



# REVUE DE LA LITTERATURE

H.F.P.V. ®

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## I : HFPV :

### Measurement of pulsatile tidal volume, pressure amplitude, and gas flow during high-frequency percussive ventilation, with and without partial cuff deflation.

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OBJECTIVE: With a high-frequency percussive ventilator and a mechanical lung model, to measure tidal volume (V(T)), pulsatile pressure amplitude (difference between peak and nadir pulsatile pressure [DeltaP]);, and mean airway pressure (P (aw)) at various pulsatile frequencies, pulsatile inspiratory-expiratory ratios (I:E(p)), and pressures (measured at the interface between the pulse-generator and the endotracheal tube [P(vent)]). METHODS: With the endotracheal tube inside an artificial trachea, we manipulated the high-frequency percussive ventilation settings and adjuncts, including pulsatile frequency, I:E(p), and P(vent) by manipulating pulsatile flow. We also studied the effects of partially deflating the endotracheal tube cuff. We measured P (aw), pulsatile pressure amplitude at the carina (DeltaP(c)), and pulsatile V(T) at the carina. With the cuff partly deflated, we measured the fraction of inspired oxygen (F(IO(2))) in the gas efflux above and below the cuff. RESULTS: Increasing the pulsatile frequency from 300 cycles/min to 600 cycles/min and changing the I:E(p) from 1:3 to 1:1 significantly reduced V(T) ( $p < 0.001$ ). P (aw) and DeltaP(c) were unaffected by the change in pulsatile frequency or I:E(p), except when we did not preserve the pulsatile flow. The measured V(T) range was from 19.1 mL (at 600 cycles/min) to 47.3 mL (at 300 cycles/min). Partial cuff deflation did not significantly reduce P (aw) or DeltaP(c), but it did significantly reduce V(T) and F(IO(2)). CONCLUSION: During high-frequency percussive ventilation, the pulsatile frequency is inversely related to V(T). Partial cuff deflation reduces the delivered F(IO(2)). PMID: 17194317 [PubMed - in process]

**[Respir Care.](#) 2007 Jan; 52(1):45-9.**



## Smoke inhalation injury: diagnosis and respiratory management

[Article in Japanese]

- [Ogura H](#), [Sumi Y](#), [Matsushima A](#), [Tohma Y](#), [Inoue Y](#), [Tasaki O](#), [Shimazu T](#), [Sugimoto H](#).

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Smoke inhalation is a significant comorbid factor following major thermal injury. Smoke exposure is only a trigger for the sequence of events responsible for the development of inhalation injury. Noxious chemicals generated by incomplete combustion injure the exposed bronchoepithelium and stimulate the release of chemical mediators that cause a progressive inflammatory process. Airway inflammation and pulmonary edema impair gas exchange and increase the susceptibility to pulmonary infection. Earlier diagnosis and treatment of inhalation injury is an important element to improve the clinical course of severe burn patients. The American Burn Association, however, recently concluded that there are insufficient data to support a treatment standard for the diagnosis of inhalation injury. At present, the diagnosis of inhalation injury is supported by the combination of history, physical examination, bronchoscopy, and laboratory findings. For accurate diagnosis of inhalation injury, helical CT scanning and examination to detect activated leukocytes in bronchoalveolar lavage fluid may be warranted. In the respiratory management of inhalation injury, repeated removal of pseudomembrane by fiberoptic bronchoscopy and the use of adequate PEEP to avoid airway obstruction are essential. High-frequency percussive ventilation can be a suitable mode of ventilation for inhalation injury.

PMID: 16869127 [PubMed - indexed for MEDLINE]

**1: [Nippon Geka Gakkai Zasshi](#). 2005 Déc.;106(12):740-4**



**High-frequency percussive ventilation improves oxygenation in trauma patients with acute respiratory distress syndrome: a retrospective review.**

- [Eastman A](#), [Holland D](#), [Higgins J](#), [Smith B](#), [Delagarza J](#), [Olson C](#), [Brakenridge S](#), [Foteh K](#), [Friese R](#).

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BACKGROUND: High-frequency percussive ventilation (HFPV), a hybrid of conventional mechanical ventilation and high-frequency oscillatory ventilation, has been used to salvage patients with persistent hypoxemia on conventional mechanical ventilation. We hypothesized that oxygenation would improve in injured patients with severe hypoxemia who were converted to HFPV after initial management with conventional ventilation. METHODS: Chart review identified patients with acute respiratory distress syndrome (ARDS) managed with HFPV. Oxygenation parameters (oxygenation index, OI; Pao(2)/Fio(2) ratio, P/F) and mean airway pressures (mPaw) were recorded at baseline and at 1 to 4, 8 to 12, and 12 to 24 hours after initiation of HFPV. Values at baseline and each time point after conversion to HFPV were compared by using analysis of variance or Kruskal-Wallis tests. RESULTS: Twelve patients, over 24 months, were reviewed. Baseline measurements were OI: 42.2 +/- 33, P/F: 70 +/- 31, (median +/- interquartile range), and mPaw: 29 +/- 8 (mean +/- standard deviation) cm H(2)O. After initiation of HFPV, mPaw did not differ from baseline. There was an improvement in OI (P = .01) from baseline at 12 to 24 hours after initiation of HFPV and in P/F at 12 to 24 hours (P = .002) and 8 to 12 hours (P = .001) after initiation of HFPV. CONCLUSIONS: HFPV may improve oxygenation in patients with ARDS without a concomitant increase in mPaw. A randomized trial of HFPV versus conventional ventilation in trauma patients is needed.

PMID: 16860628 [PubMed - indexed for MEDLINE]

[Am J Surg. 2006 Aug; 192\(2\):191-5](#)



**High-frequency percussive ventilation with systemic heparin improves short-term survival in a LD100 sheep model of acute respiratory distress syndrome.**

- [Wang D](#), [Zwischenberger JB](#), [Savage C](#), [Miller L](#), [Deyo DJ](#), [Alpard S](#), [Cardenas VJ Jr.](#)

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We undertook an assessment of high-frequency percussive ventilation (HFPV) and systemic heparin on survival in our LD100 sheep model of smoke/burn-induced acute respiratory distress syndrome (ARDS). This was a prospective controlled outcomes study in a large animal critical care laboratory. ARDS was induced in 13 sheep by a combination of 48 cotton smoke breaths and 40% full-thickness cutaneous burn (LD100) followed by mechanical ventilation (15 ml/kg tidal volume). After meeting ARDS criteria ( $\text{PaO}_2/\text{FiO}_2 < 200$ ), the sheep were divided into high-frequency percussive ventilation (HFPV;  $n = 7$ ) or volume-controlled mechanical ventilation (VCMV;  $n = 6$ ) groups. Both groups received systemic heparin to achieve an ACT 180-300 seconds. HFPV was managed with the Volumetric Diffusive Respiration Ventilator (Percussionaire Corp., Sandpoint, ID). The VCMV group was managed with up to 10 ml/kg tidal volume. Arterial blood gases and ventilator settings were monitored every 6 hours after onset of ARDS. HFPV did not affect sheep hemodynamics. Survival 84 hours after smoke and burn injury was significantly greater in the HFPV (7/7, 100%) compared with the VCMV group (3/6, 50%,  $P < .05$ ).  $\text{PaCO}_2$  was significantly greater in VCMV group at 36, 48, and 72 hours after smoke and burn injury.  $\text{PaO}_2/\text{FiO}_2$  after 36 hours of smoke and burn injury in the HFPV group was improved compared with the VCMV group, but no statistical difference was found. In the VCMV group, peak airway pressure was decreased to  $19.7 \pm 2.2$  cm H<sub>2</sub>O at 36 hours from  $29 \pm 2.8$  at 24 hours as the tidal volume changed from 15 ml/kg to 10 ml/kg and then gradually increased to  $39 \pm 5.6$  cm H<sub>2</sub>O at 72 hours. In the HFPV group, peak inspiratory pressure kept constant at a level of 30 cmH<sub>2</sub>O. In our smoke/burn-induced LD100 sheep model of ARDS, volume-controlled mechanical ventilation with systemic heparin achieved a 50% survival whereas HFPV with systemic heparin achieved 100% survival at 60 hours after the onset of ARDS.

PMID: 16819349 [PubMed - indexed for MEDLINE]

**[J Burn Care Res.](#) 2006 Jul-Aug; 27(4):463-71**



SARL I.M.A.Pe – Internationale Medical Assistance by Percussionaire – Marina Buro – 1752 RN7 – 06270 Villeneuve Loubet

**Mechanical loads modulate tidal volume and lung washout during high-frequency percussive ventilation.**

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High-frequency percussive ventilation (HFPV) has been proved useful in patients with acute respiratory distress syndrome. However, its physiological mechanisms are still poorly understood. The aim of this work is to evaluate the effects of mechanical loading on the tidal volume and lung washout during HFPV. For this purpose a single-compartment mechanical lung simulator, which allows the combination of three elastic and four resistive loads (E and R, respectively), underwent HFPV with constant ventilator settings. With increasing E and decreasing R the tidal volume/cumulative oscillated gas volume ratio fell, while the duration of end-inspiratory plateau/inspiratory time increased. Indeed, an inverse linear relationship was found between these two ratios. Peak and mean pressure in the model decreased linearly with increasing pulsatile volume, the latter to a lesser extent. In conclusion, elastic or resistive loading modulates the mechanical characteristics of the HFPV device but in such a way that washout volume and time allowed for diffusive ventilation vary agonistically.

PMID: 16448933 [PubMed - indexed for MEDLINE]

[Respir Physiol Neurobiol](#). 2006 Jan 25; 150(1):44-51.



## High-frequency percussive ventilation during surgical bronchial repair in a patient with one lung.

- [Lucangelo U](#), [Zin WA](#), [Antonaglia V](#), [Gramaticopolo S](#), [Maffessanti M](#), [Liguori G](#), [Cortale M](#), [Gullo A](#).

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We report the case of a patient that had undergone a left pneumonectomy during which a double-lumen tube was used and an undetected right bronchial laceration occurred. After diagnosis the patient underwent a second operation to repair the tear. The role of high-frequency percussive ventilation in enabling adequate gas exchange during the bronchial repair is described and discussed.

PMID: 16490764 [PubMed - indexed for MEDLINE]

[Br J Anaesth](#). 2006 Apr; 96(4):533-6. Epub 2006 Feb 20



## High-frequency percussive ventilation.

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OBJECTIVE: To review the technique and clinical application of high-frequency percussive ventilation in critically ill patients. DESIGN: Literature search and descriptive review. RESULTS: High-frequency percussive ventilation is a time-cycled, pressure-limited mode of ventilation that delivers subphysiologic tidal volumes at rates that can exceed 500 breaths/min. It offers the potential advantage over conventional ventilation of providing equal or improved oxygenation and ventilation at lower peak and end-expiratory pressures. This modality has been used to manage severe lung disease in the neonatal and pediatric population, treat inhalation injury in pediatric and adult patients, and as salvage therapy in adult patients with acute respiratory distress syndrome. CONCLUSIONS: High-frequency percussive ventilation has been shown to provide favorable gas exchange in several well-defined patient populations. It reliably improves oxygenation and provides adequate ventilation at lower peak pressures than conventional ventilation. Adequately powered, randomized, prospective studies demonstrating significant mortality benefit have not yet been performed.

PMID: 15753734 [PubMed - indexed for MEDLINE]

**[Crit Care Med.](#) 2005 Mar; 33(3 Suppl):S241-5**



## High-frequency percussive ventilation.

- [Lucangelo U](#), [Antonaglia V](#), [Gullo A](#), [Zin WA](#).

PMID: 16148519 [PubMed - indexed for MEDLINE]

[Crit Care Med](#). 2005 Sep; 33(9):2155; author reply 2155-6



## High-frequency percussive ventilation: an alternative mode of ventilation for head-injured patients with adult respiratory distress syndrome.

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BACKGROUND: Adult respiratory distress syndrome develops in up to 20% of patients with severe head injury. This complicates the treatment of head-injured patients because lung-protective strategies such as high positive end-expiratory pressure (PEEP) and permissive hypercapnia may increase intracranial pressure (ICP) and reduce cerebral perfusion pressure. The use of high-frequency percussive ventilation (HFPV) is an alternate mode of ventilation that may improve oxygenation for head-injured patients while also lowering ICP. METHODS: Clinical data were collected retrospectively over a 1-year period. Patients were included if they had a severe traumatic brain injury with a Glasgow Coma Score (GCS) of 8 or lower, a ventriculostomy drain for ICP measurement and cerebral spinal fluid drainage, and adult respiratory distress syndrome. Patients were switched from conventional mechanical ventilation to HFPV at the discretion of the attending trauma surgeon. Data for partial pressure of oxygen to fraction of inspired oxygen (PF) ratio, peak inspiratory pressure (PIP), ICP, partial pressure of carbon dioxide level (PCO<sub>2</sub>), PEEP, and mean airway pressure were compared before and then 4 and 16 hours after institution of HFPV therapy. RESULTS: A total of 10 patients met study criteria. Data were expressed as mean +/- standard error. There was an increase in PF ratio (91.8 +/- 13.2 vs. 269.7 +/- 34.6; p < 0.01), PEEP (14 +/- 2.5 vs. 16 +/- 3.5), and mean airway pressure (20.4 +/- 4.8 vs. 23.6 +/- 6.8) 16 hours after institution of HFPV. There was a decrease in ICP (30.9 +/- 3.4 vs. 17.4 +/- 1.7; p < 0.01), PCO<sub>2</sub> (37.7 +/- 4.1 vs. 32.7 +/- 1.1; p < 0.05), and PIP (49.4 +/- 10 vs. 41 +/- 7.9; p < 0.05) at 16 hours. Overall mortality was 10%. CONCLUSIONS: Therapy with HFPV produced a significant improvement in oxygenation with a concomitant reduction in ICP during the first 16 hours. This therapy may represent an important new method for the management of adult respiratory distress syndrome among head-injured trauma patients, although the long-term outcome of HFPV still needs evaluation.

PMID: 15454800 [PubMed - indexed for MEDLINE]

1: [J Trauma](#). 2004 Sep; 57(3):542-6.



SARL I.M.A.Pe – Internationale Medical Assistance by Percussionnaire – Marina Buro – 1752 RN7 – 06270 Villeneuve Loubet

**Effects of mechanical load on flow, volume and pressure delivered by high-frequency percussive ventilation.**

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High-frequency percussive ventilation (HFPV) has proved its unique efficacy in the treatment of acute respiratory distress, when conventional mechanical ventilation (CMV) has demonstrated a limited response. We analysed flow ( $\dot{V}$ ), volume (V) and airway pressure ( $P_{aw}$ ) during ventilation of a single-compartment mechanical lung simulator, in which resistance (R) and elastance (E) values were modified, while maintaining the selected ventilatory settings of the HFPV device. These signals reveal the physical effect of the imposed loads on the output of the ventilatory device, secondary to constant (millisecond by millisecond) alterations in pulmonary dynamics.  $\dot{V}$ , V and  $P_{aw}$  values depended fundamentally on the value of R, but their shapes were modified by R and E. Although peak  $P_{aw}$  increased 70.3% in relation to control value, mean  $P_{aw}$  augmented solely 36.5% under the same circumstances (maximum of 9.4 cm H<sub>2</sub>O). Finally, a mechanism for washing gas out of the lung was suggested.

PMID: 15351306 [PubMed - indexed for MEDLINE]

- 1: [Respir Physiol Neurobiol](#). 2004 Aug 20; 142(1):81-91



## High frequency percussive ventilation (HFPV). Case reports.

[Article in English, Italian]

- [Lucangelo U](#), [Fontanesi L](#), [Antonaglia V](#), [Antolini F](#), [BerloT G](#), [Liguori G](#), [Gullo A](#).

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Treatment of acute respiratory failure is still a hot issue in intensive care everyday practice: in the last few years high frequency ventilation techniques have been employed as a therapy for adult respiratory distress syndrome (ARDS) and acute respiratory failure (ARF). We applied high frequency percussive ventilation (HFPV) to 3 patients affected by ARDS or ARF, who did not improve after 24 hours of conventional mechanical ventilation (CMV). All our patient underwent 12 hours of HFPV, and showed an improvement of both respiratory exchange and radiological imaging. Even if the pathogenesis of ARF was quite different, in all patient we registered a good response and no complications.

PMID: 14735025 [PubMed - indexed for MEDLINE]

1: [Minerva Anesthesiol.](#) 2003 Nov;69(11):853-7, 858-60



## High frequency percussive ventilation (HFPV). Principles and technique.

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In recent years, the usefulness of high frequency ventilation (HFV) has been clinically reassessed as an alternative to conventional mechanical ventilation (CMV). HFV has often been combined with or in some cases even completely replaced CMV in the attempt to reduce iatrogenic injury. High frequency percussive ventilation (HFPV) is a specific mode of HFV that has been successfully applied in the treatment of acute respiratory failure after smoke inhalation; it has also been more widely used in pediatric than in adult patients. This article gives an introduction to and a description of the basic principles of HFPV, a mode of ventilation which we found particularly versatile and reliable in our preliminary clinical experience with the maneuver.

PMID: 14735024 [PubMed - indexed for MEDLINE]

- **1:** [Minerva Anesthesiol](#). 2003 Nov; 69(11):841-8, 848-51.



## High frequency percussive ventilation in burn patients: hemodynamics and gas exchange.

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High frequency percussive ventilation (HFPV) is a recent ventilatory mode, which combines conventional cycles with high frequency percussions. HFPV was initially instituted as salvage therapy after acute respiratory failure following smoke inhalation injury achieving in each case a dramatic improvement of blood oxygenation, PaCO<sub>2</sub> and ventilatory pressures. This study investigates the influence of HFPV on hemodynamics, blood oxygenation and ventilatory parameters in eight stable ICU burn patients requiring artificial ventilatory support during a postoperative period following traumatic injury. Periods of 2h were analysed receiving conventional ventilation and HFPV with a high frequency of 400 and 800 cycles/min. Hemodynamic data were not significantly modified; peak inspiratory pressure was significantly lower under HFPV but mean airway pressure was unchanged. Blood oxygenation and CO<sub>2</sub> elimination were significantly improved under HFPV. No side effects were noted. These observations suggest that HFPV could improve pulmonary gas exchanges under lower peak pressures and without hemodynamic compromise. HFPV could represent an interesting alternative open lung strategy method to improve alveolar recruitment.

PMID: 12927989 [PubMed - indexed for MEDLINE]

1: [Burns](#). 2003 Sep; 29(6):603-8.



## High-frequency percussive ventilation as a salvage modality in adult respiratory distress syndrome: a preliminary study.

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Despite multiple advances in critical care patients with severe adult respiratory distress syndrome (ARDS) can exhaust the capability of conventional ventilation; this results in respiratory failure and death. High-frequency percussive ventilation (HFPV), which was initially utilized for salvage of burn patients with smoke inhalation injury refractory to conventional ventilation, has evolved as a standard of burn care. Based on our experience with HFPV in burn patients the burn team was consulted to provide salvage ventilation for non-burn surgical intensive care unit patients with refractory respiratory failure. Over a 14-month period ten patients with refractory ARDS from multiple causes were treated. Retrospective chart review was performed. Respiratory parameters were assessed before and 24 hours after initiation of HFPV. Mean values of fraction of inspired oxygen (FiO<sub>2</sub>), pH, partial pressure of O<sub>2</sub> in arterial blood (PaO<sub>2</sub>), partial pressure of CO<sub>2</sub> in arterial blood (PaCO<sub>2</sub>), HCO<sub>3</sub>, oxygen saturation in arterial blood (SaO<sub>2</sub>), PaO<sub>2</sub>/FiO<sub>2</sub>, and peak inspiratory pressure were compared. Significant improvement in oxygenation was reflected by increases in SaO<sub>2</sub>, PaO<sub>2</sub>, and the PaO<sub>2</sub>/FiO<sub>2</sub> ratio in the first 24 hours of HFPV. No significant increase in peak inspiratory pressure was documented by conversion from conventional ventilation to HFPV. No hemodynamic changes directly associated with HFPV were noted. Seven of ten patients failing conventional ventilation survived to hospital discharge after salvage therapy with HFPV. We advocate further studies of HFPV in non-burn patients with ARDS both as salvage therapy and as replacement for conventional ventilation for the initial treatment for ARDS.

PMID: 12412709 [PubMed - indexed for MEDLINE]

**1: [Am Surg](#). 2002 Oct; 68(10):852-6; discussion 856**



**Bronchial stenting and high-frequency percussive ventilation treatment of descending aortic aneurysm-induced atelectasis of the left lung.**

- [Heringlake M](#), [Schumacher J](#), [Sedemund-Adib B](#), [Bahlmann L](#), [Eleftheriadis S](#), [Sievers HH](#), [Dalhoff K](#), [Schmucker P](#).

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IMPLICATIONS: This case report shows that atelectasis of the left lung-induced by extrinsic compression of the left main bronchus by an aortic aneurysm and persisting despite aggressive conservative treatment-may be effectively treated by bronchial stenting and high-frequency percussive ventilation.

PMID: 12401590 [PubMed - indexed for MEDLINE]

**1: [Anesth Analg](#). 2002 Nov; 95(5):1189-91, table of contents.**



**High frequency percussive ventilation and conventional ventilation after smoke inhalation: a randomised study.**

- [Reper P, Wibaux O, Van Laeke P, Vandeenen D, Duinslaeger L, Vanderkelen A.](#)

Critical Care Department, Queen Astrid Military Hospital, Bruinstreet 1, 1120 B, Brussels, Belgium. [reper@smd.be](mailto:reper@smd.be)

Inhalation injury and bacterial pneumonia represent some of the most important causes of mortality in burn patients. Thirty-five severely burned patients were randomised on admission for conventional ventilation (CV; control group) versus high frequency percussive ventilation (HFPV; study group). HFPV is a ventilatory mode, introduced 10 years ago which combines the advantages of CV with some of those of high frequency ventilation. Arterial blood gases, ventilatory and hemodynamic variables were recorded for 5 days at 2h intervals. Incident complications were classically managed. A statistical analysis (Student's t-test and Wilcoxon signed rank test) demonstrated a significant higher PaO<sub>2</sub>/FiO<sub>2</sub> from days 0 to 3 in the HFPV group. No significant differences were observed for the other parameters. Our findings suggest that HFPV can improve blood oxygenation during the acute phase following inhalation injury allowing reduction of FiO<sub>2</sub>. No significant differences were observed between groups for mortality nor incidence of infectious complications in this study.

PMID: 12163294 [PubMed - indexed for MEDLINE]

1: [Burns](#). 2002 Aug; 28(5):503-8.



## High-frequency percussive ventilation improves oxygenation in patients with ARDS.

- [Velmahos GC](#), [Chan LS](#), [Tatevossian R](#), [Cornwell EE 3rd](#), [Dougherty WR](#), [Escudero J](#), [Demetriades D](#).

Division of Trauma/Critical Care, University of Southern California and the Los Angeles County + USC Medical Center, Los Angeles 90033, USA. [velmahos@usc.edu](mailto:velmahos@usc.edu)

STUDY OBJECTIVES: To evaluate changes in respiratory and hemodynamic function of patients with ARDS and requiring high-frequency percussive ventilation (HFPV) after failure of conventional ventilation (CV). DESIGN: Retrospective case series. SETTING: Surgical ICU (SICU) and medical ICU (MICU) of an academic county facility. MEASUREMENTS AND RESULTS: Thirty-two consecutive patients with ARDS (20 from SICU, 12 from MICU) who were unresponsive to at least 48 h of CV and were switched to HFPV were studied. Data on respiratory and hemodynamic parameters were collected during the 48 h preceding and the 48 h after institution of HFPV and compared. Between the period of CV and the period of HFPV, the ratio of PaO<sub>2</sub> to the fraction of inspired oxygen (F(IO<sub>2</sub>)) increased ([mean+/-SE] 130+/-8 vs. 172+/-17; p = 0.027), peak inspiratory pressure (PIP) decreased (39.5+/-1.7 vs. 32.5+/-1.9 mm Hg; p = 0.002), and mean airway pressure (MAP) increased (19.2+/-1.2 vs. 27.5+/-1.4 mm Hg; p<0.001). The rate of change of PaO<sub>2</sub>/F(IO<sub>2</sub>) per hour was also significantly improved between the two periods. The same changes in PaO<sub>2</sub>/F(IO<sub>2</sub>), PIP, and MAP were observed when the last value recorded while the patients were on CV was compared with the first value recorded after 1 h of HFPV. This improvement was sustained but not amplified during the hours of HFPV. The patterns of improvement in these three parameters were similar in SICU and MICU patients as well as in volume-control and pressure-control patients. There were no changes in hemodynamic parameters. CONCLUSION: The HFPV improves oxygenation by increasing MAP and decreasing PIP. This improvement is achieved soon after institution of HFPV and is maintained without affecting hemodynamics.

PMID: 10453874 [PubMed - indexed for MEDLINE]

1: [Chest](#). 1999 Aug; 116(2):440-6.



## **High frequency percussive ventilation in pediatric patients with inhalation injury.**

- [Cortiella J, Mlcak R, Herndon D.](#)

**University of Texas Medical Branch at Galveston, USA.**

The objective of this study was to present data that showed high frequency percussive ventilation (HFPV) was superior to traditional mechanical ventilation for the treatment of children with inhalation injuries. Inhalation injuries continue to be the number one cause of death of patients with thermal injuries in the United States. Therapy for this condition has consisted of conservative pulmonary toilet and mechanical ventilation. Despite improvements in the management of burn injury, patients with inhalation injury develop pneumonia and pneumothorax, leading to adult respiratory distress syndrome. Unfortunately, inhalation injury that is complicated by pneumonia has been shown to increase mortality by 60% in these patients. Cioffi has shown that prophylactic use of HFPV in adult patients with inhalation injury has been a successful method of reducing the incidence of pneumonia and mortality. The effects of HFPV on the incidence of pneumonia, peak inspiratory pressures, and arterial partial pressure of oxygen/fraction of inspired concentration of oxygen (P/F) ratios were retrospectively studied in 13 children with inhalation injuries and compared with historic controls treated with conventional mechanical ventilation. All patients were treated with our standard inhalation injury protocol and extubated when they met standard extubation criteria. Patients ranged in age from 6 to 9 years, and most had burns covering greater than 50% of their total body surface areas. No deaths occurred in either group, but the patients who were treated with HFPV had no cases of pneumonia ( $P < .05$ ), better P/F ratios ( $P < .05$ ), lower peak inspiratory pressures, and less work of breathing ( $P < .05$ ) as compared with our control group. On the basis of our clinical experience and data, the use of HFPV seems to be an effective treatment for the reduction of pulmonary morbidity in pediatric patients with inhalation injuries.

PMID: 10342478 [PubMed - indexed for MEDLINE]

**1: [J Burn Care Rehabil.](#) 1999 May-Jun; 20(3):232-5**



## High-frequency percussive ventilation compared with conventional mechanical ventilation.

- [Gallagher TJ](#), [Boysen PG](#), [Davidson DD](#), [Miller JR](#), [Leven SB](#).

Department of Anesthesiology, University of Florida College of Medicine, Gainesville 32610-0254.

In seven patients with severe respiratory distress, conventional mechanical ventilation and PEEP were used initially for respiratory support, which was changed to high-frequency percussive ventilation (HFPV) at the same level of airway pressure and FIO<sub>2</sub>. During both modes of ventilation, patients could breathe spontaneously via a low-threshold demand valve. With HFPV, PaO<sub>2</sub> improved significantly (p less than .01) compared with PaO<sub>2</sub> during conventional methods. Cardiac output was unaffected by the change to HFPV.

PMID: 2495212 [PubMed - indexed for MEDLINE]

1: [Crit Care Med](#). 1989 Apr; 17(4):364-6



## High-frequency percussive ventilation in patients with inhalation injury.

- [Cioffi WG](#), [Graves TA](#), [McManus WF](#), [Pruitt BA Jr.](#)

U. S. Army Institute of Surgical Research, Fort Sam Houston, Texas 78234-6200.

Inhalation injury complicated by bacterial pneumonia is now one of the primary causes of morbidity and mortality in patients with thermal injury. We have investigated the use of high-frequency percussive ventilation (HFPV) as a means of ventilatory support for these patients. We propose that high-frequency ventilation may decrease the incidence of pulmonary infection following inhalation injury and decrease the incidence of iatrogenic barotrauma caused by conventional ventilation. High-frequency ventilation was instituted initially as salvage therapy in a group of five patients. In each case, normocapnia or arterial pO<sub>2</sub> saturation of greater than 90% on a FIO<sub>2</sub> of 60% or less was achieved with high-frequency ventilation but not with conventional ventilation. A second group of ten patients was prospectively entered into a study on the use of HFPV in patients with inhalation injury. One patient was removed from the study, and one patient was unable to be ventilated because of severely noncompliant lungs. Eight patients with a mean age of 29 years and a mean burn size of 38% of the total body surface completed the protocol. All patients survived, two developed pneumonia, and one developed subcutaneous emphysema. These results suggest that HFPV is effective in the treatment of patients with severe inhalation injury.

PMID: 2926848 [PubMed - indexed for MEDLINE]

1: [J Trauma](#). 1989 Mar; 29(3):350-4



## High-frequency percussive ventilation in the management of elevated intracranial pressure.

- [Hurst JM](#), [Branson RD](#), [Davis K Jr.](#)

Department of Surgery, University of Cincinnati Medical Center, OH.

We evaluated 38 patients with combined head injury and respiratory failure requiring manipulation of mean airway pressure in order to achieve satisfactory oxygenation. All patients were initially maintained on conventional ventilatory support. When entry criteria were met, patients were transitioned to high-frequency percussive ventilation (HFPV) and cardiorespiratory variables were measured. HFPV resulted in a statistically significant decrease in intracranial pressures in patients when ICP remained greater than 15 mm Hg in spite of optimum medical management. Satisfactory oxygenation was obtained at approximately half the level of CPAP and peak inspiratory pressure as that on conventional ventilation. Thus HFPV provides an acceptable alternative method of ventilatory support in patients with combined head injury and respiratory failure.

PMID: 3418762 [PubMed - indexed for MEDLINE]

□ 1: [J Trauma](#). 1988 Sep; 28(9):1363-7.



## Improved ventilatory function in burn patients using volumetric diffusive respiration.

- [Rodeberg DA](#), [Housinger TA](#), [Greenhalgh DG](#), [Maschinot NE](#), [Warden GD](#).

Shriners Burns Institute, Cincinnati, OH 45229-3095.

BACKGROUND: Volumetric diffusive respiration (VDR) offers theoretical advantages over conventional mechanical ventilation (CV) by using lower airway pressures, recruiting alveoli, and mobilizing secretions. STUDY DESIGN: Forty-eight thermally injured pediatric patients with failing respiratory status were changed from CV to VDR. Data were obtained just before transition for CV and after stabilization on VDR, within six hours of transition. RESULTS: Both ventilation and oxygenation were significantly improved with PaCO<sub>2</sub> decreasing from 47 +/- 3 to 39 +/- 11 mm Hg and PaO<sub>2</sub> increasing from 105 +/- 8 to 171 +/- 12 mm Hg after transition to VDR. Treatment with the VDR ventilator also resulted in a significant decrease in peak inspiratory pressures (PIP) from 52 +/- 2 to 38 +/- 2 cm H<sub>2</sub>O. The PaO<sub>2</sub> to FiO<sub>2</sub> ratio increased from 189 +/- 16 using CV, to 329 +/- 21 using VDR, suggesting an improvement in the ventilation and perfusion matching. Ventilatory efficiency, measured by the PaO<sub>2</sub>/FiO<sub>2</sub>/PIP ratio, greatly improved after transition from CV to VDR with fraction of inspired oxygen increasing from 3.9 +/- 0.4 to 10.3 +/- 1.0. Hemodynamic function (blood pressure and pulse rate) were not adversely affected by VDR. CONCLUSIONS: The VDR ventilator is more effective than conventional ventilation for maintaining optimal gas exchange at lower airway pressures in thermally injured pediatric patients.

PMID: 7952452 [PubMed - indexed for MEDLINE]

1: [J Am Coll Surg](#). 1994 Nov; 179(5):518-22.



**Decreased pulmonary barotrauma with the use of volumetric diffusive respiration in pediatric patients with burns: the 1992 Moyer Award.**

- [Rodeberg DA](#), [Maschinot NE](#), [Housinger TA](#), [Warden GD](#).

**Shriners Burns Institute, Cincinnati, OH 45229.**

Pulmonary barotrauma is a frequent, life-threatening complication in the pediatric patient who is treated with mechanical ventilation. The volumetric diffusive respiration (VDR) ventilator, which employs a high-frequency progressive accumulation of subtidal volume breaths in a pressure-limited format with a percussive waveform, is capable of providing adequate gas exchange at lower airway pressures; this theoretically decreases the incidence of pulmonary barotrauma compared with conventional mechanical ventilation (CV). The incidence of pulmonary barotrauma since 1988 was evaluated in pediatric patients with burns who were younger than 2 years of age. Twenty-four patients who were treated with only CV were compared with 15 patients who were treated with only VDR. Pulmonary barotrauma was defined as the development of pneumothorax, pneumomediastinum, pneumopericardium, or pneumoperitoneum. There were no significant differences between CV-treated and VDR-treated groups (mean +/- SEM) in the patient characteristics of age (15.9 +/- 1.3 months vs 16.6 +/- 1.8 months), weight (11.2 +/- 0.5 kg vs 12.5 +/- 0.7 kg), percent total body surface burn (46.2% +/- 4.9% vs 55.6% +/- 6.2%), percent full-thickness burn (38.1% +/- 5.3% vs 50.0% +/- 6.6%), inhalation injury (40% vs 60%), or total number of days that mechanical ventilation was required (18.2 +/- 4.2 days vs 22.4 +/- 5.9 days); although these parameters show a slightly more severe degree of injury in the VDR-treated group. There was a reduction in the incidence of pulmonary barotrauma when VDR was used.(ABSTRACT TRUNCATED AT 250 WORDS)

PMID: 1452583 [PubMed - indexed for MEDLINE]

**1: [J Burn Care Rehabil.](#) 1992 Sep-Oct; 13(5):506-11**



**A prospective, randomized comparison of the Volume Diffusive Respirator vs conventional ventilation for ventilation of burned children. 2001 ABA paper.**

- [Carman B](#), [Cahill T](#), [Warden G](#), [McCall J](#).

**Shriners Burns Hospital, Cincinnati, Ohio, USA.**

The Volume Diffusive Respirator (VDR) is a high-frequency time cycled pressure ventilator that can ventilate, oxygenate, and promote secretion removal. The VDR provides ventilation at lower airway pressures than those required for conventional ventilation in the pressure control mode (PCV). A prospective, randomized, institutional review board-approved study was conducted comparing the VDR to PCV in burned children with respiratory failure from all causes. METHODS: Pediatric burn patients requiring ventilation were stratified by presence of inhalation injury and ventilated by VDR or PCV to achieve predefined arterial blood gases. RESULTS: Sixty-four patients were prospectively assigned ventilator type; 32 to VDR, 32 to PCV. Data are reported as mean + SEM. Patient age was 7.4 + 0.7 years, TBSA was 56 + 3%, and number of patients with inhalation injuries was 55 (86%). Maximum peak inspiratory pressure with the VDR was significantly less than with PCV (30.9 + 0.8 cm H<sub>2</sub>O vs 39.5 + 1.8 cm H<sub>2</sub>O, P < 0.05) and the best PaO<sub>2</sub> /FIO<sub>2</sub> ratio was significantly higher with the VDR compared with PCV (563 + 15 vs 507 + 13, P < 0.05). No patient in the VDR group had evidence of barotrauma compared with two in the PCV group. Five patients in the PCV group died compared with two in the VDR group. CONCLUSION: Patients ventilated with the VDR required significantly lower peak inspiratory pressure and achieved a significantly higher PaO<sub>2</sub> /FIO<sub>2</sub> ratio compared with PCV. This demonstrates the VDR is a safe and effective method of ventilation for pediatric burn patients and it offers advantages when compared with conventional ventilation.

PMID: 12432322 [PubMed - indexed for MEDLINE]

**1: [J Burn Care Rehabil](#). 2002 Nov-Dec; 23(6):444-8**



## Improved ventilatory function in burn patients using volumetric diffusive respiration.

- [Rodeberg DA](#), [Housinger TA](#), [Greenhalgh DG](#), [Maschinot NE](#), [Warden GD](#).

Shriners Burns Institute, Cincinnati, OH 45229-3095.

BACKGROUND: Volumetric diffusive respiration (VDR) offers theoretical advantages over conventional mechanical ventilation (CV) by using lower airway pressures, recruiting alveoli, and mobilizing secretions. STUDY DESIGN: Forty-eight thermally injured pediatric patients with failing respiratory status were changed from CV to VDR. Data were obtained just before transition for CV and after stabilization on VDR, within six hours of transition. RESULTS: Both ventilation and oxygenation were significantly improved with PaCO<sub>2</sub> decreasing from 47 +/- 3 to 39 +/- 11 mm Hg and PaO<sub>2</sub> increasing from 105 +/- 8 to 171 +/- 12 mm Hg after transition to VDR. Treatment with the VDR ventilator also resulted in a significant decrease in peak inspiratory pressures (PIP) from 52 +/- 2 to 38 +/- 2 cm H<sub>2</sub>O. The PaO<sub>2</sub> to FiO<sub>2</sub> ratio increased from 189 +/- 16 using CV, to 329 +/- 21 using VDR, suggesting an improvement in the ventilation and perfusion matching. Ventilatory efficiency, measured by the PaO<sub>2</sub>/FiO<sub>2</sub>/PIP ratio, greatly improved after transition from CV to VDR with fraction of inspired oxygen increasing from 3.9 +/- 0.4 to 10.3 +/- 1.0. Hemodynamic function (blood pressure and pulse rate) were not adversely affected by VDR. CONCLUSIONS: The VDR ventilator is more effective than conventional ventilation for maintaining optimal gas exchange at lower airway pressures in thermally injured pediatric patients.

PMID: 7952452 [PubMed - indexed for MEDLINE]

1: [J Am Coll Surg](#). 1994 Nov; 179(5):518-22



**High-frequency ventilation in the treatment of infants weighing less than 1,500 grams with pulmonary interstitial emphysema: a pilot study.**

- [Gaylord MS](#), [Quissell BJ](#), [Lair ME](#).

Pulmonary interstitial emphysema is one of the most serious complications of the respiratory distress syndrome. Its presence significantly increases morbidity and mortality. Preliminary reports have demonstrated the success of high-frequency ventilation in the treatment of pulmonary interstitial emphysema. In a previous investigation, we were able to develop a formula for predicting death in infants weighing less than 1,500 g with pulmonary interstitial emphysema. Using this subgroup of severely affected infants, we studied the efficacy of high-frequency ventilation in nine infants. Using the Volumetric Diffusive Respirator, we observed improvement in all respiratory values measured (pH, PCO<sub>2</sub>, and PO<sub>2</sub>), a significantly decreased mean airway pressure (MAP), and improvement in neonatal mortality. Complications of severe bleeding diatheses, hypotension, bronchopulmonary dysplasia, and necrotizing tracheobronchitis were observed. Our investigation was the first to systematically choose infants who might benefit from high-frequency ventilation and to compare them with similar infants with known outcomes. We realize that the study was rescue in nature using historical controls, but we felt compelled to assure the safety of the device before randomizing less sick infants. High-frequency ventilation appears to be effective in the acute management of low birth weight infants with pulmonary interstitial emphysema.

PMID: 3588146 [PubMed - indexed for MEDLINE]

1: [Pediatrics](#). 1987 Jun; 79(6):915-21



**Successful management of severe respiratory failure combining heliox with noninvasive high-frequency percussive ventilation.**

- [Stucki P](#), [Scalfaro P](#), [de Halleux Q](#), [Vermeulen F](#), [Rappaz I](#), [Cotting J](#).

**Pediatric Intensive Care Unit, CHUV University Hospital, Lausanne, Switzerland.**

Heliox has been shown to be beneficial in the management of different obstructive pulmonary disorders. High-frequency percussive ventilation has recently been advocated to treat lung injury in children with reduced lung compliance. We report our experience of combining heliox with noninvasive high-frequency percussive ventilation in a 5-yr-old boy with severe acute respiratory failure resulting from advanced cystic fibrosis lung disease. The dramatic improvement allowed stabilization and withholding of endotracheal intubation. We hypothesize that this approach improved gas exchange by enhancing molecular diffusion and by favoring laminar flow throughout the upper and lower airways. Further investigations should study the mechanisms of this noninvasive bimodal therapy.

PMID: 11990935 [PubMed - indexed for MEDLINE]

**1: [Crit Care Med](#). 2002 Mar; 30(3):692-4**



## Lung compliance, airway resistance, and work of breathing in children after inhalation injury.

- [Mlcak R](#), [Cortiella J](#), [Desai M](#), [Herndon D](#).

**Shriners Burns Institute, Galveston, Texas 77550, USA.**

Pathophysiologic changes associated with inhalation injury make mechanical ventilation in children a challenge. Decreased lung compliance and increased airway resistance after inhalation injury may lead to elevated airway pressures and barotrauma. Previous studies have shown significant decreases in the incidence of pneumonia and death in adult patients with inhalation injury treated with high-frequency percussive ventilation (HFPV) as compared with conventional mechanical ventilation (CMV). No studies to date have compared lung compliance, airway resistance, or work of breathing in children being treated with HFPV versus CMV. The purpose of this study was to evaluate lung compliance, airway resistance, and work of breathing in pediatric patients with inhalation injury who required mechanical ventilation. Ten children with bronchoscopically identified inhalation injury requiring mechanical ventilation were studied. Five children received CMV and five children received HFPV. All patients were treated according to our standard inhalation injury protocol. Based on our data and patient population, children receiving ventilation with the HFPV have a significant decrease in the work of breathing as compared with CMV.

PMID: 9404988 [PubMed - indexed for MEDLINE]

**1: [J Burn Care Rehabil.](#) 1997 Nov-Dec; 18(6):531-4.**



## Prophylactic use of high-frequency percussive ventilation in patients with inhalation injury.

- [Cioffi WG Jr](#), [Rue LW 3rd](#), [Graves TA](#), [McManus WF](#), [Mason AD Jr](#), [Pruitt BA Jr](#).

U.S. Army Institute of Surgical Research, Fort Sam Houston, San Antonio, TX 78234-5012.

Death and the incidence of pneumonia are significantly increased in burn patients with inhalation injury, despite application of conventional ventilatory support techniques. The effect of high-frequency percussive ventilation on mortality rate, incidence of pulmonary infection, and barotrauma were studied in 54 burn patients with documented inhalation injury admitted between March 1987 and September 1990 as compared to an historic cohort treated between 1980 and 1984. All patients satisfied clinical criteria for mechanical ventilation. High-frequency percussive ventilation was initiated within 24 hours of intubation. The patients' mean age and burn size were 32.2 years and 47.8%, respectively (ranges, 15 to 88 years; 0% to 90%). The mean number of ventilator days was 15.3 +/- 16.7 (range, 1 to 150 days), with 26% of patients ventilated for more than 2 weeks. Fourteen patients (25.9%) developed pneumonia compared to an historic frequency of 45.8% (p less than 0.005). Mortality rate was 18.5% (10 patients) with an expected historic number of deaths of 23 (95% confidence limits of 17 to 28 deaths). The documented improvement in survival rate and decrease in the incidence of pneumonia in patients treated with prophylactic high-frequency ventilation (HFV), as compared to a cohort of patients treated in the 7 years before the trial, indicates the importance of small airway patency in the pathogenesis of inhalation injury sequelae and supports further use and evaluation of HFV.

PMID: 2039288 [PubMed - indexed for MEDLINE]

**1: [Ann Surg](#). 1991 Jun; 213(6):575-80; discussion 580-2**



**The usefulness of combined high-frequency percussive ventilation during acute respiratory failure after smoke inhalation.**

- [Reper P, Dankaert R, van Hille E, van Laeke P, Duinslaeger L, Vanderkelen A.](#)

**Burn Center Brussels, Queen Astrid Military Hospital, Brussels, Belgium.**

Inhalation injury and bacterial pneumonia represent some of the most important causes of mortality in burn patients. We describe 11 severely burned patients with acute respiratory failure due to inhalation injury who did not respond adequately to conventional respiratory support. High-frequency percussive ventilation (HFPV) is a recent ventilatory mode, which combines the advantages of conventional ventilation with some of those of high-frequency ventilation. Seven patients developed pulmonary infection during the acute phase; one patient died of multiple organ failure on day 25. All the other patients survived; two developed bronchiolitis obliterans symptoms before discharge. No side-effects were noted and haemodynamic tolerance of HFPV was excellent. Our findings suggest that HFPV can improve pulmonary function and gas exchange in these catastrophic pulmonary failures following inhalation injury.

PMID: 9601588 [PubMed - indexed for MEDLINE]

□ 1: [Burns](#). 1998 Feb; 24(1):34-8.



**Gas exchange during conventional and high-frequency pulse ventilation in the surfactant-deficient lung: influence of positive end-expiratory pressure.**

- [Jibelian G, Lachmann B.](#)

High-frequency pulse ventilation (HFPV) was compared to conventional ventilation (CV) in a model of severe respiratory failure induced by serial lung lavages with warm saline in 8 mongrel dogs. Before the lavage, during HFPV at 4 Hz with a pulse volume (PV) of 125 ml, mean PaO<sub>2</sub> was 107 torr and mean PaCO<sub>2</sub> was 34 torr. After the last lavage, during CV at an inspired oxygen fraction FIO<sub>2</sub> of 1.0 and a tidal volume (VT) of 535 ml, the PaO<sub>2</sub> averaged 60 torr and PaCO<sub>2</sub> was 45 torr. At an FIO<sub>2</sub> of 0.21, 20 cm H<sub>2</sub>O of positive end-expiratory pressure (PEEP) was applied to prevent hypoxemia. The resulting PaO<sub>2</sub> was 87 torr; PaCO<sub>2</sub> was 40 torr. Peak airway pressure (Ppa) rose from 21 to 51 cm H<sub>2</sub>O. When ventilation was switched to HFPV on room air, a PV similar to the control levels was associated with severe hypoxemia (PaO<sub>2</sub> less than 45 torr, PaCO<sub>2</sub> greater than 50 torr). As PV was increased PaO<sub>2</sub> improved, reaching 113 torr at a PV of about 470 ml. The corresponding mean airway pressure (Paw) was about 20 cm H<sub>2</sub>O. Thus, application of PEEP during HFPV at low PV did not improve PaO<sub>2</sub> even when measured Paw approximated 20 cm H<sub>2</sub>O. This suggests that HFPV with high PV is more effective than either CV with PEEP, or HFPV with low PV and PEEP.

PMID: 6432439 [PubMed - indexed for MEDLINE]

**1: [Crit Care Med.](#) 1984 Sep; 12(9):769-7**



## **Use of High-Frequency Percussive Ventilation in Inhalation Injuries.**

**[Hall JJ](#), [Hunt JL](#), [Arnoldo BD](#), [Purdue GF](#).**

**From the Department of Surgery, Division of Trauma, Burns, and Critical Care, UT Southwestern Medical Center, Dallas, Texas.**

Inhalation injury causes significant morbidity and mortality, accounting for nearly 80% of non-fire-related deaths and affecting nearly 25% of all patients hospitalized with thermal injury. High-frequency percussive ventilation (HFPV) has been reported to decrease both the incidence of pulmonary barotrauma and pneumonia in inhalation injury. It has evolved into a ventilatory modality promoted to rapidly remove airway secretions and improve survival of patients with smoke inhalation injury. From 1997 to 2005, a total of 92 patients with inhalation injury were treated with HFPV. This group was compared with 130 patients treated with conventional mechanical ventilation between 1997 and 2005. The diagnosis of inhalation injury was made on admission, based on the following clinical criteria: injury in a closed space, carbonaceous sputum, and/or positive bronchoscopy (presence of carbonaceous deposits, erythema or ulceration). Both modes of ventilation were begun within 24 hours of injury. Both groups were similar with respect to demographics and injury severity. The mean number of ventilator days, days in the intensive care unit, length of stay, and incidence of pneumonia did not differ significantly between groups. Twenty-six of 92 (28%) patients treated with HFPV, and 56 of 130 with conventional mechanical ventilation (43%) died. There was a significant decrease in both overall morbidity and mortality in the subset of patients with  $\leq 40\%$  TBSA treated with HFPV. Future randomized, controlled trials are needed to determine the precise role of HFPV in the treatment of inhalation injuries.

PMID: 17438509 [PubMed - as supplied by publisher]

**[J Burn Care Res.](#) 2007 Apr 10;**



## **High-frequency percussive ventilation in a pediatric patient with hydrocarbon aspiration.**

**[Mabe TG](#), [Honeycutt T](#), [Cairns BA](#), [Kocis KC](#), [Short KA](#).**

**From the Departments of Respiratory Care (TM, KS), Pediatrics (TH, BC, KK), and Surgery (BC), University of North Carolina Hospitals, Chapel Hill, NC.**

INTRODUCTION:: To describe ventilator management using a high-frequency percussive ventilator (HFPV), after other modes of mechanical ventilation failed. DESIGN:: Case series. SETTING:: Pediatric intensive care unit. PATIENTS:: Previously healthy 11-month-old male with severe aspiration pneumonitis from mineral oil. INTERVENTIONS:: The patient was initially placed on a conventional ventilator in a pressure-regulated volume-control mode but needed higher-than-normal pressures to maintain adequate ventilation. A decision was made to switch the patient to a pressure-control/pressure-support mode. At the end of the third day of pressure-control/pressure-support mode, a decision was made to attempt airway pressure-release ventilation. During a trial attempt, saturation levels deteriorated and a decision was made to place the patient on a high-frequency oscillator. The patient remained on this mode of ventilation for 6 days. On the sixth day, the chest radiograph showed a worsening of his pneumonia, and the patient started to deteriorate. A decision was made to try the HFPV in an attempt to mobilize secretions and any residual mineral oil. Immediately after initiating the HFPV and for 4 hrs thereafter, large amounts of secretions-including a thick, oily substance-were suctioned from the airways. Within 12-24 hrs, oxygenation improved dramatically and Fio2 was weaned. During the next 12 hrs, the patient was weaned off HFPV onto a conventional ventilator, and he was extubated 48 hrs after initiating HFPV. CONCLUSIONS:: In this case, HFPV used as an alternative mode of ventilation successfully mobilized secretions that were otherwise unobtainable and that we believe led to the swift recovery of this child. HFPV should be given consideration as a mode of ventilation when mobilization of secretions is an issue.

PMID: 17417121 [PubMed - in process]

**1: [Pediatr Crit Care Med](#). 2007 Jul; 8(4):383-5.**



## **Corrective measures for compromised oxygen delivery during endotracheal tube cuff deflation with high-frequency percussive ventilation.**

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**OBJECTIVE:** To determine the effect of endotracheal-tube cuff deflation on airflow and F(IO<sub>2</sub>) during high-frequency percussive ventilation (HFPV), and explore methods of correcting the cuff-deflation-associated decrease in mean airway pressure and F(IO<sub>2</sub>) at the carina. **METHODS:** Using a mechanical lung model in our respiratory research laboratory, we measured circuit pressure near the connection to the endotracheal tube (P(vent)), mean airway pressure (P(aw)), pulsatile tidal volume (V(T)), and F(IO<sub>2</sub>) at the artificial carina. During cuff deflation we manipulated the pulsatile frequency, pulsatile flow, and the HFPV integral nebulizer. We then assessed 4 methods of correcting the decreased F(IO<sub>2</sub>) and airway pressure during cuff deflation: (1) oxygen delivery at the inspiratory fail-safe valve, (2) oxygen delivery at the T-piece between the HFPV and the endotracheal tube, (3) continuous activation of the HFPV's integral nebulizer, and (4) oxygen insufflation into the suction channel of the endotracheal tube. **RESULTS:** Cuff deflation reduced P(vent), P(aw), pulsatile V(T), and F(IO<sub>2</sub>). Increasing the pulsatile flow and decreasing the pulsatile frequency further reduced F(IO<sub>2</sub>) during cuff deflation. Injecting supplemental oxygen at the inspiratory fail-safe valve provided the best F(IO<sub>2</sub>) increase. Injecting oxygen at the T-piece provided the second best F(IO<sub>2</sub>) increase. Continuous activation of the integral nebulizer provided the third best F(IO<sub>2</sub>) increase. Oxygen insufflation to the suction channel was least effective in correcting the F(IO<sub>2</sub>) decrease caused by cuff deflation. **CONCLUSION:** Cuff-deflation-associated F(IO<sub>2</sub>), P(aw), and pulsatile V(T) compromise can be partially corrected by any of the 4 methods we studied. Injecting supplemental oxygen at the inspiratory fail-safe valve is the most effective method.

PMID: 17328825 [PubMed - indexed for MEDLINE]

1: [Respir Care](#). 2007 Mar; 52(3):271-7.  [Links](#)



## **Clinical and pathophysiologic problems associated with smoke inhalation injury**

[Article in Japanese]

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Smoke inhalation injury is one of the primary determinants of survival following major burn injury. The primary site of injury in smoke inhalation appears to be the small airway rather than the alveoli, and thus small airway occlusion caused by edema and pseudomembrane formation are the primary mechanisms of progressive hypoxia. Ventilation-perfusion (VA/Q) alterations after smoke inhalation are characterized by increased blood flow to low VA/Q compartments, although an increase in true shunt (VA/Q = 0) was not a consistent finding. This differs considerably from most adult respiratory distress syndrome (ARDS) patients or oleic acid-induced lung edema models, in which an increase in true shunt is the major mechanism of hypoxia. Such differences lead to different responses to nitric oxide (NO) inhalation therapy, and NO does not improve oxygenation and outcome in patients with smoke inhalation injury. In the treatment of inhalation injury, meticulous removal of pseudomembrane by fiberoptic bronchoscopy is essential, the use of high concentrations of oxygen should be avoided since it can cause absorption atelectasis. High-frequency percussive ventilation is a suitable treatment for inhalation injury, as it improves oxygenation and facilitates removal of pseudomembrane.

PMID: 9547747 [PubMed - indexed for MEDLINE]

**1: [Nippon Geka Gakkai Zasshi.](#) 1998 Jan;99(1):46-51.**



## **Airway clearance applications in the elderly and in patients with neurologic or neuromuscular compromise.**

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Respiratory compromise is the leading cause of morbidity and mortality in patients with neuromuscular and neurologic disease, and in elderly patients, who have a reduced pulmonary reserve from deterioration of the respiratory system associated with the normal aging process. Although the otherwise healthy older patient is normally asymptomatic, their pulmonary reserve is further compromised during stressful situations such as surgery, pneumonia, or exacerbation of a comorbid condition. The inability to effectively remove retained secretions and prevent aspiration contribute to this compromise. Although no secretion-management therapies are identified as having specific application to the elderly, clinicians must be attentive and understand the needs of the elderly to prevent the development of respiratory compromise. Patients with neuromuscular disease often can not generate an effective cough to mobilize and evacuate secretions. Respiratory muscle training, manual cough assistance, mechanical cough assistance, high-frequency chest wall compression, and intrapulmonary percussive ventilation have each been suggested as having potential benefit in this population. Although strong evidence supporting the benefit of these therapies is lacking, clinicians must be guided as to whether there is a pathophysiologic rationale for applying the therapy, whether adverse effects are associated with the therapy, the cost of therapy, and whether the patient prefers a given therapy.

PMID: 17894904 [PubMed - indexed for MEDLINE]

[Respir Care](#). 2007 Oct; 52(10):1362-81; discussion 1381.



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## **High-frequency percussive ventilation attenuates lung injury in a rabbit model of gastric juice aspiration.**

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**OBJECTIVE:** To test the effects of high-frequency percussive ventilation (HFPV) compared with high-frequency oscillatory ventilation (HFOV) and low-volume conventional mechanical ventilation (LVCMV), on lung injury course in a gastric juice aspiration model. **DESIGN:** Prospective, randomized, controlled, in-vivo animal study. **SETTING:** University animal research laboratory. **SUBJECTS:** Forty-three New Zealand rabbits. **INTERVENTIONS:** Lung injury was induced by intratracheal instillation of human gastric juice in order to achieve profound hypoxaemia ( $\text{PaO}_2/\text{FIO}_2 \leq 50$ ). Animals were ventilated for 4h after randomization in one of the following four groups: HFPV (median pressure 15cmH<sub>2</sub>O); LVCMV (V(T) 6ml/kg(-1) and PEEP set to reach 15cmH<sub>2</sub>O plateau pressure); HFOV (mean pressure 15cmH<sub>2</sub>O); and a high-volume control group HVCMV (V(T) 12ml/kg(-1) and ZEEP). **MEASUREMENTS AND RESULTS:** Static respiratory compliance increased after the ventilation period in the HFPV, LVCMV and HFOV groups, in contrast with the HVCMV group.  $\text{PaO}_2/\text{FIO}_2$  improved similarly in the HFPV, LVCMV and HFOV groups, and remained lower in the HVCMV group than in the three others. Lung oedema, myeloperoxidase and histological lung injury score were higher in the HVCMV group, but not different among all others. Arterial lactate markedly increased after 4h of ventilation in the HVCMV group, while lower but similar levels were observed in the three other groups. **CONCLUSION:** HFPV, like HFOV and protective CMV, improves respiratory mechanics and oxygenation, and attenuates lung damage. The HFPV provides attractive lung protection, but further studies should confirm these results before introducing HFPV into the clinical arena.

PMID: 17885748 [PubMed - as supplied by publisher]

[Intensive Care Med.](#) 2007 Sep 21 [Epub ahead of print]  
[Intensive Care Med.](#) 2008 Jan; 34(1):91-100. Epub 2007 Sep 21.



## II : IPV

### Efficacy and safety of intrapulmonary percussive ventilation superimposed on conventional ventilation in obese patients with compression atelectasis.

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PURPOSE: To investigate the efficacy and safety of intrapulmonary percussive ventilation (IPV) in obese patients, we assessed their respiratory and hemodynamic functions during IPV superimposed on conventional ventilation. MATERIALS AND METHODS: Ten obese patients with acute respiratory failure due to compression atelectasis who had not improved by conventional ventilation were treated with IPV. Hemodynamic parameters, ventilator settings, and intracranial pressure (n = 1) were recorded every hour. Arterial blood gas was analyzed every 3 hours. The efficacy and safety of IPV was assessed at the start of weaning. RESULTS: Before IPV, Pao<sub>2</sub>/Fio<sub>2</sub> ratio remained low (189 +/- 63 mm Hg), which significantly increased to 243 +/- 67 mm Hg at 3 hours from the initiation of IPV (P < .01). Furthermore, it continuously increased to 280 +/- 50 mm Hg at 24 hours (P < .01). Intrapulmonary percussive ventilation induced significant increase in dynamic compliance from control value of 30 +/- 8 mL/cm H<sub>2</sub>O at 0 hours to 35 +/- 9 mL/cm H<sub>2</sub>O at 12 hours (P < .05) and to 38 +/- 8 mL/cm H<sub>2</sub>O at 24 hours (P < .01). Heart rate and mean arterial pressure were not significantly changed during IPV. Improvement of compression atelectasis was confirmed by their chest computed tomographic scans. Adverse effects such as pneumothorax and intracranial hypertension were not seen. CONCLUSIONS: These results demonstrated that IPV was effective and safe in improving compression atelectasis without adverse effects in obese patients.

PMID: 17175419 [PubMed - in process]

- 1: [J Crit Care](#). 2006 Dec; 21(4):328-32.



## **Intrapulmonary percussive ventilation improves the outcome of patients with acute exacerbation of chronic obstructive pulmonary disease using a helmet.**

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**OBJECTIVE:** To evaluate the effect of intrapulmonary percussive ventilation (IPV) by mouthpiece during noninvasive positive-pressure ventilation with helmet in patients with exacerbation of chronic obstructive pulmonary disease (COPD). **DESIGN:** Randomized clinical trial. **SETTING:** General intensive care unit, university hospital. **PATIENTS:** Forty patients with exacerbation of COPD ventilated with noninvasive positive-pressure ventilation by helmet were randomized to two different mucus clearance strategies: IPV (IPV group) vs. respiratory physiotherapy (Phys group). As historical control group, 40 patients receiving noninvasive positive pressure and ventilated by face mask treated with respiratory physiotherapy were studied. **INTERVENTIONS:** Two daily sessions of IPV (IPV group) or conventional respiratory physiotherapy (Phys group). **MEASUREMENTS AND MAIN RESULTS:** Physiologic variables were measured at entry in the intensive care unit, before and after the first session of IPV, and at discharge from the intensive care unit. Outcome variables (need for intubation, ventilatory assistance, length of intensive care unit stay, and complications) were also measured. All physiologic variables improved after IPV. At discharge from the intensive care unit, Pao<sub>2</sub>/Fio<sub>2</sub> was higher in IPV (274 +/- 15) than the other groups (Phys, 218 +/- 34; control, 237 +/- 20; p < .01). In the IPV group, time of noninvasive ventilation (hrs) (median, 25th-75th percentile: 61, 60-71) and length of stay in the intensive care unit (days) (7, 6-8) were lower than other groups (Phys, 89, 82-96; control, 87, 75-91; p < .01; and Phys, 9, 8-9; control, 10, 9-11; p < .01). **CONCLUSIONS:** IPV treatment was feasible for all patients. Noninvasive positive-pressure ventilation by helmet associated with IPV reduces the duration of ventilatory treatment and intensive care unit stay and improves gas exchange at discharge from intensive care unit in patients with severe exacerbation of COPD.

PMID: 17075375 [PubMed - indexed for MEDLINE]

**1: [Crit Care Med](#). 2006 Dec; 34(12):2940-5**



## Intrapulmonary percussive ventilation in tracheostomized patients: a randomized controlled trial.

- [Clini EM](#), [Antoni FD](#), [Vitacca M](#), [Crisafulli E](#), [Paneroni M](#), [Chezzi-Silva S](#), [Moretti M](#), [Trianni L](#), [Fabbri LM](#).

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OBJECTIVE: To investigate whether the addition of intrapulmonary percussive ventilation to the usual chest physiotherapy improves gas exchange and lung mechanics in tracheostomized patients. DESIGN AND SETTING: Randomized multicenter trial in two weaning centers in northern Italy. PATIENTS AND PARTICIPANTS: 46 tracheostomized patients (age 70[Symbol: see text]+/[Symbol: see text]7[Symbol: see text]years, 28 men, arterial blood pH[Symbol: see text]7.436[Symbol: see text]+/[Symbol: see text]0.06, PaO(2)/FIO(2) 238[Symbol: see text]+/[Symbol: see text]46) weaned from mechanical ventilation. INTERVENTIONS: Patients were assigned to two treatment groups performing chest physiotherapy (control), or percussive ventilation (IMP2 Breas, Sweden) 10[Symbol: see text]min twice/day in addition to chest physiotherapy (intervention). MEASUREMENTS AND RESULTS: Arterial blood gases, PaO(2)/FIO(2) ratio, and maximal expiratory pressure were assessed every 5th day for 15[Symbol: see text]day. Treatment complications that showed up in 1[Symbol: see text]month of follow-up were recorded. At 15[Symbol: see text]days the intervention group had a significantly better PaO(2)/FIO(2) ratio and higher maximal expiratory pressure; after follow-up this group also had a lower incidence of pneumonia. CONCLUSIONS: The addition of percussive ventilation to the usual chest physiotherapy regimen in tracheostomized patients improves gas exchange and expiratory muscle performance and reduces the incidence of pneumonia.

PMID: 17061020 [PubMed - in process]

1: [Intensive Care Med](#). 2006 Dec; 32(12):1994-2001. Epub 2006 Oct 24.



## Airway clearance in children with neuromuscular weakness.

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PURPOSE OF REVIEW: Assistance with airway clearance is critical for reducing morbidity and mortality in children with neuromuscular weakness. Several techniques and devices are available to enhance airway clearance in patients with neuromuscular disease. Only recently, however, has assessment of their effectiveness included children. This review highlights the rationale for use of both secretion extraction and mucus mobilization techniques and devices, emphasizing findings in pediatric patients whenever possible. RECENT FINDINGS: Cough in adults is adequate when peak cough flow exceeds 160 l/min. Similar threshold values in young children have not been established. Those methods that enhance secretion extraction include breath stacking, manual or mechanical insufflation, manually assisted cough, and mechanical insufflation-exsufflation. All are well tolerated in children and can increase peak cough flows, although the greatest increase occurs with mechanical insufflation-exsufflation. Techniques successfully used to help mobilize secretions include high frequency chest wall oscillation and intrapulmonary percussive ventilation. Various modalities can be used successfully alone or in combination. SUMMARY: Secretion extraction and mobilization techniques are safe, even in infants who require airway clearance assistance. To date, however, criteria specific for children are lacking to determine when such modalities should be used and which ones are most effective.

PMID: 16721148 [PubMed - as supplied by publisher]

**1: [Curr Opin Pediatr.](#) 2006 Jun; 18(3):277-281**



## Physiological response to intrapulmonary percussive ventilation in stable COPD patients.

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Intrapulmonary percussive ventilation (IPV) is a ventilatory technique that delivers bursts of high-flow respiratory gas into the lung at high rates, intended for treating acute respiratory failure and for mobilization of secretions. We performed a study, aimed at assessing the physiological response to IPV, on patients' breathing pattern, inspiratory effort, lung mechanics and tolerance to ventilation. Ten COPD patients underwent randomized trials of IPV through a face mask at different pressure/frequency combinations (1.2 bar/250 cycles/min; 1.8/250; 1.2/350; 1.8/350), separated by return to baseline (SB), using the IMP2 ventilator. In 5 patients we have also compared the physiological changes of IPV with those obtained during pressure support ventilation (PSV). Minute ventilation did not vary among the trials, but tidal volumes (VT) were significantly greater during 1.2/250, 1.2/350 and 1.8/350 compared to SB. The pressure time product of the diaphragm per minute (PTPdi/min) estimate of the diaphragm oxygen expenditure was also significantly reduced during 1.2/250 and 1.8/250 (209 cmH<sub>2</sub>O x s/min for SB vs. 143 and 125 for 1.2/250 and 1.8/250, respectively P < 0.05), as well as dynamic intrinsic end-expiratory pressure (PEEPi,dyn). Similar reduction in PTPdi/min were obtained also during PSV. Tolerance to ventilation and oxygen saturation were satisfactory and did not change during the different trials. In 5 normal subjects a prolonged apnea trial lasting > 2 min was also performed, without any significant decrease in SaO<sub>2</sub> or subjective discomfort. In conclusion, IPV was able to guarantee an adequate ventilation, while inducing a significant unloading of the diaphragm during the "low-frequency" trials.

PMID: 16490350 [PubMed - in process]

- 1: [Respir Med.](#) 2006 Sep; 100(9):1526-33. Epub 2006 Feb 21.



**Intrapulmonary percussive ventilation in acute exacerbations of COPD patients with mild respiratory acidosis: a randomized controlled trial [ISRCTN17802078].**

- [Vargas F](#), [Bui HN](#), [Boyer A](#), [Salmi LR](#), [Gbikpi-Benissan G](#), [Guenard H](#), [Gruson D](#), [Hilbert G](#).

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INTRODUCTION: We hypothesized that the use of intrapulmonary percussive ventilation (IPV), a technique designed to improve mucus clearance, could prove effective in avoiding further deterioration in patients with acute exacerbations of chronic obstructive pulmonary disease (COPD) with mild respiratory acidosis. METHODS: The study was performed in a medical intensive care unit of a university hospital. Thirty-three patients with exacerbations of COPD with a respiratory frequency  $\geq 25$ /min, a PaCO<sub>2</sub> > 45 Torr and 7.35  $\leq$  pH  $\leq$  7.38 were included in the study. Patients were randomly assigned to receive either standard treatment (control group) or standard treatment plus IPV (IPV group). The IPV group underwent two daily sessions of 30 minutes performed by a chest physiotherapist through a full face mask. The therapy was considered successful when both worsening of the exacerbation and a decrease in pH to under 7.35, which would have required non-invasive ventilation, were avoided. RESULTS: Thirty minutes of IPV led to a significant decrease in respiratory rate, an increase in PaO<sub>2</sub> and a decrease in PaCO<sub>2</sub> ( $p < 0.05$ ). Exacerbation worsened in 6 out of 17 patients in the control group versus 0 out of 16 in the IPV group ( $p < 0.05$ ). The hospital stay was significantly shorter in the IPV group than in the control group (6.8  $\pm$  1.0 vs. 7.9  $\pm$  1.3 days,  $p < 0.05$ ). CONCLUSION: IPV is a safe technique and may prevent further deterioration in patients with acute exacerbations of COPD with mild respiratory acidosis.

PMID: 16137351 [PubMed - indexed for MEDLINE]

1: [Crit Care](#). 2005 Aug; 9(4):R382-9. Epub 2005 Jun 1.



## Effect of intrapulmonary percussive ventilation in a severely disabled patient with persistent pulmonary consolidation

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An intrapulmonary percussive ventilator (IPV) improves airway clearance and lung function, and is useful for wide variety of respiratory disorders, such as cystic fibrosis, chronic obstructive pulmonary disease, aspiration pneumonia, and neuromuscular diseases. However, there are few reports on IPV use in patients with severe neurological impairment, scoliosis and thoracic deformity. They have poor mobility of the rib cage and difficulty in sputum expectoration. The use of IPV significantly improved persistent consolidation shown by chest computed tomography (CT) in one of such patients. The patient was a 33-year-old woman with severe spastic quadriplegia and tracheostomy and she was dependent on mechanical ventilation because of chronic restrictive respiratory failure. After fever and mild hypoxemia for one day, chest CT revealed consolidation of the left lower lobe. An IPV-I ventilator was used for 15 min once a week, with a stroke frequency of 250-300 cycles/min and pressure of 22 PSI. Mechanical ventilation was withheld during the IPV therapy. Chest physiotherapy was also done. According to the worsening of the consolidation on chest CT, the frequency of IPV was changed to once a day at day 23 and then to twice a day. Chest CT at day 44 showed further improvement. In patients with severe motor and intellectual disabilities, it is sometimes difficult to control progressive deterioration of pulmonary function and persistent atelectasis even with tracheostomy, mechanical ventilation, and conventional physiotherapy. Our results indicate that IPV may improve respiratory function and the quality of life in such patients.

PMID: 16026100 [PubMed - indexed for MEDLINE]

1: [No To Hattatsu](#). 2005 Jul; 37(4):332-6



## **Intrapulmonary percussive ventilation vs incentive spirometry for children with neuromuscular disease.**

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**BACKGROUND:** Pulmonary infections can be life threatening for children with neuromuscular diseases who have impaired ability to clear secretions. Intrapulmonary percussive ventilation (IPV) is a pneumatic device that delivers air and aerosol to the lungs at frequencies of 200 to 300 cycles per minute at peak pressures from 20 to 40 cm H<sub>2</sub>O. Anecdotal reports and pilot studies show its safety and effectiveness in mobilizing secretions in patients with cystic fibrosis. **OBJECTIVE:** To test the hypothesis that IPV used in a pulmonary program for adolescents with neuromuscular disease would reduce the number of days of antibiotic use for pulmonary infection. **METHODS:** A randomized, controlled study was conducted to compare efficacy of IPV with incentive spirometry (IS) in reducing number of days of antibiotic use in adolescents with neuromuscular disease. The secondary endpoints were the number of respiratory infections, hospitalizations, and school days missed. **RESULTS:** A total of 18 patients were enrolled (9 IPV, 9 IS). Antibiotic use was significantly higher with IS (24/1000 patient-days) compared with IPV (0/1000 patient-days), (incidence rate ratio, 43; 95% confidence interval, 6-333). The IS group spent more days hospitalized (4.4/1000 patient-days vs 0/1000 patient-days) than the IPV group (incidence rate ratio, 8.5; 95% confidence interval, 1.1-67). The IPV group had 0 episodes of pneumonia or bacterial bronchitis compared with 3 events in the IS group, although this did not meet statistical significance. **CONCLUSION:** Intrapulmonary percussive ventilation as part of a preventive pulmonary regimen reduced days of antibiotic use and hospitalization for respiratory illness in adolescents with neuromuscular disease.

PMID: 15939850 [PubMed - indexed for MEDLINE]

**[Crit Care Med](#). 2005 Sep; 33(9):2155; author reply 2155-6**



**Effect of intrapulmonary percussive ventilation on mucus clearance in Duchenne muscular dystrophy patients: a preliminary report.**

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**OBJECTIVE:** To determine the effects of intrapulmonary percussive ventilation (IPV) on mucus clearance in tracheostomized Duchenne muscular dystrophy patients. **METHODS:** We studied 8 patients, 5 of whom had mucus hypersecretion (> 30 mL/d). In a randomized, cross-over study we compared assisted mucus clearance techniques with and without IPV. There were 2 treatment sequences and each patient received 5 consecutive days of each treatment sequence, delivered 3 times a day. One sequence consisted of (1) assisted mucus clearance technique (AMCT, which involves forced expiratory technique and manual assisted cough), (2) endotracheal suctioning, (3) nebulizer administration of 5 mL of 0.9% sodium chloride solution for 5 min, (4) a second AMCT session, (5) endotracheal suctioning, (6) 45 min after the end of the nebulizer treatment a third AMCT session, (7) endotracheal suctioning. The other treatment sequence was the same except that it included IPV during the 5-min nebulizer treatment. The collected secretions were weighed. Vital capacity was measured once, before the treatments. Heart rate, respiratory rate, oxyhemoglobin saturation, end-tidal carbon dioxide, airway resistance, and peak expiratory flow were measured before and at 45 min after the treatments. Mean values were compared using analysis of variance with repeated measures. **RESULTS:** In patients with hypersecretion the mean +/- SD weight of the collected secretions was significantly higher with IPV (6.53 +/- 4.77 g vs 4.57 +/- 3.50 g, p = 0.01). Heart rate, respiratory rate, oxyhemoglobin saturation, end-tidal carbon dioxide, airway resistance, and peak expiratory flow did not differ statistically between the 2 treatments. **CONCLUSIONS:** IPV is a safe airway clearance method for tracheostomized Duchenne muscular dystrophy patients, and this preliminary study suggests that IPV increases the effectiveness of assisted mucus clearance techniques.

PMID: 14525630 [PubMed - indexed for MEDLINE]

1: [Respir Care](#). 2003 Oct; 48(10):940-7.



**A comparison of the therapeutic effectiveness of and preference for postural drainage and percussion, intrapulmonary percussive ventilation, and high-frequency chest wall compression in hospitalized cystic fibrosis patients.**

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INTRODUCTION: Cystic fibrosis (CF) patients have abnormally viscid bronchial secretions that cause airway obstruction, inflammation, and infection that leads to lung damage. To enhance airway clearance and reduce airway obstruction, daily bronchopulmonary hygiene therapy is considered essential. OBJECTIVE: Compare the effectiveness of and patient preferences regarding 3 airway clearance methods: postural drainage and percussion (PD&P), intrapulmonary percussive ventilation (IPV), and high-frequency chest wall compression (HFCWC). METHODS: The participants were hospitalized CF patients  $\geq 12$  years old. Effectiveness was evaluated by measuring the wet and dry weights of sputum obtained with each method. In random order, each patient received 2 consecutive days of each therapy, delivered 3 times daily for 30 minutes. Sputum was collected during and for 15 minutes after each treatment, weighed wet, then dried and weighed again. Participants rated their preferences using a Likert-type scale. Mean weights and preferences were compared using analysis of variance with repeated measures. Patient preferences were compared using Friedman's test. RESULTS: Twenty-four patients were studied. The mean  $\pm$  SD wet sputum weights were 5.53  $\pm$  5.69 g with PD&P, 6.84  $\pm$  5.41 g with IPV, and 4.77  $\pm$  3.29 g with HFCWC. The mean wet sputum weights differed significantly ( $p = 0.035$ ). Wet sputum weights from IPV were significantly greater than those from HFCWC ( $p < 0.05$ ). The mean dry sputum weights were not significantly different. With regard to overall preference and to the subcomponents of preference, none of the 3 methods was preferred over the others. CONCLUSIONS: HFCWC and IPV are at least as effective as vigorous, professionally administered PD&P for hospitalized CF patients, and the 3 modalities were equally acceptable to them. A hospitalized CF patient should try each therapy and choose his or her preferred modality.

PMID: 12556258 [PubMed - indexed for MEDLINE]

**1: [Respir Care](#). 2003 Jan; 48(1):24-8.**



**A comparison of intrapulmonary percussive ventilation and conventional chest physiotherapy for the treatment of atelectasis in the pediatric patient.**

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**OBJECTIVE:** Compare intrapulmonary percussive ventilation (IPV) to conventional chest physiotherapy (CPT) and determine their effects on improving atelectasis and static compliance in pediatric patients. **METHODS:** We conducted a retrospective study of 46 patients who received IPV therapy with the Percussionator IPV-1 ventilator at frequencies of 180-220 cycles/min and pressures of 15-30 cm H<sub>2</sub>O. Medicated aerosol therapy with albuterol 2.5 mg in 6 mL normal saline solution was delivered with each IPV treatment. Baseline and subsequent chest radiographs were evaluated by a pediatric radiologist. We used an ordinal scoring system to measure the degree of atelectasis to evaluate chest radiographs (4 = complete collapse, 0 = complete resolution). Then we conducted a prospective, randomized, controlled study of intubated and mechanically ventilated patients to compare changes in atelectasis and static compliance. Baseline and daily chest radiographs were evaluated using the same scoring system as in the retrospective pilot evaluation. Patients were ventilated in the volume-controlled, synchronized intermittent mandatory ventilation mode, with tidal volumes of 6-10 mL/kg. Patients were randomized to CPT (clapping and vibration) or IPV at frequencies of 180-220 cycles/min and pressures of 15-30 cm H<sub>2</sub>O (equal to the peak pressures on the ventilator), with 6 mL of normal saline solution via medicated aerosol. Both treatments were given every 4 h and lasted 10-15 min. Static compliance measurements were calculated from exhaled tidal volumes and plateau pressures. **RESULTS:** In the retrospective study the median age of patients receiving IPV was 4.2 years and the median duration of IPV was 6.2 days. A change in atelectasis score from 3 to 1 ( $p < 0.001$ ) was seen. In the randomized, controlled trial the median age of patients was 3.1 years. Atelectasis scores before treatment were comparable between the CPT and IPV groups (median 2.0 for both groups,  $p = 0.530$ ). Atelectasis scores after treatment were unchanged in the CPT group (median 2.0,  $p = 0.421$ ) but improved in the IPV group (median 1.0,  $p = 0.026$ ). Treatment lasted an average of 6.2 days in the CPT group and 2.1 days in the IPV group ( $p = 0.018$ ). Neither group showed any change in static compliance following treatment. **CONCLUSIONS:** In the retrospective study a clinically important improvement in atelectasis was seen in patients who received IPV therapy. In the controlled, clinical trial the IPV group showed more clinically important improvement in atelectasis than the CPT group. IPV is a safe and effective method of alternative airway clearance and can be used on patients with artificial airways.

PMID: 12354335 [PubMed - indexed for MEDLINE]

**1: [Respir Care](#). 2002 Oct; 47(10):1162-7**



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## Physiotherapy for airway clearance in adults.

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Techniques for augmenting, when necessary, the normal mucociliary and cough clearance mechanisms of the lungs are not new, but, in more recent years, techniques have been developed which are effective, comfortable and can be used independent of an assistant in the majority of adolescents and adults. Postural drainage with chest clapping and chest shaking has, in most parts of the world, been replaced by the more effective techniques of the active cycle of breathing, autogenic drainage, R-C Cornet, Flutter, positive expiratory pressure mask, high-frequency chest wall oscillation and intrapulmonary percussive ventilation. Glossopharyngeal breathing is being considered again and is often a useful technique for increasing the effectiveness of cough in patients with tetraplegia or neuromuscular disorders. The evidence in support of these techniques is variable, and the literature is confusing and conflicting. There may or may not be significant differences among the techniques in the short or long term. Many of the regimens now include the forced expiratory manoeuvre of a "huff" and this has probably increased the effectiveness of airway clearance. If objective differences are small, individual preferences and cultural influences may be significant in increasing adherence to treatment and in the selection of an appropriate regimen or regimens for an individual patient.

PMID: 10624775 [PubMed - indexed for MEDLINE]

[Eur Respir J.](#) 1999 Dec; 14(6):1418-24



**Alternatives to percussion and postural drainage. A review of mucus clearance therapies: percussion and postural drainage, autogenic drainage, positive expiratory pressure, flutter valve, intrapulmonary percussive ventilation, and high-frequency chest compression with the ThAIRapy Vest.**

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The purpose of this article is to review published studies on the efficacy of old and new mucus clearance techniques and to develop recommendations for different groups of patients. Mucus clearance is a problem in cystic fibrosis, bronchiectasis, and many other pulmonary conditions. Percussion and postural drainage (P & PD) was the traditional method of facilitating mucus clearance, but the many hazards and contraindications along with the onerous nature and resultant poor patient compliance of this procedure have led to the development of alternative therapies. Research studies with cystic fibrosis patients support the efficacy of P & PD in patients who can tolerate it. However, equivalent sputum production can be accomplished with autogenic drainage, positive expiratory pressure, and Flutter valve therapy without the assistance of another caregiver, as long as the patient has the motivation, breath control, and neuromuscular function to perform these modalities. The Intrapulmonary Percussive Ventilation device and high-frequency chest compression with the ThAIRapy vest involve more elaborate and expensive equipment, yet these devices provide mucus clearance assistance to patients who lack the ability to perform the simpler techniques. Both mechanized modalities promote independence and self-care in the patient, and the effectiveness of both has been supported by the limited research published to date. Which alternative to recommend depends on the ability, motivation, preference, needs, and resources of each patient.

PMID: 9702607 [PubMed - indexed for MEDLINE]

**1: [J Cardiopulm Rehabil.](#) 1998 Jul-Aug; 18(4):283-9.**



**Persistent pulmonary consolidation treated with intrapulmonary percussive ventilation: a preliminary report.**

- [Birnkrant DJ](#), [Pope JF](#), [Lewarski J](#), [Stegmaier J](#), [Besunder JB](#).

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Intrapulmonary percussive ventilation (IPV) is a novel form of chest physiotherapy delivered by a percussive pneumatic device (IPV, Percussionaire, Sand Point, ID). There are few published reports about the use of IPV for diseases other than cystic fibrosis. We report our experience with three pediatric patients and one adult patient with persistent pulmonary consolidation refractory to conventional therapies. Three of the four patients had neuromuscular disease; one patient had segmental atelectasis due to aspiration. Three of the four patients showed clinical and radiographic improvement within 48 hours of starting IPV. The fourth patient experienced brief episodes of third-degree atrioventricular block, hypoxemia, and bradycardia during two IPV treatments. IPV was safely restarted and he slowly improved. We conclude that while IPV requires further clinical evaluation, it appears to be a safe and effective therapy for selected patients. However, close observation is essential during and after IPV treatments, especially in patients who have difficulty mobilizing or expectorating sputum.

PMID: 9121855 [PubMed - indexed for MEDLINE]

**1: [Pediatr Pulmonol](#). 1996 Apr; 21(4):246-9**



**The usefulness of combined high-frequency percussive ventilation during acute respiratory failure after smoke inhalation.**

- [Reper P, Dankaert R, van Hille E, van Laeke P, Duinslaeger L, Vanderkelen A.](#)

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Inhalation injury and bacterial pneumonia represent some of the most important causes of mortality in burn patients. We describe 11 severely burned patients with acute respiratory failure due to inhalation injury who did not respond adequately to conventional respiratory support. High-frequency percussive ventilation (HFPV) is a recent ventilatory mode, which combines the advantages of conventional ventilation with some of those of high-frequency ventilation. Seven patients developed pulmonary infection during the acute phase; one patient died of multiple organ failure on day 25. All the other patients survived; two developed bronchiolitis obliterans symptoms before discharge. No side-effects were noted and haemodynamic tolerance of HFPV was excellent. Our findings suggest that HFPV can improve pulmonary function and gas exchange in these catastrophic pulmonary failures following inhalation injury.

PMID: 9601588 [PubMed - indexed for MEDLINE]

**1: [Burns](#). 1998 Feb; 24(1):34-8.**



**Comparison of intrapulmonary percussive ventilation and chest physiotherapy. A pilot study in patients with cystic fibrosis.**

- [Natale JE](#), [Pfeifle J](#), [Homnick DN](#).

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STUDY OBJECTIVE: To compare the intrapulmonary percussive ventilator (IPV) to chest physiotherapy (P&PD) with respect to acute changes in (1) pulmonary function and (2) sputum physical properties in patients with cystic fibrosis (CF). DESIGN: Randomized crossover. SETTING: Community-based CF referral center. PARTICIPANTS: Nine nonhospitalized person (range, 7 to 40 years; median, 12.4 years) with moderate to excellent Shwachman scores. INTERVENTIONS: Three treatment regimens: (1) 2.5 mg albuterol delivered via IPV (internal percussive component activated); (2) 2.5 mg. albuterol delivered via IPV (internal percussive component inactivated), followed by P&PD; and (3) 2.5 mg albuterol delivered via updraft nebulizer, followed by P&PD. MEASUREMENTS AND RESULTS: Outcome measures included pulmonary function testing (PFTs) and quantitative and qualitative sputum analysis. Among the three treatment groups, there were no significant differences in the change in predicted PFTs 1 h or 4 h after treatment, nor in the volume of sputum expectorated in the first 4 or in the subsequent 20 h. Among patients receiving IPV, more serious disease was associated with greater improvement in FEF25-75 1 h after treatment, but these differences disappeared by 4 h. There were no meaningful differences in viscoelastic characteristics of sputum expectorated after each treatments. Participants reported general satisfaction with no adverse effects while using IPV. CONCLUSIONS: This initial pilot study suggests (1) stable patients with CF tolerated one treatment of IPV without adverse sequelae, and (2) IPV was as effective as standard aerosol and P&PD in improving short-term PFT results and enhancing sputum expectoration.

PMID: 8205878 [PubMed - indexed for MEDLINE]

**1: [Chest](#). 1994 Jun; 105(6):1789-93**



**Comparison of effects of an intrapulmonary percussive ventilator to standard aerosol and chest physiotherapy in treatment of cystic fibrosis.**

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Impaired mucociliary clearance due to defective ion and water transport and the effects of chronic airway infections lead to stasis of secretions and progressive pulmonary damage in patients with cystic fibrosis (CF). Methods to improve removal of tenacious lung secretions in CF patients contribute to slowing the decline in respiratory function. We have evaluated an intrapulmonary percussive ventilator (IPV), which is a device designed to enhance airway clearance and preserve lung function. A previous pilot study by us had determined that the device was acceptable to patients and is safe. We undertook a 6 month parallel comparative trial of the IPV versus standard, manual chest physiotherapy in 16 CF children and adults. No significant differences in spirometric measures, numbers of hospitalizations, use of oral or IV antibiotics, or anthropometric measurements were detected between the standard aerosol/chest physiotherapy group and the IPV group over the duration of the trial. Patient acceptance, as determined by participant survey, was good. The device appeared to be safe and durable. It was concluded that the IPV is as effective as standard aerosol and chest physiotherapy in preserving lung function and anthropometric measures, and there was no difference in the use of antibiotics and hospitalizations.

PMID: 7478782 [PubMed - indexed for MEDLINE]

- **1: [Pediatr Pulmonol.](#) 1995 Jul; 20(1):50-5.**



## **The intrapulmonary percussive ventilator and flutter device compared to standard chest physiotherapy in patients with cystic fibrosis.**

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Stasis of viscid secretions in cystic fibrosis (CF) leads to chronic infection, inflammation, and lung destruction. Chest physiotherapy (CPT) has been used for many years to assist in the removal of these secretions. However, the need for independently administered CPT exists, particularly for adolescents and the older CF patient. Two devices, the intrapulmonary percussive ventilator (IPV) and the Flutter device (Flutter) have been promoted for this purpose. This study compares these devices to standard, manual CPT. There was no difference in sputum quantity produced with any method studied. Transiently lower oxygen saturation was noted with standard CPT compared with the IPV and Flutter. Inconsistent but significant improvements in flow rates were noted with the two devices compared to standard CPT. Important trends to lower lung volumes, probably indicating decreased air trapping, were also noted with all three therapies at 1 and 4 hours after administration. There were no adverse effects with any treatment regimen. Larger and longer studies of these devices compared to standard CPT and with each other are warranted to assess their value for independent administration of CPT in CF patients and to determine long-term effects on maintenance of pulmonary function.

PMID: 9675436 [PubMed - indexed for MEDLINE]

**1: [Clin Pediatr \(Phila\)](#). 1998 Jul; 37(7):427-32. [Links](#)**



## **Atelectatic children treated with intrapulmonary percussive ventilation via a face mask: Clinical trial and literature overview.**

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Background: Persistent atelectasis in children is lacking a gold standard treatment. Intrapulmonary percussive ventilation (IPV) is presented as a promising chest physiotherapy technique in the treatment of atelectasis. This study aimed to follow the evolution of atelectasis resolution with noninvasive IPV in young children and to detect eventual adverse effects. Methods: Six children were hospitalized for respiratory distress with suspicion of atelectasis. A 15 min IPV treatment was immediately started at D1 twice a day for 5 days. Children were free of any other treatment. Chest X-Ray (CXR) was performed on the second day (D2) and was repeated 3 days later (D5). After the study, CXR were retrospectively reviewed by three specialists who had no knowledge of the clinical observations of the patients. They were asked to assess atelectasis by a score between 4 (complete collapse) and 0 (complete resolution). A clinical score on a maximum of 4 points was assessed by appetite deterioration, dyspnoea, mucus production and cough presence at D1 and D5 (1 point per symptom present). Paired t-test compared D1 and D5 results. Results: All patients returned home after 5 days IPV. SpO<sub>2</sub> normalized (93.2 +/- 0.8 to 95.3 +/- 0.8; P = 0.002) and patients all improved clinically (score, 2.8 +/- 0.9 to 0.8 +/- 0.6; P < 0.05). Out of four patients with radiographic evidence of atelectasis, three improved their atelectasis score. Conclusions: No side-effect or adverse effect was observed during IPV treatments. IPV was safe and effective in atelectasis resolution in 3/4 of the cases. Patients all recovered a stable clinical state. CXR improved in 4/5 children. They were all discharged home after 5 days of IPV treatment.

PMID: 17587276 [PubMed - in process]

**1: [Pediatr Int.](#) 2007 Aug; 49(4):502-7.**



## **Young's syndrome in the adult age: home treatment with a mechanical device of intrapulmonary percussive ventilation**

[Article in Spanish]

**[Ruescas Escolano E](#), [Chiner Vives E](#), [Andreu Rodríguez AL](#), [Camarasa Escrig A](#), [Llombart Cantó M](#), [Sancho Chust J](#)**

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We studied a man with bronchiectasis, chronic sinopulmonary infections and obstructive azoospermia diagnosed of Young's syndrome in the adult age. The patient was treated at home by a mechanical system of respiratory care based in intrapulmonary percussive ventilation (Percussionaire) reaching a significant clinical and functional improvement. Our case enhanced the importance to make a proper history of fertility in patients with bronchiectasis in order to establish the diagnostic. We review different methods of respiratory mechanical assistance in patients with bronchiectasis.

PMID: 18198952 [PubMed - in process]

**[An Med Interna](#). 2007 Sep; 24(9):435-8. [Links](#)**

