Volume Targeted Ventilation in ELBW Infants at Birth to Reduce Risk of Hypocarbia

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BACKGROUND

Low birth weight infants are at a higher risk for several conditions due to their distinct physiology and the medical interventions necessary to sustain life. One of such conditions is periventricular leukomalacia (PVL), which increases the risk for cerebral palsy. [1,2] One major cause of PVL is cumulative hypocarbia (time in hours infant spent as a $PaCO_2$ of <35mm Hg) due to mechanical ventilation. This has been found to be statistically significant as a cause across all multivariable analysis models when compared to cumulative hyperoxemia and prolonged ventilation.[3] PVL is a hypoxic-ischemic insult to brain tissues, especially in the watershed zones (ventriculopedal and ventriculofugal arteries).[4] The suggested mechanism for this injury is decreased cerebral perfusion resulting from hypocarbia-induced vasoconstriction.[1] A significant cause of hypocarbia is the usage of mechanical ventilation. Traditionally, a pressure-limited ventilation system has been employed in these infants. In delivering a fixed pressure, the infants are often hyperventilated leading to volutrauma and hypocarbia. The risk for cerebral hypoperfusion and hypoxic ischemia from hypocarbia is increased especially in compromised infants with a low birth weight. Switching to a volume-targeted-ventilation (VTV) is a strategy to reduce the incidence of volutrauma and hypocarbia, as well as linked adverse outcomes. [3] In VTV, the tidal volume is set while the pressure and flow are adjusted by the ventilator to achieve the set tidal volume.[2] A distinct advantage of VTV, is that the ventilator self-weans as lung compliance improves. This decreases the occurrence of volutrauma and hypocarbia, thereby stabilizing cerebral blood flow and preventing injury. [5]

PROJECT AIM

To decrease the incidence of hypocarbia in Extremely Low Birthweight Infants (ELBW) infants during the first week of life by 50% using volume targeted ventilation by March of 2017 (6 months).

PROJECT DESIGN/STRATEGY

Our project is designed around implementation of evidence-based medicine in the NICU. It is believed that VTV may be advantageous in the ventilation of ELBW infants. We will use the evidence to establish a new protocol in our NICU to decrease rates of hypocarbia and the sequelae of adverse events related to overventilation during this critical time in ELBW infants. We will attempt to decrease incidence of hypocarbia by implementing the use of VTV in ELBW infants in the first week of life. Education of staff, making sure the appropriate ventilators are available when an ELBW infant is born and eventually a ventilator policy will be utilized.

Setting:

- Academic level IV NICU, 50 beds with additional 21 step down beds
- Admits over 1000 babies annually with some of the highest rates of preterm birth <32 weeks in the state of North Carolina
- > 90% of ELBW babies are intubated and >50% are started on pressure controlled ventilation
- Retrospective review of ELBW infants born at VMC NICU from May - August 2016 shows 85% incidence of hypocarbia (CO2 <40) in the first week
- CLD rates – 53.6% compared to 33.3% (VON mean) in babies < 30 weeks

Factors of Change and Changes Made

PDSA Cycles

PDSA 1
Conducted literature review to establish relationship between hypocarbia and PVL, advantages of VTV versus pressure limited CV or high frequency ventilation in neonates. Interdisciplinary team established, confirmed rationale for improvement project, established selected population and timeframe for project.

PDSA 2
Conference held with neonatology providers regarding education/awareness of hypocarbia, education on the proper use of the VTV mode/initiation/weaning by ventilator company representative. Baseline data collected

PDSA 3
We identified that the lack of an adequate number of ventilators was a real impediment to progress. We then strategically reserved ventilators for ELBW infants since we were unable to acquire more ventilators within the targeted period.

PDSA 4
Survey was developed and sent out to staff to evaluate the attitudes of the staff towards the project and perceived/identified problems. The survey revealed that providers desired and required more education on the proper use of the VTV mode of ventilation.

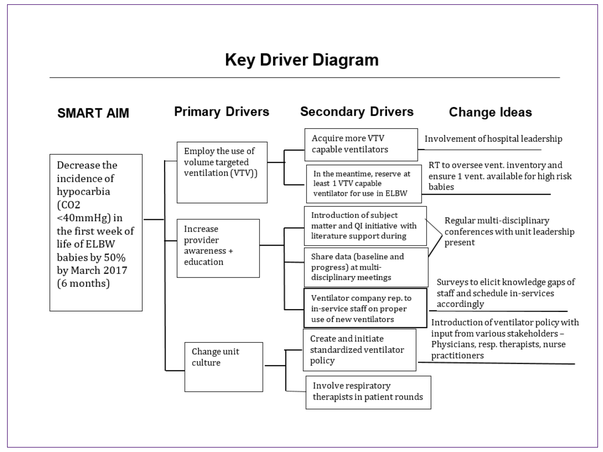
PDSA 5
Ventilator company representative was invited back for further education of staff. Further feedback and analysis of data suggested the need for a ventilator use protocol to help streamline the use of ventilators.

PDSA 6
Ventilator guidelines developed with plan to initiate soon.

Process Measures

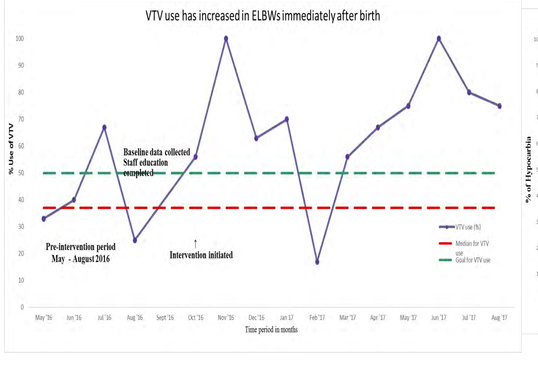
Outcome measure	Incidence of hypocarbia (a single blood gas with a CO_2 <40mmHg for any ELBW on a conventional ventilator during the first week of life	In all babies, values still around baseline with range from 83-100%. In the first few months of observation, a steady decline in the babies on VTV was observed, down to 50% but a rebound to 100% was noted in the last month. The number in babies on 'other' modes of ventilation has also begun to decline, now at 80% in the last month of observation.	Value obtained monthly by EHR chart review and compared between the different groups.	All data shared with staff during conferences. Senior leaders engaged with data.
Process measures	50% of ELBWs to be started on VTV	60-70% of ELBWs now started on VTV, compared to 42% at beginning of project	Value obtained monthly via EHR chart review	
	Hospital to acquire more VTV capable ventilators	2 additional ventilators acquired as of now, soon to be put into service	Measure obtained over the entire time span of project	
Balancing measures	Education of staff to increase awareness and risk of hypocarbia	62-93% (varied across disciplines) reported being aware of rationale or QI	Ensured at 3 different time points	
	Education of staff on the proper use of VTV capable ventilators	50-80% (varied across disciplines) reported comfort with starting ELBWs on VTV at birth	At the beginning of project and midway through the stipulated time frame	

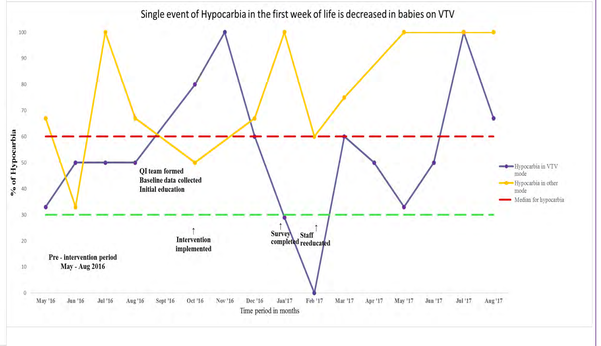
Drivers of change



RESULTS/OUTCOMES

Overall decrease in hypocarbia using VTV and increase in VTV use as shown:





DISCUSSION

The main objectives of our QI project were to increase use of Volume-Targeted Ventilators (VTV) and to decrease the incidence of hypocarbia in ELBW infants during the first week of life. We increased use of VTV from 37% to 60% during our 6-month study period. Our study also found VTV had lower rates of hypocarbia incidence when compared to other modes of ventilation, 54.8% and 70.4% respectively (during time constrained study period). However, we did not meet our goal of decreasing hypocarbia by 50% (goal of hypocarbia occurring in only 30% of ELBW infants) during the first week of life in our studied time frame.

There are several factors that affected our ability to meet all our predefined goals. The challenges of our study include limited amount of VTV on reserve, financial inability to acquire more, inadequate staff knowledge and comfort with initiating an infant on the VTV across all levels of providers, and ability to train staff on both shifts with the ventilator company representative. We developed several strategies to tackle each of these problems. As we establish a long-term protocol, we will continue to periodically assess our progress. In the several months after our officially study period ended in March 2017, we have continued to initiate VTV greater than 50% of the time and VTV continues to yield less incidence of hypocarbia when compared with other modes of ventilation in the same infant population.

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