight Group, kg</th>
<th>Type of NC Support, n/N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stable O2 Only</td>
</tr>
<tr>
<td>&lt;1.0</td>
<td>0/5 (0)</td>
</tr>
<tr>
<td>1.0–1.5</td>
<td>0/11 (0)</td>
</tr>
<tr>
<td>1.5–2.0</td>
<td>0/7 (0)</td>
</tr>
<tr>
<td>2.0–2.5</td>
<td>1/15 (7)</td>
</tr>
<tr>
<td>2.5–3.0</td>
<td>2/17 (12)</td>
</tr>
<tr>
<td>&gt;3.0</td>
<td>9/35 (26)</td>
</tr>
</tbody>
</table>

**TABLE 3** Time on NC and Oxygen in Relation to Type of NC Support.

<table>
<thead>
<tr>
<th>Type of Support</th>
<th>Weeks on NC</th>
<th>Days on O2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stable O2 ((n = 12))</td>
<td>1.3 ± 0.5</td>
<td>37 ± 45</td>
</tr>
<tr>
<td>Stable flow ((n = 47))</td>
<td>2.1 ± 1.4</td>
<td>9 ± 14</td>
</tr>
<tr>
<td>Switched ((n = 24))</td>
<td>5.0 ± 2.4</td>
<td>50 ± 36</td>
</tr>
</tbody>
</table>

Data are means ± SD.

![Figure 2](http://pediatrics.aappublications.org/) Final disposition of infants on the basis of type of NC support used. The “stable O2 only” group followed the NC order set for stable O2 delivery for the entire time they were on NC. The “stable flow only” group followed the NC order set for flow/pressure support for the entire time they were on NC. The “switched” group switched between the 2 order sets during their NC course.
tained for a previous QI project1 and through a history of subjective concerns regarding the system that was in place. The NC practice that was in place evolved without focus on process and allowed the elements of support (flow and Fio2) to be changed without a systematic approach by the bedside caregiver. There was little direction as to how these changes should take place and depended on individual experience and bias, not on patient disease process and requirements. Through multiple steps of consensus-building and education, a standard NC order form was created. This form was embraced with enthusiasm. The enthusiastic reception of this standardization may be attributable to the involvement of all disciplines of caregivers. The Delphi technique of consensus-building, although modified for this purpose, was very helpful.14

Initially, it was perceived that the best evidence-supported use of NC for stable O2 delivery through weaning flow to minimal levels, and then Fio2. Only after the process progressed was the possibility for providing NC support for flow/pressure entertained. The adoption of a 2-armed standard order form forced caregivers to consider which method of support would be beneficial, communicate this thought process to the team that was caring for the infant, educate as to why this method was chosen, and document the arm of their choice.

As a result of this 2-armed standardized approach, the practice seems to be evolving in a way that should benefit the patients. A subpopulation of patients now are being supported on NC flow 0.5 to 1.0 L, with Fio2 of 21%. It has been documented that often when flow is weaned in these infants, they develop an O2 requirement. That they do not require O2 when supported by flow/pressure but then develop a requirement as this pressure support is withdrawn may indicate that in these cases, pressure is needed, not O2. By supporting these infants with flow/pressure only, perhaps the microatelectasis that contributes to inflammation and ultimately CLD may be avoided while also avoiding the O2 exposure that contributes to CLD and retinopathy of prematurity.12,16

Providing low flow/high O2 may expose these infants to unnecessarily high O2, whereas the pressure support approach may allow for decreased O2 exposure. In addition, this change in practice may be associated with a decreased need for home O2 therapy as suggested by the 23% decrease in patients who were discharged on O2 that was seen in the second 10 weeks of the observation period, temporally correlating with the increased use of higher flow, lower O2 support by NC. Conversely, the decrease in patients who were discharged on O2 just as likely could have been related to the process of following a standardized approach to treatment, as much as the actual treatment arm that was prescribed. Another confounding factor regarding the disposition of infants in the “stable O2 only” group compared with those in the “stable flow only” group was that only larger infants were supported in the former. These larger infants likely required O2 therapy as a result of different disease processes than did the low birth weight infants. The drawback of maintaining infants on higher flow NC for prolonged periods of time is nasal mucosal drying and irritation of the nasal passages. Options to humidify and heat the gas that is delivered by NC are being explored.

The rigorous process of consensus development, information dissemination, education, and communication has allowed this project to proceed in an efficient manner. A prospectively well-designed data collection and review system has provided the ability to monitor compliance with standardization, offer immediate feedback, and assess trends in disposition. The goal of this discussion was to describe that this center identified different circumstances (disease states) in which different approaches to NC support may be used, rather than to conclude that 1 method of NC support was superior to another. When used for a well-thought-out, physiologically sound reason, either approach may be more appropriate.

ACKNOWLEDGMENTS
We thank Marge Ellgen and Jeanette Kinser for hard work in helping us refine the manuscript. We also thank all of the bedside nurses, respiratory therapists, and neonatal nurse practitioners for hard work in applying the lessons that we learned. We also thank the members and facilitators of the Vermont Oxford Network Breathsavers focus group for support and willingness to share information. Finally, we thank Dr Howard Kilbride, our section head and medical director, for facilitating rigorous QI within the NICU.

REFERENCES


### APPENDIX 1 Predicted Patient FIO2 on 100% FiO2 NC

<table>
<thead>
<tr>
<th>Weight, g</th>
<th>FIO2</th>
<th>0.1 L</th>
<th>0.2 L</th>
<th>0.3 L</th>
<th>0.4 L</th>
<th>0.5 L</th>
</tr>
</thead>
<tbody>
<tr>
<td>700</td>
<td>0.32</td>
<td>0.44</td>
<td>0.55</td>
<td>0.66</td>
<td>0.77</td>
<td></td>
</tr>
<tr>
<td>750</td>
<td>0.32</td>
<td>0.42</td>
<td>0.53</td>
<td>0.63</td>
<td>0.74</td>
<td></td>
</tr>
<tr>
<td>800</td>
<td>0.31</td>
<td>0.41</td>
<td>0.51</td>
<td>0.61</td>
<td>0.70</td>
<td></td>
</tr>
<tr>
<td>850</td>
<td>0.30</td>
<td>0.40</td>
<td>0.49</td>
<td>0.58</td>
<td>0.67</td>
<td></td>
</tr>
<tr>
<td>900</td>
<td>0.30</td>
<td>0.39</td>
<td>0.47</td>
<td>0.56</td>
<td>0.65</td>
<td></td>
</tr>
<tr>
<td>950</td>
<td>0.29</td>
<td>0.38</td>
<td>0.46</td>
<td>0.54</td>
<td>0.63</td>
<td></td>
</tr>
<tr>
<td>1000</td>
<td>0.29</td>
<td>0.37</td>
<td>0.45</td>
<td>0.53</td>
<td>0.61</td>
<td></td>
</tr>
<tr>
<td>1050</td>
<td>0.29</td>
<td>0.36</td>
<td>0.44</td>
<td>0.51</td>
<td>0.59</td>
<td></td>
</tr>
<tr>
<td>1100</td>
<td>0.28</td>
<td>0.35</td>
<td>0.43</td>
<td>0.50</td>
<td>0.57</td>
<td></td>
</tr>
<tr>
<td>1150</td>
<td>0.28</td>
<td>0.35</td>
<td>0.42</td>
<td>0.48</td>
<td>0.55</td>
<td></td>
</tr>
<tr>
<td>1200</td>
<td>0.28</td>
<td>0.34</td>
<td>0.41</td>
<td>0.47</td>
<td>0.54</td>
<td></td>
</tr>
<tr>
<td>1250</td>
<td>0.27</td>
<td>0.34</td>
<td>0.40</td>
<td>0.46</td>
<td>0.53</td>
<td></td>
</tr>
<tr>
<td>1300</td>
<td>0.27</td>
<td>0.33</td>
<td>0.39</td>
<td>0.45</td>
<td>0.51</td>
<td></td>
</tr>
<tr>
<td>1350</td>
<td>0.27</td>
<td>0.33</td>
<td>0.39</td>
<td>0.44</td>
<td>0.50</td>
<td></td>
</tr>
<tr>
<td>1400</td>
<td>0.27</td>
<td>0.32</td>
<td>0.38</td>
<td>0.44</td>
<td>0.49</td>
<td></td>
</tr>
<tr>
<td>1450</td>
<td>0.26</td>
<td>0.32</td>
<td>0.37</td>
<td>0.43</td>
<td>0.48</td>
<td></td>
</tr>
<tr>
<td>1500</td>
<td>0.26</td>
<td>0.32</td>
<td>0.37</td>
<td>0.42</td>
<td>0.47</td>
<td></td>
</tr>
<tr>
<td>1550</td>
<td>0.26</td>
<td>0.31</td>
<td>0.36</td>
<td>0.41</td>
<td>0.46</td>
<td></td>
</tr>
<tr>
<td>1600</td>
<td>0.26</td>
<td>0.31</td>
<td>0.36</td>
<td>0.41</td>
<td>0.46</td>
<td></td>
</tr>
<tr>
<td>1650</td>
<td>0.26</td>
<td>0.31</td>
<td>0.35</td>
<td>0.40</td>
<td>0.45</td>
<td></td>
</tr>
<tr>
<td>1700</td>
<td>0.26</td>
<td>0.30</td>
<td>0.35</td>
<td>0.40</td>
<td>0.44</td>
<td></td>
</tr>
<tr>
<td>1750</td>
<td>0.26</td>
<td>0.30</td>
<td>0.35</td>
<td>0.39</td>
<td>0.44</td>
<td></td>
</tr>
<tr>
<td>1800</td>
<td>0.25</td>
<td>0.29</td>
<td>0.34</td>
<td>0.39</td>
<td>0.43</td>
<td></td>
</tr>
<tr>
<td>1850</td>
<td>0.25</td>
<td>0.29</td>
<td>0.34</td>
<td>0.38</td>
<td>0.42</td>
<td></td>
</tr>
<tr>
<td>1900</td>
<td>0.25</td>
<td>0.29</td>
<td>0.33</td>
<td>0.38</td>
<td>0.42</td>
<td></td>
</tr>
</tbody>
</table>
# APPENDIX 2  Nasal Cannula Oxygen Administration Standardized Order Form

## ICN Nasal Cannula Oxygen Administration

**Doctor’s ORDER Sheet for Treatment (Front)**

<table>
<thead>
<tr>
<th>DATE</th>
<th>Time Order Written</th>
<th>Doctor</th>
<th>It is necessary to record all the patient’s known allergies in admission orders (if none, please write &quot;N/A&quot;).</th>
<th>Nurse’s Signature/Time Orders Transcribed</th>
<th>WEIGHT:</th>
<th>KG</th>
</tr>
</thead>
</table>

### Allergies:

- **Oxygen Saturation Target Range:**
  - □ 80-84% OR □ ____ %

- **Oxygen Saturation Alarm Limits:**
  - □ 85-89% OR □ ____ %

- **Yes** □ _NO_  
  **Nasal Cannula for Stable Oxygen Delivery**

  1. Begin at 0.5 liters per minute and 100% FIO₂.

  2. Ween oxygen supplementation to keep oxygen saturation in target range:

     a. Decrease flow by 0.1 liter per minute every 5-10 minutes.

     b. When stable on 0.1 liter per minute at 100% FIO₂ for 1 hour, decrease FIO₂ by 5-10% every 5-10 minutes.

     c. When stable on 0.1 liter per minute at 21% FIO₂ for 1 hour, discontinue nasal cannula.

  3. For mild persistent desaturation, increase oxygen supplementation to keep saturation in target range:

     a. Increase FIO₂ by 5-10% every 3-5 minutes to 100%.

     b. When at 100% FIO₂, increase flow by 0.1 liter per minute as needed up to 0.5 liters per minute.

     c. If oxygen saturation still not in desired range, call physician or nurse practitioner.

  4. For severe desaturation, support as required and call for new orders as needed.

### OR

- **Yes** □ _NO_  
  **Nasal Cannula for Pressure (Stable Flow) Delivery**

  1. Begin flow at ________ liters per minute (0.5 to 1 liter per minute recommended) and 100% FIO₂.

  2. Ween oxygen supplementation to keep oxygen saturation in target range by decreasing FIO₂ by 5-10% every 5-10 minutes.

  3. For mild persistent desaturation, increase oxygen supplementation to keep saturation in target range by increasing FIO₂ by 5-10% every 3-5 minutes.

  4. For severe desaturation, support as required and call for new orders as needed.

  5. Notify physician or nurse practitioner for oxygen saturation continuously out of target range, increased work of breathing, increased respiratory rate, or increased apnea and bradycardia events, as patient may need additional pressure support (i.e. NCPAP via ventilator).

  6. Liter flow should not be changed without order by physician or nurse practitioner.

  **NOTE:** When a decrease in flow is ordered, goal is for FIO₂ not to be increased. If oxygen saturation decreases, call physician or nurse practitioner for order to return to increased flow.

  **Signature:**

**DO NOT WRITE BELOW THIS LINE**
Nasal Cannula for Stable Oxygen Delivery

Begin with 100% FIO2 at 0.6 liter per minute flow.

Oxygen Satuations High

If oxygen saturations are above the desired range, keep FIO2 at 100% and wean flow in 0.1 liter increments every 5-10 minutes to maintain the infant within desired oxygen saturation limits.

When at 0.1 liters per minute flow, wean FIO2 in 5-10% increments every 5-10 minutes until minimum FIO2 at 0.1 liter per minute is tolerated. Do not wean FIO2 if the infant is requiring greater than 0.1 liter per minute flow.

Notify NNP or physician when at 0.1 liter and room air.

Oxygen Satuations Low

If at 0.1 liter per minute flow and < 100% FIO2, increase FIO2 in increments of 5-10% every 3-5 minutes to 100%.

If at 100% FIO2 and < 0.5 liter flow, increase flow in increments of 0.1 liter per minute up to 0.5 liters.

If oxygen saturations are persistently below desired range, notify NNP or physician to consider higher flow, NCPAP, or hood oxygen delivery.

Nasal Cannula for Pressure (Stable Flow) Delivery

Begin with 100% FIO2 at 0.5-1 liter per minute flow per physician order. Patients on NO-CLD study remain on 1 liter flow until study complete.

Oxygen Satuations High

If oxygen saturations are above the desired range, wean FIO2 by 5-10% every 5-10 minutes to maintain the infant within desired oxygen saturation limits.

Do not wean flow unless ordered by physician or NNP. Flow weaning to be based on clinical assessment of work of breathing, respiratory rate, and chest x-rays.

When a decrease in flow is ordered, goal is for FIO2 not to be increased. If oxygen saturations decrease, will likely need to return to increased flow.

Oxygen Satuations Low

Increase FIO2 in increments of 5-10% every 3-5 minutes to 100%.

If oxygen saturations are persistently below desired range, notify NNP or physician to increase to higher flow or NCPAP.
Standardizing Nasal Cannula Oxygen Administration in the Neonatal Intensive Care Unit
Jodi K. Jackson, Susannah P. Ford, Kerri A. Meinert, Mary Kay Leick-Rude, Betsi Anderson, Michael B. Sheehan, Barbara M. Haney, Sherri R. Leeks and Stephen D. Simon

*Pediatrics* 2006;118;S187
DOI: 10.1542/peds.2006-0913Q

<table>
<thead>
<tr>
<th>Updated Information &amp; Services</th>
<th>including high resolution figures, can be found at: <a href="http://pediatrics.aappublications.org/content/118/Supplement_2/S187">http://pediatrics.aappublications.org/content/118/Supplement_2/S187</a></th>
</tr>
</thead>
<tbody>
<tr>
<td>References</td>
<td>This article cites 14 articles, 6 of which you can access for free at: <a href="http://pediatrics.aappublications.org/content/118/Supplement_2/S187.full#ref-list-1">http://pediatrics.aappublications.org/content/118/Supplement_2/S187.full#ref-list-1</a></td>
</tr>
<tr>
<td>Subspecialty Collections</td>
<td>This article, along with others on similar topics, appears in the following collection(s): <a href="http://classic.pediatrics.aappublications.org/cgi/collection/fetus:newborn_infant_sub">Fetus/Newborn Infant</a></td>
</tr>
<tr>
<td>Permissions &amp; Licensing</td>
<td>Information about reproducing this article in parts (figures, tables) or in its entirety can be found online at: <a href="https://shop.aap.org/licensing-permissions/">https://shop.aap.org/licensing-permissions/</a></td>
</tr>
<tr>
<td>Reprints</td>
<td>Information about ordering reprints can be found online: <a href="http://classic.pediatrics.aappublications.org/content/reprints">http://classic.pediatrics.aappublications.org/content/reprints</a></td>
</tr>
</tbody>
</table>
Standardizing Nasal Cannula Oxygen Administration in the Neonatal Intensive Care Unit

Jodi K. Jackson, Susannah P. Ford, Kerri A. Meinert, Mary Kay Leick-Rude, Betsi Anderson, Michael B. Sheehan, Barbara M. Haney, Sherri R. Leeks and Stephen D. Simon

*Pediatrics* 2006;118;S187
DOI: 10.1542/peds.2006-0913Q

The online version of this article, along with updated information and services, is located on the World Wide Web at:

http://pediatrics.aappublications.org/content/118/Supplement_2/S187