DISCUSSION

Respiratory distress is a leading cause of morbidity and mortality in preterms and remains a major problem for clinicians and researchers in neonatology. (7) Mechanical ventilation remains an essential tool in treatment of respiratory distress, especially in preterm infants. Preterm infants represent the vast majority of all ventilated neonates. (13)

In spite of the widespread use of mechanical ventilation in the newborn since the 1960s, there is no clear evidence of an optimal ventilatory strategy for the preterm infant across different gestational ages and types of pulmonary disease. Technological advances in the design of mechanical ventilators and improved understanding of factors responsible for VILI have occurred over the past two decades, resulting in improving outcomes in extremely low gestational age infants (ELGANTs).

For more than three decades, neonatal ventilatory support has consisted of time-cycled pressure-limited ventilation with its associated complications of patient-ventilator asynchrony resulting in inefficient gas exchange, air leaks and increased risk of intraventricular hemorrhage.

As a result of the overwhelming evidence that excessive tidal volume, rather than high inspiratory pressure, is the primary determinant of lung injury. This finding has given rise to the concept of volutrauma, which is fundamental to understanding the concept of lung volume-pressure hysteresis and the mechanisms of VILI. (93-95) This led to attempts to use traditional VCV in preterm infants, which soon proved impractical because of technological limitations, including long response times, an ineffective triggering system and inability to deliver the small tidal volumes needed by preterm newborns. (13)

The introduction of microprocessor-based ventilators, leads it possible to ventilate even the smallest of babies using VCV. This use has been facilitated by the development of sensitive and accurate flow sensors and servo-controlled mechanics allowing accurate measurement and tracking of gas flow to avoid overexpansion (volutrauma) or underexpansion (atelectotrauma) of the lungs and damage attributable to airway flow that is too high or too low (rheotrauma). This development may have advantages particularly in newborns that have respiratory disorders in which lung compliance (and hence delivery of gas volume to the lungs) may rapidly change in response to the disease process or treatment, such as surfactant therapy. (96,108,114)

Because TCPLV and VCV have specific advantages, a hybrid form of ventilation (volume targeted ventilation) has been developed in an attempt to combine the best features of each. Volume-targeted ventilation is an essentially pressure-limited mode of ventilation that uses dual loop control to maintain tidal volume delivery in the target range. VTV is another addition to the already overwhelming array of options available on various ventilators. Volume targeted modes include VG, TTV, PRVC or VAPS. During VTV, the PIP set on the ventilator during the standard trigger modes acts as an upper limit for the PIP during VTV, while the ventilator attempts to deliver the set tidal volume using the lowest airway pressure possible. (96,108,114) A software algorithm for VTV is shown in the figure (25). According to this algorithm, the ventilator constantly attempts to deliver the tidal volume set by the operator. If the expired tidal volume measured by the ventilator is smaller than the tidal volume set by the clinician, and the ventilator cannot deliver the set tidal volume within the PIP limit set by the clinician, an alarm is triggered, suggesting that the clinician should increase the PIP limit, the inspiratory time, or flow, to deliver the set tidal volume. After breaths in which the measured expired tidal volume exceeds the set tidal volume, the ventilator uses a lower PIP during the next breath. This process of readjustment is repeated after every mechanical breath and the PIP delivered by the ventilator varies between the set PIP and PEEP. [97,123]

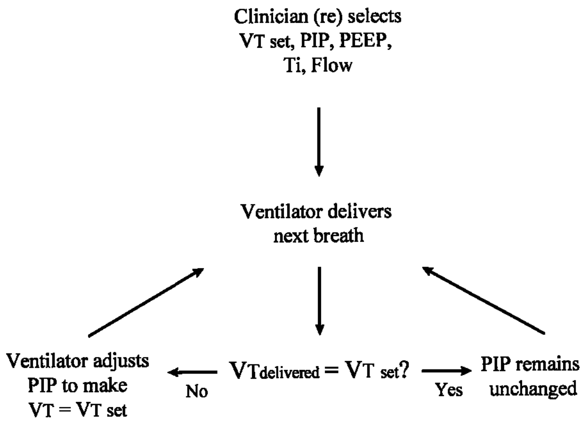

Figure (25): The Software algorithm of VTV

Therefore, VTV is a self-weaning mode, with the microprocessor continuously adjusting the working pressure to maintain the target VT and so it may reduce the chances of "volutrauma" which is considered to be a major component of Ventilator Induced Lung Injury (VILI).

The present study is a prospective comparative one that was conducted in the neonatal intensive care (NICU) at Alexandria university children's hospital (AUCH) on 60 newborn infants with gestational age 28-34 weeks from March 2013 to March 2014. They were divided in to 2 equal groups according to mode of ventilation:

- Group A (PLV group) ventilated with pressure limited time cycled ventilation as primary mode or secondary to failure of NCPAP
- Group B (VTV group) ventilated with Volume targeted ventilation using TTV software in SLE ventilators as a primary mode or secondary to failure of NCPAP.

Our study design was similar to keszler 2004 study, which was conducted on 18 neonates with < 34 weeks of gestation having RDS who needed to be ventilated within 6 hrs after birth and were divided equally according to mode of ventilation to (PLV and VTV). There were differences between both studies; first, our study used SLE 4000 and 5000 ventilators with TTV software to apply the VTV while keszler used volume guarantee mode in Drager Babylog 8000 plus ventilator. Second, patients with pneumonia were included in our study on the contrary to keszler's study. [99]

Our study was also similar to Duman et al study 2012, which was conducted on 45 neonates with (23 to 31) weeks of gestation who needed tracheal intubation within the 1st hour of life. The studied neonates were divided almost equally into 2 groups according to mode of ventilation to (22 PLV and 23 VTV). The differences between our study and theirs were the lower gestational age (23-31w.) assigned for their study and the ventilator used which was the Drager Babylog 8000 plus. Again, patients with pneumonia were included in our study on the contrary to Duman's study. (111)

In the current study, the results showed no statistically significant difference as regards the demographic characteristics and maternal data among the studied groups. (Table 1,2)

As for the resuscitation data, there was no statistically significant difference regarding the delivery room management between both groups. (Table 3)

In our study, the results showed no significant difference among the studied groups as regards the admission diagnosis, which was limited to 2 diagnosis (congenital pneumonia and RDS). (Table 4) This finding is consistent with previous studies that reported the principal differential diagnosis in the preterm infant with RD in the first 4 hours after birth are RDS and/or congenital pneumonia, as the two conditions may coexist. (124) Congenital pneumonia occurs perinatally or postnatally in about 1% of term neonates and from 10-28%for preterm infants in the NICU. The difficulty in diagnosing pneumonia especially when it coincides with RDS puts the clinician in a therapeutic dilemma. Sometimes it is impossible to differentiate between pneumonia and RDS radiologically. The difference between the initial diagnosis and the radiological diagnosis proves this point. The initial diagnosis among the PLV group showed 15 cases of congenital pneumonia while the radiological diagnosis of the same cases showed 16. Moreover the initial diagnosis among the VTV group showed 18 cases of pneumonia but the radiological diagnosis showed only 17 cases. (Table 5) This dilemma was confirmed by Shahri et al 2014 who reported chest radiography as one of the most usual and accessible diagnostic tools in respiratory distress in neonates, but inaccurate specificity and sensitivity in some disease must be considered. For pneumonia, radiography had 73% sensitivity and 87% specificity while for RDS the sensitivity and specificity were 35% and 82% respectively. (125) Moreover, Rocha et al 2011 assessed the agreement between clinical diagnosis of hyaline membrane disease (HMD) and lung necropsy pathological findings. They found that the clinical diagnosis of HMD needs a cautious interpretation, as it may be mistaken, or HMD may occur in association with other pathological situations enhancing a more ominous prognosis. The concordance between clinics and necropsy for the diagnosis of HMD was 43%. They further reported that 57% of clinically diagnosed HMD were associated to or were pneumonia, meconium aspiration or pulmonary hemorrhage. Moreover, 88% of the pneumonia cases were associated with histological chorioamnionitis. Some centers have the result of placenta histological examination in a few days after birth, and this may help in understanding the course of the disease and response to treatment. Therefore, it may help in the decision of keeping on or discontinue antibiotics. (126)

Neonatal pneumonia should always be suspected in preterm infants with respiratory distress especially when there are risk factors for sepsis such as prolonged rupture of the membranes (PROM), maternal fever, chorioamnionitis and when there are clinical signs such as early onset of apnoea, hypotension, poor tissue perfusion and metabolic acidosis.

In the present study, the mean values of heart rate, mean arterial blood pressure and temperature measured on admission for all the studied cases showed no significant differences among the studied groups. (Table 4)

Moreover, there was no significant difference between both studied groups as regards ABG, need for surfactant, compliance, resistance, C20 and alveolar arterial gradient on entry to the study. These results are similar to those of the studies done by Duman 2012 and singh 2006. That indicates similar severity in the lung pathology affecting both groups. The measured lung mechanics can be used to follow the optimality of ventilation and also provide parameters (flow-volume loop and pressure-volume loop), which are important for the clinical decision during ventilation (i.e. the selection of the ideal mode of ventilation and the set pressure and volume) and also for the prognosis and outcome. Moreover they can be used to follow the effects of surfactant therapy, fluid therapy and ductus arteriosus shunting therapy on the lung function. [(127)] (Table 5)

The initial ventilatory setting of the current study showed that the initial PIP and MAP were higher in the VTV group however that was statistically not significant. These results were in agreement with singh 2006 but both Duman and Keszler reported higher initial PIP and MAP in the PLV group unlike our study. Moreover we reported in our study non significantly higher initial FIO2 in the PLV group similar to Duman 2012, however keszler 2004 showed higher initial FIO2 in the VTV group. (Table 6) Furthermore, there was no significant difference between both groups regarding both the initial oxygenation and ventilation indices. That's similar to the studies done by singh 1997 and singh 2006 as regards oxygenation index. Oxygenation and ventilation indices are currently used to evaluate MV duration and/or the severity of ventilation disorders in pediatric patients, as well as to evaluate therapeutic interventions. High values of mean VI in both groups (>37) can be associated with prolonged duration of ventilation reflecting the severity of the ventilatory disorder and the need for support. (Group A 48.53 ± 19.25, Group B 59.0±21.68). [(117)] (Table 7)

In our study, The VTV group showed lower MAP and PIP in day 1 and statistically significant lower MAP and PIP in day 2. The percentage of decrease in both PIP and MAP in the VTV group from day 0 to day 1 was non significantly higher however it was significantly higher from day 0 to day 2. (Table 13,16) The VTV group showed significantly lower mean ETV in day 1 and non-significantly lower mean ETV in day 2 compared to the PLV group. (Table15) These results are similar to that reported by Cheema 2001 and Duman 2012. [(97,111)] The lower PIP and MAP used during VTV compared with PLV alone were not unexpected. During conventional trigger modes, the ventilator responds to the patient's inspiratory efforts by delivering a mechanical breath. The PIP used during each of these breaths is the PIP set by the operator. The tidal volume delivered to the patient is not taken into account by the ventilator and varies according to airway resistance, lung compliance, and the strength and duration of patient's inspiratory effort. Thus, unless PIP is frequently altered, inadvertently PLV may deliver small VT with the changing lung mechanics resulting in lower alveolar ventilation in infants with a relatively large anatomic dead space, thus requiring them to increase their respiratory effort in order to compensate for increased dead space ventilation. Conversely, PLV may deliver too high VT causing volutrauma and overriding the infant's inspiratory effort, allowing the ventilator to take over ventilation and thereby inhibiting the infant's own respiratory drive. In contrast, during VTV, the ventilator attempts to continuously compare expired tidal volume with the set tidal volume and reduces the PIP in subsequent ventilatory cycles if the expired (delivered) tidal volume exceeds the set tidal volume. [(97,123)]

The VTV group required significantly lower FIO2 in the first 2 days in comparison to the PLV group. Moreover, it showed significantly higher dynamic lung compliance in the first 2 days and significantly improvement in the lung compliance from day 0 to day 2 compared to the PLV group. That is explained by achieving better lung recruitment by the VTV leading to faster increase in the lung compliance and decrease in fio2 requirement. (Table 14,17)

In the current study, the PLV group had higher incidence of hypocarbic episodes during the course of ventilation than VTV group. (Table 8)The studies done by keszler 2004 and cheema 2007 similar to our study reported significantly lower incidence of hypocarbia in the volume targeted ventilated group. [(99,123)] During PLV, the tidal volume delivered to the patient is dependent on lung compliance and resistance, the patient's inspiratory effort, as well as the applied ventilator pressure. Improving lung mechanics, either because of surfactant administration or during recovery phase of RDS, can lead to delivery of inadvertently large tidal volumes. Large variations in tidal volume and alveolar ventilation not only raise the possibility of volutrauma, but if the problem is not recognized in time, could also lead to hypocarbia with its recognized deleterious effects on cerebral blood flow. On the contrary, during VTV, the ventilator attempts to continuously compare expired tidal volume with the set tidal volume and reduces the PIP in subsequent ventilatory cycles if the expired (delivered) tidal volume exceeds the set tidal volume.[(96,108,114)] Of note is the fact that neither hypocarbia nor excessively large or small VT was completely eliminated in the VTV group. This is explained by the fact that the VTV algorithm is designed to adjust working pressure incrementally over several breaths when responding to low VT. The response time is more than adequate to compensate for changes in lung compliance, but large breath-to-breath changes in infant respiratory effort e.g. hyperventilating vigorous infant cannot be fully compensated for individual breaths, and so VTV provides more stable minute ventilation decreasing the incidence of hypocarbia. [(99)]

Moreover, the PLV group in our study had higher incidence of non-permissible hypercarbia (respiratory acidosis) during the course of ventilation than VTV group. [(Table 8)] Unlike in our study, keszler and cheema studies showed no statistically significant difference in the incidence of respiratory acidosis between both groups. This may be explained by assigning heterogeneous lung pathologies (RDS and congenital pneumonia) in our study, unlike keszler and cheema studies, that only assigned RDS cases. Both RDS and congenital pneumonia are characterized by abnormal lung compliance. Although RDS is challenging to manage, but the administration of exogenous surfactant can significantly improve the biomechanical properties of the lung, thus facilitating mechanical ventilation and minimizing secondary lung injury. In contrast, patients with pneumonias are less likely to benefit from surfactant replacement and require heightened attention in the choice of mechanical ventilation strategies due to the inhomogeneous nature of these diseases, i.e. vastly different mechanical properties of the dependent and non-dependent lung regions. The actual distribution of lung injury is largely inhomogeneous, with inflammation, atelectasis and consolidation affecting primarily the dependent lung regions while the non-dependent lung regions are largely spared. It is the inhomogeneous distribution of lung disease that makes mechanical ventilation in pneumonia so challenging, as one may contribute unintentionally to further lung damage in what has been called ventilator-induced lung injury (VILI) i.e. (a strategy that is effective in opening damaged areas may result in over-inflation and trauma to more normal areas of the lung). And so in mechanical ventilation of pneumonia using PLV, the non-uniformly involved lung can show areas of over-inflation (volutrauma), atelectasis (atelectotrauma) and biotrauma affecting gas exchange causing respiratory acidosis and hypoxemia. [128]

The application of a lung protective strategy in patients using VTV can lead to the use of reduced tidal volumes to avoid volutrauma and the use of adequate PEEP to prevent atelectotrauma. Such an approach would theoretically promote ventilation in a "safe zone".[128]

In conclusion, in contrast to PLV, the use of VTV provided more stable tidal volume delivery achieving better lung recruitment decreasing both atelectotrauma and volutrauma in both RDS and congenital pneumonia

In our study, the VTV group showed higher incidence of successful extubation whether from 1st or 2nd trial in comparison to the PLV group (90%, 70% respectively) which was nearly significant (x^2 =3.75,p= 0.053). Successful extubation was defined as not requiring reintubation within 48 hours after the extubation attempt. Duman 2012 compared successful extubation in both groups within 48 hr. from birth. His study reported 60% successful extubation within 48 hr. in the VTV group in comparison to only 40% in the PLV group. (Table 9)

In the current study the VTV group showed statistically significant shorter duration of ventilation compared to the PLV group.(Table 10) This was similar to the studies done by keszler 2004, lista 2004,singh 2006+2009 and D'angio 2005 that showed lower duration of ventilation in the VTV group in comparison to the PLV group. This is explained by the fact that VTV is a self-weaning mode leading to weaning taking place in real time rather than in response to intermittent blood-gas sampling. [99,129]

There was no statistically significant difference between both studied groups concerning the duration of hospital stay (median 13 days in both group with range 2.0 – 40.0 in PLV and range 4.0 – 69.0 in VTV). (Table 10) These results were similar to that done by keszler 2004. In view of these results although the duration of ventilation is significantly lower in the vtv group in comparison to the plv group, there was no difference in the duration of the hospital stay due to presence of other factors that affects the duration of stay of the neonates in the NICU besides ventilation such as development of sepsis, NEC, BPD, IVH ……etc.

In our study, 70% of cases in both groups showed nosocomial infection (NI). (Table 12) The pressure limited group showed non-statistically significant higher incidence of VAP than the volume targeted ventilated group (23.3%, 3.3% respectively). This can be explained by the shorter duration of ventilation in the VTV group and so decreasing incidence of VAP. Moreover the PLV group had higher incidence of blood stream infection (70%) in comparison to the VTV group (56.7%). Nosocomial infections are one of the main causes of prolonged stay in the developing countries. NICU infection rates have increased worldwide during the past decade. The increasing number of technology-dependent infants is the primary determinant in the increase in NIs. VLBW, gestational age <29 weeks, birth outside the reference hospital, duration of mechanical ventilation, parenteral nutrition, and central catheters (umbilical artery/vein catheter, central venous catheter [CVC], percutaneous CVC) are reported as the risk factors for NIs. Resource-limited and overcrowded NICUs with poor nursing to patient ratios cause lack of adherence to infection control practices leading to overdependence upon antimicrobial agents and so encouraging the emergence of multi-drug-resistant nosocomial pathogens. The incidence of NI varies from 6% to 32% in the United States and from 8% to 10% in Europe- based studies. Nosocomial infection rates are 3-20 times higher in developing countries than in developed countries. The variation between the reports from different countries and centers results from not only the different healthcare practices and specific environment but also the non-standard definitions of NIs and from differences in patient populations with respect to mean gestational age, birth weight and severity of the underlying illness, which significantly affect the incidence of NIs. The comparison of device-related infection rates is more difficult because of the limited data from developing countries. (130)

In our study there was no statistically significant difference between both groups as regards the development of air leaks and BPD (3.3% for each variable in both groups). (Table 11) This is similar to the results reported by Piotrowski 1997, keszler 2004, singh 2006+2009, lista 2004, D'angio 2005 and Nafday 2005. However Piotrowski 1997 shower higher incidence of air leaks in the pressure limited group. This difference may be explained by our increased awareness of the importance of volutrauma in development of air leaks and BPD that led to more monitoring of the tidal volume given in pressure limited ventilation. The low incidence of air leaks and BPD in the VTV group can be attributed to the safety of VTV in preventing lung injury from volutrauma.

The most common cause of air leak syndrome is mechanical ventilation on the fragile and immature lungs. Therefore, air leak syndrome occurs more routinely during the neonatal period than any other age, and the incidence is inversely related to the birth weights of newborn infants. Air leak syndrome occurs in 1% to 2% of all newborns, and the incidence rises to as high as 40% among infants on mechanical ventilation in some situations and is the highest in the infants with meconium aspiration syndrome. (131)

The mechanical support required by ventilator dependent preterm infants varies from minute to minute because of the spontaneous changes in inspiratory effort and sudden changes in respiratory compliance and resistance associated with breath-holding and active expiration. Slower changes in lung mechanics can occur with development or resolution of atelectasis, pulmonary edema, and accumulation of secretions in the airway. During PLV, these varying conditions are met with a constant PIP regardless of the tidal volume achieved. The PIP is chosen to provide stability of gas exchange throughout these changing conditions, and, therefore, pressure settings are usually higher than those required. This increases the risks of ventilator-induced lung injury and may result in air leaks, BPD and hypocarbia. VTV was developed to maintain a minimal preset tidal volume (VT) by microprocessor- controlled PIP adjustments. The automatic PIP adjustments during VTV are determined by the difference between set and exhaled VT. The proposed mechanism by which VTV may benefit mechanically ventilated preterm infants is by ensuring a tidal volume close to a physiologic level, which would result in a more efficient use of their spontaneous inspiratory effort. Down regulation of PIP when VT remains at or above the physiologic level releases the infant's own respiratory drive from the suppression caused by superimposed ventilation and averts over-inflation pressures that increase the risk of baro- and volutrauma reducing the risk of air leaks and BPD. In addition, prevention of excessively low tidal volumes, attributable to sudden deterioration in the mechanical characteristics of the respiratory system, can preserve alveolar gas exchange and prevent atelectasis. (102)

In our study there was no statistically significant difference between both groups as regards incidence of development of IVH, although higher incidence of IVH were noted among the pressure limited ventilated group (group A) especially IVH grade 3 and 4. (Table 11) These results were similar to the study done by D'angio 2005 which reported higher incidence of IVH in the pressure limited group especially IVH grade 3 and 4. This can be explained by shorter duration of ventilation in VTV group. Hany et al 2011 in that study concluded that the duration of ventilation is one of the main determinants of severe IVH.(132) Moreover VTV provided more stable minute ventilation and PaCO2 evidenced by lower incidence of hypocarbia and respiratory acidosis leading to decreased fluctuations in cerebral blood flow and so decreases the risk of brain injury. Mechanical ventilation can directly or indirectly affect CBF via modulating cardiac output by impeding venous return or via changes in the acid-base balance. Impedance of venous return may result from elevated mean airway pressure, which can result in increased central venous pressure and, therefore, increased intracranial venous pressure. Moreover, mechanical ventilation can result in hypocapnic and hypercapnic episodes leading to fluctuation in CBF. Prolonged exposure to these fluctuations with prolonged mechanical ventilation presumably results in repeated insults throughout the course of intensive care. (26) Fabres et al 2007 reported that both extremes and fluctuations of PaCO2 are associated with increased risk for severe intraventricular hemorrhage. (133)

In our study there was no statistically significant difference between both groups as regards incidence of development of PDA. (Table 11) This is similar to the studies done by lista 2004 and singh 2006+2009,although they reported higher incidence of PDA than our study (lista 2004 (80%) and singh 2006+2009 (30%) in both groups). the difference may be explained by the fact that their studied neonates gestational age were from 24 to 32 weeks while our studied neonates were from 28 to 34 weeks. (96,105)

This study points that the choice of mechanical ventilation strategy influences the progression of lung injury in premature infant with respiratory distress. Despite different ways to provide a pre-specified tidal volume, all these modalities, which use different devices, have in common an objective to control tidal volume delivery in an attempt to provide optimal lung inflation. Stability of tidal volume delivery proved to be beneficial, especially in very low birth weight infants, who are at increased risk of sustaining complications associated with mechanical ventilation. This is further supported by the findings of Cochrane review showing a significant beneficial effect of volume-targeted ventilation in the newborns. (113)

The ideal mode of ventilation should maintain adequate and consistent tidal volume and minute ventilation at low airway pressures. It should be able to respond quickly to sudden or unpredictable changes in pulmonary mechanics or patient demand. It should provide the lowest possible work of breathing for the baby. The use of VTV achieved adequate gas exchange using lower MAP and with less variability in tidal volume thus reducing the risk of volutrauma. It would appear that the consistency of tidal volume delivery during VTV in the face of varying lung compliance, variable respiratory drive and the auto weaning of airway pressure was clinically advantageous, especially in conditions in which lung compliance changes rapidly, such as after surfactant treatment of RDS.

The ideal ventilator is one that achieves all of the goals of mechanical ventilation. It should provide a variety of modes and modalities that can ventilate even the most challenging pulmonary diseases like what we face daily in our NICU. It must have monitoring capabilities to adequately assess ventilator and patient performance and interaction. It must also have safety features and alarms that offer lung protective strategies. Finally, it should be operated by an experienced clinician who continues to ask the right questions and seek the right answers.

SUMMARY

Respiratory distress (RD) is a leading cause of morbidity and mortality in preterms and remains a major problem for clinicians and researchers in neonatology. Mechanical ventilation (MV) remains an essential tool in treatment of respiratory distress, especially in preterm infants. Preterm infants represent the vast majority of all ventilated neonates.

In spite of the widespread use of mechanical ventilation in the newborn since the 1960s, there is no clear evidence of an optimal ventilatory strategy for the preterm infant across different gestational ages and types of pulmonary disease. Technological advances in the design of mechanical ventilators and improved understanding of factors responsible for ventilator-induced lung injury (VILI) have occurred over the past two decades, resulting in improving outcomes in extremely low gestational age infants (ELGANTs).

For more than three decades, neonatal ventilatory support has consisted of PLV with its associated complications of patient-ventilator asynchrony resulting in inefficient gas exchange, BPD, air leaks and increased risk of intraventricular hemorrhage.

As a result of the overwhelming evidence that excessive tidal volume, rather than high inspiratory pressure, is the primary determinant of VILI, This led to attempts to use traditional VCV in preterm infants, which soon proved impractical because of technological limitations. The introduction of microprocessor-based ventilators led to development of a hybrid form of ventilation (volume targeted ventilation) in an attempt to combine the features of both PLV and VCV. Volume-targeted ventilation is an essentially pressure-limited mode of ventilation that uses dual loop control to maintain tidal volume delivery in the target range. VTV is another addition to the already overwhelming array of options available on various ventilators. The PIP set on the ventilator during the standard trigger modes acts as an upper limit for the PIP during VTV, while the ventilator attempts to deliver the set tidal volume using the lowest airway pressure possible. Moreover VTV is a self-weaning mode, with the microprocessor continuously adjusting the working pressure to maintain the target VT.

The aim of the study was to evaluate the efficiency of volume targeted versus pressure-limited ventilation for preterm infants with respiratory distress. To achieve this goal, 60 newborn infants with gestational age 28-34 weeks fulfilling the inclusion criteria were ventilated with either volume targeted ventilation (VTV) or pressure limited time-cycled ventilation (PLV) as primary mode or secondary to failure of NCPAP.

The 2 groups enrolled in this study were subjected to thorough history taking, full physical examination, laboratory investigations, ABG, chest radiographs, echocardiography and cranial U/S.

The demographic characteristics, the clinical characteristics, the respiratory and ventilatory status of each group at time of randomization were similar

During the course of ventilation, the PIP, MAP and FIO2 levels showed a significant decrease and the dynamic lung compliance showed significant increase in the VTV group during the first 48 hrs. The VTV achieved adequate gas exchange using lower MAP and with less variability in tidal volume thus reducing the risk of baro- and volutrauma. The

VTV group showed significantly lower incidence of hypocarbia and non-permissible hypercarbia and so decreasing the fluctuation in the cerebral blood flow and its associated complications. The VTV group showed significantly shorter duration of ventilation and so decreasing ventilator induced lung injury and its associated complications. There was no statistical significant difference between both groups as regards IVH, air leaks, BPD, PDA and nosocomial infection.

The ideal mode of ventilation should maintain adequate and consistent tidal volume and minute ventilation at low airway pressures. It should be able to respond quickly to sudden or unpredictable changes in pulmonary mechanics or patient demand.

VTV in the current study was shown to result in lower PIP and MAP and to be an effective mode of mechanical ventilation. Our data support the hypothesis VTV can reduce the incidence of hypocarbia and respiratory acidosis and maintain VT within target range more consistently than PLV alone in both homogenous lung pathology (RDS) and non homogenous lung pathology (congenital pneumonia). Additionally, VTV is a self-weaning mode, with the microprocessor continuously adjusting the working pressure to maintain the target VT. Therefore; weaning takes place in real time, rather than in response to intermittent blood-gas sampling

It would appear that the consistency of tidal volume delivery during VTV in the face of varying lung compliance, variable respiratory drive and the auto weaning of airway pressure is clinically advantageous, especially in conditions in which lung compliance can change rapidly, such as after surfactant treatment of RDS.

The ideal ventilator is one that achieves all of the goals of mechanical ventilation. It should provide a variety of modes and modalities that can ventilate even the most challenging pulmonary diseases like what we face daily in our NICU. It must have monitoring capabilities including pulmonary graphics to adequately assess ventilator and patient performance and interaction. It must also have safety features and alarms that offer lung protective strategies. Finally, it should be operated by an experienced clinician who continues to ask the right questions and seek the right answers.

CONCLUSION

The results of our study suggest that

- The VTV (targeted tidal volume (TTV) in SLE 4000 and 5000) when combined with patient triggered pressure limited ventilation adheres very closely to the proposed theoretical VTV algorithm and this appears to achieve highly effective ventilation and potentially enables the use of lower airway pressures.

- Despite different ways to provide a pre-specified tidal volume, all these modalities, which use different devices, have in common an objective to control tidal volume delivery in an attempt to provide optimal lung inflation.

- The use of VTV in the current study resulted in lower PIP and MAP and proved to be an effective mode of mechanical ventilation. Our data support the hypothesis VTV can reduce the incidence of hypocarbia and respiratory acidosis and maintain VT within target range more consistently than PLV alone in both homogenous lung pathology (RDS) and non homogenous lung pathology (congenital pneumonia). Additionally, TTV is a self-weaning mode, with the microprocessor continuously adjusting the working pressure to maintain the target VT. Therefore, weaning takes place in real time, rather than in response to intermittent blood-gas sampling.

- The consistency of tidal volume delivery during VTV ventilation in the face of varying lung compliance, variable respiratory drive and the auto weaning of airway pressure was clinically advantageous, especially in very low birth weight and preterm infants, who are at increased risk of sustaining complications associated with mechanical ventilation

- Lack of blinding surely constitutes a limit to this study but this did not interfere with the results we reported. Moreover, knowledge of group assignment was never a factor in the decision to modify ventilatory strategy, weaning or extubation for which precise rules exist in our Nicu.

- Further studies are needed to identify whether VTV modes improve neurodevelopmental outcomes and to compare and refine VTV strategies.