Intrapulmonale Percussie Ventilatie (IPV2)
Literatuur onderzoek overzicht 2002 - 2013

R. Janssen - Dean

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2007	Intra-pulmonary Percussive Ventilation – Brief Review of Clinical and Physiological Studies	Frédéric Vargas and Jean Dellamonica	FR
2006	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.	IT
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2006	Physiological response to intrapulmonary percussive ventilation in stable COPD patients.	Nava S, Barbarito N, Piaggi G, De Mattia E, Cirio S.	IT
2006	Efficacy and safety of intrapulmonary percussive ventilation superimposed on conventional ventilation in obese patients with compression atelectasis.	Tsuruta R, Kasaoka S, Okabayashi K, Maekawa T.	JPN

2005	Intrapulmonary percussive ventilation in acute exacerbations of COPD patients with mild respiratory acidosis: a randomized controlled trial	Vargas F, Bui HN, Boyer A, Salmi LR, Gbikpi-Benissan G, Guenard H, Gruson D, Hilbert G.	FR
2005	Intrapulmonary percussive ventilation vs incentive spirometry for children with neuromuscular disease.	Reardon CC, Christiansen D, Barnett ED, Cabral HJ.	USA
2003	Effect of intrapulmonary percussive ventilation on mucus clearance in Duchenne muscular dystrophy patients: a preliminary report.	Toussaint M, De Win H, Steens M, Soudon P.	BE
2002	A comparison of intrapulmonary percussive ventilation and conventional chest physiotherapy for the treatment of atelectasis in the pediatric patient.	Deakins K, Chatburn RL.	USA

{2013} Beneficial effects of intrapulmonary percussive ventilation in patients with respiratory insufficiency in the ICU

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Critical Care 2013, **17**(Suppl 2):P119 doi:10.1186/cc12057

Introduction: Intrapulmonary percussive ventilation (IPV) is a therapy that is used to clear endobronchial secretions. The IPV ventilator was designed and developed by FM Bird in 1979. The ventilator consists of a phasitron that delivers rapid, high-flow, mini bursts of oxygen, mixed with air. The potential aims of this mechanism are pulmonary recruitment, improved mucus clearance with a direct high-frequency oscillatory effect. We investigated whether IPV has a positive effect on ventilatory values in adult patients on the ICU.

Methods: All patients presenting during a 4-month period in 2011 with respiratory insufficiency on our mixed adult ICU were included in this study. Patients were monitored before, directly after and 15 minutes after therapy with IPV using a Bird Intrapulmonary Ventilator Model IPV-2C. All patients received IPV for a period of 20 minutes consisting of two cycles of 10 minutes. Peripheral oxygen saturation (SpO_2), tidal volume (Vt), respiratory rate, end-tidal CO_2 (ET-CO_2), dynamic lung compliance (C-dyn) and work of breathing (WOB) were monitored at the different time points. Paired Student *t* tests were performed in order to compare the values immediately before IPV, with directly after therapy and 15 minutes later. $P < 0.05$ was considered significant.

Results: Eighty-three patients were examined. SpO_2 improved significantly from 93.7 ± 3.7 before IPV to 95.7 ± 2.8 after IPV ($P < 0.001$) and 15 minutes later to 95.2 ± 2.8 ($P < 0.001$). Vt improved from 418 ± 111 before IPV to 476 ± 102 directly after ($P < 0.001$) and to 480 ± 131 15 minutes later ($P < 0.01$). Respiratory rate improved from 24 ± 6 to 23 ± 6 only after 15 minutes significantly ($P < 0.01$). WOB and C-dyn did not change. ET-CO_2 decreased from 34.9 ± 14.8 to 33.3 ± 13.3 ($P < 0.05$) directly after IPV and to 32.1 ± 12.8 ($P < 0.01$) 15 minutes later.

Conclusion: In this study we demonstrated a beneficial effect of IPV on oxygen saturation, tidal volume and end-tidal CO_2. IPV has this effect in addition to the mobilization of bronchial secretions.

Nederlands:
Doelstelling: Heeft IPV een positief effect op de respiratoire parameters bij patienten met respiratoire insufficientie?
Setting: Enkel centra. Volwassen ICU, 83 patiënten
Methode: twintig minuten IPV met thorax compressies werd toegepast bij 83 patiënten, wel of niet mechanisch beademd . SpO_2, Vt, ademfrequentie, $ETCO_2$, C-dyn & WOB waren geregistereed direct voor, na en 15 minuten na de behandeling
Resultaten: De SpO_2 was significant verbeterd van 93.7 ± 3.7 vóór IPV tot 95.7 ± 2.8 na IPV ($P < 0.001$) en 15 minuten daarna 95.2 ± 2.8 ($P < 0.001$). Vt verbeterd van 418ml ± 111 vóór IPV tot 476ml ± 102 direct daarna ($P < 0.001$) en 480ml ± 131 15 minuten daarna ($P < 0.01$). AH frequentie verbeterd van 24 ± 6 to 23 ± 6 dit was alleen na 15 minuten significant ($P < 0.01$). WOB en C-dyn bleven onveranderd. ET-CO_2 daalt van 34.9 ± 14.8 to 33.3 ± 13.3 ($P < 0.05$) direct na IPV en tot 32.1 ± 12.8 ($P < 0.01$) 15 minuten later.
Conclusie: IPV heeft een positief effect op SpO_2, Vt en $ETCO_2$ zowel als op sputum mobilisatie.

{2013} Characterization of the mechanical behavior of intrapulmonary percussive ventilation

E Fornasa1, M Ajčević and A Accardo

Physiological Measurement Volume 34 Number 12
E Fornasa *et al* 2013 *Physiol. Meas.* **34** 1583 doi:10.1088/0967-3334/34/12/1583

A new device delivering intrapulmonary percussive ventilation (IPV), called Impulsator® (Percussionaire Corporation, Sandpoint, ID, USA), has recently been introduced in an effort to provide effective clearance and to promote homogeneity of ventilation in the lungs of patients with cystic fibrosis. In order to optimize the treatment based on its use, a better understanding of its functioning is still necessary. In fact, up to now, a complete characterization of this device has not been carried out, thus reducing its effective utilization in clinical practice. With the aim of overcoming this lack, in this study, data concerning flow and pressure delivered during *in vitro* IPV were acquired under different combinations of device settings and respiratory loads. Quantitative information was obtained about the physical variables administered by the device like percussive frequency, ratio of inspiratory to expiratory time, flow and pressure magnitudes and volume exchanged. The analysis of the data determined the relations among these variables and between them and the mechanical loads, laying the basis for an optimal clinical application of the device.

Nederlands.

Doelstelling: vaststellen van mechanische werking van intrapulmonale percussie ventilatie
Setting: in vitro studie
Methode: flow en druk gemeten tijdens IPV werden getest met verschillende combinaties van apparaat instellingen en respiratoire volumes. Kwantitatieve informatie verkreeg men via de fysieke variabele zoals; frequentie, ratio inspiratoire/expiratoire tijd, flow en druk en volume veranderingengende.
Resultaten: de analyse bepaalde de relaties tussen de variabelen, zowel als tussen de variabelen en de mechanische lading. Hiermee werd een basis gelegd voor een optimale klinische toepassing van de apparatuur.

{2012} Clearing away pulmonary secretions

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PRUITT, BILL RRT, AE-C, CPFT, MBA; JACOBS, MICHAEL RN, CCRN, CEN, MSNSpecialized Respiratory Management for Acute Cervical Spinal Cord Injury: A Retrospective Analysis
Volume 18, Number 4 / Fall 2012 - Respiratory Care and Management in SCI
283-290
10.1310/sci1804-283

Abstract
Excess or retained pulmonary secretions impair ventilation, invite infection, and may threaten survival. Find out who's at greatest risk and how to keep airways clear.
Background: In individuals with cervical spinal cord injury (SCI), respiratory complications arise within hours to days of injury. Paralysis of the respiratory muscles predisposes the patient toward respiratory failure. Respiratory complications after cervical SCI include hypoventilation, hypercapnea, reduction in surfactant production, mucus plugging, atelectasis, and pneumonia. Ultimately, the patient must use increased work to breathe, which results in respiratory fatigue and may eventually require intubation for mechanical ventilation. Without specialized respiratory management for individuals with tetraplegia, recurrent pneumonias, bronchoscopies, and difficulty in maintaining a stable respiratory status will persist. **Objective:** This retrospective analysis examined the effectiveness of specialized respiratory management utilized in a regional SCI center. **Methods:** Individuals with C1-C4 SCI (N = 24) were the focus of this study as these neurological levels present with the most complicated respiratory status. **Results:** All of the study patients' respiratory status improved with the specialized respiratory management administered in the SCI specialty unit. For a majority of these patients, respiratory improvements were noted within 1 week of admission to our SCI unit. **Conclusion:** Utilization of high tidal volume ventilation, high frequency percussive ventilation, and mechanical insufflation-exsufflation have demonstrated efficacy in stabilizing the respiratory status of these individuals. Optimizing respiratory status enables the patients to participate in rehabilitation therapies, allows for the opportunity to vocalize, and results in fewer days on mechanical ventilation for patients who are weanable.

Nederlands

Achtergrond: bij patienten met CS letsel komen respiratoire complicaties uren tot dagen na letsel voor. Respiratoire complicaties na een CS letsel kunnen zijn; hypoventilatie, hypercapnie, afname surfactant productie, sputum proppen, atelectase en pneumonieen. Uiteindelijk treedt er respiratoire insufficientie op en moet de patiënt geintubeerd en mechanisch beademd worden.
Doel: deze retrospectieve analyse onderzoekt de effectiviteit van gespecialiseerde respoiratoir management uitgevoerd in een regionaal CS center.
Methoden: individueen met C1-C4 CS (N=24) waren het onderwerp van de studie, aangezien letsels op deze hoogte van de ruggenwervel zich het meest presenteren met gecompliceerde respiratoire status.
Resultaten: gebruik van hoog tidal volume ventilatie, hoge frequentie percussie ventilatie en mechanische inspiratie-expiratie laten effectiviteit zien in het stabilizeren van de respiratoire status van deze individuen. Het optimaliseren van de respiratoire status maakt het voor de patiënt mogelijk om te participeren in revalidatie therapieen, te vocaliseren en laat in minder aantal dagen aan mechanische ventilatie meer resultaat zien voor patiënten die geweaned kunnen worden.

{2012} Intrapulmonary effects of setting parameters in portable intrapulmonary percussive ventilation devices.

Toussaint M1, Guillet MC, Paternotte S, Soudon P, Haan J.

Respir Care. 2012 May;57(5):735-42. doi: 10.4187/respcare.01441. Epub 2011 Dec 6.

BACKGROUND:

Despite potential benefits of intrapulmonary percussive ventilation (IPV) in various respiratory diseases, the impact of setting parameters on the mechanical effects produced by IPV in the lungs is unknown. We hypothesized that changing the parameters on IPV would modulate these effects. This in vitro study aimed at comparing the changes in intrapulmonary effects resulting from changes in parameters in 3 portable IPV devices (IMP2, Impulsator, and Pegaso).

METHODS:

Parameters were set in 72 combinations of frequency (90-250 cycles/min), inspiratory to expiratory (I/E) time ratio (from 1/2 to 3/1), and pressure (10-60 cm H(2)O). Four resulting effects were recorded on a test lung via a pneumotachometer: the expiratory to inspiratory flow ratio (E/I flow ratio), the PEEP, the ventilation, and the percussion. Percussion was assessed by the end-slope of the pressure curve. Analysis of variance was used for data analysis.

RESULTS:

E/I flow ratio increased with increasing I/E time ratio ($P < .001$). The Pegaso produced the lowest E/I flow ratio. PEEP raised 6 cm H(2)O in both IMP2 and Impulsator, and 17 cm H(2)O in the Pegaso with increasing frequency ($P < .01$), pressure, and I/E time ratio ($P < .001$). In all devices, ventilation increased with increasing pressure and decreasing frequency ($P < .001$). Percussion increased with increasing frequency and decreasing I/E time ratio ($P < .001$), and with increasing pressure when I/E time ratio was 1/1 or less. The Pegaso provided the poorest percussion.

CONCLUSIONS:

This study suggests that changing the parameters considerably modulates the mechanical effects produced by portable IPV devices in the lungs. Increasing frequency increased PEEP and percussion, but decreased ventilation. Increasing I/E time increased PEEP and E/I flow ratio, and decreased percussion. Finally, increasing pressure increased PEEP and ventilation. The Pegaso produced the highest PEEP, least percussion, and smallest change in E/I flow ratio.

Nederlands:

Achtergrond: ondanks mogelijke voordelen van het gebruik van IPV bij verschillende aandoeningen is de impact van de setting parameters van de mechanische effecten door IPV in de longen onbekend

Doel: deze in vitro studie zocht de verschillen in intrapulmonale effecten resulterend van veranderingen in de parameters van drie draagbare IPV apparaten (IMP2, Impulsator end Pegaso).

Methoden: de parameters zijn gezet in 72 combinaties van frequentie (90-250 cyclussen/min), inspiratie tot expiratie (I/E) tijdsratio (van ½ tot 3/1) en druk (10-60 cm H2O). Vier effecten worden vastgesteld met een test long via een pneumotachometer: de expiratie-inspiratie flow ratio, de PEEP, de ventilatie en de percussie. Percussie werd gebruikt bij het einde van de druk curve.

Resultaten: de studie verondersteld dat verandering van de parameters significant effect heeft op de mechanische effecten, geproduceerd door de draagbare IPV apparaten, in de longen.
De IMP2 Impulsator gaf betere percussies dan de Pegaso.

{2012} Safety and effect of intermittent intrapulmonary percussive ventilation on oxygen saturation and hemodynamic functions

I Blum, R Janssen-Dean, A Van Overdijk, and B Speelberg
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Crit Care. 2012; 16(Suppl 1): P122. Published online Mar 2012

Intrapulmonary percussive ventilation (IPV) is a ventilatory technique which is used to clear endobronchial secretions in patients. IPV uses a Phasitron, which delivers rapid, high-flow, minibursts of air mixed with oxygen to the patients. We investigated the safety of IPV on hemodynamic values and the effect of IPV on oxygen saturation and respiratory rate.

Methods:

From April until August 2011 we investigated 42 consecutive patients admitted to our eight-bed adult general ICU with respiratory failure. Variables such as heart rate, mean arterial pressure, respiratory rate, and oxygen saturation were measured and compared at three different time points: before starting IPV therapy, directly after and 15 minutes later. All patients received IPV using a Bird Intrapulmonary Percussionator Ventilator Model IPV-2C for a period of 20 minutes consisting of two cycles of 10 minutes. After the first 10 minutes of IPV therapy in combination with chest compressions the frequency rate was reduced in order to suction the mobilized secretions. This cycle was then repeated. Statistical analysis was done with SPSS version 17. Student's *t* test was used to compare values before therapy with directly after and after 15 minutes of therapy. $P < 0.05$ was considered significant.

Results
Neither heart rate, mean arterial pressure nor respiratory rate showed any significant change after IPV. Oxygen saturation improved immediately after

Conclusion
We demonstrated that IPV is a safe therapy, and oxygen saturation improved after therapy with IPV.

Nederlands

Doel: Om te onderzoeken of IPV veilig is voor de HD en zuurstof saturatie.

Setting: Enkel centra. Volwassen ICU

Methode: IPV werd toegepast voor twintig minuten bij tweeenveertig patienten met respiratoire falen, wel of niet beademd. HF, MAP, ademhalings frequentie en SpO_2 waren geregistreerd op drie meet momenten. Voor, direct na en vijftien minuten na behandeling.

Resultaten: HF, MAP en ademhalings frequentie bleven onveranderd. SpO_2 liet significante verbetering zien.

Conclusie: IPV is een veilig therapie voor de HD en verbeterd de SpO_2.

{2011} Airway Clearance in COPD: Need for a Breath of Fresh Air? A Systematic Review

June 2011, Vol. 8, No. 3 , Pages 196-205 (doi:10.3109/15412555.2011.560582)

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Background*:* Airway clearance is a key component of respiratory physiotherapy management for patients with excess secretions, including patients with chronic obstructive pulmonary disease (COPD). The aim of this review is to give an overview of the available evidence for the use of different airway clearance techniques (ACT) and their effects in patients with COPD.

Methods: A systematic literature search was performed on CEBAM, PUBMED, Cochrane CT, Science Direct and Biomed central data bases. After screening, a total of 26 articles were included.

Results: Studies that provide solid evidence of the effectiveness of different airway clearance techniques in patients with COPD are rather scarce. The available evidence indicates that active breathing techniques, such as active cycle of breathing techniques, autogenic drainage and forced expiration, can be effective in the treatment of COPD. The evidence for passive techniques such as postural drainage and percussion is low. Supporting techniques such as intrapulmonary percussive ventilation, positive expiratory pressure and non-invasive ventilation have little evidence because of the small number of studies. Little evidence is found for the combined use of active techniques and supporting techniques such as (oscillating) positive expiratory pressure, postural drainage and vibration in COPD patients. There is clearly a need for well-powered controlled clinical trials on the long-term effects of (combined) airway clearance techniques in COPD.

Nederlands:
Kris Ides en collega's in de Universiteit Antwerpen hebben een Systematic Review geschreven.

Doel: Een overzicht te maken van de verschillende evidence based technieken voor ACT(airway clearance techniques) bij COPD patienten.
Methode: Een systematic literatuur onderzoek.

Resultaten: Hard bewijs van het effect van de verschillende technieken voor COPD patienten is er niet. De resultaten tonen aan dat huffen, FET en autodrainage effectief kan zijn. Er is te weinig bewijs voor IPV, NIV & PEP omdat er te weinig studies gedaan zijn.

Conclusie: Verder zijn er Controlled clinical trails nodig om de lange termijn effecten van ACT bij COPD aan te tonen.

{2011} Intrapulmonary percussive ventilation superimposed on spontaneous breathing: a physiological study in patients at risk for extubation failure.

Dimassi S, Vargas F, Lyazidi A, Roche-Campo F, Dellamonica J, Brochard L.

Intensive Care Med. 2011 Aug;37(8):1269-76. doi: 10.1007/s00134-011-2249-6. Epub 2011 Jun 9.

PURPOSE:
Intrapulmonary percussive ventilation (IPV) is a high-frequency ventilation modality that can be superimposed on spontaneous breathing. IPV may diminish respiratory muscle loading and help to mobilize secretions. The aim of this prospective study was to assess the short-term effects of IPV in patients at high risk for extubation failure who were receiving preventive non-invasive ventilation (NIV) after extubation.
METHODS:
Respiratory rate, work of breathing, and gas exchange were evaluated in 17 extubated patients during 20 min of IPV and 20 min of NIV delivered via a facial mask, separated by periods of spontaneous breathing. The pressure-support level during NIV was adjusted until tidal volume reached 6-8 ml/kg and positive end-expiratory pressure (PEEP) 4-5 cmH(2)O. For IPV, the pressurisation frequency was set at 250 cycles/min and driving pressure at 1.2 bar. The pressure-time product of the diaphragm (PTPdi/min) was measured using an oesophageal and gastric double-balloon catheter.
RESULTS:
Transdiaphragmatic pressure and PTPdi/min improved significantly ($p < 0.01$), from a median [25th-75th percentiles] of 264 [190-300] to 192 [152-221] cmH(2)O s/min with IPV and from 273 [212-397] to 176 [120-216] cmH(2)O s/min with NIV. Respiratory rate decreased significantly from 23 [19-27] to 22 [17-24] breaths/min for IPV and from 25 [19-28] to 20 [18-22] breaths/min for NIV ($p < 0.01$). Mean PaCO(2) decreased after NIV (from 46 [42-48] to 41 [36-42] mmHg, $p < 0.01$) but not after IPV. There was no noticeable effect on oxygenation.
CONCLUSIONS:
IPV is an interesting alternative to NIV in patients at risk for post-extubation respiratory failure. Both NIV and IPV diminished the respiratory rate and work of breathing, but IPV was less effective in improving alveolar ventilation.

Nederlands.
Doelstelling: Om het effect op korte termijn van IPV bij patiënten in een hoog risico voor extubatie fallen die preventieve NIV na extubatie ontvingen.
Setting: Enkel centra. Prospectieve studie. zeventien patiënten.
Methode: De ademhalingsfrequentie, de ademhalings inspanning en gasuitwisseling werden geëvalueerd in zeventien geëxtubeerd patiënten gedurende twintig min. van IPV en twintig min van NIV via een gezichtsmasker, geschieden door periodenvan spontane ademhaling. De druk ondersteuning van de NIV werd aangepast totdat tidal volume van 6-8ml/kg bereikt werd en PEEP 4 – 5 cm H2O. Voor de IPV werd de frequentie op 250 cycli/min en het werk druk op 1,2 bar. Het pressure time product van de diafragma (PTPdi/min) werd gemeten met een slokdarm en maag dubbele ballonkatheter.
Resultaten: De transdiaphragmatic druk en PTPdi/min significant verbeterd met de IPV zowel als met de NIV. De ademhalingsfrequentie daalde aanzienlijk met IPV en NIV. Er was een significant daling in PCO2 bij de NIV maar niet met IPV. Er was geen merkbaar effect op de PO2.
Conclusies: IPV is een interessant alternatief voor de NIV bij patiënten met een risico op post – extubatie respiratoir falen. Zowel de NIV en IPV verminderde de ademhaling en het work of breathing, maar IPV was minder effectief in het verbeteren van de alveolaire ventilatie.

{2011} Safety and efficacy of short-term intrapulmonary percussive ventilation in patients with bronchiectasis.

Paneroni M, Clini E, Simonelli C, Bianchi L, Degli Antoni F, Vitacca M.

Respir Care. 2011 Jul;56(7):984-8. doi: 10.4187/respcare.01098. Epub 2011 Feb 21

Abstract
BACKGROUND:
Treatment of bronchiectasis includes drugs, oxygen therapy, and bronchial-clearance maneuvers.
OBJECTIVE:
To assess the safety and efficacy of intrapulmonary percussive ventilation (IPV) compared to traditional standard chest physical therapy in patients with bronchiectasis and productive cough.
METHODS:
In a randomized crossover study, 22 patients underwent, on consecutive days, IPV and chest physical therapy. Before each treatment session, immediately after the session, 30 min after the session, and 4 hours after the session we measured S(pO(2)), heart rate, respiratory rate, and (with a visual analog scale) the patient's subjective sensation of phlegm encumbrance and dyspnea. Immediately after each treatment session we also measured (via visual analog scale) the patient's discomfort. We also measured the volume and wet and dry weight of collected sputum.
RESULTS:
No adverse effects were so severe as to require discontinuation of treatment, and the incidence of adverse effects was similar in the groups (27%). Heart rate (P = .002) and respiratory rate (P = .047) decreased during treatment, and sensation of phlegm encumbrance improved (P = .03) with both treatments. Only IPV improved (P = .004) the sensation of dyspnea. The patients found IPV more comfortable than our traditional standard chest physical therapy (P = .03). Both treatments caused important phlegm production, but there were no differences in sputum volume, wet weight, or dry weight.
CONCLUSIONS:
In patients with bronchiectasis and productive cough, short-term IPV was as safe and effective as traditional chest physical therapy, with less discomfort.

Nederlands.
Doelstelling: Om het effect en de veiligheid van IPV te vergelijken met reguliere thorax fysiotherapie
Setting: Twee centra. Gerandomized crossover studie. Tweeentwintig patiënten
Methode: tweeentwintig patiënten onder gingen afwisselend behandeling van IPV en thorax fysiotherapie– een dag IPV en de volgende dag thorax fysiotherapie gedurende dertig minuten. Vóór, direct na, dertig minuten en vier uur na iedere behandeling werd de SpO2, hart frequentie, ademhalings frequentie, dyspnoe/ benauwdhieds score (door middel van de VAS score) en subjectieve gevoel van sputum productie gemeten.
Resultaten: Geen complicaties traden op bij beide behandelmethodes.
Bij IPV en thorax fysiotherapie daalde de hart frequentie en ademhalings frequentie. Beide behandelmethodes levert veel sputum productie op, maar er was geen verschil in het volume en gewicht van sputum. Enkel bij IPV nam het gevoel van benauwdheid af. De patient vonden de IPV behandelmethode meer comfortable dan de thorax fysiotherapie.
Conclusie: Bij patiënten met bronchiectasis en een productieve hoest, IPV is een even veilig en effectief behandelmethode als thorax fysiotherapie. En IPV geeft minder discomfort.

{2010} Management of Localized Pneumothoraces After Pulmonary Resection With Intrapulmonary Percussive Ventilation

Tindaro Gatani, MD, Nicola Martucci, MD, Antonello La Rocca, MD,
Carmine La Manna, MD, Francesco Scognamiglio, MD, Rosario Salvi, MD, and
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Ann Thorac Surg2010 ;90:1658–61.

Background. Intrapulmonary percussive ventilation (IPV) aims at clearing retained secretions through oscillary vibrations generated by high frequency bursts of gas delivered into the airways at rates between 200 and 300 breaths per minute and at a delivery pressure of 10 to 20cm water. In addition, IPV can improve recruitment of alveolar units and deliver aerosolized medications. The use of IPV to resolve challenging postlobectomy localized pneumothoraces is hereafter described.
Methods. Between January 2005 and March 2009, four patients with long-term complicated postresectional residual air spaces persisting 6 months (mean, 187 days) after primary surgery were treated by IPV. The type of operation was upper lobectomy and lower lobectomywedge resection in 1 and 3 patients, respectively. Mean preoperative and immediate postsurgical forced expiratory volume in the first second of expiration were 2.31 L and 1.49 L, respectively. Mean preoperative and immediate postsurgical forced vital capacity were 3.13 L and 2.1L, respectively. Patients were subjected to 12-minutelong IPV sessions up to a total of 8 to 12 sessions administered every other day in an outpatient setting.
Results. Complete resolution of the spaces within a mean of 22 days of beginning of treatment was noted.
The post-IPV forced expiratory volume in the first second of expiration and forced vital capacity were 1.72 and 2.4 liters, respectively. No treatment-related morbidity was observed.
Conclusions. Intrapulmonary percussive ventilation can be expected to decisively contribute to resolving
long-term localized pneumothoraces after subtotal pulmonary resections in an outpatient setting.

Nederlands.
Doelstelling: Onderzoek van het toepassen van IPV poliklinisch om persistente pneumothoraces na long resecties te behandelen.
Setting: Enkel centra. Onderzoek periode tussen januari 2005 en maart 2009.
Methode: Inclusie groep vier patienten met persisente pneumothoraces na long resecties (lobectomie of lobectomie wedge) die zonder succes met medisch behandeling en fysiotherapie al behandeld waren. De FEV_1 metingen preoperatief en direct post operatief waren 2,31lit en 1,49 lit, en de mean preoperatief en direct post operarief FVC waren 3,13lit en 2,1lit. De patiënten waren behandeld met twaalf minuten sessies van IPV om de dag op een poliklinisch basis zonder thorax fysiotherapie. Totaal aantal sessies waren tussen acht en twaalf. Er traden geen complicaties op tijdens de therapie.
Resultaten: Bij alle patiënten waren de longen binnen drie weken weer open (mean 22 dagen). De mean FEV_1 en FVC post IPV verbeterd bij 8,7% en 9,6% in vergelijking met direct post OK. Daarbij de D_{LCO} (diffusing capacity of lung for CO) post IPV was 83,7%, mean verbetering van 14,6% en ook de PO_2 was 97,2% (mean verbetering van 2,2%)
Conclusie: Toepassen van IPV op een poliklinisch basis bij patiënten na sub totaal long resecties heeft een positief effect in het behandelen van langere termijn long consolidaties.

{2009} Effect of intrapulmonary percussive ventilation on expiratory flow limitation in chronic obstructive pulmonary disease patients.

Vargas F, Boyer A, Bui HN, Guenard H, Gruson D, Hilbert G.

J Crit Care. 2009 Jun;24(2):212-9. doi: 10.1016/j.jcrc.2008.02.006. Epub 2008 May 14.Abstract

PURPOSE:
The aims of this prospective study were (1) to select, after weaning and extubation, chronic obstructive pulmonary disease (COPD) patients with expiratory flow limitation (EFL) measured by the negative expiratory pressure method and (2) to assess, in these patients, the short-term (30 minutes) physiologic effect of a session of intrapulmonary percussive ventilation (IPV).
MATERIALS AND METHODS:
All COPD patients who were intubated and needed weaning from mechanical ventilation were screened after extubation. The patients were placed in half-sitting position and breathed spontaneously. The EFL and the airway occlusion pressure after 0.1 second (P0.1) were measured at the first hour after extubation. In COPD patients with EFL, an IPV session of 30 minutes was promptly performed by a physiotherapist accustomed to the technique. Expiratory flow limitation, gas exchange, and P0.1 were recorded at the end of the IPV session.
RESULTS:
Among 35 patients studied after extubation, 25 patients presented an EFL and were included in the study. Intrapulmonary percussive ventilation led to a significant improvement in EFL, respectively, before and 30 minutes after IPV (65.4 +/- 18.2 vs 35.6 +/- 22.8; P < .05). Three patients were not expiratory flow limited after IPV. Intrapulmonary percussive ventilation led to a significant decrease in P0.1 (3.9 +/- 1.6 vs 2.8 +/- 1.1; P < .05). Thirty minutes of IPV led to a significant increase in Pao(2) and pH and a decrease in Paco(2) and respiratory rate (P < .05).
CONCLUSION:
In COPD patients, a session of IPV allowed a significant reduction of EFL and of P01 and a significant improvement of gas exchange.

Nederlands.
Doelstelling: De doelstellingen van dit prospectieve onderzoek waren (1) te selecteren, na het weanen en extubatie, COPD patiënten met expiratoire flow beperking (EFL) gemeten dooe de negatieve expiratoire druk method en (2) om te beoordelen, bij deze patiënten, de korte termijn (dertig minuten) fysiologische effect van een behandeling van IPV.
Setting: Enkel centra. vijfendertig patiënten
Methode: Alle COPD patiënten die werden geïntubeerd en mechanisch beademd werden gescreend na extubatie. De patiënten werden in een half- zittende positie geplaatst. De EFL en luchtwegen occlusiedruk na 0.1 sec (PO.1 waarde) werden gemeten één uur na extubatie. Bij COPD patiënten met een expiratoire flow beperking (EFL) werd een IPV behandeling van dertig minuten uitgevoerd. De EFL, gasuitwisseling en PO.1 werden na de IPV behandeling gemeten.
Resultaten: Onder de vijfendertig onderzochte patiënten na extubatie, vijfentwintig patiënten presenteerde zich met een EFL en waren geïncludeerd in de studie. IPV gaf een significant verbetering van de EFL. Zelfs drie patiënten hadden geen EFL na IPV. IPV gaf een significant daling in de PO.1. 30 minuten van IPV gaf een significant verbetering van de PaO2 en pH, en een daling in de PCO2 en ademfrequentie.
Conclusie: Bij COPD patiënten leidt een behandeling met IPV tot een significante daling en de EFL en PO.1 en een significante verbetering in gasuitwisseling.

{2008} Intrapulmonary percussive ventilation superimposed on conventional ventilation: bench study of humidity and ventilator behaviour.

Dellamonica J, Louis B, Lyazidi A, Vargas F, Brochard L.

Intensive Care Med. 2008 Nov;34(11):2035-43. doi: 10.1007/s00134-008-1190-9. Epub 2008 Jul 1.
Abstract
OBJECTIVE:
Intrapulmonary percussive ventilation (IPV) is a form of high-frequency ventilation that can be superimposed on spontaneous breathing or conventional ventilation. Drawbacks include difficulties achieving adequate airway humidification and an inability to monitor delivered volumes and pressures, which may vary with patient characteristics. The objectives of this study were to assess various humidification set-ups, to measure intrapulmonary pressures and volumes resulting from IPV superimposed on a conventional driving ventilator (DV) and to test several ventilators regarding their ability to accept added IPV.
DESIGN:
Bench study in a test-lung set-up was used to measure humidification and the effects of adding IPV to a DV under various conditions of compliance, resistance, plateau and positive end-expiratory pressures. Then, five ventilators were tested in combination with IPV.
MEASUREMENTS AND RESULTS:
Adequate humidification required a heated humidifier on the inspiratory line downstream of the IPV device. IPV increased end-inspiratory intrapulmonary pressures up to 10 cmH(2)O, increased delivered volumes up to 237 ml and generated intrinsic PEEP from 1.7 to 4.3 cmH(2)O when no PEEP was set on the DV. Intrinsic PEEP was lower or absent when PEEP was set on the DV. With most tested ventilators, IPV prevented reliable flow monitoring. Autotriggering and missing cycles were common and the PEEP effect varied across DVs.
CONCLUSION:
Achieving adequate humidification with IPV requires a specific set-up. Superimposing IPV on standard ventilation can increase intrapulmonary pressures and tidal volumes importantly and interfere with the triggering sensors of the ventilator. These factors must be taken into account before clinical use.

Nederlands.
Doelstelling: vergelijking van verschillende bevochtiginggraden, om de intrapulmonaire druk te meten en de volumes afkomstig van IPV met conventionele ventilatie en om de verschillende ventilatoren te testen met betrekking tot het vermogen om IPV toe te voegen.
Setting: bench study met een test long set-up
Methode: gebruik van een test long, om de vochtigheidsgraad te meten en de effecten door het toevoegen van IPV bij conventionele ventilatie, onder verschillende omstandigheden van compliance, druk, plateau en positieve eind-respiratoire drukken. Vijf ventilatoren werden getest in combinatie met IPV.
Resultaten: een goede vochtigheidsgraad met IPV vereist specifieke set-ups. Superimposing IPV in combinatie met standaard ventilatie kan de intrapulmonaire druk en de tidal volumes verhogen, deze kunnen het triggeren van de sensoren van de ventilator belemmeren.

{2007} Intra-pulmonary Percussive Ventilation – Brief Review of Clinical and Physiological Studies

a report by
Frédéric Vargas and Jean Dellamonica
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The intra-pulmonary percussive ventilation (IPV) device, designed to improve mucus clearance, was developed by Forrest M Bird in 1979. IPV is a form of high-frequency ventilation that delivers small bursts of high-flow respiratory gas with frequency higher than 1Hz (usually 4–10Hz). This causes airway pressure to oscillate between 5 and 35cm H2O, and the airway walls vibrate in synchrony with these oscillations.1 Unique to IPV is the Phasitron®, which employs a sliding flow regulator based on the Venturi effect. As found with other high-frequency ventilatory modes (high-frequency oscillation [HFO], high-frequency jet ventilation, etc.), inspiration during IPV is active using small tidal volumes. In contrast to HFO, expiration is passive. This technique maybe associated with nebulisation and has the potential to improve secretion clearance.2–4 This device is positioned at the patient's proximal airway. During the percussive bursts of air into the lungs, a continued pressure is maintained, while a high-velocity percussive inflow opens airways and enhances intra-bronchial secretion mobilisation. We will briefly present the clinical and physiological studies concerning IPV in order to demonstrate its usefulness in successfully managing intensive care unit (ICU) patients.

Clinical Studies

Mucus Clearance Device

To date, few studies have been published on the use of IPV in adult patients with pulmonary disease. IPV has been used primarily for the treatment of atelectasis and retained secretions in patients in a stable state, as occurs in a wide variety of conditions, including cystic fibrosis and neuromuscular disease.5–10 Ravez et al. studied the use of IPV in a small group of adults with chronic bronchitis.11 They found that total lung clearance of radioaerosol was enhanced with IPV therapy, but it was unclear to what extent IPV-stimulated cough contributed to the observed benefit.11 In addition, small pilot studies with the IPV device have shown it to be useful for the relief of lobar atelectasis and increased sputum production in patients with chronic obstructive pulmonary disease (COPD).

Patients with Chronic Obstructive Pulmonary Disease

Rationale

Patients hospitalised for acute exacerbations of COPD with rapid clinical deterioration should be considered for non-invasive positive-pressure ventilation (NPPV) to prevent further deterioration in gas exchange and respiratory workload as well as the need for endotracheal intubation. The addition of NPPV to standard therapy in patients with acute exacerbations of COPD significantly decreases the rate of endotracheal intubation, leads to a shorter hospital stay and decreases inpatient mortality rates. However, subgroup analysis performed in a recent review showed that these beneficial effects occurred only in patients with severe exacerbations, not in those with milder ones.14 Enhancing ventilation by unloading fatigued ventilatory muscles is an important treatment goal in the case of acute exacerbation of COPD that is complicated by respiratory failure, and this objective can be achieved by NPPV. On the other hand, airway inflammation, bronchospasm and the increase in sputum volume are constant in these patients and are responsible for an increase in airway resistance and air trapping.

Let us recall that patients unlikely to benefit from NPPV include those with excessive secretions. In addition, excessive secretions can lead to NPPV failure and the need for intubation and invasive mechanical ventilation. In such situations, methods of treatment directed against the onset of decompensation are attractive in theory, although the benefits of mucus clearance therapies have been regularly challenged.

Two studies have shown that chest physiotherapy based on a mucus clearance strategy could represent a useful therapeutic option in COPD patients. It was demonstrated in the first study that chest physiotherapy using a positive expiratory pressure mask in patients with mild acidosis requiring NPPV with pressure support could produce benefits in sputum clearance and could reduce the amount of time for which the patient requires NPPV. Wolkove et al. reported significant improvement in lung function after inhaled bronchodilator therapy. The prior use of a mucus clearance device, compared with a sham mucus clearance device, improved the subsequent bronchodilator response in patients with stable COPD.

Acute Exacerbations with Mild Respiratory Acidosis

In a randomised, controlled study, it was hypothesised that the use of IPV could prove effective in avoiding further deterioration with acute exacerbations of COPD with mild respiratory acidosis.
Thirty-three patients with exacerbations of COPD with a respiratory frequency of ≥25/min, a partial pressure of carbon dioxide (PaCO2) >45 Torr and 7.35 ≤ pH ≤ 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 30-minute sessions through a full face-mask that were performed by a chest physiotherapist. The therapy was considered successful when both worsening of exacerbation and a decrease in pH to under 7.35 (which requires non-invasive ventilation) were avoided. The session of IPV was well tolerated. Thirty minutes of IPV led to a significant decrease in respiratory rate, an increase in PaO2 and a decrease in PaCO2 ($p<0.05$). Exacerbation worsened in six out of 17 patients in the control group versus zero 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±1.0 versus 7.9±1.3 days; $p<0.05$).

Bi-modal Therapy in Patients with Acute Exacerbation

Dr Antonaglia and colleagues19 evaluated the effect of IPV by mouthpiece during NPPV with helmet in patients with acute exacerbation of COPD. The authors conducted a randomised clinical trial comparing three groups of patients with exacerbation of COPD. Two groups were prospectively studied: 20 patients treated with NPPV with helmet and 'conventional' respiratory physiotherapy, and 20 patients treated with NPPV with helmet and two daily sessions of IPV. In addition, 20 patients non-invasively ventilated with face-mask were included retrospectively. The rates of intubation and complications, such as sepsis and pneumonia, were comparable between groups. A benefit in favour of the NPPV-helmet plus IPV group was found in terms of a reduction in the duration of ventilatory treatment and ICU stay and improvements in gas exchange at ICU discharge. Improvement in gas exchange and other physiological variables was found after the first IPV session. To strengthen the value of these data, because two daily sessions of IPV were used in one group in place of the conventional respiratory physiotherapy used in the other group, it should have been relevant to measure the selected physiological variables not only after IPV in this group but also after conventional respiratory physiotherapy in the other group prospectively studied. The original and the most important clinical message of the study by Dr Antonaglia and colleagues is that bi-modal therapy combining NPPV and non-invasive IPV can be useful in successfully managing patients with acute exacerbation of COPD.

Tracheostomised Patients

In a randomised, multicentre trial, Dr Clini and colleagues evaluated the addition of IPV to standard chest physiotherapy to improve gas exchange and lung mechanics in tracheostomised patients.20 Forty-six tracheostomised patients were assigned to two treatment groups performing chest physiotherapy (control) or percussive ventilation for 10 minutes twice a day in addition to chest physiotherapy (intervention).
Arterial blood gases, PaO2/FIO2 ratio and maximal expiratory pressure were assessed every fifth day for 15 days. Treatment complications that showed up in one month of follow-up were recorded. At 15 days the intervention group had a significantly better PaO2/FIO2 ratio and higher maximal expiratory pressure; after follow-up this group also had a lower incidence of pneumonia. The addition of percussive ventilation to the usual chest physiotherapy regimen in tracheostomised patients could improve gas exchange and expiratory muscle performance, and also reduces the incidence of pneumonia.

How Does Intra-pulmonary Ventilation Improve the Clinical Status of Patients?

Hypothesis

It seems that IPV can improve gas exchange in selected patients.18–20 The mechanisms of improvement with IPV do not seem to be clearly elucidated. Potential mechanisms of action include improved mucus clearance, enhanced alveolar recruitment and direct high-frequency oscillatory ventilation-like effect.

Mucus Clearance

During HFO, several mechanisms to improve mucus clearance have been studied. An increased mucus/flow interaction could lead to a decrease in the mucus viscoelasticity. Moreover, the changes in air flow with each high-frequency cycle could produce shearing at the air–mucus interface and provide a cough-like force to the mucus layer.

High-frequency Oscillatory-like Effect

Considering the effect of HFO ventilation on gas exchange and breathing pattern, one can hypothesise similar effects with IPV. Indeed, any high-frequency ventilation is a positive-pressure ventilation that would increase the airway pressure, induce a positive end expiratory pressure (PEEP) effect and thus improve oxygenation. Two mechanisms explain gas transport with respect to the clearance of CO2 during HFO: convection and molecular diffusion. HFO maximises CO2 removal primarily through facilitated diffusion. The theoretical increase in mean airway pressure observed with IPV, however, is less important than the increase in mean airway pressure observed with HFO. Similarly, the frequency used in HFO, generally set at 5Hz, is more important than in IPV.

Positive End Expiratory Pressure Effect

Any high-frequency ventilation induces a PEEP effect that can increase lung volume. However, according to the 'waterfall theory', if intrinsic PEEP (PEEPi) is the result of expiratory flow limitation (EFL), application of extrinsic PEEP should decrease the pressure gradient between the mouth and alveoli at the end of expiration. This should be achieved without further hyperinflation. However, O'Donoghue et al. found that only high levels of continuous positive airway pressure reduced PEEPi and indices of muscle effort in patients with severe but stable COPD, but only at the expense of a substantial increase in lung volume.

Physiological Studies

Intra-pulmonary Ventilation and Inspiratory Effort

Dr Nava and colleagues performed a study aimed at assessing the physiological response to IPV on the breathing patterns of patients, inspiratory effort, lung mechanics and tolerance to ventilation. Ten COPD patients underwent randomised trials of IPV through a face-mask at different pressure/frequency combinations (1.2bar/250cycles/min; 1.8/250; 1.2/350; 1.8/350), separated by return to baseline. In five patients they also compared the physiological changes of IPV with those obtained during NPPV. Minute ventilation did not vary among the trials, but tidal volumes were significantly greater during 1.2/250, 1.2/350 and 1.8/350 compared with spontaneous breathing (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 (209cmH2O.s/min for SB versus 143 and 125 for 1.2/250 and 1.8/250, respectively; p=0.05), as well as dynamic intrinsic end expiratory pressure. A similar reduction in PTPdi/min was also obtained during NPPV. Tolerance to ventilation and oxygen saturation was satisfactory and did not change during the different trials. IPV was able to guarantee adequate ventilation while inducing a significant unloading of the diaphragm during the 'low-frequency' trials.

Intra-pulmonary and Expiratory Flow Limitation

In a study, published only in abstract form, we evaluated the effect of IPV on EFL in COPD patients. The aim of this prospective study was to select, after weaning and extubation, COPD patients with EFL measured by the negative expiratory pressure (NEP) method and to assess, in these patients, the short-term (30-minute) physiological effects of a session of IPV. All COPD patients who were intubated and needed weaning from mechanical ventilation were screened after extubation. The patients were placed in a half-sitting position and breathed spontaneously. The EFL and the airway occlusion pressure after 0.1s (p=0.1) were measured at the first hour after extubation. In COPD patients with EFL, an IPV session of 30 minutes was performed by a physiotherapist accustomed to the technique. EFL, gas exchange and P0.1 were recorded at the end of the IPV session. Among 35 patients studied after extubation, 25 patients presented an EFL and were included in the study. IPV led to a significant improvement in EFL ($p<0.05$). Three patients were not expiratory-flow-limited after IPV. IPVled to a significative decrease in P0.1 ($p<0.05$). We found that in EFL COPD patients, IPV superimposed on SB improved gas exchange and relieved the load of the inspiratory muscles.

Bench Study

IPV has been used during SB, but is also proposed for use in addition to conventional ventilation. We designed a bench study with three resistances and compliances to assess the effect of IPV on tidal volume generated by conventional ventilation, PEEP and maximal alveolar pressure during volume-controlled ventilation.27 IPV was connected on the inspiratory line of a ventilator using a heater humidifier. Maximal alveolar pressure and PEEP were recorded inside the test lung. Tidal volume was inferred using flow integration at Y-piece. Resistances of 5, 20 and 50cm of H2O/l/s and compliance of 20, 50 and 100ml/cm of H2O were tested on a Michigan test lung. Three pauses (0, 0.2 and 0.4s) were used with two driving pressures of 12 and 18cm H2O. No PEEP was set on

conventional ventilation. Results are different between patients treated with and without IPV. PEEP, tidal volume and maximal alveolar pressure all increased with IPV. Pressures (maximal alveolar pressure and PEEP) and volumes increased due to IPV are strongly dependent on resistance and compliance. This bench study, published in abstract form and presented in the European Society of Intensive Care Medicine of Berlin, may confirm a PEEP effect and real ventilatory effect of IPV.

Conclusion

It can be said that IPV will in particular benefit patients with excessive secretions and a frequent need to remove them. Indeed, patients with a repeated need to remove secretions may be difficult to treat with NPPV. However, IPV is not exculsively suitable for patients presenting with acute exacerbation of COPD. The technique should be evaluated in other types of acute respiratory failure, including respiratory distress after extubation, where the interest of NPPV is challenged and where an excess of secretions is a frequent cause of extubation failure.
Further studies are needed to confirm the advantage of adding IPV sessions to the strongly recommended practice of NPPV and to improve the selection of those patients likely to benefit from IPV, before being able to adopt strength through unity for the noninvasive challenges.

Dit is een review van onderzoeken van 1994 - 2006

{2006} 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.

Department of Pulmonary Rehabilitation, University of Modena, and Ospedale Villa Pineta, Via Gaiato 127, 41020, Pavullo, Italy.

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 ± 7 years, 28 men, arterial blood pH 7.436 ± 0.06, PaO_2/FIO_2 238 ± 46) weaned from mechanical ventilation.
INTERVENTIONS: Patients were assigned to two treatment groups performing chest physiotherapy (control), or percussive ventilation (IMP2 Breas, Sweden) 10 min twice/day in addition to chest physiotherapy (intervention).
MEASUREMENTS AND RESULTS: Arterial blood gases, PaO_2/FIO ratio, and maximal expiratory pressure were assessed every 5th day for 15 days. Treatment complications that showed up in 1month of follow-up were recorded. At 15 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.

Nederlands:

Vraagstelling : Wordt de gasuitwisseling en long mechanica verberterd bij patienten met een tracheostoma wanneer IPV + thorax fysiotherapie toegepast wordt in plaats van alleen thorax fysiotherapie?

Setting: Randomized multicentra onderzoek in noord italie

Doelgroep: zesenveertig patienten met een tracheostoma leeftijd 70 ± 7 jaar, achtentwintig mannen, ABG pH 7.436 ± 0.06, PaO_2/FIO_2 238 ± 46) geweaned van mechanisch ventilatie.
Methode: Groep verdeeld in twee groepen. Groep 1(controle) kreeg alleen thorax fysiotherapie, Groep 2 (interventie) kreeg thorax therapie + 2 x dgs IPV

Metingen &Resultaten:
ABG, P/F ratio en max expiratie drukken werden iedere vijf dagen over een periode van vijftien dagen gemeten. Na vijftien dagen verbeterde de, P/F ratio en expiratiore max drukken in de interventie groep significant, en bij verdere controles werd de incidentie van pneunomie significant minder dan in de controle groep.

Conclusie:
IPV + thorax fysiotherapie heeft een positive effect op de P/F ratio en max expiratiore drukken dan alleen thorax fysiotherapie. De incidentie van pneumonieen kan worden verminderd.

{2006} Intrapulmonary percussive ventilation and noninvasive positive pressure ventilation in patients with chronic obstructive pulmonary disease: "Strength through unity"?

Vargas F, Hilbert G. Subset Clin Med 2006; 34:3043–3045.

The originality and the most important clinical message of the study by Dr. Antonaglia and colleagues are that a bimodal therapy combining NPPV and noninvasive IPV can be useful to manage successfully patients with acute exacerbation of COPD. Even if that is not demonstrated, one can think that IPV will benefit more particularly the patients with very excessive secretions and a frequent need to remove them. Indeed, patients with a repeated need to remove secretions may be difficult to treat with NPPV. This therapy is right not only for patients presenting with acute exacerbation of COPD. The technique should be evaluated in other types of acute respiratory failure including respiratory distress after extubation, where the interest of NPPV is challenged and where the excess of secretions is a frequent cause of extubation failure. Further studies are needed to confirm the advantage of adding IPV sessions to the strongly recommended practice of NPPV and to improve the selection of the patients likely to benefit from IPV, before being able to adopt "strength through unity for the noninvasive challenges."

Nederlands.
Doelstelling: effectiviteit combinatie IPV en NPPV
Setting: onbekend
Methode: onbekend.
Resultaten: combinatie van NPPV en non-invasieve IPV kan succesvol gebruikt worden bij patienten met acute excacerbatie van COPD. Verdere onderzoeken zijn nodig om de effectiviteit van het toevoegen van IPV aan NPPV te bevestigen.

{2006} Physiological response to intrapulmonary percussive ventilation in stable COPD patients.

• Nava S, Barbarito N, Piaggi G, De Mattia E, Cirio S.

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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. 10 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 cmH2O 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 SaO2 or subjective discomfort. **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.

Nederlands.
Doelstelling: fysiologische respons van stabiele COPD patienten met IPV
Setting: randomized trials. Tien COPD patienten
Methode: bij tien COPD patienten werd IPV toegepast op een mondmasker met verschillende druk/frequentie combinaties(1.2 bar/250 cycles/min; 1.8/250; 1.2/350; 1.8/350), gesepareerd door terugkomst baseline, met gebruik van IMP2 ventilator. Bij vijf patienten warden ook de fysiologische verandering met gebruik van IPV vergeleken met pressure support ventilation. Minute ventilation varieerde niet, tidal volumes waren significant groter gedurende 1.2/250, 1.2/350 and 1.8/350 compared to SB.
De PTPdi/min (pressure time product van de diaphragm) of de geschat O2 verbruik van de diaphragm was significant verminderd gedurende 1.2/250, 1.2/350 and 1.8/350.
Vegelijkbare vermindering PTPdi/min werd ook gezien bij PSV. Een apnoe test > 2min werd gedaan bj 5 patienten zonder enige significante daling in SaO2 of subjectieve ongemak.
Resultaten: IPV garandeerde een adequate ventilatie en geeft een significante lossen/ inspanning van de diaphragm tijdens laag frequentie trials.

{ 2006} Efficacy and safety of intrapulmonary percussive ventilation superimposed on conventional ventilation in obese patients with compression atelectasis.

• Tsuruta R, Kasaoka S, Okabayashi K, Maekawa T.
OUbe, Yamaguchi 755-8505, Japan. ryosanygc@ umin.ac.jp

PURPOSE: To investigate the efficacy and safety of intrapulmonary percussive 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_2/FiO_2 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_20 at 0 hours to 35 +/- 9 mL/cm at 12 H_2O (P < .05) and to 38 +/- 8 mL/cm H_2O 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

Nederlands.
Doelstelling: De werkzaamheid en veiligheid van IPV bij obese patiënten te onderzoeken. De respiratoire en hemodynamisch functies zijn beoordeeld tijdens gebruik van IPV met conventionele ventilatie.
Setting: Enkel centra. tien patiënten
Methode: tien patiënten met respiratoire insufficiëntie als gevolg van compressie atelectase die niet verbeterd met conventionele ventilatie werden behandeld met IPV. HD parameters, beademings instellingen en ICP (n=1) werden ieder uur geregistreerd. En ABG iedere drie uur.
Resultaten: Voordat IPV gestart werd bleef de P/F ratio lag (189+/- 63mm Hg). Na drie uur IPV werd de P/F ratio significant verbeterd en bleef continu verhoogd tot 280mmHg. IPV gaf een significante verbetering in dynamisch compliance. De hart frequentie en MAP bleven gelijk. Verbetering van de compressive atelectase werd aangetoond door middle van thorax tomografie. Bijwerkingen zoals pneumothorax en verhoogde ICP werden niet gezien.
Conclusie: IPV is veilig en effectief in het behandelen van compressie atelectase bij obese patiënten zonder bijwerkingen.

{2005} Intrapulmonary percussive ventilation in acute exacerbations of COPD patients with mild respiratory acidosis: a randomized controlled trial

[ISRCTN17802078].

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1: Crit Care. 2005 Aug; 9(4):R382-9. Epub 2005 Jun 1. {2005}

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 admitted to the emergency room with exacerbations of COPD diagnosed on the basis of clinical history, chest xray and a respiratory frequency ≥25/min, a PaCO2 > 45 Torr and 7.35 <or= pH <or= 7.38 after the patient had been breathing room air for at least 10 minutes 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 PaO2 and a decrease in PaCO2 ($p < 0.05$). 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 +/- 1.0 vs. 7.9 +/- 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.

Nederlands.
Hypothese: Het gebruik van IPV kan effectief verdere achteruitgang voorkomen bij patiënten met acute exacerbaties van COPD met een milde respiratoire acidose.
Setting: Enkel centra. Prospectieve, gerandomiseerde, gecontroleerde studie
Methode: drieendertig patiënten met exacerbatie van COPD met een ademfrequentie van ≥ 25/min, PCO2 > 45 nadat ze tien minuten kamer lucht ademde. Torr en pH 7,35 ≤ of ≤ 7,38 zonder metabole acidose. Patiënten werden willekeurig toegewezen aan de standaard behandeling (controlegroep n= 17) of standaard behandeling plus IPV (IPV groep n= 16). Patiënten toegewezen aan de standaard behandeling kregen O2 via nasale canule met het doel SpO2 opgenomen door pulsoxymetrie van 88% tot 92%. Bij alle patiënten werd de hartslag en RR continu bewaakt. Het hoofd van het bed werd verhoogd bij een hoek van 45 graden. De IPV groep onderging 2 x dgs IPV therapie (30 minuten) via een gezichts masker uitgevoerd door een thorax fysiotherapeut. De therapie werd als succesvol beschouwd wanneer beide verslechtering van de exacerbatie en daling in pH tot onder de 7,35 waaronder NIV nodig zou hebben, werden vermeden.
Resultaten: dertig minuten van IPV gaf een significante daling in ademfrequentie, verhoging in PaO2 en daling in PaCo2. Verergering in exacerbatie tradt op in zes van de zeventien patiënten in de controle groep en nul van de zestien in de IPV groep. De ziekenhuis opname duur was significant korter in de IPV groep in vergelijking met de controle groep
Conclusie: IPV is een veilige techniek en kunnen verdure verslechtering bij patiënten met acute exacerbaties van COPD met een milde respiratoire acidose voorkomen.

{2005} 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_2O. 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

Nederlands.
Pulmonale infecties kunnen levensbedreigend zijn voor kinderen met neuromusculaire aandoeningen.
Hypothese: Als IPV gebruikt wordt in een pulmonale programma voor adolescenten met een neuromusculaire aandoening zou het aantal dagen van het gebruik van antibiotic voor pulmonale infecties verminderen.
Setting: Enkel centra. Gerandomiseerde, gecontroleerde studie.
Methode: In deze studie werd de efficientie van IPV vergeleken met incentive spirometrie (IS). 18 patiënten werden geïncludeerd – 9 in IPV groep en 9 in IS groep.
Resultaten: Antibioticagebruik was significant hoger met de IS groep (24/1000 patiënt – dagen) in vergelijking met IPV groep (0/1000 patiënt – dagen). De IS groep bracht meer dagen in het ziekenhuis door dan de IPV groep. De IPV groep had 0 patiënten met pneumonie of bacteriële bronchitis, vergeleken met 3 patiënten in de IS groep. Hoewel dit statistische niet significant werd gevonden.
Conclusies: IPV als onderdeel van een preventieve pulmonale regime verminderde dagen van het gebruik van antibiotica en hospitalisatie voor respiratoire aandoeningen bij jongeren met een neuromusculaire aandoening.

{2003} 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, endtidal 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 statisticallybetween 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.

Nederlands.

Doel: Om het effecten van IPV op mucus klaring in Duchenne patiënten met een tracheostoma.

Setting: Gerandomiseerde, cross over studie. Enkel centra. Brussels, Belgie

Methode: Assist mucus klaring technieken zijn gebruikt met en ook zonder IPV. De resultaten van met of zonder IPV zijn vergeleken.

Studie groep -8 patiënten, 5 met mucus hypersecretie (>30ml/d). Alle kandidaten onderging een serie van behandel methoden 3 x dgs gedurende 5 dagen

Een behandel serie bestond uit:

- Assisted mucus clearance technique (AMCT) – geforceerd expiratoire techniek en manueel cough assist
- ET uitzuigen
- Verneveling met 5 ml NaCl 0,9% ged 5minuten
- Nogmaals AMCT
- ET uitzuigen
- Na 45 minuten na de verneveling periode nogmaals AMCT
- ET uitzuigen

Daarna werd IPV togevoegd tijdens de verneveling sessie van 5 minuten.

De opgevangen mucus secreties waren gewogen. VC was 1 x voor de behandeling gedaan. HF, Ademhalings frequentie, SpO2, ETCO2, luchtweg weerstand en exp piekstroom zijn voor en 45 minuten na behandelingen gemeten.

Resultaten: Bij de patiënten met mucus hypersecretie was de opgevangen secreties significant hoger wanneer IPV aan de behandel sessie toegevoegd werd. Alle andere parameters bleven gelijk in beide behandel sessies.

Conclusie: IPV is een veilige method om de luchtweg vrij te maken bij Duchenne patiënten met een tracheostoma. Deze studie suggereert dat IPV verhoogt de effectiviteit van assisted mucus klaring technieken.

{2002} 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(2)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_2O (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

Nederlands.

Doelstelling: Om IPV met conventionele fysiotherapie van de thorax (CPT) te vergelijken en het bepalen van hun effecten op de verbetering van atelectase en statische compliance in pediatrische patiënten.

Setting: Enkel centra. Studie 1 - Retrospectieve studie. 46 patiënten.

Studie 2 – Prospectieve, gerandomiseerde, gecontroleerde studie

Methode: Studie 1 - 46 IPV patiënten met mediane leeftijd van 4,2 jaar werden met IPV behandeld met IPV, mediane duur van de IPV was 6,2 dagen. Medicanale aerosol therapie met albuterol 2,5mg in 6ml zoutoplossing werd geleverd met elke IPV behandeling. Baseline en de daaropvolgende thoraxfoto's werden beoordeeld door een pediatrische radioloog. Een ordinale scoresysteem om de mate van atelectase te meten werd gebruikt. (4 = volledige atelectase , 0 = volledige resolutie).

Studie 2 – Een groep van geïntubeerde en beademde patiënten (n= niet beschreven), werden geventileerd met VC modus, met teug volumes van 6 -10ml/kg. Patiënten warden gerandomiseerd naar CPT (klappen en trilling door fysiotherapeut) of IPV bij een

frequentie van 180 – 220 cycli/min en druk van 15-30cmH2O. Beide behandelingen werden elke 4 uur gedaan met een duur van 10 – 15 minuten. Statische naleving metingen werden berekend uit uitgeademde TV en plateau druk. Dezelfde scoresysteem voor de thorax foto's als in de eerste studie werd gebruikt om de mate van atelectase te meten.

Resultaten: In de retrospectieve studie een belangrijke verbetering in atelectase werd gezien in de IPV groep. In de tweede studie, gecontroleerde studie de IPV groep liet meer verbetering zien in atelectase dan in de CPT groep.

Conclusie: IPV is een veilige en effectieve techniek om luchtwegen vrij te maken en kan gebruikt worden bij geïntubeerde patiënten.