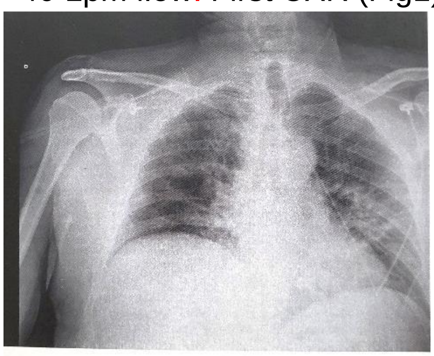
Case Report

High Frequency Percussive Ventilation Used as a Recruitment Therapy for a COVID-19 Patient on ECMO

David Schramme, RT ICU ZOL Genk, Belgium

A 67 year old male with a medical history of nose surgery, arterial hypertension, and multiple myeloma (with a good prognosis) was admitted to our hospital with diagnosis of COVID-19. Due to his high oxygen needs the patient was initially placed on a Vapotherm® high flow nasal cannula (Vapotherm, Exeter, N.H., USA) at FiO2 60% and 40 Lpm flow. First CXR (Fig1) when placed on Vapotherm.



(Fig 1)

After slightly less than 24 hours of high flow nasal cannula therapy, the patients increasing respiratory distress necessitated intubation for higher support. He was ventilated with a Drager Evita® XL ventilator (Drager, Lubeck, Germany). Ventilator settings were FiO2 60%, Autoflow Vt 420, RR 25, PEEP 15 cm/H2O.

CXR post bronchoscopy showing increasing bilateral infiltrates (Fig 2). Over the course of the next 11 days patient was managed by attempting various ventilator modes and settings. On day 7 (11/21/2020) Continuous Veno-Venous Hemofiltration (CVVH) was started because of increasing renal failure. In addition to the COVID-19 diagnosis, sputum culture showed Escherichia Coli pneumoniae on 11/22/2020. The patient continued to have increased need of FiO2 and showed increasing PaCO2, decreasing chest compliance (avg 35 cm/H2O) and lowering of blood pressure. On Day 11 (11/25/2020), the patient developed worsening of the hemodynamic and respiratory status. CXR revealed a pneumomediastinum and subcutaneous emphysema, (Fig 3). During the night of 11/26/2020 we saw further deterioration of the patient with increasing need of FiO2 up to 100% as well as increasing subcutaneous emphysema and a pneumomediastinum. Chest compliance was down to 20 cm/H2O.

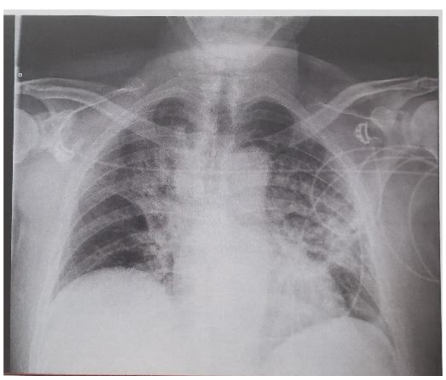
Patient was proned at this point and the ventilator was switched from SPN-CPAP/PS to VC-MMV and autoflow with compliance rising to 50 cm/H2O . By 6:30 am on 11/27/2020 in supine position again, the CXR showed improvement of the pneumomediastinum but increasing lung consolidation. (Fig 4) At 12:00 noon on 11/27/2020 bilateral chest tubes were placed, and extracorporeal membrane oxygenation (ECMO) was started: VV-ECMO settings were FiO2 of 100%, blood flow of 5L and sweep flow of 6L. (Fig 5)

By 11/28/2020 (day 14) the patient was in septic shock with hyperdynamic circulation. VV-ECMO settings at 100% FiO2, blood flow 4.7L, sweep flow 6L. The ventilator was switched from VC-MMV with autoflow back to SPN-CPAP/PS. Compliance was down to 15 cm/H2O, Fio2 70%. A second bronchoscopy was performed which showed atelectasis of the left lung with a large amount of sputum and bloody clots but without full obstruction. Active bleeding in the left hemithorax was drained by chest tube. By day 16 (11/30/2020) the patient was still on VV-ECMO with blood flow 5.1L, sweep flow 8L, FiO2 90% and ventilation was SPN-CPAP/PS. CT scan showed full consolidation of the left lung. A third bronchoscopy was performed only showing some old blood clots .

On day 17 (12/01/2020) at 07:00 am, the ventilator settings were SPN-CPAP/PS with a of FiO2 80%, a respiratory rate of 16, PEEP 8, and a PS of 18 . VV-ECMO settings were blood flow 5L, sweep flow 6L and FiO2 90% . The CXR showed continued consolidation of the left lung . Sputum culture showed an Aspergillus infection on 12/01/2020. After discussion within the staff, High Frequency Percussive Ventilation (HFPV) was started as a recruitment therapy using the IPV-2C (Percussionaire Corporation, Sandpoint, ID, USA). Therapy was started with the IPV2C directly connected to the endotracheal tube, without working in line with the ventilator, for a 90 minute continuous treatment, Q 12 hours. Treatment was continued for 4 days. CT scans below document the changes pre-IPV and post-IPV. (Fig 6 & 7). Immediately after the first treatment , nurses were able to suction approximately twice as much sputum from the endotracheal tube. In the late afternoon after a second treatment, we were able to reduce the FiO_2 on the ventilator from 80% to 30%. . We were also able to reduce the sweep flow from 6 l to 5 l and the FiO_2 from 90% to 85% on the VV-ECMO.

By the evening of day 18 (12/02/2020) after 4 IPV treatments, the ventilator settings were the same and VV-ECMO FiO_2 was down to 70%. CXR shows better aeration of the left upper lobe and right lower lobe with better visualization of right diaphragm (Fig 8)

By day 20 (12/04/2020) after 4 days of Q 12, 90 minute IPV treatments the CXR improved significantly (Fig 9) with both ventilator and VV-ECMO FiO_2 settings at 45%. Unfortunately, the patient became more septic and hemodynamically unstable with increasing ascites and rising lactate levels. On day 23 (12/07/2020) the patient went for an explorative laparotomy witch showed sigmoid perforation and fecal peritonitis. Sigmoid resection and omentectomy were performed. The next day, the patient became more hemodynamically unstable, requiring significant transfusions. It was decided to stop all therapies and patient expired shortly after. The last CXR on 12/08/2020 showed continued improvement in all lung fields. (Fig10)



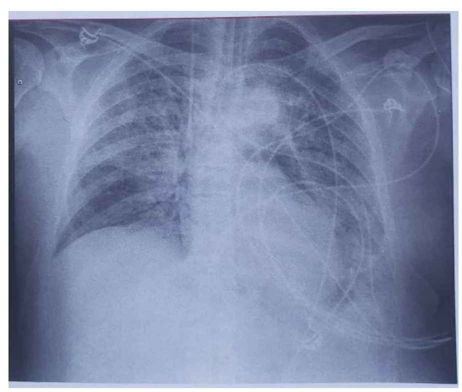


Fig 2. CXR just prior to intubation

Fig 3. pneumomediastinum & subcutaneous emphysema

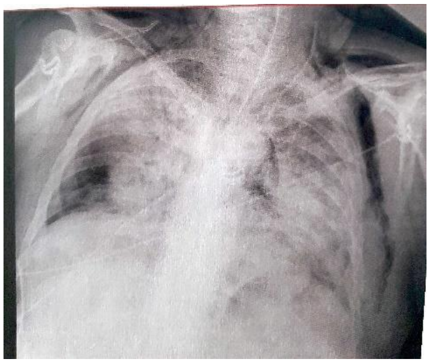


Fig4. Supine before ECMO

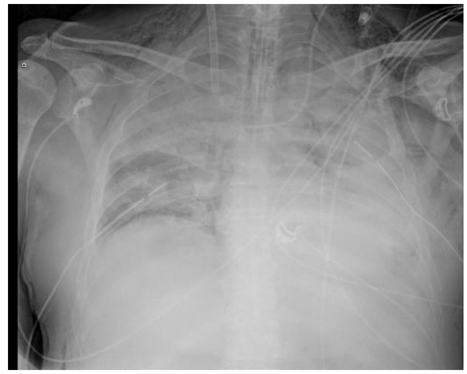


Fig 5. Post chest tube placement, start of ECMO

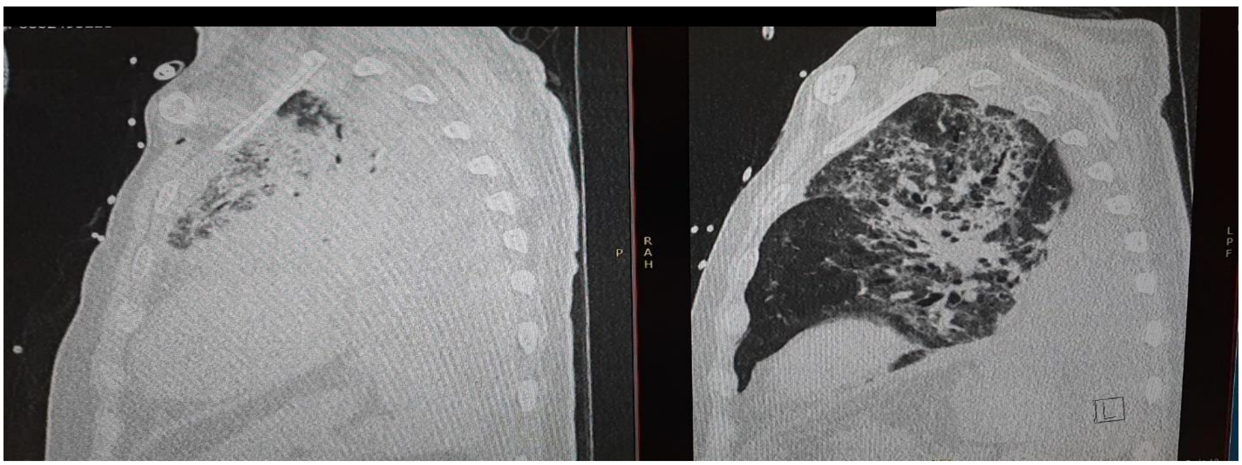
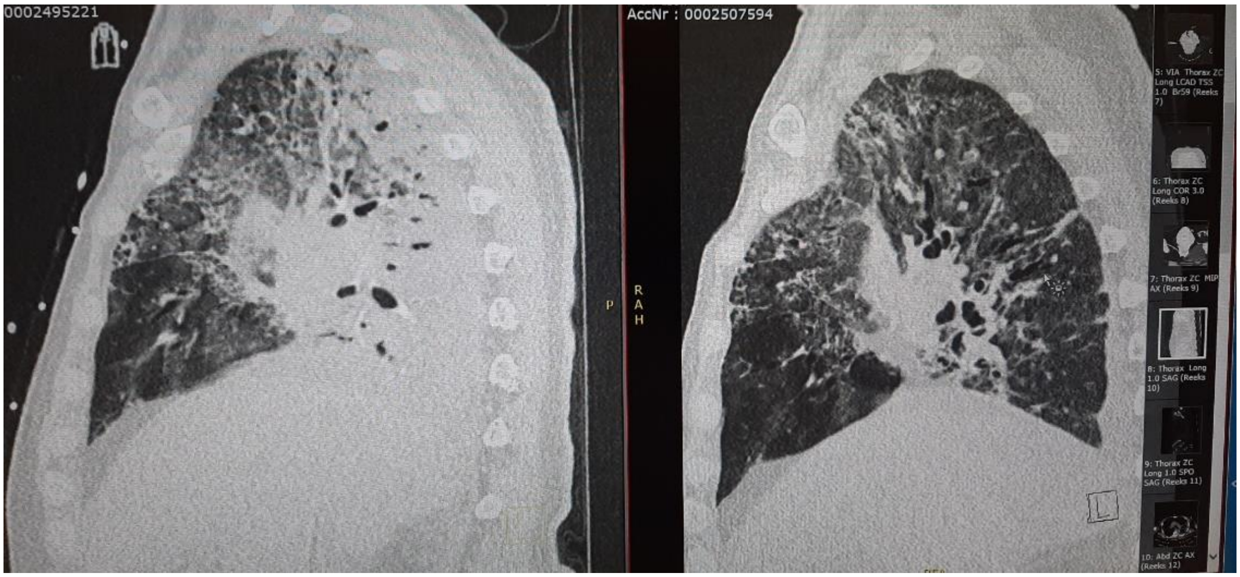
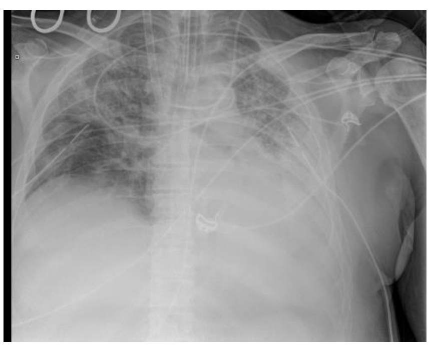


Fig 6 11/30/2020 CT scan left lung 12/07/2020 CT scan left lung



(Fig 7) 11/30/2020 CT scan right lung 12/07/2020 CT scan right lung



(Fig 8) 12/02/2020

(Fig 9) 12/04/2020

(Fig 10) 12/08/2020

Discussion

Management of COVID-19 remains multi-pronged and highly variable between patients. The main focus has been to prevent potentially fatal complications from respiratory failure and ARDS due to severe COVID-19 pneumonia. Other complications arise frequently from cardiac failure and coagulopathies. High flow nasal oxygen has shown promise for managing adults with SARS-CoV-2. Nevertheless, for many patients presenting with clinical deterioration, impending respiratory failure, high inflammatory markers, and increasing opacification of lung fields, mechanical ventilation remains the only option. It is important to undertake prompt therapeutic measures to reduce interstitial and intra-alveolar edema and to recruit collapsed alveoli, decreasing intrapulmonary right to left shunting and improving oxygenation without causing lung over-distention.

This can be challenging. Extracorporeal membrane oxygen (ECMO) is often employed early on, to rest the lung and allow for the SARS-CoV-2 viral pneumonia to resolve. In this patient, complicated by the Escherichia Coli pneumonia and Aspergillus fungal lung infection, resting" ventilator settings could not prevent consolidation of the left lung. Intrapulmonary percussive ventilation, IPV, uses high frequency percussive ventilation (HFPV) as a therapy. HFPV has been proven to clear the airways of excessive secretions and restore functional residual capacity (FRC). HFPV can be used both as a therapy in the case of IPV or as a mode of ventilation with the VDR® ventilator. It works by use of the Phasitron® (Percussionaire Corp, Sandpoint, ID) which automatically adjusts to the conditions of resistance and compliance of the lung. There is evidence that the high rate along with high velocity, low pressure micro pulses of the Phasitron,

deliver an optimum volume to the heterogenic lung fields while avoiding overdistention. For this reason, we decided to use our IPV device in a novel manner by giving prolonged treatments rather than the usual 20 minutes treatment. We felt that the longer treatment would give more time for alveolar recruitment and reestablishment of the FRC of the patients lungs. It was the ideal way to recruit the dorsal parts of the lung without the need of turning the patient on ECMO in prone position.
After the IPV treatments were started we noticed an increased amount of secretions suctioned from the patient and decreasing oxygen requirements. Chest x-rays and CT scans consequently showed decreased atelectasis and improved aeration of the lung fields.

Conclusion
In this patient, the use of high frequency percussive ventilation via the IPV-2C succeeded in recruiting collapsed alveoli while conventional ventilation did not, and without the necessity of proning what is more complicated certainly for a patient on ECMO
Though the patient expired, death was due to other comorbidities i.e., sepsis, and overwhelming coagulopathies.
The use of IPV should be considered early in the course of treating SARS-CoV-2 . When a patient is on non-invasive HFNC ventilation or invasive ventilated , High Frequency Percussive Ventilation should be considered as a fully-fledged alternative of recruitment technique and treatment. Larger studies need to be performed before making definitive recommendations.

Conflict of interest: **None**