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Neonatology

A Retrospective Pilot Study on the Effect of Volume Gurarantee on High Frequency Oscillatory Ventilation in Neonates

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Abstract **Original Research Article**

Because of improved survival rate of low birth weight infants (LBW), there is increasing need of safe ventilation. Conventional ventilation is associated with ventilation induced lung injury (VILI). High frequency oscillatory ventilation (HFO) reduces VILI as it uses subphysiological tidal volume. Preclinical studies have shown that more effective stabilization of DCO2 can be achieved by combining volume guarantee to high frequency ventilation, as in HFO VG tidal volume can be directly controlled. This study is done to evaluate the clinical applicability of this finding of preclinical studies by analyzing the ventilation parameters and physiological parameters of those newborns who are ventilated on HFO or on HFO VG. In this retrospective study neonates ventilated on HFO or HFO VG in the year 2018 were identified and data collected from medical records. Twelve neonates were included in the study. Six of them received high frequency ventilation and other 6 were ventilated on HFO VG mode. VThf (tidal volume in high frequency) were almost same in both groups (1.94 in HFO and 1.9 in HFO VG). It is found that fluctuations in DCO2 (diffusion coefficient of CO2) was less in HFO VG group (SD 43.44 & 92.58 P value0.015). Also babies on HFO VG had better SpO2 values (95.67, 85.83 p value 0.05) and lesser fluctuations in SpO2 (SD 7.0 & 13.64) indicating better oxygenation and lesser hypoxia in HFO VG group. This pilot study suggests VG combined with HFO reduces fluctuations in DCO2 and SpO2.

Keywords: Volume guarantee, high frequency oscillatory ventilation, new born, ventilator induced lung injury, subphysiological tidal volume.

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INTRODUCTION

The improved survival rate of low and very low birth weight infants have led to the need for safe and adequate ventilation to these infants who have structurally and functionally immature lungs. The most important aspect of providing safe ventilation is low tidal volume ventilation. This idea of gentle ventilation is being partially fulfilled by volume targeted conventional ventilation. High frequency oscillatory ventilation and volume guaranteed HFOV are more promising in prevention of VILI. The key difference between HFOV and conventional ventilation is that in HFO unusually low tidal volume and high frequency is being used. The large cyclic change of tidal volume in conventional ventilation is an important factor causing VILI, which also contributes to neonatal mortality and morbidity. In HFOV VG large swings of tidal volume is prevented with additional benefit that the operator has the opportunity of directly adjusting the tidal volume according to the need of the neonate thus can directly control ventilation. Maintaining stable DCO2 in HFOV requires manual fine tuning of delta P and frequency. By adding volume guarantee to HFO, delta P is automatically adjusted to maintain desired tidal volume and so stable DCO2 is maintained more effectively. While using HFO without volume guarantee it is recommended to set the frequency as high as possible while not compromising VThf, to minimize barotrauma [1]. However with activation of VG mode it is possible to combine best frequency and VThf and thus can be a preventive strategy to reduce lung damage [2]. In HFO pressure and volume swings are attenuated as the gas moves towards the alveoli so that volume changes may not be large enough to induce volutrauma [3]. Poorly controlled ventilation resulting in either hypercapnea or hypocapnea can induce changes in cerebral arterial blood volume [4] and is also found to be associated with increased incidence of intraventricular hemorrhage [5]. VG applied to HFO theoretically allows VThf to remain stable with an automated adjustment in pressure

amplitude when the lung and airway conditions are changing and thus achieving stable ventilation.

Till now there are many preclinical studies comparing HFOV and volume guaranteed HFOV done in animal models [6, 7]. Data from these preclinical studies in normal and surfactant depleted lungs have demonstrated the feasibility of HFO VG in directly controlling VThf and reduced production of inflammatory mediators involved in ventilation associated lung injury. Sanches *et al*., [7] showed a drop in PCO2 from 60±11 to 50±8, when ventilation mode changed from HFOV to HFO-VG. They also suggested that volume guaranteed HFO can stabilize PCO2 through stable DCO2. In HFO VG more control over CO2 washout was possible with lower tidal volume. It has been proved that HFO VG is associated with reduction in cytokine mediated lung inflammation as compared to conventional ventilation [8]. The flow volume scalars from computational studies [9] have shown that the tidal volume increases in the first 4 breaths at initiation of HFO VG ventilation and then remains static which again explain the reason for reduced chances for volutrauma in high frequency ventilation and in HFO VG [10]. But there are only a few clinical trials comparing HFOV and HFO-VG [11-14]. The results of these clinical studies were in parallel to preclinical trials. But most of them are short term cross over trials. In this retrospective study the clinical applicability of HFO VG is analyzed by looking at the effect of adding volume guarantee to HFOV in stabilizing ventilator parameters and physiological parameters of the neonates.

MATERIALS AND METHODS

Neonates ventilated with high frequency oscillatory ventilation with and without volume guarantee at Jubilee Mission Medical College Hospital NICU in the year 2018 were identified from the medical records and the data is used for analysis. Statistical analysis was performed using SPSS software programme. Data are expressed as mean or standard deviation. Statistical significance was set at P<0.05.

RESULTS AND DISCUSSION

Twelve neonates were included in the study. Six of them received high frequency ventilation and other 6 were ventilated on HFO VG mode. VThf (tidal volume in high frequency) were almost same in both groups (1.94 in HFO and 1.9 in HFO VG). It is found that fluctuations in DCO2 (diffusion coefficient of CO2) was less in HFO VG group (SD 43.44 & 92.58 P value0.015). Also babies on HFO VG had better SpO2 values (95.67, 85.83 p value 0.05) and lesser fluctuations in SpO2 (SD 7.0 & 13.64) indicating better oxygenation and lesser hypoxia in HFO VG group.

All twelve babies included in the study were initially on volume targeted conventional ventilation changed over to high frequency as a rescue mode. The cohorts were found to have identical gestational age distribution (Figure1 & 2).

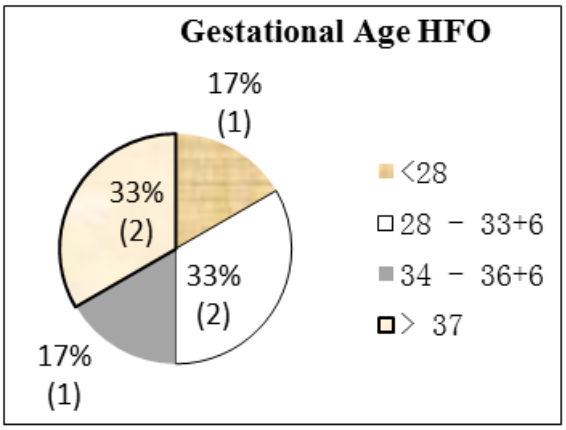

Fig-1

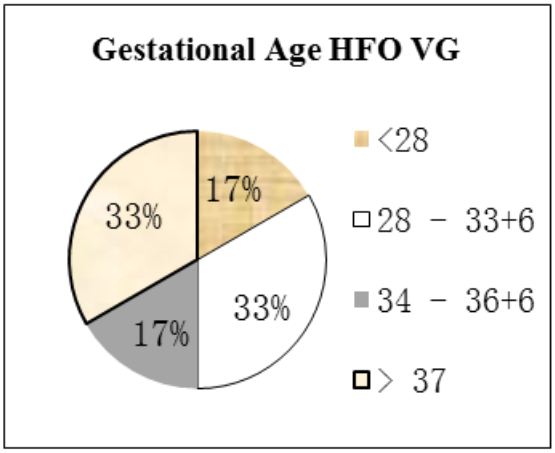

Fig-2

Among the babies in HFO VG group, 66.6% received surfactant and 50% in HFO group.41% of the babies were outborn and postnatally referred to us.

For intubation endotracheal tube size was selected according to the birth weight of each baby and high frequency ventilation is delivered either by SLE5000 or VN500 ventilator. While starting HFO initial MAP was selected as 2 digit higher than the MAP used in conventional ventilation and alveolar recruitment done to achieve adequate oxygenation. Initial delta P for HFO was set to get adequate wiggling whereas in HFO VG required tidal volume is set and ventilator adjusts delta P to maintain the set tidal volume. Adequacy of ventilation is then confirmed by blood gas first at 1 hour of ventilation and then 6th hourly. VThf (tidal volume in high frequency) were almost same in both groups (1.94 in HFO and 1.9 in HFO VG).Better ventilation was found in HFO VG group with same tidal volume than HFO group. It is found that fluctuations in DCO2 (diffusion coefficient

of CO2) was less in HFO VG group (SD 43.44 & 92.58 P value0.09) Figure-3. Though the association was not statistically significant, DCO2 had more fluctuation in babies without volume guarantee, indicating more stable ventilation in HFO VG group as compared to babies on HFO.

Mean Pco2 was noted to be low in HFO VG group indicating better ventialion in babies ventilated with HFO VG(37.9,47.5 P value 0.19) Figure-5. There was remarkable reduction in PCO2 with any increase in VThf in babies with volume guaranteed HFOV.

Also babies on HFO VG had statistically significant SpO2 values (95.61 &85.83 Pvalue 0.05) and lesser fluctuations in SpO2 (SD 7.02 & 13.64) (Figure-4) indicating better oxygenation and lesser hypoxia in HFO VG group. These results are consistent with previous cross over trials with HFO VG [12, 13].

HR (heart rate) was also found to be more stable in HFO VG group (129 &142 P value 0.005). Statistically significant association noted here indicates that patient tolerance is better in HFO VG as compared to HFO Figure-6.

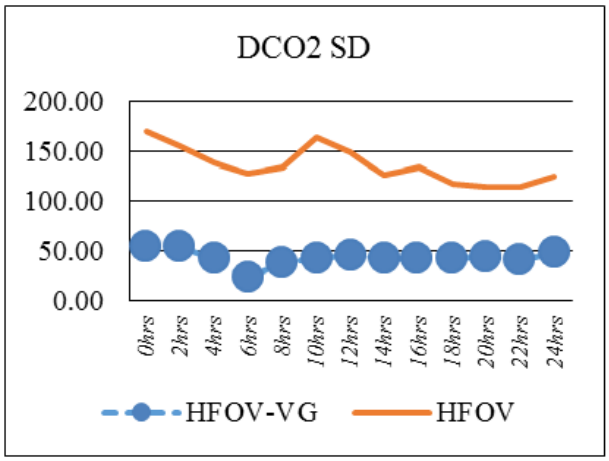

Fig-3

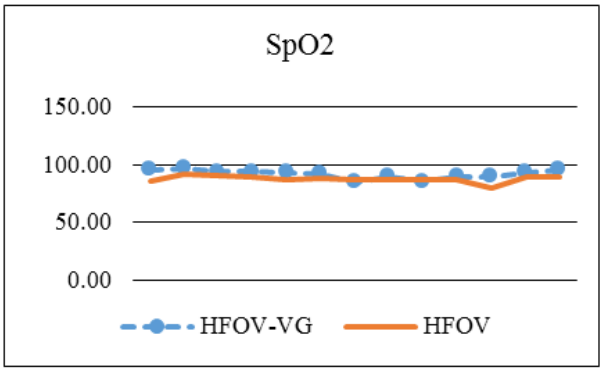

Fig-4

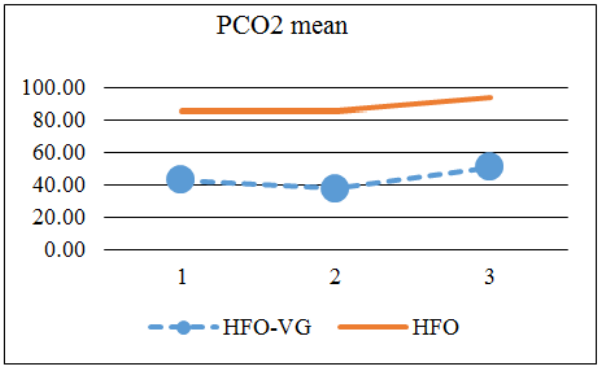

Fig-5

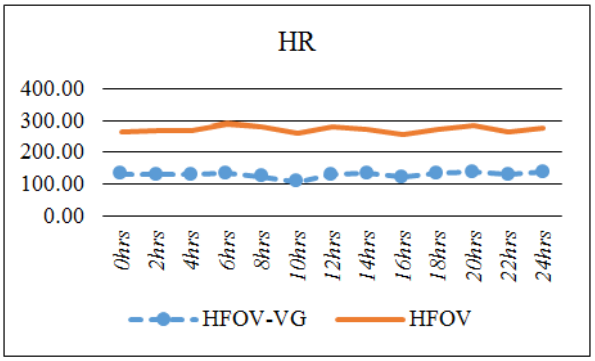

Fig-6

As in HFO tidal volume is the product of Vthf [2] and frequency, one challenge in using HFO without volume guarantee has been unwanted fluctuations in tidal volume, DCO2 and PCO2 according to the changes in the lung condition of the neonate. These fluctuations can cause serious cerebral hemorrhage. In this study though the association is not statistically significant, promising stabilization of DCO2 and PCO2 are seen with HFO VG.

As this being a retrospective study, obviously there was no randomization or matching was done between the groups. So the difference between the groups like the basic underlying disease condition would have influenced the results. This study has only looked at the short term effects of HFO VG in neonates. The effect in mortality rate, incidence of intraventricular hemorrhage, long term effect in terms of neurodevelopmental outcome and reduction of chronic lung disease of prematurity are the other factors which need to be followed up.

CONCLUSION

The use of HFOV combined with VG ventilation allows the intensivist to directly set the VThf instead of ΔPhf to modify CO2 removal from the lung and thus have direct control over ventilation. A significant decrease in PCO2 with any increase in VThf was found with volume guaranteed HFO. This study suggest that HFO VG attenuates fluctuations of SpO2, PCO2 and DCO2 and is effective in maintaining

adequate ventilation with minimal lung injury, along with good oxygenation. The babies on HFO VG group also had better SpO2 levels measured by pulseoximeter and fewer episodes of hypoxia. Therefore HFO VG is a promising ventilation option in neonatal intensive care units as a lung protective ventilation strategy for reducing the morbidity and mortality in sick neonates requiring ventilation.

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