# The use of mechanical ventilation protocols in Canadian neonatal intensive care units

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**OBJECTIVES:** To identify the proportion of Canadian neonatal intensive care units with existing mechanical ventilation protocols and to determine the characteristics and respiratory care practices of units that have adopted such protocols.
**METHODS:** A structured survey including 36 questions about mechanical ventilation protocols and respiratory care practices was mailed to the medical directors of all tertiary care neonatal units in Canada and circulated between December 2012 and March 2013.
**RESULTS:** Twenty-four of 32 units responded to the survey (75%). Of the respondents, 91% were medical directors and 71% worked in university hospitals. Nine units (38%) had at least one type of mechanical ventilation protocol, most commonly for the acute and weaning phases. Units with pre-existing protocols were more commonly university-affiliated and had higher ratios of ventilated patients to physicians or respiratory therapists, although this did not reach statistical significance. The presence of a mechanical ventilation protocol was highly correlated with the coexistence of a protocol for noninvasive ventilation (P<0.001, OR 4.5 [95% CI 1.3 to 15.3]). There were overall wide variations in ventilation practices across units. However, units with mechanical ventilation protocols were significantly more likely to extubate neonates from the assist control mode (P=0.039, OR 8.25 [95% CI 1.2 to 59]).
**CONCLUSION:** Despite the lack of compelling evidence to support their use in neonates, a considerable number of Canadian neonatal intensive care units have adopted mechanical ventilation protocols. More research is needed to better understand their role in reducing unnecessary variations in practice and improving short- and long-term outcomes.

**Key Words:** *Mechanical ventilation; Protocols; Neonatal intensive care units; Weaning*

## L'utilisation des protocoles de ventilation mécanique dans les unités de soins intensifs néonatales canadiennes

**OBJECTIFS :** Déterminer la proportion d'unités de soins intensifs néonatales canadiennes disposant de protocoles de ventilation mécanique ainsi que les caractéristiques et les pratiques de soins respiratoires des unités qui ont adopté ces protocoles.
**MÉTHODOLOGIE :** Les chercheurs ont posté un sondage structuré comportant 36 questions sur les protocoles de ventilation mécanique et les pratiques de soins respiratoires aux directeurs médicaux de toutes les unités néonatales de soins tertiaires du Canada et les ont fait circuler entre décembre 2012 et mars 2013.
**RÉSULTATS :** Vingt-quatre des 32 unités ont répondu au sondage (75 %). Parmi les répondants, 91 % étaient des directeurs médicaux et 71 % travaillaient dans un hôpital universitaire. Neuf unités (38 %) avaient au moins un type de protocole de ventilation mécanique, généralement pour la phase aiguë et le sevrage. Les unités disposant déjà de protocoles étaient surtout affiliées à une université et présentaient des ratios plus élevés de patients sous respirateur par médecin ou par inhalothérapeute, sans toutefois que cette observation soit statistiquement significative. La présence d'un protocole de ventilation mécanique était fortement corrélée avec la coexistence d'un protocole de ventilation non invasive (P<0,001, RC 4,5 [95 % IC 1,3 à 15,3]). Dans l'ensemble, les pratiques de ventilation étaient très variables entre les unités. Cependant, les unités disposant de protocoles de ventilation mécanique étaient significativement plus susceptibles d'extuber les nouveau-nés du mode de contrôle assisté (P=0,039, RC 8,25 [95 % IC 1,2 à 59]).
**CONCLUSION :** Malgré l'absence de preuves convaincantes pour en soutenir l'utilisation chez les nouveau-nés, un nombre considérable d'unités des soins intensifs néonatales canadiennes a adopté des protocoles de ventilation mécanique. Il faudra d'autres recherches pour mieux en comprendre le rôle dans la réduction des variations de pratique inutiles et l'amélioration des résultats à court et à long terme.

The provision of mechanical ventilation (MV), along with its processes of weaning and discontinuation, are critical components of the neonatal intensive care unit (NICU). Over the past decade, a considerable body of literature has emerged in support of lung protective strategies and ways to achieve timely weaning and discontinuation from MV. Despite this, there is excessive practice style variation among neonatal practitioners with regard to their decisionmaking about MV for similar patient states (1,2). Heterogeneous MV practices are resource-intensive and may negatively affect patient care in the face of multiple changes and inconsistent treatment plans (3). One way of harmonizing MV practices is through the development and implementation of MV protocols. A protocol, by definition, is a precise and detailed plan with definite inclusion and exclusion criteria that provides standardized pathways for caring for patients with specific conditions (4,5). Protocols have been extensively studied in adult and paediatric populations. They have notably been established for the treatment of sepsis, glycemic control and weaning from MV (6-8), with results showing improved clinical outcomes associated with decreased medical costs. MV protocols have, in fact, repeatedly produced faster weaning times compared with usual physician-driven care (9), while conferring shorter duration of MV and length of ICU stay in both adult and paediatric patients (10,11). In 2001, a collective task force of pulmonary and critical care experts issued evidence-based guidelines recommending that all ICUs should develop and implement weaning protocols designed for nonphysician health care professionals (eg, nurses, respiratory therapists) as part of their standard of care (12).

Although MV protocols have been incorporated into daily practice in >70% of adult ICUs in North America (5,13), their use

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**TABLE 1**
**Association between hospital/intensive care unit characteristics and the presence of mechanical ventilation protocols**

| Characteristic | Protocol (n=9) | No protocol (n=15) |
|---|---|---|
| Type of hospital | | |
| University hospital | 89 | 60 |
| Community hospital with university-affiliation | 11 | 40 |
| Medical trainees present | 100 | 73 |
| Daily multidisciplinary rounds | 100 | 87 |
| RT coverage (24 h per day), % (n/n) | 100 | 100 (13/13) |
| RT students in-training | 100 | 87 |
| RTs and ventilator changes | | |
| Not responsible | 0 | 33 |
| Exclusively responsible | 33 | 20 |
| Jointly responsible with MD | 67 | 47 |
| Ratio of ventilated patients per RT, mean ± SD | 9.2±5 | 5.6±3 |
| Ventilated patients per RT, % (n/total n) | | |
| 1 to 5 | 25 (2/8) | 50 (7/14) |
| 6 to 10 | 50 (4/8) | 43 (6/14) |
| >10 | 25 (2/8) | 7 (1/14) |
| Ratio of ventilated patients per RN, mean ± SD | 1.6±0.5 | 1.5±0.5 |
| Ventilated patients per RN | | |
| 1 | 33 | 40 |
| 1.5 | 22 | 20 |
| 2 | 44 | 40 |
| Ratio of patients per MD, mean ± SD | 19.8±3 | 15.9±8 |
| Patients per MD, % (n/total n) | | |
| 1 to 10 | 0 | 29 (4/14) |
| 11 to 20 | 78 | 57 (8/14) |
| >20 | 22 | 14 (2/14) |

*MD Medical doctor; RN Registered nurse; RT Respiratory therapist*

in paediatric and neonatal ICUs is unknown. We conducted a survey with the aim of determining the extent to which MV protocols have been integrated into current practice in Canadian NICUs. We also investigated the factors that drive certain NICUs to implement MV protocols, and whether these protocols affect ventilatory practices.

## METHODS

### Questionnaire development

A structured questionnaire (Appendix 1) was generated by reviewing the literature and consulting respiratory therapists (RTs) and NICU physicians at the authors' institution. The framework was also inspired by a recent Canadian survey on the use of MV protocols in adult ICUs (13). A total of 36 closed-ended questions were asked regarding hospital/ICU characteristics, MV practices and MV protocols. In the present survey, protocols were defined as "standardized plans which can give step by step instructions or specific rules to follow in a given situation. They must be specific enough that given a particular set of circumstances, multiple clinicians would generally make the same decision or act in the same way".

### Study design

The survey was mailed in a preposted envelope to the medical directors of 32 tertiary care (level III) NICUs in Canada capable of providing life-sustaining respiratory support. The list was generated using the 2011 directory of NICUs and neonatologists published by the American Academy of Pediatrics. The medical directors from each unit were requested to complete the questionnaire or to assign it to one of the respiratory therapist (RT) leaders from their unit. The survey was circulated between December 2012 and March 2013 with monthly e-mail reminders, and was anonymous. Informed consent to participate was inferred by return of the completed survey.

### Analysis

The primary outcome was the proportion of Canadian NICUs with any MV protocol. The protocols were subdivided into the following categories: acute (≤7 days of MV), chronic (>7 days of MV) and weaning phases, high-frequency oscillatory ventilation (HFOV) and high-frequency jet ventilation. Questions also inquired about the presence of any other respiratory support protocols for noninvasive ventilation (NIV) or use of surfactant, caffeine or inhaled nitric oxide. As a secondary outcome, whether the following hospital/ICU characteristics were associated with the presence of MV protocols was assessed: hospital type (university versus community); presence of medical or respiratory therapist (RT) trainees; presence of daily multidisciplinary rounds; ratio of patients to physician; ratio of ventilated patients to RT and RT responsibilities with regards to ventilator changes. Whether the presence of MV protocols influenced MV practices, including the choice of ventilation mode (following intubation or pre-extubation), weaning strategies and postextubation respiratory support, were also assessed. Finally, in units in which MV protocols were available, how those protocols were developed, implemented and maintained was determined.

Results from the questionnaires were entered into an Excel database (Microsoft Corporation, USA) and analyzed using SPSS version 21 (IBM Corporation, USA). Fisher's exact test and the Mann-Whitney test were used to compare dichotomous and continuous data, respectively; $P<0.05$ was considered to be statistically significant.

## RESULTS

The survey was sent to 32 neonatal units (20 university hospitals and 12 community hospitals with university affiliation). Twenty-four (75%) of 32 units completed the survey. Most of the questionnaires were completed by medical directors (n=22 [91%]) and the other two were completed by the RT leader. The majority of respondents were from university hospitals (n=17 [71%]) and the remainder were from community hospitals with university affiliation (n=7 [29%]). All but one respondent worked in a 'closed unit' (all admissions and patient care decisions were coordinated by a single physician).

### Use of MV and other respiratory support protocols

Nine units (38%) had at least one written protocol for invasive MV. The most common protocols, present in seven units, were for the acute and weaning phases of MV. Protocols for the chronic phase of MV and for HFOV were present in four units. Six of nine units had >1 MV protocol, with an average of two MV protocols per unit.

Seven of the 24 units that responded had a protocol for NIV (29%) and the presence of a MV protocol was highly correlated with the coexistence of a protocol for NIV (OR 4.5 [95% CI [1.3 to 15.3]; $P<0.001$). The most common NIV protocol was for high-flow nasal cannula (HFNC) (n=6 [86%]) followed by both continuous positive airway pressure and low-flow nasal cannula (n=5 [71%]). With regard to other measures of respiratory support, protocols for surfactant, inhaled nitric oxide and caffeine administration were present in 67%, 67% and 38% of the 24 units, respectively.

**Factors associated with the use of MV protocols**

Table 1 summarizes the association between hospital/ICU characteristics and the presence of MV protocols. There were no statistically significant differences overall. Protocols were more commonly used in university than in community hospitals (n=8 [89%] versus n=1 [11%]; P=0.191). Medical trainees were present in all nine units that had a MV protocol compared with 11 of 15 units (73%) without a protocol (P=0.259). Despite having all units offer 24 h/seven days per week RT coverage, units with MV protocols had a modestly higher ratio of ventilated patients per RT (9.2 versus 5.6; P=0.050). Similarly, MV protocols were more commonly available in units that provided RTs with exclusive or joint responsibility (as opposed to no responsibility) for making changes on the ventilator (n=9 [100%] versus n=10 [67%]; P=0.118). The presence of MV protocols was not significantly affected by the staff-to-patient ratio (19.8 versus 15.9; P=0.184) or nurse-to-ventilated patient ratio (1.6 versus 1.5; P=0.815).

**MV practices and association with MV protocols**

There was considerable variation in overall MV practices across the 24 units (Table 2). Forty-six percent of respondents did not specify the initial mode of ventilation, while 20% used either assist control (AC) with volume guarantee, AC with pressure control or synchronized intermittent mandatory ventilation (SIMV) with pressure support. The most common pre-extubation mode was SIMV (n=17 [74%]) followed by AC or volume guarantee (n=10 [44%]) and HFOV (n=7 [30%]). The most frequent postextubation respiratory support was continuous positive airway pressure (n=23 [96%]); however, 46% of respondents (n=11) extubated to nasal intermittent positive pressure ventilation or HFNC. All units titrated oxygen concentration ($FiO_2$) based on oxygen saturation ($SpO_2$) targets. Plateau pressures were only limited 50% of the time and positive end-expiratory pressure (PEEP) was titrated inconsistently based on measurements of $FiO_2$, blood gas measurements, $SpO_2$ and chest x-ray evaluations (range 25% to 38%). Blood gases and other $CO_2$ monitoring devices were used to determine ventilator changes in only 57% of cases. None of the units included daily spontaneous breathing trials as part of their ventilation practices.

Overall, the presence of MV protocols did not confer any major changes in MV practices. However, units with MV protocols were more likely to use AC as their preferred pre-extubation mode (75% versus 27%; OR 8.25 [95% CI 1.15 to 59]; P=0.039) compared with units without protocols, in which SIMV was the most common mode (n=12 [80%]). They also more commonly used blood gas measurements and other $CO_2$ monitoring tools for making changes to the ventilator, although this did not reach statistical significance (75% versus 47%; OR 3.43 [95% CI 0.52 to 22.8]; P=0.379).

**TABLE 2**
**Association between mechanical ventilation (MV) practices and the presence of MV protocols**

| Variable | Protocol (n=9) | No protocol (n=15) | Overall (n=24) |
|---|---|---|---|
| Initial mode of MV | | | |
| Not specified | 56 | 40 | 46 |
| Assist control – volume control | 33 | 20 | 25 |
| Assist control – pressure control | 11 | 20 | 17 |
| Synchronized intermittent mandatory | | | |
| Ventilation with pressure support | 0 | 20 | 13 |
| Use of blood gas, transcutaneous and end-tidal $CO_2$ for titration | 75 (6/8) | 47 | 57 |
| Use of permissive hypercapnia* | | | |
| $PCO_2$ allowed to rise to a preset maximum | 33 | 27 | 29 |
| $PCO_2$ allowed to rise as long as pH is within a preset range | 67 | 80 | 75 |
| Plateau pressures limited | 50 (4/8) | 50 (7/14) | 50 (11/22) |
| PEEP titrated* | | | |
| Based on predetermined $SpO_2$ levels | 33 | 27 | 29 |
| Based on arterial blood gas results | 22 | 26.7 | 25 |
| Based on set $FiO_2$ | 44 | 33 | 38 |
| Based on chest x-ray evaluation | 22 | 40 | 33 |
| Mode of MV pre-extubation* | | | |
| Assist control† | 75 (6/8) | 27 | 44 (10/23) |
| Synchronized intermittent mandatory ventilation | 63 (5/8) | 80 | 74 (17/23) |
| Volume guarantee | 63 (5/8) | 33 | 44 (10/23) |
| High-frequency oscillatory ventilation | 50 (4/8) | 20 | 30 (7/23) |
| High-frequency jet ventilation | 13 (1/8) | 0 | 4 (1/23) |
| Type of postextubation support* | | | |
| Low-flow nasal cannula | 56 | 20 | 33 |
| High-flow nasal cannula | 44 | 47 | 46 |
| Continuous positive airway pressure | 100 | 93 | 96 |
| Noninvasive positive pressure ventilation | 67 | 33 | 46 |

**Total percentage may be >100% in this category because respondents could choose more than one answer; †Statistically significant (P=0.039; OR 8.25 [95% CI 1.15 to 59])*

**Protocol development and implementation**

All nine existing MV protocols were developed by a multidisciplinary team and the majority were supported by ongoing staff education (n=8 [89%]). Six units (67%) required a physician order before initiating the MV protocol. Access to the protocol was variable, but most commonly it was available on the hospital intranet (n=7 [78%]). Nevertheless, the actual protocol adherence was only monitored in five units (56%), and seven respondents (78%) did not know whether the protocol had been revised since inception.

## DISCUSSION

We found from our survey that 38% of Canadian tertiary care NICUs currently have protocols to guide the use of MV. This observation strikingly contrasts with the adult intensive care, in which evidence-based recommendations have accelerated the widespread use of protocols for MV (12,13). Compared with the adult literature, there is a paucity of data regarding the role of MV protocols in the neonatal population. Only a single Canadian observational study by Hermeto et al (14) showed that the implementation of an RT-driven ventilation protocol for premature infants resulted in earlier extubation with an increased number of successful extubations and shorter duration of MV, even two years after implementation of the protocol. On the other hand, several other respiratory support strategies, such as inhaled nitric oxide and surfactant administration, have been protocolized in more than two-thirds of Canadian NICUs, suggesting that protocols are becoming increasingly used in neonatal respiratory care.

Our survey also reveals a wide variability in ventilation practices across Canadian NICUs, which is consistent with similar

findings from recent European and Australasian studies (1,2,15). With the advent of technology and the accessibility of different modes and devices, provision of MV has become tremendously variable among institutions. Contributing to the complexity, most NICUs are structured in such a way that patients are exposed, on a daily basis, to a very high turnover of health care professionals, each with their own sets of experiences and backgrounds. This phenomenon has two major implications. First, several benchmarking studies conducted by American and Canadian neonatal networks have demonstrated significant variation among centres in the incidence of important neonatal outcomes such as bronchopulmonary dysplasia, nosocomial infections and mortality (16-19). This clustering persisted even after correcting for variables known to affect these outcomes, suggesting that differences in clinical practice may play an important role (17). The authors of these studies have advocated that neonatal outcomes could be improved through standardization of care and attenuation of these clinical practice variations. Second, it has been well demonstrated that evidence-based recommendations from clinical research are either slow to be implemented, overused or inappropriately applied in clinical practice (4,20). For instance, volume-guarantee ventilation continues to be underused, even with evidence to suggest that it may reduce ventilator-induced lung injury and duration of MV (21). Furthermore, SIMV appears to be the most widely used mode for weaning and extubation, despite the evidence that AC provides less work of breathing, more homogeneous tidal volumes and faster weaning from MV compared with SIMV (22,23). However, in the presence of MV protocols, the use of AC pre-extubation was significantly higher than SIMV, supporting the idea that protocols may promote evidence-based practice and discourage outdated approaches. In addition, units with MV protocols are significantly more likely to extend this culture into developing protocols for NIV, a therapy that has increasingly been adopted as part of the shift toward more protective lung strategies (24-26). A similar finding was observed in a survey in adult ICUs, in which 73% of units had ≥3 clinical protocols and only 2% had one protocol (5). This movement could reflect the units' positive experiences or perceived improvement in patient care delivery with protocols.

Thus, we believe that NICUs may benefit from the development and implementation of neonatal MV protocols, given their potential to reduce practice variability and improve patient safety. Using best available evidence, protocols should delineate all aspects of MV, including intubation criteria, preferred ventilator modes and settings, monitoring, weaning and postextubation management. MV protocols should also be population and disease specific. When evidence is lacking, protocols offer an excellent opportunity to involve all health care professionals and reach consensus as a team. MV protocols can further compensate for resource limitations, enabling busy clinicians to perform other tasks in the NICU while RTs perform changes in a timely manner. We noted a trend toward increased MV protocol use in units in which the ratio of ventilated patients per RT or physicians was higher, but this did not reach statistical significance, likely due to the small sample size. Evidence-based guidelines on how to construct clinical protocols exist and are beyond the scope of the present article (3,27,28).

Our study had some limitations. Given its nature, the survey was vulnerable to response bias, in that some medical directors may not have responded because they did not have any MV protocols in their institution. This would lead to an overestimation of the proportion of Canadian NICUs with MV protocols. However, we obtained a relatively high response rate (75%), and the fact that the questionnaires were anonymous may have minimized this bias. The individual completing the questionnaire may have had limited knowledge of the existence or contents of MV protocols. We assumed that clinical medical directors would be the most likely to know about the latest projects in their respective units, and gave them the opportunity to delegate to their respiratory therapy leader in case of time constraints or lack of awareness. Finally, results of the survey only describe the reported MV practices; however, this may not necessarily have reflected actual current practices in the unit, which may have changed since completion of the survey.

Despite the lack of evidence to support the use of MV protocols in neonates, 38% of Canadian NICUs have already moved forward with their development and implementation. MV protocols are preferentially being adopted in academic institutions in which staffing coverage is limited, and appear to lead to better practices. More research, in the form of randomized control trials or plan-do-study-act quality improvement initiatives, is needed to better understand the role of MV protocols in reducing unnecessary variations, improving clinical outcomes and decreasing medical costs.

## APPENDIX 1

**Use of mechanical ventilation protocols in neonatal intensive care units across Canada: A survey of current practice**

**Professional completing this survey:**

☐ Physician
☐ Respiratory therapist leader

**Demographic Information**

1. Which of the following best describes your hospital?
   ☐ University hospital
   ☐ Community hospital
   ☐ Community hospital with University affiliation
   ☐ Don't know
2. According to the Ministry of Health and social services an intensivist-led ICU management model is one in which all admissions and patient care decisions are coordinated by a single physician who has Royal College accreditation or equivalent training in critical care medicine. This is referred to as a "closed" unit. Based on this definition is your ICU a "closed" unit?
   ☐ No
   ☐ Yes
   ☐ Don't know
3. Do resident physicians train in any of your intensive care units? (Select all that apply)
   ☐ No
   ☐ Yes, Pediatric residents
   ☐ Yes, subspecialty residents training in critical care medicine
   ☐ Yes, subspecialty residents training in other fields
   ☐ Yes, fellows who are not part of a formal University-affiliated training program
4. On average, what is the assigned ratio of registered nurses (RNs) to?
   Ventilated/intubated patients in your largest intensive care unit?
   1 RN to _____ ventilated patient(s).
5. What is the approximate ratio of staff physicians on duty to patients in your intensive care unit?
   1 staff medical doctor (MD) to _____ patient(s)
6. Does your intensive care unit have Respiratory Therapist (RT) coverage?
   ☐ No (Please skip to Question 11)
   ☐ Yes, 8 – 11 hours a day in hospital but no after hours coverage
   ☐ Yes, 8 – 11 hours a day with on call coverage after hours
   ☐ Yes, 12 – 16 hours a day in hospital but no after hours coverage

- ☐ Yes, 12 – 16 hours a day, with on call coverage after hours
- ☐ Yes, 17 – 23 hours a day in hospital but no after hours coverage
- ☐ Yes, 17 – 23 hours a day, with on call coverage after hours
- ☐ Yes, 24 hours a day, 7 days a week

7. Does your hospital train Respiratory Therapy students?
   - ☐ Yes
   - ☐ No
8. Are the Respiratory Therapists responsible for changes to the ventilator settings for mechanically ventilated patients?
   - ☐ No
   - ☐ Yes, exclusively
   - ☐ Yes, and physicians can also make changes in the ventilators settings.
   - ☐ Yes, and physicians and registered nurses can also make changes in the ventilator settings.
9. What is the ratio of Respiratory Therapists to ventilated/intubated patients in your intensive care unit?
   1 RT to _____ patient(s)

For this questionnaire, we define protocols as "standardized plans which can give step by step instructions or specific rules to follow in a given situation. They must be specific enough that given a particular set of circumstances, multiple clinicians would generally make the same decision or act in the same way." Non-physician health professionals may follow the protocol's rules without specific orders (other than an order to initiate the protocol).

10. Do you have a written protocol governing any aspect of mechanical ventilation (invasive or non-invasive)?
    - ☐ No
    - ☐ Yes
11. If yes, which one? (Select all that apply)
    - ☐ Mechanical ventilation – acute phase (≤7 days)
    - ☐ Mechanical ventilation – chronic phase (>7 days)
    - ☐ Mechanical ventilation – weaning protocol
    - ☐ High frequency Oscillatory Ventilation
    - ☐ High frequency Jet Ventilation
    - ☐ Nasal Intermittent Positive Pressure Ventilation
    - ☐ Nasal CPAP
    - ☐ High flow nasal cannula therapy
    - ☐ Low flow nasal cannula therapy
12. If you indicated in Question 10 that a mechanical ventilation protocol exists in your hospital, would you be willing to enclose a copy of it with this questionnaire?
    - ☐ No
    - ☐ Yes, I will attach a copy to this questionnaire
13. In your unit, is the initial mode of ventilation specified?
    - ☐ No, the initial mode of ventilation is not specified
    - ☐ Yes, the initial mode of ventilation is assist control/volume control
    - ☐ Yes, the initial mode of ventilation is assist control/pressure control
    - ☐ Yes, the initial mode of ventilation is synchronized intermittent mandatory ventilation (SIMV) with pressure respiratory (PS)
    - ☐ Yes, other _____ (please state initial mode)
14. In your unit, are specified blood gas (ABG, CBG, VBG) or end tidal $CO_2$ ($ETCO_2$) or transcutaneous ($TcPCO_2$) limits used to determine ventilation changes?
    - ☐ No, there are no BG, $TcPO_2$ or $ETCO_2$ limits
    - ☐ Yes, there are BG, $TcPO_2$ or $ETCO_2$ limits stipulated to govern changes in ventilation
15. Does the unit ventilatory practice allow for the development of elevated $PCO_2$? (permissive hypercapnia) in certain circumstances? (Select all that apply.)
    - ☐ No, the ventilation protocol does not allow for permissive hypercapnia
    - ☐ Yes $PCO_2$ is allowed to rise to a preset maximum
    - ☐ Yes, $PCO_2$ is allowed to rise as long as pH is within a preset range
16. Are plateau pressures limited as part of the ventilation practice?
    - ☐ No, plateau pressures are not limited as part of the ventilation protocol
    - ☐ Yes, they are limited to ≤30 cm $H_2O$
    - ☐ Yes, they are limited to a value >30 cm $H_2O$
17. Is $FiO_2$ titrated? (Select any that apply)
    - ☐ No
    - ☐ Yes, it is changed according to predetermined $SpO_2$ levels
    - ☐ Yes, it is changed based on ABG results
18. Is PEEP titrated? (Select all that apply)
    - ☐ No
    - ☐ Yes, it is changed according to predetermined $SpO_2$ levels
    - ☐ Yes, it is changed based on ABG results
    - ☐ Yes, minimum PEEP is determined by set $FiO_2$
    - ☐ Yes, lung inflation evaluated by chest X-ray anteroposterior view
19. Does the ventilation practice include daily spontaneous breathing trials (SBT) for patients who meet preset criteria?
    - ☐ No, there is no inclusion of spontaneous breathing trials in the protocol
    - ☐ Yes, spontaneous breathing trials are included in the protocol for mechanically ventilated patients who meet preset criteria
    - ☐ Yes, spontaneous breathing trials are included in the protocol for all mechanically ventilated patients
20. If yes, how are SBTs most commonly performed?
    - ☐ Patient remains on the ventilator and is switched to minimal Pressure
    - ☐ Support (PS) with minimal PEEP
    - ☐ Minimal CPAP (no PS) via the ventilator
    - ☐ Other (please describe): _____

**If your unit has a ventilation protocol**

21. Is overall adherence to the protocol monitored?
    - ☐ No, adherence is not monitored
    - ☐ Yes, adherence is measured with the use of chart audits
    - ☐ Yes, adherence is measured in some other way (please describe): _____
    - ☐ Not applicable
22. Is a physician order required to initiate the mechanical ventilation protocol?
    - ☐ No
    - ☐ Yes
23. How can the staff access the mechanical ventilation protocol? (Select all that apply)
    - ☐ A copy is kept at each bedside/ventilator
    - ☐ It is printed on laminated cards for staff to carry

- ☐ A printed copy is kept in the intensive care unit
- ☐ It is available on the hospital intranet
- ☐ A poster of the protocol is posted in the intensive care unit
- ☐ Other (please specify): _____

24. Was the development of the mechanical ventilation protocol a multidisciplinary endeavor?
    - ☐ No, it was developed by the physicians
    - ☐ No, it was developed by the Respiratory Therapists
    - ☐ Yes
    - ☐ Don't know
25. Is the use of the ventilation protocols supported with ongoing staff education?
    - ☐ No
    - ☐ Yes
26. Have the ventilation protocols been revised since their inception?
    - ☐ No
    - ☐ Yes
    - ☐ Don't know

**The following questions deal with practices in your intensive care unit**

27. Does your ICU(s) have daily multidisciplinary rounds?
    - ☐ No
    - ☐ Yes
28. If multidisciplinary rounds do occur in your intensive care unit, who routinely attends? (Select all that apply)
    - ☐ Staff physicians
    - ☐ Medical trainees
    - ☐ Registered nurses
    - ☐ Respiratory Therapists
    - ☐ Clinical Pharmacists
    - ☐ Physiotherapists
    - ☐ Social Worker
    - ☐ Clinical Nutrition
    - ☐ Speech Language Pathology
    - ☐ Other (please specify): _____
29. Does your intensive care unit utilize any of the following in the treatment of refractory hypoxemia? (Select all that apply)
    - ☐ High frequency oscillatory ventilation (HFOV)
    - ☐ High frequency jet ventilation (HFJV)
    - ☐ Inverse ratio ventilation
    - ☐ Airway pressure release ventilation (APRV)
    - ☐ Inhaled nitric oxide
    - ☐ Extracorporeal membrane oxygenation (ECMO)
    - ☐ Prone positioning
    - ☐ Neuromuscular blockade
30. What route of intubation does your NICU use?
    - ☐ Nasal
    - ☐ Oral
    - ☐ Both
31. Who usually does the intubation in your unit? (Please choose by order)
    - ☐ Residents
    - ☐ Respiratory therapist
    - ☐ Neonatologist
    - ☐ Neonatal nurse practitioner
32. After extubation the neonate is placed on:
    - ☐ Low flow nasal cannula
    - ☐ High flow nasal cannula
    - ☐ CPAP
    - ☐ Nasal intermittent positive pressure ventilation (NIPPV)
33. For neonates who are mechanically ventilated, do you have a protocol for caffeine administration?
    - ☐ No
    - ☐ Yes, all babies mechanically ventilated receive caffeine immediately after intubation
    - ☐ Yes, all babies mechanically ventilated receive caffeine 1- 2 days prior to extubation
34. Do you have a protocol for nitric oxide use?
    - ☐ Yes
    - ☐ No
35. Do you have a protocol for surfactant administration?
    - ☐ Yes
    - ☐ No
36. What is the mechanical ventilation mode used prior to extubation?
    - ☐ High Frequency Oscillatory Ventilation (HFOV)
    - ☐ High frequency Jet ventilation (HFJV)
    - ☐ Assisted control Ventilation (AC)
    - ☐ Synchronized intermittent mandatory ventilation (SIMV)
    - ☐ Volume guarantee ventilation
    - ☐ 3 minute spontaneous breathing trial while providing endotracheal CPAP

Your participation in this survey is greatly appreciated. Please return the survey in the enclosed pre-addressed stamped envelope. If you answered yes to Question 12, please attach a copy of your mechanical ventilation protocol to this questionnaire. Your protocol will be treated confidentially.

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