High flow oxygen therapy

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Effect of non-invasive oxygenation strategies in immunocompromised patients with severe acute respiratory failure: a post-hoc analysis of a randomised trial

Frat JP, Ragot S, Girault C, Perbet S, Prat G, Boulain T, Demoule A, Ricard JD, Coudroy R, Robert R, Mercat A, Brochard L, Thille AW; REVA network

Lancet Respir Med. 2016 May 27 [Epub ahead of print]
PMID 27245914, **http://www.ncbi.nlm.nih.gov/pubmed/27245914**

Design	Post-hoc subgroup analysis from a multicentre, randomised, controlled trial
Patients	Subset of 82 immunocompromised patients with non-hypercapnic acute respiratory failure
Objectives	Compare the proportion of patients who required endotracheal intubation within 28 days after randomisation
Main Results	30 patients were treated with standard oxygen, 26 with HFNC alone, and 26 with NIV plus interspaced HFNC. 31% of the patients were treated with HFNC alone, 43% with standard oxygen, and 65% with NIV required intubation at 28 days (p = 0.04). Odds ratios (ORs) for intubation were higher in patients treated with non-invasive ventilation than in those treated with high flow nasal cannula: OR 4.25 (95% confidence interval 1.33-13.56). ORs were not significantly different between patients treated with high flow nasal cannula alone and standard oxygen: OR 1.72 (0.57-5.18). After multivariable logistic regression, the two factors independently associated with endotracheal intubation and mortality were age and use of non-invasive ventilation as first-line therapy.
Conclusion	Non-invasive ventilation might be associated with an increased risk of intubation and mortality and should be used cautiously in immunocompromised patients with acute hypoxaemic respiratory failure.

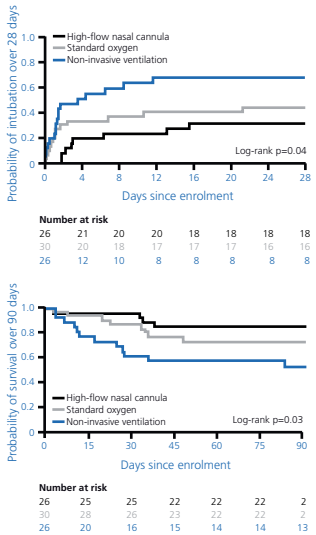

Figure 1: NIV increased intubation rate and decreased survival rate compared with HFNC

High-Flow Nasal Oxygen vs Noninvasive Positive Airway Pressure in hypoxemic patients after cardiothoracic surgery: A Randomized Clinical Trial

Stéphan F, Barrucand B, Petit P, Rézaiguia-Delclaux S, Médard A, Delannoy B, Cosserant B, Flicoteaux G, Imbert A, Pilorge C, Bérard L; BiPOP Study Group.
JAMA. 2015 Jun 16;313(23):2331-9.
PMID 25980660, **http://www.ncbi.nlm.nih.gov/pubmed/25980660**

Design	Multicenter, randomized, noninferiority trial comparing high-flow oxygen (flow = 50 l/min) and NIV (PS = 8 cmH2O; PEEP = 4 cmH2O)
Patients	830 patients after cardiothoracic surgery
Objectives	Compare the treatment failure, defined as reintubation, switch to the other study treatment, or premature treatment discontinuation between groups
Main Results	The treatment failed in 87 of 414 patients with high-flow oxygen (21.0%) and 91of 416 patients with NIV (21.9%). No significant differences were found for intensive care unit mortality (23 patients with NIV [5.5%] and 28 with high-flow oxygen [6.8%]; p = 0 .66). Skin breakdown was significantly more common with NIV.
Conclusion	High-flow oxygen was not inferior to NIV in cardiothoracic surgery patients
Comment	Noninferiority study

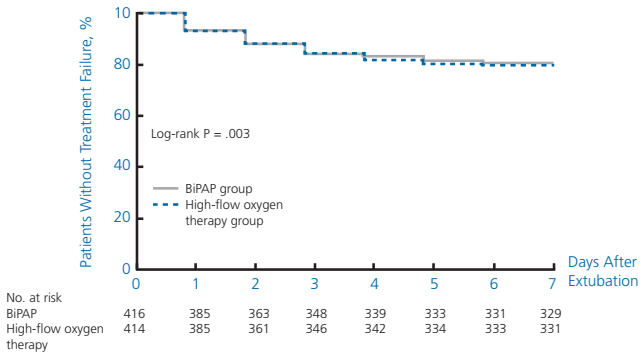

Figure 2: No difference for time from treatment initiation to treatment failure between groups

High-flow oxygen through nasal cannula in acute hypoxemic respiratory failure

Frat JP, Thille AW, Mercat A, Girault C, Ragot S, Perbet S, Prat G, Boulain T, Morawiec E, Cottereau A, Devaquet J, Nseir S, Razazi K, Mira JP, Argaud L, Chakarian JC, Ricard JD, Wittebole X, Chevalier S, Herbland A, Fartoukh M, Constantin JM, Tonnelier JM, Pierrot M, Mathonnet A, Béduneau G, Delétage-Métreau C, Richard JC, Brochard L, Robert R; FLORALI Study Group; REVA Network.

N Engl J Med. 2015 Jun 4;372(23):2185-96.
PMID 25981908, **http://www.ncbi.nlm.nih.gov/pubmed/25981908**

Design	Randomized controlled trial : high-flow oxygen therapy, standard oxygen therapy delivered through a face mask, or noninvasive positive-pressure ventilation
Patients	310 patients with acute hypoxemic respiratory failure without hypercapnia
Objectives	Compare outcomes (intubation, ventilator-free days, and mortality) between group
Main Results	The intubation rate was 38% in the high-flow-oxygen group, 47% in the standard group, and 50% in the noninvasive-ventilation group (p = 0.18 for all comparisons). In the subgroup of patients with a PaO2:FiO2 of 200 mmHg or less, the intubation rate was significantly lower in the high flow oxygen group than in the other two groups. The number of ventilator-free days at day 28 was significantly higher in the high-flow-oxygen group (24 ±8 days, vs. 22 ±10 in the standard-oxygen group and 19 ±12 in the noninvasive-ventilation group; p = 0.02 for all comparisons). The hazard ratio for death at 90 days was 2.01 (95% CI, 1.01 to 3.99) with standard oxygen versus high flow oxygen (p = 0.046) and 2.50 (95% CI, 1.31 to 4.78) with noninvasive ventilation versus high flow oxygen (p = 0.006).
Conclusion	Treatment with high flow oxygen decreased intubation rates in the most severe patients. There was a significant difference in favor of high flow oxygen in 90-day mortality.
Comment	This study shows more intubation and mortality in the group treated by NIV. The hypothesis is that NIV could induce lung injuries by applying high tidal volumes.

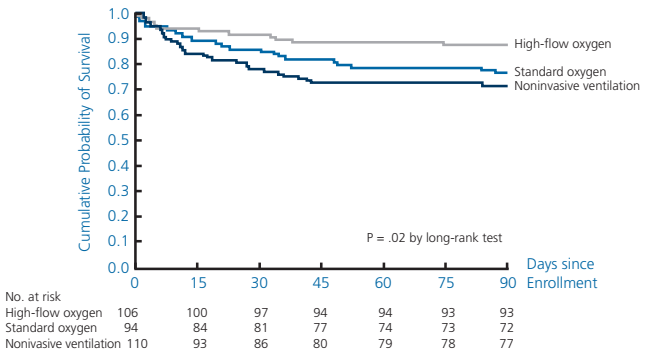

Figure 3: High flow oxygen increased the probability of survival

Effect of postextubation high-flow nasal cannula vs. conventional oxygen therapy on reintubation in low-risk patients: a randomized clinical trial

Hernández G, Vaquero C, González P, Subira C, Frutos-Vivar F, Rialp G, Laborda C, Colinas L, Cuena R, Fernández R

JAMA. 2016 Apr 5;315(13):1354-61

PMID 26975498, **http://www.ncbi.nlm.nih.gov/pubmed/26975498**

Design	Multicenter randomized clinical trial
Patients	527 patients at low risk for reintubation fulfilling extubation criteria
Objectives	Determine whether high-flow nasal cannula oxygen therapy is superior to conventional oxygen therapy for preventing reintubation
Main Results	Reintubation rate within 72 hours was lower in the high flow group compared with the conventional oxygen group (13 patients [4.9%] vs 32 [12.2%]; p = 0.004). Postextubation respiratory failure was lower in the high flow group compared with the conventional oxygen group (22/264 patients [8.3%] vs 38/263 [14.4%]; p = 0.03). Time to reintubation was not significantly different between the high flow group (19 h [12-28] vs 15 h [9-31] in the conventional oxygen group; p = 0.66].
Conclusion	The use of HFNC oxygen reduced the risk of reintubation in low risk of reintubation patients

Use of high-flow nasal cannula oxygen therapy to prevent desaturation during tracheal intubation of intensive care patients with mild-to-moderate hypoxemia

Miguel-Montanes R, Hajage D, Messika J, Bertrand F, Gaudry S, Rafat C, Labbé V, Dufour N, Jean-Baptiste S, Bedet A, Dreyfuss D, Ricard JD.

Crit Care Med. 2015 Mar;43(3):574-83.

PMID 25479117, **http://www.ncbi.nlm.nih.gov/pubmed/25479117**

Design	Prospective before/after study
Patients	101 ICU patients requiring tracheal intubation
Objectives	Compare pre- and per-procedure oxygenation with either a standard oxygen therapy or a high-flow nasal cannula oxygen (HFNC)
Main Results	Median lowest SpO2 during intubation were 94% (83-98.5) with the standard oxygen therapy versus 100% (95-100) with HFNC oxygen (p < 0.0001). SpO2 values at the end of preoxygenation were higher with HFNC oxygen. There were more episodes of severe hypoxemia in the standard oxygen therapy group (2% vs 14%, p = 0.03).
Conclusion	HFNC oxygen improved patient safety during intubation

Nasal high-flow versus Venturi mask oxygen therapy after extubation. Effects on oxygenation, comfort, and clinical outcome.

Maggiore SM, Idone FA, Vaschetto R, Festa R, Cataldo A, Antonicelli F, Montini L, De Gaetano A, Navalesi P, Antonelli M.

Am J Respir Crit Care Med. 2014 Aug 1;190(3):282-8.
PMID 25003980, **http://www.ncbi.nlm.nih.gov/pubmed/25003980**

Design	Randomized controlled trail: HFNC versus Venturi mask
Patients	105 hypoxemic patients
Objectives	Compare the effects of the Venturi mask and the NHFC on PaO2/FiO2 after extubation
Main Results	PaO2/FiO2 was higher with the HFNC (287 ±74 vs. 247 ±81 at 24 h; p = 0.03). Discomfort related both to the interface and to airway dryness was better with NHF (respectively, p = 0.006; and p = 0.002). Fewer patients had interface displacements, oxygen desaturations, required reintubation, or any form of ventilator support in the HFNC group.
Conclusion	HFNC resulted in better oxygenation, better comfort, fewer desaturations and interface displacements, and a lower reintubation rate
Comment	HFNC decreased the reintubation rate

High-flow nasal cannula oxygen therapy versus noninvasive ventilation in immunocompromised patients with acute respiratory failure: an observational cohort study

Coudroy R, Jamet A, Petua P, Robert R, Frat JP, Thille AW
Ann Intensive Care. 2016 Dec;6(1):45
PMID 27207177, **http://www.ncbi.nlm.nih.gov/pubmed/27207177**

Design	Observational cohort study over an 8-year period
Patients	115 immunocompromised patients with acute respiratory failure
Objectives	Compare outcomes between patients treated using HFNC or NIV as a first-line therapy
Main Results	52% were treated with HFNC alone and 48% with NIV as first-line therapy with 55% receiving HFNC and 45% standard oxygen between NIV sessions. The rates of intubation and 28-day mortality were higher in patients treated with NIV than with HFNC (55 vs. 35%, p = 0.04, and 40 vs. 20%, p = 0.02, respectively). Using propensity score-matched analysis, NIV was associated with mortality. Using multivariate analysis, NIV was independently associated with intubation and mortality.
Conclusion	In immunocompromised patients intubation and mortality rates could be lower in patients treated with HFNC alone than with NIV. The use of NIV remained independently associated with poor outcomes.

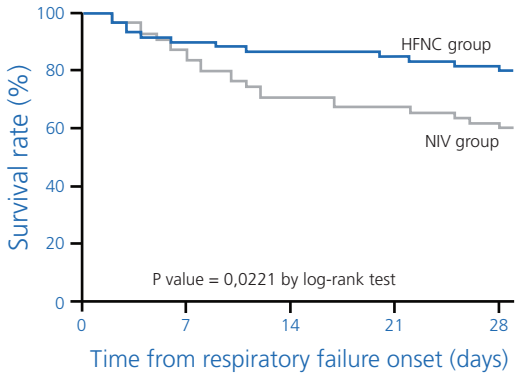

Figure 4: Survival was higher with HFNC alone than with NIV

Effect of Very-High-Flow Nasal Therapy on Airway Pressure and End-Expiratory Lung Impedance in Healthy Volunteers

Parke RL, Bloch A, McGuinness SP.
Respir Care. 2015 Oct;60(10):1397-403
PMID 26329355, **http://www.ncbi.nlm.nih.gov/pubmed/26329355**

Design	Physiological study using EIT
Patients	15 healthy volunteers
Objectives	Assess the relationship between flows of up to 100 l/min and changes in lung physiology
Main Results	Flows ranged from 30 to 100 l/min with resulting airway pressures of 2.7 ±0.7 to 11.9 ±2.7 cmH2O. A cumulative and linear increase in end-expiratory lung impedance was observed with increasing flows and a decrease in breathing frequency.
Conclusion	Very high flow oxygen therapy could be an acceptable alternative to CPAP

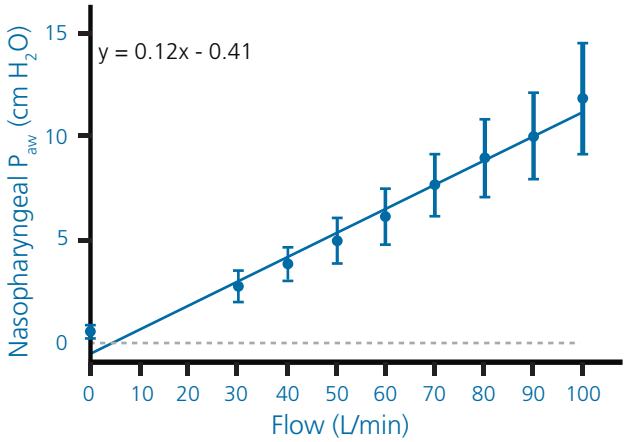

Figure 5: Airway pressure increased with flow

Efficacy of high-flow nasal cannula therapy in acute hypoxemic respiratory failure: decreased use of mechanical ventilation

Nagata K, Morimoto T, Fujimoto D, Otoshi T, Nakagawa A, Otsuka K, Seo R, Atsumi T, Tomii K.
Respir Care. 2015 Oct;60(10):1390-6
PMID 26106206, **http://www.ncbi.nlm.nih.gov/pubmed/26106206**

Design	Retrospective single-center cohort study comparing the periods before and after HFNC introduction
Patients	83 before and 89 after HFNC introduction
Objectives	Evaluate the efficacy of high-flow oxygen as a support method for acute hypoxemic respiratory failure
Main Results	In the post-HFNC period, significantly fewer subjects required mechanical ventilation (NIV or invasive ventilation). There were significantly fewer ventilator days and more ventilator-free days.
Conclusion	High flow decreased mechanical ventilation requirement in patients with respiratory failure
Comment	Retrospective study with a before and after analysis

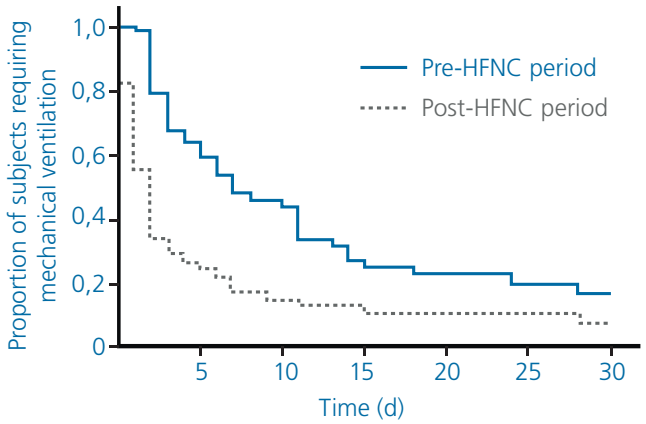

Figure 6: Mechanical ventilation before and after HFNC introduction

Pressures delivered by nasal high flow oxygen during all phases of the respiratory cycle

Parke RL, McGuinness SP.
Respir Care. 2013 Oct;58(10):1621-4.
PMID 23513246, **http://www.ncbi.nlm.nih.gov/pubmed/23513246**

Design	Prospective observational study
Patients	15 patients after elective cardiac surgery
Objectives	Measure and compare the airway pressure generated during different phases of the respiratory cycle in patients receiving HFNC oxygen at various gas flows, by a nasopharyngeal catheter
Main Results	During HFNC oxygen therapy, the mean ±SD nasopharyngeal airway pressures were 1.5 ±0.6, 2.2 ±0.8, and 3.1 ±1.2 at 30, 40, and 50 l/min.
Conclusion	HFNC oxygen therapy generated positive airway pressure

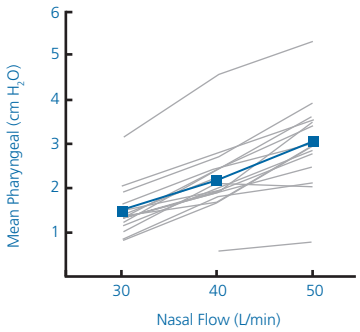

Figure 7: Increasing flow increased airway pressure

Evaluation of a humidified nasal high-flow oxygen system, using oxygraphy, capnography and measurement of upper airway pressures

Ritchie JE, Williams AB, Gerard C, Hockey H.
Anaesth Intensive Care. 2011 Nov;39(6):1103-10.
PMID 22165366, **http://www.ncbi.nlm.nih.gov/pubmed/22165366**

Design	Randomized crossover study
Patients	10 healthy patients
Objectives	Evaluate the performance of HFNC by measuring delivered FiO2 and Paw (airway pressure)
Main Results	Hypopharyngeal pressure increased with increasing delivered gas flow rate with mouth closed. At 50 l/min, the system delivered a mean airway pressure of up to 7.1 cmH20.
Conclusion	The positive Paw created by the high flow increased the efficacy of this system and may serve as a bridge to formal positive pressure systems
Comment	Healthy patients

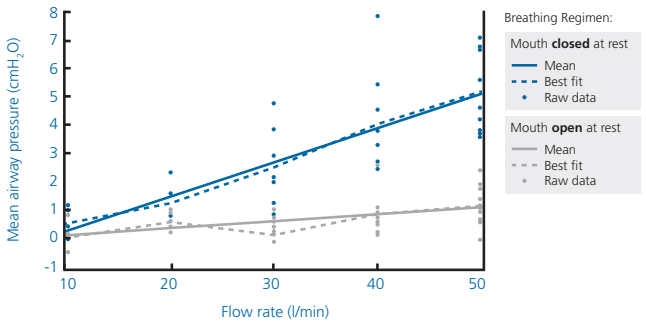

Figure 8: Paw increase with the flow rate when mouth is closed

Predicting success of high-flow nasal cannula in pneumonia patients with hypoxemic respiratory failure: The utility of the ROX index

Roca O, Messika J, Caralt B, García-de-Acilu M, Sztrymf B, Ricard JD, Masclans JR
J Crit Care. 2016 May 31;35:200-205
PMID 27481760, **http://www.ncbi.nlm.nih.gov/pubmed/27481760**

Design	Prospective observational 2-center cohort study
Patients	157 patients
Objectives	Describe early predictors and to develop a prediction tool that accurately identifies the need for intubation in patients with hypoxemic acute respiratory failure (ARF) treated with high-flow nasal cannula (HFNC)
Main Results	ROX index was defined as the ratio of pulse oximetry/fraction of inspired oxygen to respiratory rate. 44 (28%) required MV. After 12 h of HFNC, the ROX index demonstrated good prediction accuracy. The best cutoff point for the ROX index was estimated to be 4.88.
Conclusion	In patients with ARF and pneumonia, the ROX index can identify patients at low risk for HFNC failure

Physiologic Effects of High-Flow Nasal Cannula Oxygen in Critical Care Subjects

Vargas F, Saint-Leger M, Boyer A, Bui NH, Hilbert G.
Respir Care. 2015 Oct;60(10):1369-76
PMID 25944940, **http://www.ncbi.nlm.nih.gov/pubmed/25944940**

Design	Comparative study (conventional therapy, high flow oxygen and CPAP)
Patients	12 ICU patients with acute hypoxemic respiratory failure
Objectives	Assess the short-term physiologic effects (inspiratory muscle effort, gas exchange, dyspnea score, and comfort) of HFNC
Main Results	HFNC reduced inspiratory effort and breathing frequency and increased PaO2/FiO2 compared with conventional ventilation.
Conclusion	In hypoxemic respiratory failure, high flow improve a physiological patterns compare to conventional therapy

Comparison of the effectiveness of high flow nasal oxygen cannula vs. standard non-rebreather oxygen face mask in post-extubation intensive care unit patients

Brotfain E, Zlotnik A, Schwartz A, Frenkel A, Koyfman L, Gruenbaum SE, Klein M.
Isr Med Assoc J. 2014 Nov;16(11):718-22.
PMID 25558703, **http://www.ncbi.nlm.nih.gov/pubmed/25558703**

Design	Retrospective study
Patients	67 ICU patients after extubation
Objectives	Compare clinical effects of HFNC with standard oxygen face masks
Main Results	The use of HFNC improved PaO2/FiO2 ($p < 0.05$). There were more ventilator-free days in the HFNC group ($p < 0.05$) and fewer patients required reintubation (1 vs. 6).
Conclusion	HFNC may be more effective than standard oxygen supply devices for oxygenation in the post-extubation period
Comment	Retrospective study

Effect of high-flow nasal cannula on thoraco-abdominal synchrony in adult critically ill patients

Itagaki T, Okuda N, Tsunano Y, Kohata H, Nakataki E, Onodera M, Imanaka H, Nishimura M.
Respir Care. 2014 Jan;59(1):70-4.
PMID 23737548., **http://www.ncbi.nlm.nih.gov/pubmed/23737548.**

Design	Prospective crossover study
Patients	40 ICU patients requiring oxygen therapy, low-flow oxygen (up to 8 l/min) was administered via oronasal mask for 30 min, followed by HFNC at 30-50 l/min
Objectives	Compare effects of HFNC on thoraco-abdominal synchrony, using respiratory inductive plethysmography
Main Results	During HFNC, RR (respiratory rate) significantly decreased from 25 breaths/min (IQR 22-27 breaths/min) to 21 breaths/min (IQR 18-24 breaths/min) ($p < 0.001$), and thoraco-abdominal synchrony ($p < 0.001$) significantly improved.
Conclusion	HFNC improved thoraco-abdominal synchrony in patients with respiratory failure

Effect of high-flow nasal cannula and body position on end-expiratory lung volume: a cohort study using electrical impedance tomography

Riera J, Pérez P, Cortés J, Roca O, Masclans JR, Rello J.
Respir Care. 2013 Apr;58(4):589-96.
PMID 23050520, **http://www.ncbi.nlm.nih.gov/pubmed/23050520**

Design	Prospective observational study
Patients	20 healthy adults
Objectives	Investigate the effects of HFNC and body position on global and regional end-expiratory lung impedance variation (⊠EELI)
Main Results	HFNC increased global EELI by 1.26 units ($p < 0.001$) in a supine position, and by 0.87 units ($p < 0.001$) in a prone position. The distribution of ⊠EELI was homogeneous in the prone position, with no difference between ventral and dorsal lung regions, while in the supine position, a significant difference was found with increased EELI in ventral areas.
Conclusion	HFNC increased global EELI
Comment	Healthy patients

High-flow nasal cannula therapy in do-not-intubate patients with hypoxemic respiratory distress

Peters SG, Holets SR, Gay PC.
Respir Care. 2013 Apr;58(4):597-600.
PMID 22781059, **http://www.ncbi.nlm.nih.gov/pubmed/22781059**

Design	Prospective observational study
Patients	50 do-not-intubate patients with hypoxemic respiratory failure
Objectives	Determine the need for escalation to NIV
Main Results	Mean O2 saturations went from 89.1% to 94.7% ($p < 0.001$), and breathing frequency went from 30.6 breaths/min to 24.7 breaths/min ($p < 0.001$). Nine of the 50 subjects (18%) escalated to NIV, while 82% were maintained on HFNC. The median duration of HFNC was 30 hours (range 2-144 h).
Conclusion	HFNC provided adequate oxygenation and may be an alternative to NIV for DNI patients

Humidified high flow nasal oxygen during respiratory failure in the emergency department: feasibility and efficacy

Lenglet H, Sztrymf B, Leroy C, Brun P, Dreyfuss D, Ricard JD.
Respir Care. 2012 Nov;57(11):1873-8.
PMID 22417844, **http://www.ncbi.nlm.nih.gov/pubmed/22417844**

Design	Prospective observational study
Patients	17 patients with acute respiratory failure requiring > 9 l/min oxygen or with ongoing clinical signs of respiratory distress
Objectives	Study the HFNC oxygen feasibility and efficiency in patients exhibiting acute respiratory failure presenting to the ED
Main Results	HFNC was associated with a significant decrease in dyspnea. RR (respiratory rate) decreased from 28 breaths/min (25-32 breaths/min) to 25 breaths/min (21-28 breaths/min) ($p < 0.01$), and SpO2 increased from 90% (88.5%-94%) to 97% (92.5%-100%) ($p < .001$). HFNC was well tolerated and no adverse event was noted. Altogether, 76% of healthcare givers declared preferring HFNC as compared to conventional oxygen therapy.
Conclusion	HFNC was feasible in the ED and improved respiratory parameters in subjects with acute hypoxemic respiratory failure
Comment	Small number of patients

Impact of high-flow nasal cannula oxygen therapy on intensive care unit patients with acute respiratory failure: a prospective observational study

Sztrymf B, Messika J, Mayot T, Lenglet H, Dreyfuss D, Ricard JD.
J Crit Care. 2012 Jun;27(3):324.e9-13.
PMID 21958974, **http://www.ncbi.nlm.nih.gov/pubmed/21958974**

Design	Prospective observational study
Patients	20 patients with acute respiratory failure
Objectives	Determine the impact of HFNC in comparison with conventional oxygen therapy
Main Results	Use of HFNC enabled a significant reduction of respiratory rate, 28 (26-33) vs 24.5 (23-28.5) breaths per minute (p = 0.006), and a significant increase in oxygen saturation measured by pulse oximetry 93.5% (90-98.5) vs 98.5% (95.5-100) (p = 0.0003). Use of HFNC significantly increased PaO2 from 8.73 (7.13-11.13) to 15.27 (9.66-25.6) kPa (p = 0.001) and moderately increased PaCO2, 5.26 (4.33-5.66) to 5.73 (4.8-6.2) kPa (p = 0.005) without affecting pH.
Conclusion	HFNC in patients with persistent ARF was associated with improvement of both clinical and biologic parameters

Oxygen delivery through high-flow nasal cannulae increased end-expiratory lung volume and reduce respiratory rate in post cardiac surgical patients

Corley A, Caruana LR, Barnett AG, Tronstad O, Fraser JF.
Br J Anaesth. 2011 Dec;107(6):998-1004.
PMID 21908497, **http://www.ncbi.nlm.nih.gov/pubmed/21908497**

Design	Prospective observational study
Patients	20 post cardiac surgery patients
Objectives	Investigate the effects of HFNC on Paw (airway pressure) and end-expiratory lung volume (EELV)
Main Results	A strong and significant correlation existed between Paw and end-expiratory lung impedance (EELI) (r = 0.7, p < 0.001). Compared with low-flow oxygen, HFNC significantly increased EELI by 25.6% and Paw by 3.0 cmH2O. RR (respiratory rate) reduced by 3.4 bpm with HFNC, tidal impedance variation increased by 10.5%. HFNC improved subjective dyspnea scoring (P = 0.023). Increases in EELI were significantly influenced by body mass index (BMI), with larger increases associated with higher BMIs (P <0.001).
Conclusion	HFNC reduced RR and improved oxygenation by increasing both EELV and tidal volume, and are most beneficial in patients with higher BMI

Beneficial effects of humidified high flow nasal oxygen in critical care patients: a prospective pilot study

Sztrymf B, Messika J, Bertrand F, Hurel D, Leon R, Dreyfuss D, Ricard JD.
Intensive Care Med. 2011 Nov;37(11):1780-6.
PMID 21946925, **http://www.ncbi.nlm.nih.gov/pubmed/21946925**

Design	Prospective pilot study
Patients	38 ICU patients with acute respiratory failure
Objectives	Evaluate the efficiency, safety, and outcome of HFNC
Main Results	HFNC significantly reduced the respiratory rate, heart rate, dyspnea score, supraclavicular retraction and thoraco-abdominal asynchrony, and increased pulse oxymetry. HFNC was used for a mean duration of 2.8 days and a maximum of 7 days. These improvements lasted throughout the study period. It was never interrupted for intolerance. No nosocomial pneumonia occurred during HFNC.
Conclusion	HFNC had a beneficial effect on clinical signs and oxygenation
Comment	Pilot study

A preliminary randomized controlled trial to assess effectiveness of nasal high-flow oxygen in intensive care patients

Parke RL, McGuinness SP, Eccleston ML.
Respir Care. 2011 Mar;56(3):265-70.
PMID 21255498, **http://www.ncbi.nlm.nih.gov/pubmed/21255498**

Design	Randomized controlled trial: HFNC versus standard oxygen therapy
Patients	60 cardiothoracic and vascular ICU patients with mild to moderate hypoxemic respiratory failure
Objectives	Compare HFNC oxygen therapy and standard high-flow face mask (HFFM) oxygen therapy
Main Results	The rate of noninvasive ventilation in the NHF group was 3/29 (10%), compared with 8/27 (30%) in the HFFM group ($p = 0.10$). The NHF patients had significantly fewer desaturations ($p = .009$).
Conclusion	HFNC oxygen therapy may be more effective than HFFM

High-flow nasal oxygen vs high-flow face mask: a randomized crossover trial in extubated patients

Tiruvoipati R, Lewis D, Haji K, Botha J.
J Crit Care. 2010 Sep;25(3):463-8.
PMID 19781896, **http://www.ncbi.nlm.nih.gov/pubmed/19781896**

Design	Randomized crossover study
Patients	50 patients after extubation
Objectives	Compare the efficiency of HFNC oxygen to HFFM (high flow face mask) in maintaining gas exchange
Main Results	There was a significant difference (p = 0.01) in tolerance, HFNC being well tolerated. There was a trend (p = 0.09) toward better patient comfort with HFNP.
Conclusion	HFNC was as effective as HFFM and better tolerated

High-flow nasal cannula oxygen during endotracheal intubation in hypoxemic patients: a randomized controlled clinical trial

Vourc'h M, Asfar P, Volteau C, Bachoumas K, Clavieras N, Egreteau PY, Asehnoune K, Mercat A, Reignier J, Jaber S, Prat G, Roquilly A, Brule N, Villers D, Bretonniere C, Guitton C.
Intensive Care Med. 2015 Sep;41(9):1538-48.
PMID 25869405, **http://www.ncbi.nlm.nih.gov/pubmed/25869405**

Design	Multicenter randomized controlled trial: HFNC versus standard oxygen therapy
Patients	124 acute hypoxemic adults requiring intubation
Objectives	Evaluate the efficiency of HFNC for preoxygenation: HFNC was maintained throughout the procedure, whereas HFFM (high flow face mask) was removed at the end of general anaesthesia induction.
Main Results	The median lowest saturation was 91.5% (80-96) for HFNC and 89.5% (81-95) for the HFFM group (p = 0.44). There was no difference for difficult intubation, intubation difficulty scale, ventilation-free days, intubation-related adverse events including desaturation <80% or mortality.
Conclusion	HFNC did not significantly reduce the lowest level of desaturation in hypoxemic patients

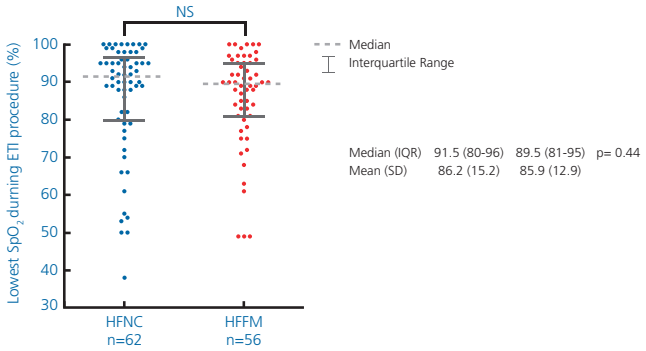

Figure 9: HFNC did not increase the saturation during intubation

High-flow nasal cannula versus conventional oxygen therapy after endotracheal extubation: a randomized crossover physiological study

Rittayamai N, Tscheikuna J, Rujiwit P.
Respir Care. 2014 Apr;59(4):485-90.
PMID 24046462, **http://www.ncbi.nlm.nih.gov/pubmed/24046462**

Design	Randomized crossover study
Patients	17 respiratory care patients after extubation
Objectives	Compare the short-term benefit of HFNC with standard oxygen therapy in terms of change in dyspnea, physiologic variables, and patient comfort in subjects after endotracheal extubation
Main Results	HFNC was associated with less dyspnea (p = 0.04) and lower breathing respiratory rate (p = 0.009) and heart rate (p = 0.006) compared with standard oxygen therapy. Most of the subjects (88.2%) preferred HFNC to a non-rebreathing mask.
Conclusion	HFNC improved dyspnea and physiologic parameters after extubation
Comment	Small number of patients

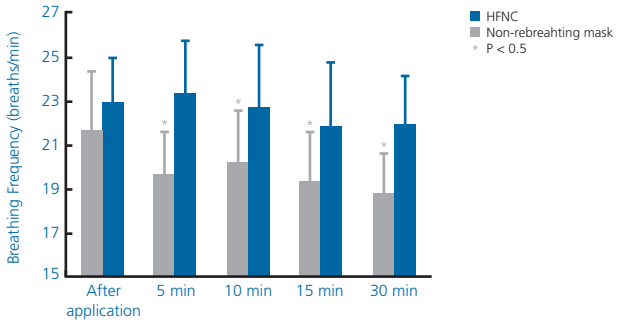

Figure 10: HFNC decreased respiratory rate during its application compared with conventional oxygen therapy

Nasal high-flow oxygen therapy in ICU: A before-and-after study

Fealy N, Osborne C, Eastwood GM, Glassford N, Hart G, Bellomo R.
Aust Crit Care. 2016 Feb;29(1):17-22
PMID 26092213, **http://www.ncbi.nlm.nih.gov/pubmed/26092213**

Design	Prospective 4-week before-and-after study
Patients	117 adult patients (57 before, 60 after) admitted to a 22-bed tertiary ICU in Melbourne, Australia
Objectives	Assess the feasibility, safety and cost-effectiveness of introducing a protocol in which HFNP was the primary oxygen delivery device for non-intubated intensive care patients
Main Results	86 patients (73.5%) received mechanical ventilation. Feasibility revealed a significant reduction in standard oxygen therapy during the after period. Costing was in favour of the after period with a consumable cost saving per patient (AUD $32.56 vs. $17.62, p<.05). During the after period, fewer patients (5 vs. 14 patients) used three or more oxygen delivery devices. Safety outcomes demonstrated no significant difference.
Conclusion	Using HFNC as the primary oxygen delivery method for non-intubated intensive care patients was feasible, safe, and the oxygen device costs were reduced
Comment	Before after single center study in Australia

The effects of a 2-h trial of high-flow oxygen by nasal cannula versus Venturi mask in immunocompromised patients with hypoxemic acute respiratory failure: a multicenter randomized trial

Lemiale V, Mokart D, Mayaux J, Lambert J, Rabbat A, Demoule A, Azoulay E.
Crit Care. 2015 Nov 2;19(1):380
PMID 26521922, **http://www.ncbi.nlm.nih.gov/pubmed/26521922**

Design	Multicenter, parallel-group randomized controlled trial
Patients	100 immunocompromised patients with acute respiratory failure
Objectives	Compare HFNC and Venturi mask oxygen to avoid mechanical ventilation during a 2-hour period
Main Results	During the 2-h study treatment period, 12 patients required IMV or NIV, and we found no significant difference between the two groups.
Conclusion	No difference between short term high flow oxygen and conventional therapy in immuno-compromised patients
Comment	The study was underpowered because of the low event rate and the one-sided hypothesis. Two hours is too short a time to get to endpoint.

High-Flow Nasal Cannula in a Mixed Adult ICU

Gaunt KA, Spilman SK, Halub ME, Jackson JA, Lamb KD, Sahr SM.
Respir Care. 2015 Oct;60(10):1383-9
PMID 26060320, **http://www.ncbi.nlm.nih.gov/pubmed/26060320**

Design	Retrospective study
Patients	145 medical and trauma ICU patients
Objectives	Evaluate timing of HFNC on patient outcomes
Main Results	24.1% received mechanical ventilation before HFNC, 14.5% received mechanical ventilation after HFNC, and 61.3% never received mechanical ventilation. Delay to first HFNC was strongly correlated with the development of ventilator-associated pneumonia. Subjects with a greater length of time between ICU admission and first use of HFNC experienced significantly longer stays in the ICU and post-ICU periods.
Conclusion	HFNC should be considered early in the ICU as first-line oxygen therapy

Failure of high-flow nasal cannula therapy may delay intubation and increase mortality

Kang BJ, Koh Y, Lim CM, Huh JW, Baek S, Han M, Seo HS, Suh HJ, Seo GJ, Kim EY, Hong SB.
Intensive Care Med. 2015 Apr;41(4):623-32.
PMID 25691263, **http://www.ncbi.nlm.nih.gov/pubmed/25691263**

Design	Retrospective observational study
Patients	175 ICU patients
Objectives	Assess mortality and outcomes of patients who received HFNC therapy that failed
Main Results	130 (74.3%) and 45 (25.7%) were intubated before and after 48 h of HFNC, respectively. The early intubated patients had better overall ICU mortality (39.2% vs. 66.7%; p = 0.001), extubation success (37.7% vs. 15.6%; p = 0.006), ventilator weaning (55.4% vs. 28.9%; p = 0.002), and ventilator-free days (8.6 ±10.1 vs. 3.6 ± 7.5; p = 0.011) than late intubated patients.
Conclusion	Failure of HFNC might cause worse clinical outcomes in patients with respiratory failure
Comment	Large prospective and randomized controlled studies on HFNC failure are needed to draw a definitive conclusion

Nasal high-flow oxygen therapy in patients with hypoxic respiratory failure: effect on functional and subjective respiratory parameters compared to conventional oxygen therapy and non-invasive ventilation (NIV)

Schwabbauer N, Berg B, Blumenstock G, Haap M, Hetzel J, Riessen R.
BMC Anesthesiol. 2014 Aug 7;14:66.
PMID 25110463, **http://www.ncbi.nlm.nih.gov/pubmed/25110463**

Design	Randomized crossover study
Patients	14 patients with acute hypoxic respiratory failure
Objectives	Compare the short-term effects of oxygen therapy via HFNC on respiratory parameters in patients with acute hypoxic respiratory failure with NIV and standard treatment via a Venturi mask
Main Results	Dyspnea was significantly reduced using an HFNC compared to NIV ($p < 0.05$). Patients gave the best ratings to HFNC, followed by Venturi mask (NS vs. HFNC) and NIV ($p < 0.01$ vs. HFNC and $p < 0.05$ vs. VM). For further treatment, 10 patients chose HFNC, 3 VM, and 1 NIV.
Conclusion	HFNC decreased dyspnea and was well tolerated by patients
Comment	Small number of patients

Open-label, phase II study of routine high-flow nasal oxygen therapy in cardiac surgical patients

Parke R, McGuinness S, Dixon R, Jull A.
Br J Anaesth. 2013 Dec;111(6):925-31.
PMID 23921199, **http://www.ncbi.nlm.nih.gov/pubmed/23921199**

Design	Randomized controlled trial: HFNC oxygen (45 l/min) versus usual care from extubation to day 2 after surgery
Patients	340 patients after cardiac surgery
Objectives	Determine whether the routine administration of HFNC oxygen improves pulmonary function
Main Results	The number of patients with an SpO2 /FiO2 ≥ 445 on Day 3 was 78 (46.4%) in the NHF group vs 72 (42.4%) standard care [OR 1.18, 95% CI 0.77-1.81, p=0.45]. Escalation in respiratory support at any time in the study occurred in 47 patients (27.8%) allocated to NHF compared with 77 (45%) standard care (OR 0.47, 95% CI 0.29-0.7, p=0.001).
Conclusion	Routine use of NHF reduced the requirement for escalation of respiratory support

Patients with New York Heart Association class III heart failure may benefit with high flow nasal cannula supportive therapy: high flow nasal cannula in heart failure

Roca O, Pérez-Terán P, Masclans JR, Pérez L, Galve E, Evangelista A, Rello J.
J Crit Care. 2013 Oct;28(5):741-6.
PMID 23602035, **http://www.ncbi.nlm.nih.gov/pubmed/23602035**

Design	Prospective observational study
Patients	10 patients with NYHA III heart failure
Objectives	Describe the hemodynamic and respiratory effects of HFNC oxygen
Main Results	Respiratory rate was significantly reduced from 23 breaths per minute at baseline to 13 breaths per minute at HFNC with 40 l/min.
Conclusion	Patients with NYHA class III heart failure may benefit with HFNC supportive therapy
Comment	Small number of patients

The effects of flow on airway pressure during nasal high-flow oxygen therapy

Parke RL, Eccleston ML, McGuinness SP.
Respir Care. 2011 Aug;56(8):1151-5.
PMID 21496369, **http://www.ncbi.nlm.nih.gov/pubmed/21496369**

Design	Prospective observational study
Patients	15 post cardiac surgery patients
Objectives	Determine the relationship between flow and pressure with HFNC
Main Results	With the mouth closed, the mean ± SD airway pressures at 30, 40, and 50 l/min were 1.93 ±1.25 cmH2O, 2.58 ±1.54 cmH2O, and 3.31 ±1.05 cmH2O, respectively. There was a positive linear relationship between flow and pressure.
Conclusion	The mean nasopharyngeal pressure during nasal high-flow oxygen increases as flow increases

High-flow oxygen therapy in acute respiratory failure

Roca O, Riera J, Torres F, Masclans JR.
Respir Care. 2010 Apr;55(4):408-13.
PMID 20406507, **http://www.ncbi.nlm.nih.gov/pubmed/20406507**

Design	Prospective observational study
Patients	20 patients with acute respiratory failure
Objectives	Compare the comfort of oxygen therapy via HFNC versus HFFM (high flow face mask)
Main Results	The HFNC was associated with less dyspnea ($p = .001$) and mouth dryness ($p < .001$), and was more comfortable ($p < .001$). HFNC was associated with higher PaO2 (127 [83-191] mmHg vs 77 [64-88] mmHg, $p = .002$) and lower RR (respiratory rate) (21 [18-27] breaths/min vs 28 [25-32] breaths/min, $p < .001$), but no difference in PaCO2.
Conclusion	HFNC was better tolerated and more comfortable than HFFM, associated with better oxygenation and lower RR

Additional files

Comparison of high-flow nasal oxygen therapy with conventional oxygen therapy and noninvasive ventilation in adult patients with acute hypoxemic respiratory failure: A meta-analysis and systematic review

Maitra S, Som A, Bhattacharjee S, Arora MK, Baidya DK.
J Crit Care. 2016 May 25;35:138-144.
PMID 27481749, **http://www.ncbi.nlm.nih.gov/pubmed/27481749**

Design	Meta-analysis of prospective randomized controlled trials
Patients	7 randomized controlled trials
Objectives	Compare HFNO with NIV and conventional oxygen therapy in adult patients with acute hypoxemic respiratory failure
Main Results	HFNC did not decrease the requirement for higher respiratory support compared with the control group, however it was associated with an improved respiratory rate, dyspnea score and better comfort.
Conclusion	HFNC improved patient comfort and dyspnea

High-Flow Nasal Cannula Oxygen Therapy in Adults: Physiological Benefits, Indication, Clinical Benefits, and Adverse Effects

Nishimura M.
Respir Care. 2016 Apr;61(4):529-41.
PMID 27016353, **http://www.ncbi.nlm.nih.gov/pubmed/27016353**

Design	Review
Conclusion	HFNC has emerged as an innovative and effective modality for early treatment of adults with respiratory failure with diverse underlying diseases

Current evidence for the effectiveness of heated and humidified high flow nasal cannula supportive therapy in adult patients with respiratory failure

Roca O, Hernández G, Díaz-Lobato S, Carratalá JM, Gutiérrez RM, Masclans JR; Spanish Multidisciplinary Group of High Flow Supportive Therapy in Adults (HiSpaFlow)
Crit Care. 2016 Apr 28;20(1):109
PMID 27121707, **http://www.ncbi.nlm.nih.gov/pubmed/27121707**

Design	Review
Conclusion	HFNC is safe and useful in patients with respiratory failure, improving oxygenation and comfort in different clinical situations

Use of high-flow nasal cannula oxygenation in ICU adults: a narrative review

Papazian L, Corley A, Hess D, Fraser JF, Frat JP, Guitton C, Jaber S, Maggiore SM, Nava S, Rello J, Ricard JD, Stephan F, Trisolini R, Azoulay E.
Intensive Care Med. 2016 Mar 11. [Epub ahead of print]
PMID 26969671, **http://www.ncbi.nlm.nih.gov/pubmed/26969671**

Design	Review
Conclusion	The main aim of this review is to guide clinicians towards evidence-based clinical practice guidelines

High-flow oxygen administration by nasal cannula for adult and perinatal patients

Ward JJ.
Respir Care. 2013 Jan;58(1):98-122.
PMID 23271822, **http://www.ncbi.nlm.nih.gov/pubmed/23271822**

Design	Review

High-flow nasal interface improves oxygenation in patients undergoing bronchoscopy

Lucangelo U, Vassallo FG, Marras E, Ferluga M, Beziza E, Comuzzi L, Berlot G, Zin WA.
Crit Care Res Pract. 2012;2012:506382
PMID 22666567, **http://www.ncbi.nlm.nih.gov/pubmed/22666567**

Design	Prospective study comparing HFNC 60 l/min, HFNC40 l/min, and Venturi mask 40l/min
Patients	45 patients undergoing bronchoscopy and BAL
Objectives	To determine the effects of high-flow devices on gas exchange and cardiovascular variables in patients undergoing bronchoscopy and BAL
Main Results	At the end of bronchoscopy, HFNC60 presented higher PaO2, PaO2/FiO2, and SpO2 than-Venturi 40 and HFNC40 that did not differ between them. Nasal cannula associated with a 60 l/min flow produced the better results.
Conclusion	Under a flow rate of 40 l/min both the Venturi mask and HFNC behaved similarly, but nasal cannula associated with a 60 l/min flow produced the better results, thus indicating its use in mild respiratory dysfunctions

Discomfort associated with underhumidified high-flow oxygen therapy in critically ill patients

Chanques G, Constantin JM, Sauter M, Jung B, Sebbane M, Verzilli D, Lefrant JY, Jaber S.
Intensive Care Med. 2009 Jun;35(6):996-1003
PMID 19294365, **http://www.ncbi.nlm.nih.gov/pubmed/19294365**

Design	Randomized crossover study
Patients	30 ICU patients, during 3 days
Objectives	Compare discomfort in nonintubated patients under high-flow oxygen therapy humidified with bubble (BH) to heated humidifiers (HH)
Main Results	The median intensities of both mouth and throat dryness were significantly lower with the heated humidifiers than with those humidified with bubble [7.8 (5.0-9.4) vs. 5.0 (3.1-7.0), p = 0.001 and 5.8 (2.3-8.5) vs. 4.3 (2.0-5.0), p = 0.005, respectively].
Conclusion	The use of a heated-humidifier in patients with high-flow oxygen therapy is associated with a decrease of dryness symptoms, compared to a bubble humidifier

Use of High-Flow Nasal Cannula for Acute Dyspnea and Hypoxemia in the Emergency Department

Rittayamai N, Tscheikuna J, Praphruetkit N, Kijpinyochai S.
Respir Care 2015;60(10):1377–1382.
PMID 26060321, **http://www.ncbi.nlm.nih.gov/pubmed/26060321**

Design	Prospective randomized comparative study
Patients	40 patients with acute dyspnea and hypoxemia in the emergency room
Objectives	Investigated the physiologic effects of high-flow nasal oxygen cannula (HFNC) compared with conventional oxygen therapy (COT) in subjects with acute dyspnea and hypoxemia in the emergency room
Main Results	HFNC significantly improved dyspnea (2.0 ±1.8 vs 3.8 ±2.3, p = .01) and subject comfort (1.6 ±1.7 vs 3.7 ± 2.4, p = .01) compared with COT.
Conclusion	HFNC improved dyspnea and comfort in subjects presenting with acute dyspnea and hypoxemia in the emergency department

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