# Standardizing Umbilical Catheter Usage in Preterm Infants


## abstract

**BACKGROUND AND OBJECTIVE:** Absence of guidelines on umbilical arterial catheter (UAC) and umbilical venous catheter (UVC) use and inability to predict the hospital course may sway the frontline staff to overuse umbilical catheters in preterm infants. Our objective was to evaluate the feasibility of implementing guidelines standardizing the use of umbilical catheters and its impact on the incidence of sepsis and resource use.

**METHODS:** All inborn infants delivered at $<$33 weeks' gestation and admitted to the NICU were included in this quality improvement study. The primary outcome was proportion of infants receiving umbilical catheters. Secondary outcomes were central venous catheter (CVC) use and central line–associated bloodstream infection (CLABSI).

**RESULTS:** The proportion of infants receiving UACs and UVCs was significantly lower in postintervention (sustainment) phase than in the preintervention phase (93 [42.3%] vs 52 [23.6%], $P$ = .0001) and (137 [62.6%] vs 93 [42.3%], $P$ = .0001), respectively. There was no corresponding increase in the proportion of infants receiving peripherally inserted central catheters (PICCs) or surgical CVCs (SCVCs) during the sustainment phase. There was a significant reduction in the proportion of infants receiving CVCs (UVC, PICC, and SCVC) in the sustainment phase. The incidence of CLABSI was similar in the preintervention and sustainment phases.

**CONCLUSIONS:** Implementation of guidelines standardizing the use of umbilical catheters in the NICU is feasible. Fewer infants were exposed to the risk of UVC or UAC, and fewer resources were used. *Pediatrics* 2014;133:e1742–e1752



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**KEY WORDS**

newborn, umbilical catheter, infection, ventral line


**ABBREVIATIONS**

BPD—bronchopulmonary dysplasia
CVC—central venous catheter
CLABSI—central line–associated bloodstream infection
CNN—Canadian Neonatal Network
PICC—peripherally inserted central catheter
PIV—peripheral intravenous catheter
PPV—positive pressure ventilation
QI—quality improvement
SCVC—surgically inserted central venous catheter
SGA—small for gestational age
SNAP—Score for Neonatal Acute Physiology
UAC—umbilical arterial catheter
UVC—umbilical venous catheter


Dr Shahid coordinated and supervised data collection, carried out the initial analysis, and drafted the initial manuscript; Dr Dutta carried out the statistical analysis and critically reviewed and revised the manuscript; Ms Symington and Dr Shivananda conceptualized and designed the study, implemented the protocol, and reviewed the manuscript; and all authors approved the final manuscript as submitted.

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Umbilical venous catheters (UVCs) and umbilical arterial catheters (UACs) are commonly used in NICUs to provide intravenous fluids and nutrition, to provide intravenous medications, for blood sampling, and for invasive monitoring of blood pressure.[1–3] They provide painless, quick, and reliable vascular access immediately after birth in high-risk newborns and avoid the painful skin punctures needed for other forms of vascular access such as peripheral intravenous or arterial catheters, peripherally inserted central catheters (PICCs), and surgically inserted central venous catheters (SCVCs). Together, UVCs, PICCs, and SCVCs are known as central venous catheters (CVCs).

However, umbilical catheter use can cause life-threatening complications including central line–associated bloodstream infection (CLABSI),[4–8] prevent NICU infants from being placed prone (a position often needed to optimize respiratory function),[9,10] require skilled personnel for insertion, and use extra resources for their maintenance.[11] Many strategies have been suggested to reduce the risk of complications associated with umbilical catheters and other CVCs.[2] The most important of these is appropriate patient selection and use of CVCs only when equivalent care cannot be provided by safer alternative methods.[12] However, criteria for selecting patients in whom the benefits of umbilical catheter placement outweigh the risks are often nonspecific and subjective.[13]

Umbilical catheters are often inserted during the first few minutes or hours of life by frontline staff such as residents, nurse practitioners, fellows, and transport team members. At the time of insertion, it is often difficult to predict the infant's hospital course with respect to hemodynamic stability, enteral feeding tolerance, need for frequent blood sampling, and degree of difficulty establishing peripheral vascular access. This uncertainty combined with an absence of clear criteria on umbilical catheter use may cause the frontline staff to overuse umbilical catheters in preterm infants.

Guidelines for appropriate selection of patients for umbilical catheter insertion based on gestational age, birth weight, or severity of illness have been proposed by various authors.[12,14,15] However, these guidelines are not evidence based and not validated. Moreover, feasibility of their implementation, staff compliance rates, and accrued benefits with adoption of these guidelines have not been reported. An internal audit done in our center showed that the rate of UVC use steadily increased from 53% in 2004 to 76% in 2009 in infants born at <33 weeks' gestational age. A review of the charts of 25 randomly selected infants born at <33 weeks in whom a UVC or UAC was inserted was performed in 2009. It suggested that umbilical catheters were being used unnecessarily, without due consideration for peripheral intravenous catheter (PIV) access during the initial hours of life. Placement of umbilical catheters shortly after birth in stable nondepressed infants but removal within first few hours or days (<48 hours for UAC and <5 days of life for UVC) was considered unnecessary for the review. There was no guideline or protocol for insertion of umbilical catheters in our unit. We hypothesized that guidelines standardizing the criteria for inserting umbilical catheters would reduce the proportion of preterm infants receiving umbilical catheters inappropriately and eventually reduce the incidence of CLABSI. However, many staff members expressed serious concern about compensatory increases in PICC and SCVC use. This study was designed to evaluate the feasibility of implementing guidelines standardizing the use of umbilical catheters, its effect on the frequency of alternative vascular access methods, and its impact on the incidence of sepsis and resource use.

Our quality improvement (QI) aim was to reduce the unnecessary placement of umbilical venous and arterial catheters in preterm infants and standardize practice within our unit by using a multimodal intervention consisting of local unit practice guidelines, staff education, and monitoring and feedback.

## METHODS

### Design

This was a QI study. No experimental practices or equipment were involved.

### Study Population and Setting

All inborn preterm infants delivered at <33 weeks' gestation and admitted to McMaster University NICU from January 2010 to March 2012 were included. Infants with omphalocele and gastroschisis, as well as those with >150 days' hospital stay were excluded from the analysis. This study was approved with a waiver of consent by the McMaster University Research Ethics Board. All deliveries were attended by a neonatal fellow, nurse practitioner, nurse, and respiratory therapist. A neonatologist attended the resuscitation and stabilization for infants born at <26 weeks' gestation.

### Planning the Intervention (Pilot Study)

In 2010, a large QI project aimed at improving practices during resuscitation, stabilization, and initial hours of life in preterm infants was introduced in our center. Standardizing the use of umbilical catheters was a project nested within the larger project. A QI subteam composed of a nurse practitioner, registered nurse, and physician was formed to define the criteria for selecting infants for umbilical catheter insertion.

We initially developed indications for umbilical catheter placement based on gestational age, cardiorespiratory stability, and anticipated difficulty in establishing a PIV access. From October 2010 to December 2010, the QI subteam members presented their initial guidelines to nurses, physicians, and nurse practitioner groups in their monthly meeting. The primary goal of this exercise was to create awareness of increasing use of umbilical catheters in our unit and its potential drawbacks and risk of complications. The secondary goal was to gather care providers' input on the initial guidelines. The initial guidelines recommended using UAC and UVC in <27-week infants. The care providers expressed their concerns about workload, workflow, adherence to guidelines, feasibility of establishing a PIV, and effectively managing sick infants without a UVC. Thus the criteria for umbilical catheter insertion were refined on the basis of published protocols from other centers, available expertise, and anticipated compliance of our staff members. The second iteration of the guidelines was easy to follow and addressed the concerns expressed by care providers. Indications for UAC and UVC were separated to improve clarity. The number of attempts by nurses to establish PIV access were limited to 4 to prevent protracted attempts. The interpretation and application of guidelines at the point of care and the ability to manage the infants without a UVC or UAC were assessed in a pilot study of 5 infants. We observed that a PIV was established in a timely manner when a UVC was not indicated and resorting to PICC or SCVC was not necessary. During the piloting, all concerns related to workload and workflows were gathered from nurses involved in establishing PIV access, and solutions were sought. Final consensus guidelines were created by incorporating suggestions from interdisciplinary NICU team members.

## Interventions and Rollout

The final consensus guidelines provided indications for using umbilical catheter placement on the basis of gestational age, severity of illness, and ease of establishing PIV access (Table 1). Implementation strategy included[1] creating awareness, improving access, monitoring compliance and reinforcing use of the guidelines,[2] and acknowledging and addressing caregivers' concerns about the guidelines (Table 2). Practices related to the duration of umbilical and other central catheter use, catheter position, infusion fluids, central line insertion, and maintenance practices remained unchanged during the baseline and sustainment phases. Similarly, the technique for insertion,[13] aseptic precautions, criteria for discontinuation, and catheter product remained unchanged. UAC and UVC catheter tip position was confirmed by 2 views of chest and abdomen radiographs. PICC was indicated when >5 days of vascular access was anticipated at the time of discontinuation of umbilical venous catheter or when difficulty establishing a PIV access was noted. SCVC was indicated when a PICC could not be established.

## Planning the Study

The interventions were implemented over a 3-month period (intervention phase) from January to March 2011. A period before implementation (January to December 2010) was designated as the baseline phase and that after implementation (April 2011 to March 2012) as the sustainment phase.

## Outcomes

Our primary outcome measure was the proportion of infants receiving umbilical catheters (UAC or UVC) during hospital stays. Secondary outcome measures were the proportion of infants receiving PICC or SCVC, compliance with the guidelines, duration of CVC and PIV use, CLABSI rates,[16] duration of antibiotic use (in days), mortality, bronchopulmonary dysplasia (BPD) at 36 weeks' corrected age, necrotizing enterocolitis of stage ≥2, brain lesions (any of stage ≥3 intraventricular hemorrhage, periventricular leukomalacia, intraparenchymal echogenicity, or cerebellar hemorrhage), retinopathy of prematurity (ROP) stage ≥3, patent ductus arteriosus treated medically or surgically, pneumothorax, and length of hospital stay. BPD was defined as the need for oxygen or positive pressure support at 36 weeks' postmenstrual age. Indicators of feasibility were defined and measured as follows: technical feasibility of PIV (frequency of failure to establish PIV despite 4 attempts), implementation (percentage of NICU care providers who received inservicing), and integration (percentage of use of umbilical catheters per months in the last 6 months of sustainment phase).[17]

## Methods of Evaluation (Data Recording)

We used the McMaster NICU data stored in the Canadian Neonatal Network (CNN) database. This database contains data on all infants admitted to our NICU since 2006 as part of CNN membership. Dedicated abstractors take data from

**TABLE 1** Guidelines for Vascular Access in Preterm Infants <33 Weeks' Gestation

| Gestation | UVC | UAC | PIV |
|---|---|---|---|
| ≤26 wk | Recommended | Recommended | |
| 27–28 wk | Recommended | Recommended for selected cases[a] | |
| ≥29 wk | Avoid except in selected cases[a,b] | Recommended for selected cases[a] | Recommended |

Nurses were to inform the staff neonatologist if PIV could not be established after 4 attempts.

[a] Use only if the patient is intubated and ventilated, or $FiO_2 > 40\%$ on continuous positive airway pressure, or the patient is hemodynamically unstable, needing fluid bolus or inotropes.

[b] Difficulty establishing PIV access.

**TABLE 2** Interventions and Rollout

| | |
|---|---|
| Create awareness of potential problems with CVC and indications for umbilical catheter placement | Formal classroom education: divisional seminar, annual nursing day, and 20-min sessions for care providers working at night. |
| | Informal education: posters, e-mails, newsletters, one-on-one bedside teaching. |
| Improving access to guidelines | Guidelines posted on walls adjacent to resuscitaries in infant stabilization room, on the intranet, and in every case sheet. |
| | Pocket card containing the guidelines was provided to all care providers. |
| Defining roles and expectations for care providers | Decision on umbilical catheter placement and insertion of umbilical catheter: fellow or nurse practitioner. |
| | Insertion of PIV: nurse and backup support by attending neonatologist. |
| | Decision on PICC or SCVC: attending neonatologist. |
| | Identify and understand rationale for deviation from guidelines: all care providers. |
| Monitoring compliance | Deviation of practice from guidelines was identified and brought to the decision maker by QI subteam members during intervention period. |
| | Attending neonatologist reviewed the appropriateness of umbilical catheter placement during first day of NICU stay during bedside rounds. |
| Reinforcing the guidelines | Formal approval of the guidelines was sought and obtained from the neonatal operations committee before the interventions were launched. |
| | Indications for umbilical catheter placement were actively discussed during resuscitation team prebriefing huddle every morning. |
| | Umbilical catheter use per month was tracked and displayed as run charts in newsletters to show the impact of the guidelines. |
| Mechanism for eliciting and addressing care providers' concerns | Care providers were encouraged to express their concerns about interpretation, implementation, and any inadvertent adverse effects related to the guidelines by contacting QI subteam members. |
| | Concerns were acknowledged and addressed promptly by QI subteam. |

different sources in the patient record and enter them into the CNN database using standard definitions.[18] The CNN abstractor team did not participate in this study in any way. We also extracted additional data from our NICU's local electronic patient record (Meditech) to validate CLABSI data with CNN database data. We determined the appropriateness of umbilical catheter use by reviewing patient charts manually.

We calculated the number of catheter days by counting the number of NICU calendar days on which the infants were on a catheter. When a PICC was inserted and a UVC was removed on the same day (as usually occurs), we counted that day as the last day of usage for that particular UVC and the first day for the PICC (ie, the day was double counted when the total duration of any CVC usage was calculated). The proportion of infants receiving umbilical catheters per month over time was presented in run charts to monitor and communicate process performance. Use of umbilical catheter was classified as "appropriate" (eligible infant and received catheter), "underuse" (eligible infant but did not receive catheter), and "inappropriate" (ineligible infant and received catheter).

### Statistical Analysis

Outcomes in the basement and sustainment phases were compared by using Pearson's $\chi^2$ test or Fisher's exact test for categorical variables and Student's *t* test or Mann–Whitney *U* test for continuous variables. To adjust for covariates, we used multivariable regression analysis. Covariates included birth weight, small for gestational age (SGA) status, receipt of prenatal steroids, administration of positive pressure ventilation (PPV) using endotracheal tube during resuscitation, and severity of illness (Score for Neonatal Acute Physiology [SNAP II] and Score for Neonatal Acute Physiology and Perinatal Extension). Incidence rates for episodes of culture positive sepsis, all sepsis episodes, and CLABSI were compared between the 2 periods by using incidence rate ratios (IRRs). The association between duration of antibiotic use and duration of UVCs and CVCs was calculated by using Spearman's test of correlation. Significance required a 2-sided $P$ value of $<.05$. This study had an 80% power (calculated retrospectively) to detect a 20% difference in the proportion of infants receiving UVC in the 2 phases at $\alpha = 0.05$. Statistical analyses were performed by using SPSS version 20 (IBM SPSS Statistics, IBM Corporation) and StatsDirect version 2.7.9 (StatsDirect Ltd, Altrincham, UK).

## RESULTS

### Demographics

We included 219 infants in the baseline and 220 infants in the sustainment phase (Fig 1). In the sustainment phase, the proportion of infants with SGA and those receiving prenatal steroids was higher, whereas that of infants receiving endotracheal intubation and PPV during resuscitation was lower. Severity of illness was lower in infants during the sustainment phase (Table 3).

### Intervention and Rollout

One hundred sixty NICU care providers (~80%) received in-service training during the intervention period. Ten educational sessions of 20 minutes each were conducted during the night shift. Newsletters displaying run charts were circulated every 2 months.

## Primary Outcomes

### *UVC Use*

The proportion of infants receiving UVCs was significantly lower in the sustainment phase (Table 4). There was a 32% relative reduction in UVC use in the sustainment phase. Appropriate placement of UVCs decreased from 97% to 91%, whereas inappropriate placement of UVCs decreased from 25% to 3% ($P$ = .0001) (Table 5). There was an increase in underuse of UVC from 3% to 9% ($P$ = .04)

### *UAC Use*

The proportion of infants receiving UACs was significantly lower, with a relative reduction of 44% in the sustainment phase (Table 4). Appropriate placement of UACs decreased from 76% to 54%, and underuse of UACs increased from 13% to 42% in the sustainment phase ($P$ = .0001). Inappropriate placement of UACs decreased from 8% to 1% in the sustainment phase ($P$ = .01) (Table 5). Peripheral arterial line use did not increase in the sustainment phase (Table 4).

### *PICC and SCVC Use*

There was a 25% relative reduction in the proportion of infants receiving PICC in the sustainment phase, whereas the proportion of infants receiving SCVCs did not change significantly (Table 4).

### *All CVC Use*

There was a significant reduction in proportion of infants receiving CVCs in the sustainment phase (50% vs. 68%, $P$ = .0001) (Table 4). This reduction remained significant after a multivariable logistic regression analysis was performed, adjusting for baseline differences in birth weight, SGA status, prenatal steroid use, and PPV during resuscitation, and SNAP II in the baseline and sustainment phases.

### *Subgroup Analysis*

A subgroup analysis of vascular catheter use on the basis of gestational age showed a reduction in UAC, UVC, and PICC use in all subgroups (Table 6). The magnitude of reduction in 29- to 32-week infants was higher than in the other subgroups.

## Secondary Outcomes

For UVCs, UACs, and PICCs, the median duration of each was not significantly different in the baseline and sustainment phases (Table 7). However, the median duration of surgical CVC use was significantly shorter by about 10 days. The total duration of CVC patient days was significantly lower in the sustainment phase (1561 vs 2181 catheter patient days, $P$ = .0001). Similarly, the CVC utilization ratio (Total number of CVC days/Total number of patient days) was significantly lower in the sustainment phase (0.25 vs 0.34, $P$ = .0001). The incidence of sepsis and CLABSI was similar in the 2 phases

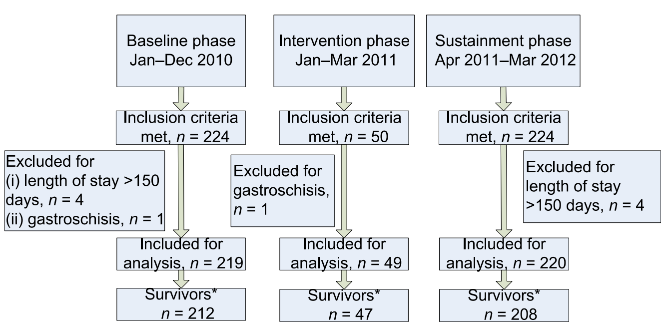


**FIGURE 1**
Flow diagram of the study. *BPD, retinopathy of prematurity, necrotizing enterocolitis, and brain lesions were compared among survivors.

**TABLE 3** Comparison of Demographic Features Between Baseline and Sustainment Phases

| Demography | Baseline Phase January 2010–December 2010, $N$ = 219 | Intervention Phase January 2011–March 2011, $N$ = 49 | Sustainment Phase April 2011–March 2012, $N$ = 220 | $P$, Baseline Versus Sustainment Phase |
|---|---|---|---|---|
| Gestational age (wk), mean (SD) | 29.1 (2.6) | 29.2 (2.6) | 29.1 (2.4) | .88 |
| Birth wt (g), mean (SD) | 1310 (467) | 1380 (493) | 1391 (482) | .07 |
| SGA[a] | 28 (12.8) | 2 (4) | 14 (6.4) | .02 |
| Cesarean section[a] | 129 (58.9) | 26 (53) | 133 (60.5) | .77 |
| Prenatal steroids[a] | 199 (90.8) | 42 (86) | 214 (96.8) | .01 |
| PPV by bag and mask or T piece resuscitator[a] | 168 (76.7) | 25 (51) | 142 (64.5) | .006 |
| PPV endotracheal tube[a] | 80 (36.5) | 11 (22) | 48 (21.8) | .001 |
| Apgar 1 min[b] | 6 [4–7] | 6 [4–7] | 6 [5–8] | .69 |
| Apgar 5 min[b] | 8 [7–9] | 8 [7–9] | 8 [7–9] | .28 |
| SNAP II[b] | 9 [0–14] | 9 [0–12] | 7 [0–9] | .005 |

$\chi^2$ test, Student's $t$ test.

[a] No. of infants (%).

[b] Median [interquartile range].

**TABLE 4** Proportion of Infants <33 wk Gestation Receiving Various Vascular Catheters During Hospital Stay

| | Baseline Phase January 2010–December 2010, $N = 219$ | Intervention Phase, January 2011–March 2011, $N = 49$ | Sustainment Phase April 2011–March 2012, $N = 220$ | Unadjusted $P$, Baseline Versus Sustainment Phase | Adjusted $P$, Baseline Versus Sustainment Phase[a] |
|---|---|---|---|---|---|
| UAC | 93 (42.5) | 11 (22) | 52 (23.6) | .00001 | .008 |
| UVC | 137 (62.6) | 14 (29) | 93 (42.3) | .00001 | .004 |
| PICC | 86 (39.3) | 12 (24) | 65 (29.5) | .027 | .27 |
| SCVC | 5 (2.3) | 2 (4) | 7 (3.2) | .77 | .64 |
| Central venous catheter (UVC, PICC, or SCVC) | 150 (68.5) | 17 (35) | 110 (50.0) | .0001 | .001 |
| PIV | 196 (89.5) | 48 (98) | 211 (95.9) | .01 | .032 |
| Peripheral arterial line | 10 (5.0) | 2 (4.0) | 21 (7.3) | .31 | .41 |

No. of infants (%). $\chi^2$ test.

a Adjusted for birth wt, SGA status, received prenatal corticosteroids, received PPV by mask, received PPV by intubation, and SNAP II score.

**TABLE 5** Compliance With Guidelines in the Baseline and Sustainment Phases

| | Baseline Phase January 2010–December 2010, $N = 219$ | Intervention Phase January 2011–March 2011, $N = 49$ | Sustainment Phase April 2011–March 2012, $N = 220$ | $P$, Baseline Versus Sustainment Phase |
|---|---|---|---|---|
| Infants eligible for UAC and | 112 | 19 | 94 | .0001 |
| who received UAC (appropriate use) | 85 (76) | 11 (58) | 51 (54) | |
| who did not receive UAC (underuse) | 15 (13%) | 6 (42%) | 39 (42%) | |
| could not be established (unsuccessful) | 12 (11%) | 0 (0%) | 4 (4%) | |
| Infants ineligible for UAC | 107 | 30 | 126 | .01 |
| who received UAC (inappropriate use) | 8 (8%) | 0 (0%) | 1 (1%) | |
| Infants eligible for UVC and | 113 | 24 | 98 | .04 |
| who received UVC (appropriate use) | 110 (97%) | 14 (58%) | 89 (91%) | |
| who did not receive UVC (underuse) | 3 (3%) | 10 (42%) | 9 (9%) | |
| Infants ineligible for UVC | 106 | 25 | 122 | .0001 |
| who received UVC (inappropriate use) | 27 (25%) | 0 (0%) | 4 (3%) | |

$\chi^2$ test.

(Table 8). However, there was a significant reduction in the duration of antibiotic use in the sustainment phase ($P = .01$). The duration of antibiotic use had a statistically significant correlation with duration of UVC use (Spearman correlation coefficient of 0.19, $P = .003$). There was no difference in mortality, BPD at 36 weeks' corrected age, stage ≥2 necrotizing enterocolitis, brain lesions, ROP stage ≥3, patent ductus arteriosus, pneumothorax, and length of stay between the 2 time periods (Table 8).

### *Changes in Practice Over Time*

There was a gradual reduction in umbilical catheter use over time. A reduction in umbilical catheter use was noted for the first time during the last few months of baseline phase (October to December 2010). During the implementation period, there was additional reduction in the use of umbilical catheters. Although a rebound increase in umbilical catheter use was noted in the initial 6 months of the sustainment phase, a consistent decrease in umbilical catheter use was noted in next 6 months. Run charts on UVC use per month showed a reduction in UVC use over time (median line shift from 65% to 35%) (Fig 2A). Run charts on UAC use per month showed a reduction in UAC use over time (median line shift from 43% to 15%) in the sustainment phase (Fig 2B).

### *Feasibility*

There were 3 (1.4%) and 6 (2.7%) instances where PIV access could not be established after 4 attempts in the baseline and sustainment phases respectively. One hundred sixty NICU caregivers (~80%) received in-service training on guidelines. The median use of UVC and UAC per month was 36% and 15%, respectively, in the last 6 months of sustainment phase and showed no decay of intervention effects.

## DISCUSSION

We have demonstrated a significant reduction in the proportion of preterm infants receiving umbilical catheters without a corresponding increase in PICC or SCVCs after implementing guidelines standardizing the use of umbilical catheters in the NICU. The impact of the guidelines was higher in infants born at 29 to 32 weeks' gestation. Secondary benefits associated with our efforts were reductions in PICC use, overall CVC days, and number of days on antibiotics. Implementation of our guidelines was feasible, and

**TABLE 6** Comparison of Vascular Catheter Use Patterns During Baseline and Sustainment Phases Stratified by Gestational Age Categories

| Gestational Age | Access Method | Baseline Phase January–December 2010, No. of Infants (%) | Sustainment Phase April 2011–March 2012, No. of Infants (%) | *P* |
|---|---|---|---|---|
| ≤26 wk | | *n* = 40 | *n* = 37 | |
| | UAC | 36 (90.0) | 29 (78.4) | .16 |
| | UVC | 39 (97.5) | 35 (94.6) | .60[a] |
| | PIV | 37 (92.5) | 36 (97.3) | .62[a] |
| | PICC | 30 (75.0) | 27 (73.0) | .84 |
| | Surgical CVC | 4 (10.0) | 5 (13.5) | .73[a] |
| 27–28 wk | | *n* = 42 | *n* = 35 | |
| | UAC | 33 (78.6) | 11 (31.4) | <.001 |
| | UVC | 40 (95.2) | 28 (80.0) | .07[a] |
| | PIV | 37 (88.1) | 33 (94.3) | .45 |
| | PICC | 27 (64.3) | 16 (45.7) | .1 |
| | Surgical CVC | 0 | 0 | — |
| 29–32 wk | | *n* = 137 | *n* = 148 | |
| | UAC | 24 (17.4) | 12 (8.1) | .02 |
| | UVC | 58 (42.0) | 30 (20.3) | <.001 |
| | PIV | 122 (89.0) | 142 (95.9) | .03 |
| | PICC | 29 (21.1) | 22 (14.9) | .13 |
| | Surgical CVC | 1 (0.7) | 2 (1.4) | 1[a] |

[a] Fisher's exact test.

fewer infants were exposed to the risk of UAC or UVC.

We made a few interesting observations on trends in umbilical catheter use over time. A decreasing trend in umbilical catheter use was noted even before official implementation of the guidelines. The last few months of the baseline phase were contaminated because of widespread awareness about the process of developing the guidelines, and several NICU care providers started restricting umbilical catheter use even before the official guidelines were rolled out. An additional reduction in umbilical catheter use was noted during the implementation period and could have been secondary to multimodality efforts to increase awareness and reinforcement of the guidelines. A sustained decrease in umbilical catheter use noted during the second half of the sustainment phase was an indicator of adoption and integration of the guidelines into NICU routines.

A significant reduction in the frequency of CVC use but not the duration of CVC was noted in the sustainment phase. This observation strengthens our impression that reduction in umbilical catheter use is a direct result of implementation of guidelines aimed at reducing its placement and not its duration of use. Concurrent with the reduction in inappropriate use, we also noticed a small increase in underuse of UVCs and UACs. A growing comfort in managing stable infants without resorting to UVC or UAC among care providers may have contributed to an inadvertent increase in underuse of catheters. We believe that this small increase in underuse is an acceptable corollary effect of the large reduction noted in inappropriate use of catheters. The net benefit to the infants in terms of reducing risk exposure to CLABSI is likely to outweigh the risks associated with underuse of catheters. Finally, we speculate that a heightened awareness of potential risks, a conscious effort to avoid UACs, and reassurance among NICU care providers must have contributed to a sustained reduction in umbilical catheter use.

Another interesting observation was reduction in the use of PICCs in the sustainment phase. We observed that all instances of difficult PIV access were promptly brought to an attending neonatologist's attention by nurses. This process resulted in attending neonatologists being proactive in consciously mapping and identifying all potential veins for PIV and preserving larger veins for PICC. Venepuncture for sampling blood was kept to a bare minimum. We speculate that 1 or more of these factors may have contributed to the reduction in the use of PICC.

A decline in CVC utilization ratio was observed in the postintervention period. This was an indicator of a significant

**TABLE 7** Comparison of Duration of Vascular Catheter Use Among Infants Who Received Catheters

| | Baseline Phase January 2010–December 2010, *N* = 219 | Intervention Phase January 2011–March 2011, *N* = 49 | Sustainment Phase April 2011–March 2012, *N* = 220 | *P*, Baseline Versus Sustainment Phase |
|---|---|---|---|---|
| UAC days | 4 [2–5] | 4 [3–7] | 4 [2–5] | .68 |
| UVC days | 6 [5–8] | 6 [4–7] | 6 [4–7] | .10 |
| Surgical CVC days | 26 [22–44] | 9 [9–10] | 16 [11–20] | .006 |
| PICC days | 9 [7–14] | 14 [9–26] | 10 [6–23] | .61 |
| Total CVC days[a] | 10 [6–17] | 14 [7–26] | 10 [6–19] | .73 |
| PIV days | 6 [3–9] | 6 [4–12] | 6 [4–9] | .32 |
| Peripheral arterial line days | 6 [3–11] | 5 [1–5] | 3 [2–7] | .06 |

Median [interquartile range] unless specified otherwise. Mann–Whitney *U* test.

[a] UVC + PICC + surgical CVC days and data among those who had CVC.

**TABLE 8** Comparison of Outcomes Before Discharge During the Baseline and Sustainment Phases

| | Baseline Phase, January–December 2010 | Sustainment Phase, April 2011–March 2012 | *P* |
|---|---|---|---|
| Infants with sepsis, *n* (%) | 31 (14.2) | 24 (10.9) | .31 |
| Number of sepsis episodes | 44 | 35 | |
| Incidence of sepsis/1000 patient days | 6.8 | 5.6 | IRR = 0.82, *P* = .40[a] |
| Incidence of sepsis/1000 central catheter days | 19.1 | 22.4 | IRR = 1.16, *P* = .48[a] |
| Incidence of CLABSI/1000 patient days | 5.1 | 3.2 | IRR = 0.63, *P* = .10[a] |
| Incidence of CLABSI/1000 central catheter days | 14.3 | 12.8 | IRR = 0.89, *P* = .68[a] |
| Antibiotic days[b] | 4 [2–13] | 3 [0–8] | .04 |
| Mortality[c] | 8 (3.7) | 12 (5.4) | .49 |
| BPD at 36 wk[c] | 24 (11.0) | 26 (12.5) | .70 |
| NEC stage ≥2[c] | 4 (1.8) | 7 (3.4) | .11 |
| Brain lesions[c] | 32 (15.1) | 29 (13.1) | .57 |
| ROP stage ≥3[c] | 9 (4.1) | 5 (2.4) | .29 |
| PDA[c] | 33 (15.1) | 20 (9.6) | .06 |
| Pneumothorax[c] | 8 (3.7) | 15 (7.2) | .12 |
| Length of stay[b] | 16 [7–43] | 13 [8–43] | .70 |

$\chi^2$ test. IRR, incidence rate ratio; NEC, necrotizing enterocolitis.
a IRR post versus pre period *P* value.
b Median [interquartile range].
c Number of infants (%).

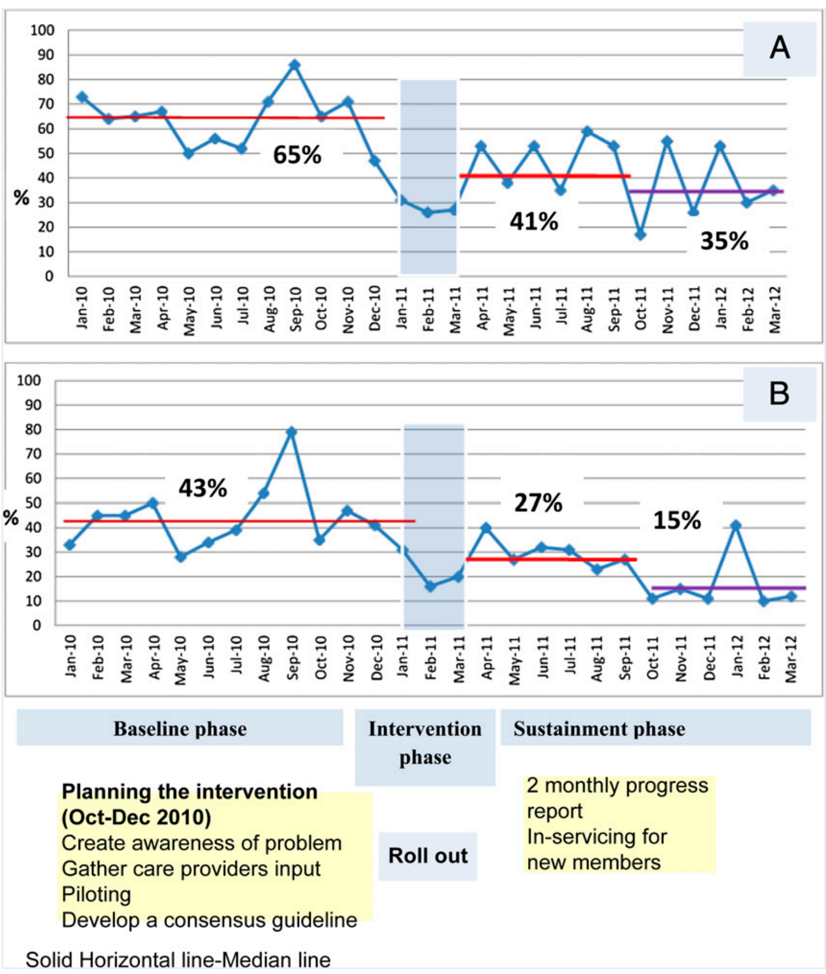


**FIGURE 2**
Percentage of infants receiving UVC (A) and UAC (B) per month over time during the 2 time periods.

decrease in patient days with CVC and thus translates into a reduction in risk exposure to adverse events related to CVCs, such as CLABSI. Similarly, a relative reduction in UAC and UVC use by 44% and 32%, respectively, and CVC patient days by 735 days in the postintervention period have huge implications for resource utilization. Personnel time associated with insertion and maintenance of umbilical catheters and the cost of vascular devices, insertion packs, and maintenance supplies will be reduced significantly.

Our observation demonstrates that a focused QI intervention to standardize umbilical catheter insertion reduces inappropriate use of such catheters without causing harm. However, by itself it does not necessarily improve patient outcomes, which may be affected only by a wider multifaceted set of interventions. For example, we did not notice a change in sepsis and CLABSI rates. The incidence of sepsis in our study was 14.5% and 10.9% in the baseline and sustainment phases, respectively. During the same period CNN NICU centers had an incidence of sepsis of 15.4%. Thus, our center's sepsis rates were comparable to those of any other center in the CNN.[19]

There was no significant reduction in the incidence rate of sepsis and CLABSI as a result of our interventions. Published evidence indicates that reducing the incidence of sepsis and CLABSI requires a multifaceted approach including adoption of best practices in skin preparation, hand hygiene,[20,21] IV hub cleansing,[22,23] standardized processes for inserting and maintaining central lines,[24] early feeding and standardized advancement schedules,[25] changing staff perceptions[26,27] of infection prevention, and increasing family engagement.[28]

Our results are consistent with those of others who have reported improvements in process outcomes through systematic implementation and evaluation of QI interventions. This is the first study that has demonstrated feasibility and validated guidelines standardizing the use of umbilical catheters in preterm infants. Assessing feasibility and measuring the impact on clinical outcomes were additional strengths of this study. The guidelines and implementation strategy could be easily adopted by any other tertiary care neonatal center. Fewer infants were exposed to the risk of UAC or UVC, and fewer resources were used with similar patient outcomes in our study. Thus, our QI intervention adds value to health care by improving quality of care and reducing costs.

We believe that the following factors played a major role in achieving a sustained reduction in umbilical catheter usage in our unit: identifying the problem of high umbilical catheter use and its potential drawbacks, developing the guidelines and effective implementation, creating awareness of the guidelines using multiple methods, accessibility and applicability of guidelines at the point of care, setting expectations from every professional group, and tracking the implementation process and presenting the impact of implementation to care providers at regular intervals. In the past, 7 factors have been shown to influence practice changes in NICU: staffing issues, consistency in practice, the approval process, a multidisciplinary approach to care, frequency and consistency of communication, rationale for change, and the feedback process.[29] The QI subteam proactively considered all these factors were while developing, implementing, and evaluating the guidelines. This may also have contributed to the success of this project. Several challenges and barriers noted during implementation and methods to address them are presented in Table 9.

Interestingly, we observed that the number of days of antibiotic use in the sustainment phase was significantly lower and was associated with the duration of UVC use. We speculate that this association could have resulted from a higher threshold to initiate antibiotics or greater willingness to discontinue them by NICU staff as a result of our project.

Our study had several limitations. The intervention and control periods were not concurrent. During the study period undetected changes that affected our measured results could have occurred with practices such as insertion and maintenance of CVCs, enteral feeding practices, and delivery room practices. However, no formal policy or guideline changes were made in such practices in our NICU during the study period. Some of the observed results could have occurred because of differences in patient variables between the baseline and sustainment phases, differences that were not detected despite a multivariate analysis. We did not measure changes in staff attitudes toward use of umbilical and other central catheters, and such attitudinal change could be an important mediator of our intervention. Complications related to umbilical catheter use (eg, bleeding,

**TABLE 9** Challenges and Barriers to Improvement

| Challenges and Barriers | System-Based Solution |
|---|---|
| Achieving a consensus on indications for umbilical catheter placement in the absence of published evidence | Guidelines were developed by interdisciplinary team members by reviewing literature, practices from other centers and availability of local expertise.<br>Concerns related to workload, workflow, and feasibility were elicited and addressed pro-actively. |
| Lack of confidence among nurses in their ability to establish PIV access in a timely manner | Feasibility was demonstrated by piloting the guidelines on 5 infants.<br>PIV access attempts by nurses were limited to 4, and backup support by attending neonatologist was predefined. |
| Decreasing opportunity to perform umbilical catheterization among residents | Alternative learning and practicing opportunities were created (eg, enhanced buddying process and umbilical catheterization simulation skill station on procedural skills day). |
| Apprehension about increase in pokes related to PIV and increased use of PICC and SCVC in the absence of umbilical catheters | Apprehension was acknowledged and included as an outcome measure in this QI project. |
| Creating awareness of the guidelines among new employees and learners rotating through the NICU | All new members were oriented to the guidelines during resuscitation team huddle and were encouraged to obtain the pocket card from QI subteam members. |
| Creating buy-in and ownership and sustaining practice change | Creating awareness of guidelines and their underlying principles among all NICU care providers.<br>Acknowledging care providers' effort and encouraging them to initiate discussion when deviation from guidelines was observed.<br>Demonstrating the benefits of guidelines in the form of easy-to-understand run charts. |

thrombus, dislodgement) or PIV placement (eg, number of skin punctures, pain, and handling episodes) were not measured. Backup support by neonatologists was not measured or quantified, which may affect the replication of results in different units. Finally, cost-effectiveness analysis, adaptability of the guidelines to a different population or a different unit, and a survey to elicit acceptability of our guidelines by care providers were not done in this project.

## CONCLUSIONS

Implementation of guidelines standardizing the use of umbilical catheters in the NICU is feasible and reduces overuse, that is, it results in significant reduction in the proportion of infants receiving UACs and UVCs without any corresponding increase in use of PICC or SCVCs. Fewer infants were exposed to the risk of UACs and UVCs, and fewer resources were used with similar patient outcomes.

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## REFERENCES

1. Lee SK, McMillan DD, Ohlsson A, et al. Variations in practice and outcomes in the Canadian NICU network: 1996–1997. *Pediatrics*. 2000;106(5):1070–1079
2. Nash P. Umbilical catheters, placement, and complication management. *J Infus Nurs*. 2006;29(6):346–352
3. Hansen A, Greene A, Puder M. ONE: General Considerations. Part 5, Vascular Access. Boston, MA: People's Medical Publishing House USA; 2009: 42–55
4. Grisoni ER, Mehta SK, Connors AF. Thrombosis and infection complicating central venous catheterization in neonates. *J Pediatr Surg*. 1986;21(9):772–776
5. Cronin WA, Germanson TP, Donowitz LG. Intravascular catheter colonization and related bloodstream infection in critically ill neonates. *Infect Control Hosp Epidemiol*. 1990;11(6):301–308
6. Schiff DE, Stonestreet BS. Central venous catheters in low birth weight infants: incidence of related complications. *J Perinatol*. 1993;13(2):153–158
7. Chien LY, Macnab Y, Aziz K, Andrews W, McMillan DD, Lee SK; Canadian Neonatal Network. Variations in central venous catheter–related infection risks among Canadian neonatal intensive care units. *Pediatr Infect Dis J*. 2002;21(6):505–511
8. Butler-O'Hara M, Buzzard CJ, Reubens L, McDermott MP, DiGrazio W, D'Angio CT. A randomized trial comparing long-term and short-term use of umbilical venous catheters in premature infants with birth weights of less than 1251 grams. *Pediatrics*. 2006;118(1). Available at: www.pediatrics.org/cgi/content/full/118/1/e25
9. Janet M. *Renni. Roberton's Textbook of Neonatology*. 4th ed. London, England: Elsevier Churchill; 2005
10. Dimitriou G, Greenough A, Pink L, McGhee A, Hickey A, Rafferty GF. Effect of posture on oxygenation and respiratory muscle strength in convalescent infants. *Arch Dis Child Fetal Neonatal Ed*. 2002;86(3):F147–F150
11. College of Respiratory Therapists of Ontario. Central access umbilical artery and vein cannulation. Available at: http://www.crto.on.ca/pdf/PPG/Umbilical_CBPG.pdf. Accessed April 26, 2013
12. Green C, Yohannan MD. Umbilical arterial and venous catheters: placement, use, and complications. *Neonatal Netw*. 1998;17(6):23–28
13. MacDonald MG, Wortham BM, Rais-Bahrami K. Umbilical vein catheterization. In: MacDonald MG, Ramasethu J, eds. *Atlas of Procedures in Neonatology*, 4th ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2007:28–29
14. NHS. Guidelines for umbilical venous catheterization, management and removal of catheter. Neonatal Transfer Service Web site. Available at: www.neonatal.org.uk/documents/1480.pdf. Accessed April 7, 2013
15. NW Newborn Clinical Guideline. Umbilical artery and vein catheterization. Available at: www.adhb.govt.nz/newborn/guidelines/vascularcatheters/UmbilicalCatheters.htm. Accessed May 2001
16. Centers for Disease Control and Prevention. July 2013 CDC/NHSN protocol. Device-associated module: CLABSI, page 4-3 clarifications. Available at: www.cdc.gov/nhsn/PDFs/pscManual/4PSC_CLABScurrent.pdf. Accessed November 15, 2013
17. Bowen DJ, Kreuter M, Spring B, et al. How we design feasibility studies. *Am J Prev Med*. 2009;36(5):452–457
18. The Canadian Neonatal Network. Abstractor's manual v.2.1.1. 2013. Available at: www.canadianneonatalnetwork.org/portal/CNNHome/Publications.aspx. Accessed March 23, 2013
19. Shah PS, Lee SK, Yoon W, Chan P, Param V; Members of the Annual Report Review Committee. The Canadian Neonatal Network annual report. 2011. Available at: www.canadianneonatalnetwork.org/Portal/LinkClick.aspx?fileticket=rCVwkKIA4pc%3D&tabid=39. Accessed March 23, 2013
20. Horbar JD, Rogowski J, Plsek PE, et al; NIC/Q Project Investigators of the Vermont Oxford Network. Collaborative quality improvement for neonatal intensive care. *Pediatrics*. 2001;107(1):14–22
21. Toltzis P, Walsh M. Recently tested strategies to reduce nosocomial infections in the neonatal intensive care unit. *Expert Rev Anti Infect Ther*. 2010;8(2):235–242
22. Ho KM, Litton E. Use of chlorhexidine-impregnated dressing to prevent vascular and epidural catheter colonization and infection: a meta-analysis. *J Antimicrob Chemother*. 2006;58(2):281–287
23. Noorani A, Rabey N, Walsh SR, Davies RJ. Systematic review and meta-analysis of preoperative antisepsis with chlorhexidine versus povidone–iodine in clean-contaminated surgery. *Br J Surg*. 2010;97(11):1614–1620
24. Guerin K, Wagner J, Rains K, Bessesen M. Reduction in central line–associated bloodstream infections by implementation of a postinsertion care bundle. *Am J Infect Control*. 2010;38(6):430–433

25. Payne NR, Barry J, Berg W, et al; Stop Transmission of Pathogens (STOP) team of the St. Paul Campus; Prevent Infection Team (PIT) of the Minneapolis Campus of Children's Hospitals and Clinics of Minnesota. Sustained reduction in neonatal nosocomial infections through quality improvement efforts. *Pediatrics*. 2012;129(1). Available at: www.pediatrics.org/cgi/content/full/129/1/e165

26. Chudleigh J, Fletcher M, Gould D. Infection control in neonatal intensive care units. *J Hosp Infect*. 2005;61(2):123–129

27. Eldridge NE, Woods SS, Bonello RS, et al. Using the six sigma process to implement the Centers for Disease Control and Prevention Guideline for Hand Hygiene in 4 intensive care units. *J Gen Intern Med*. 2006; 21(Suppl 2):S35–S42

28. Thomas LM. The changing role of parents in neonatal care: a historical review. *Neonatal Netw*. 2008;27(2):91–100

29. Stevens B, Lee SK, Law MP, Yamada J; Canadian Neonatal Network EPIC Study Group. A qualitative examination of changing practice in Canadian neonatal intensive care units. *J Eval Clin Pract*. 2007;13(2): 287–294

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