

High flow nasal cannula therapy bibliography

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Table of Contents

1	Effect of postextubation noninvasive ventilation with active humidification vs high-flow nasal cannula on reintubation in patients at very high risk for extubation failure: a randomized trial.....	6
2	Closed-loop oxygen control improves oxygen therapy in acute hypoxemic respiratory failure patients under high flow nasal oxygen: a randomized cross-over study (the HILOOP study)	7
3	Non-invasive ventilation versus high-flow nasal oxygen for postextubation respiratory failure in ICU: a post-hoc analysis of a randomized clinical trial	8
4	Retrospective analysis of high flow nasal therapy in COVID-19-related moderate-to-severe hypoxaemic respiratory failure	9
5	Effects of High-Flow Nasal Cannula on the Work of Breathing in Patients Recovering from Acute Respiratory Failure	10
6	High-Flow Nasal Cannula Therapy Versus Intermittent Noninvasive Ventilation in Obese Subjects after Cardiothoracic Surgery	11
7	Effect of non-invasive oxygenation strategies in immunocompromised patients with severe acute respiratory failure: a post-hoc analysis of a randomised trial.....	12
8	High-Flow Nasal Oxygen vs Noninvasive Positive Airway Pressure in hypoxemic patients after cardiothoracic surgery: A Randomized Clinical Trial	14
9	High-flow oxygen through nasal cannula in acute hypoxemic respiratory failure	15
10	FLORALI-IM study group and the REVA Research Network. High-flow nasal oxygen alone or alternating with non-invasive ventilation in critically ill immunocompromised patients with acute respiratory failure: a randomised controlled trial	16
11	Respiratory Drive in Patients with Sepsis and Septic Shock: Modulation by High-flow Nasal Cannula ..	17
12	High-Flow Nasal Cannula Therapy in COVID-19: Using the ROX Index to Predict Success	18
13	High-flow nasal oxygen in patients with COVID-19-associated acute respiratory failure	19
14	High-Flow Nasal Oxygen in Coronavirus Disease 2019 Patients With Acute Hypoxemic Respiratory Failure: A Multicenter, Retrospective Cohort Study	20
15	High-flow nasal cannula oxygen therapy versus non-invasive ventilation for chronic obstructive pulmonary disease patients after extubation: a multicenter, randomized controlled trial	21
16	Non-invasive ventilation versus high-flow nasal cannula oxygen therapy with apnoeic oxygenation for preoxygenation before intubation of patients with acute hypoxaemic respiratory failure: a randomised, multicentre, open-label trial	22
17	The effect of high-flow nasal oxygen on hospital length of stay in cardiac surgical patients at high risk for respiratory complications: a randomised controlled trial	23
18	Effect of High-Flow Nasal Oxygen vs Standard Oxygen on 28-Day Mortality in Immunocompromised Patients with Acute Respiratory Failure: The HIGH Randomized Clinical Trial	23

19	Effect of Postextubation High-Flow Nasal Cannula vs Noninvasive Ventilation on Reintubation and Postextubation Respiratory Failure in High-Risk Patients: A Randomized Clinical Trial	24
20	Effect of postextubation high-flow nasal cannula vs. conventional oxygen therapy on reintubation in low-risk patients: a randomized clinical trial	25
21	Use of high-flow nasal cannula oxygen therapy to prevent desaturation during tracheal intubation of intensive care patients with mild-to-moderate hypoxemia.....	25
22	Nasal high-flow versus Venturi mask oxygen therapy after extubation. Effects on oxygenation, comfort, and clinical outcome.	26
23	High-flow nasal cannula failure in critically ill cancer patients with acute respiratory failure: Moving from avoiding intubation to avoiding delayed intubation	27
24	High-flow nasal cannula for Acute Respiratory Distress Syndrome (ARDS) due to COVID-19	28
25	High-flow nasal oxygen reduces endotracheal intubation: a randomized clinical trial	29
26	High-flow nasal cannula oxygen therapy versus noninvasive ventilation in immunocompromised patients with acute respiratory failure: an observational cohort study	30
27	Effect of Very-High-Flow Nasal Therapy on Airway Pressure and End-Expiratory Lung Impedance in Healthy Volunteers	31
28	Efficacy of high-flow nasal cannula therapy in acute hypoxemic respiratory failure: decreased use of mechanical ventilation	32
29	Pressures delivered by nasal high flow oxygen during all phases of the respiratory cycle.....	33
30	Evaluation of a humidified nasal high-flow oxygen system, using oxygraphy, capnography and measurement of upper airway pressures.....	34
31	High-flow nasal oxygenation or standard oxygenation for gastrointestinal endoscopy with sedation in patients at risk of hypoxaemia: a multicentre randomised controlled trial (ODEPHI trial)	35
32	High-flow nasal cannula oxygen therapy decreases postextubation neuroventilatory drive and work of breathing in patients with chronic obstructive pulmonary disease.....	36
33	A randomised controlled trial comparing high-flow nasal oxygen with standard management for conscious sedation during bronchoscopy.....	36
34	Hypoxemic Patients With Bilateral Infiltrates Treated With High-Flow Nasal Cannula Present a Similar Pattern of Biomarkers of Inflammation and Injury to Acute Respiratory Distress Syndrome Patients.....	37
35	Physiologic Effects of High-Flow Nasal Cannula in Acute Hypoxemic Respiratory Failure.....	37
36	High-Flow Nasal Cannula Oxygenation in Immunocompromised Patients with Acute Hypoxemic Respiratory Failure: A Groupe de Recherche Respiratoire en Réanimation Onco-Hématologique Study	38

37	Predicting success of high-flow nasal cannula in pneumonia patients with hypoxemic respiratory failure: The utility of the ROX index	38
38	Physiologic Effects of High-Flow Nasal Cannula Oxygen in Critical Care Subjects	39
39	Comparison of the effectiveness of high flow nasal oxygen cannula vs. standard non-rebreather oxygen face mask in post-extubation intensive care unit patients.....	39
40	Effect of high-flow nasal cannula on thoraco-abdominal synchrony in adult critically ill patients	40
41	Effect of high-flow nasal cannula and body position on end-expiratory lung volume: a cohort study using electrical impedance tomography.....	40
42	High-flow nasal cannula therapy in do-not-intubate patients with hypoxemic respiratory distress	41
43	Humidified high flow nasal oxygen during respiratory failure in the emergency department: feasibility and efficacy.....	41
44	Impact of high-flow nasal cannula oxygen therapy on intensive care unit patients with acute respiratory failure: a prospective observational study.....	42
45	Oxygen delivery through high-flow nasal cannulae increased end-expiratory lung volume and reduce respiratory rate in post cardiac surgical patients.....	43
46	Beneficial effects of humidified high flow nasal oxygen in critical care patients: a prospective pilot study	44
47	A preliminary randomized controlled trial to assess effectiveness of nasal high-flow oxygen in intensive care patients.....	44
48	High-flow nasal oxygen vs high-flow face mask: a randomized crossover trial in extubated patients ...	45
49	High-flow nasal cannula oxygen during endotracheal intubation in hypoxemic patients: a randomized controlled clinical trial.....	46
50	High-flow nasal cannula versus conventional oxygen therapy after endotracheal extubation: a randomized crossover physiological study.....	48
51	High-flow nasal cannula oxygen therapy to treat acute respiratory failure in patients with acute exacerbation of idiopathic pulmonary fibrosis.....	49
52	Nasal high-flow oxygen therapy in ICU: A before-and-after study	50
53	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.....	51
54	High-Flow Nasal Cannula in a Mixed Adult ICU	52
55	Failure of high-flow nasal cannula therapy may delay intubation and increase mortality.....	52

56	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)	53
57	Open-label, phase II study of routine high-flow nasal oxygen therapy in cardiac surgical patients.....	54
58	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.....	55
59	The effects of flow on airway pressure during nasal high-flow oxygen therapy	55
60	High-flow oxygen therapy in acute respiratory failure	56
	Additional files	57
61	High-flow nasal cannula reduces intubation rate in patients with COVID-19 with acute respiratory failure: a meta-analysis and systematic review	57
62	The effects of flow settings during high-flow nasal cannula support for adult subjects: a systematic review	58
63	ERS clinical practice guidelines: high-flow nasal cannula in acute respiratory failure	59
64	High-flow nasal cannulae for respiratory support in adult intensive care patients	60
65	Use of nasal high flow oxygen during acute respiratory failure.....	61
66	The role for high flow nasal cannula as a respiratory support strategy in adults: a clinical practice guideline	62
67	The effect of high-flow nasal oxygen therapy on postoperative pulmonary complications and hospital length of stay in postoperative patients: A Systematic Review and Meta-Analysis	63
68	Effect of high-flow nasal cannula oxygen therapy compared with conventional oxygen therapy in postoperative patients: a systematic review and meta-analysis.	63
69	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	64
70	High-Flow Nasal Cannula Oxygen Therapy in Adults: Physiological Benefits, Indication, Clinical Benefits, and Adverse Effects	64
71	Current evidence for the effectiveness of heated and humidified high flow nasal cannula supportive therapy in adult patients with respiratory failure	65
72	Use of high-flow nasal cannula oxygenation in ICU adults: a narrative review	65
73	The efficacy of high-flow nasal cannula (HFNC) versus non-invasive ventilation (NIV) in patients at high risk of extubation failure: a systematic review and meta-analysis.....	66

74	Effect of high-flow nasal cannula oxygen therapy vs conventional oxygen therapy on adult postcardiothoracic operation: A meta-analysis	67
75	High-Flow Nasal Cannula Oxygen in Adults: An Evidence-based Assessment	67
76	High-flow oxygen administration by nasal cannula for adult and perinatal patients.....	67
77	High-flow nasal interface improves oxygenation in patients undergoing bronchoscopy.....	68
78	Discomfort associated with underhumidified high-flow oxygen therapy in critically ill patients	68
79	Use of High-Flow Nasal Cannula for Acute Dyspnea and Hypoxemia in the Emergency Department ...	69

Effect of postextubation noninvasive ventilation with active humidification vs high-flow nasal cannula on reintubation in patients at very high risk for extubation failure: a randomized trial

Hernández G, Paredes I, Moran F, Buj M, Colinas L, Rodríguez ML, Velasco A, Rodríguez P, Pérez-Pedrero MJ, Suarez-Sipmann F, Canabal A, Cuenca R, Blanch L, Roca O.

Intensive Care Med. 2022 Dec;48(12):1751-1759

PMID 36400984, <http://www.ncbi.nlm.nih.gov/pubmed/36400984>

Design	Randomized controlled trial in two intensive care units
Patients	182 patients ready for planned extubation with ≥ 4 of the following risk factors for reintubation were included: age > 65 years, II score > 12 on extubation day, BMI > 30, inadequate secretions management, difficult or prolonged weaning, ≥ 2 comorbidities, acute heart failure indicating mechanical ventilation, moderate-to-severe chronic obstructive pulmonary disease, airway patency problems, prolonged mechanical ventilation, or hypercapnia on finishing the spontaneous breathing trial
Objectives	Determine whether 48 hours of noninvasive ventilation (NIV) with active humidification is superior to high flow nasal cannula (HFNC) in preventing reintubation in patients with ≥ 4 risk factors (very high risk for extubation failure)
Main Results	92 received NIV and 90 HFNC. Reintubation was required in 21 (23.3%) patients receiving NIV vs 35 (38.8%) of those receiving HFNC (difference -15.5%; 95% CI -28.3 to -1%). Hospital length of stay was lower in those patients treated with NIV (20 [12-6.7] days vs 26.5 [15-45] days in those receiving HFNC, difference 6.5 [95%CI 0.5-21.1]).
Conclusion	Among adult critically ill patients at very high risk of extubation failure, NIV with active humidification was superior to HFNC for preventing reintubation

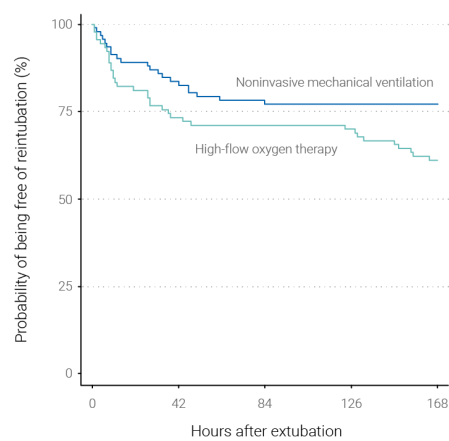


Figure 1: Kaplan-Meier curve of time between extubation and reintubation

Number at risk	
Noninvasive mechanical ventilation	92 77 72 71 71
High-flow oxygen therapy	90 66 64 63 55

Closed-loop oxygen control improves oxygen therapy in acute hypoxemic respiratory failure patients under high flow nasal oxygen: a randomized cross-over study (the HILOOP study)

Roca O, Caritg O, Santafé M, Ramos FJ, Pacheco A, García-de-Acilu M, Ferrer R, Schultz MJ, Ricard JD

Crit Care. 2022 Apr14;26(1):108

PMID 35422002, <http://www.ncbi.nlm.nih.gov/pubmed/35422002>

Design	Single-center, single-blinded, randomized crossover study
Patients	45 patients with moderate-to-severe acute hypoxemic respiratory failure (AHRF) and treated with high flow nasal oxygen (HFNO) were randomly assigned to start with either a 4-hour period of closed-loop oxygen control or a 4-hour period of manual oxygen titration, after which each patient was switched to the alternate therapy
Objectives	Assess the efficacy of closed-loop oxygen control in critically ill patients with moderate-to-severe AHRF treated with HFNO
Main Results	Patients spent more time in the optimal SpO2 range with closed-loop oxygen control than with manual titrations of oxygen ($p < 0.0001$). Patients spent less time in the suboptimal range during closed-loop oxygen control, both above and below the cutoffs of the optimal SpO2 range, and less time above the suboptimal range. A lower number of manual adjustments per hour was needed with closed-loop oxygen control. The number of events of SpO2 $< 88\%$ and $< 85\%$ was not significantly different between groups.
Conclusion	Closed-loop oxygen control improves oxygen administration in patients with moderate-to-severe AHRF treated with HFNO, increasing the percentage of time in the optimal oxygenation range and decreasing the workload of healthcare personnel

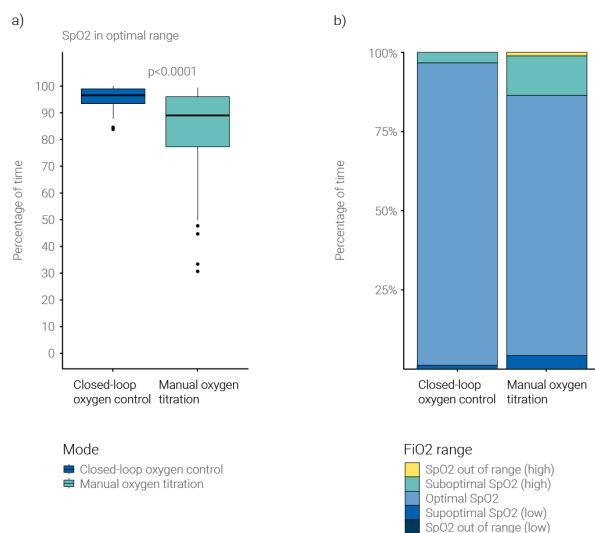


Figure 2: Comparison of SpO2 values between closed-loop oxygen control and manual oxygen titration. A: Percentage of time in the optimal range. B: Percentage of time spent in optimal and suboptimal ranges, and out of range. The height of each bar in B represents the mean of the values

Non-invasive ventilation versus high-flow nasal oxygen for postextubation respiratory failure in ICU: a post-hoc analysis of a randomized clinical trial

Thille AW, Monseau G, Coudroy R, Nay MA, Gacouin A, Decavèle M, Sonnevile R, Beloncle F, Girault C, Dangers L, Lautrette A, Levrat Q, Rouzé A, Vivier E, Lascarrou JB, Ricard JD, Razazi K, Barberet G, Lebert C, Ehrmann S, Massri A, Bourenne J, Pradel G, Bailly P, Terzi N, Dellamonica J, Lacave G, Robert R, Ragot S, Frat JP; HIGH-WEAN Study Group and the REVA research network

Crit Care. 2021 Jun 28;25(1):221

PMID 34183053, <http://www.ncbi.nlm.nih.gov/pubmed/34183053>

Design	Post-hoc analysis of a multicenter, randomized, controlled trial
Patients	146 patients who experienced post-extubation respiratory failure within the 7 days following extubation
Objectives	Compare mortality between patients treated with noninvasive ventilation (NIV) alternating with high flow nasal cannula (HFNC) or HFNC alone
Main Results	Mortality at day 28 was 18% (15/84) using NIV alternating with high-flow nasal oxygen and 29% (18/62) with HFNC alone ($p = 0.12$). Among the 46 patients with hypercapnia at the onset of respiratory failure, mortality at day 28 was 3% (1/33) with NIV and 31% (4/13) with HFNC alone ($p = 0.006$). The proportion of patients reintubated 48 h after the onset of post-extubation respiratory failure was 44% (37/84) with NIV and 52% (32/62) with HFNC alone ($p = 0.21$).
Conclusion	In patients with post-extubation respiratory failure, NIV alternating with HFNC may not increase the risk of death

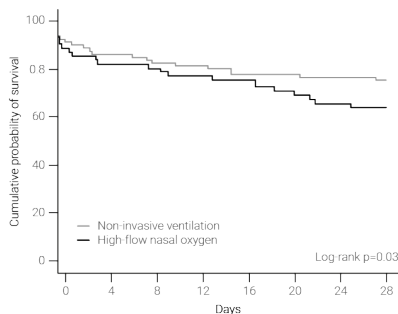


Figure 3: Mortality at day 28 did not differ between NIV/HFNC and HFNC alone

Number at risk	
Non-invasive ventilation	62 55 54 52 51 48 45 44
High flow nasal oxygen	84 78 75 74 71 71 70 69

Figure 1 Kaplan-Meier analysis of time from the onset of post-extubation respiratory failure to death according to oxygenation strategy. Mortality rates at 28 did not significantly differ between patients treated with high-flow oxygen alone (black line) and those treated with non-invasive ventilation (gray line). Mortality at day 28 was 18% (15 out of 84 patients) with NIV and 29% (18 out of 62 patients) with high-flow nasal oxygen (difference: -11% [95% CI, -25 to 2], $p=0.12$ using log-rank test)

Retrospective analysis of high flow nasal therapy in COVID-19-related moderate-to-severe hypoxaemic respiratory failure

Patel M, Gangemi A, Marron R, Chowdhury J, Yousef I, Zheng M, Mills N, Tragesser L, Giurintano J, Gupta R, Gordon M, Rali P, D'Alonso G, Fleece D, Zhao H, Patlakh N, Criner G

BMJ Open Respir Res. 2020 Aug;7(1):e000650

PMID 32847947, <http://www.ncbi.nlm.nih.gov/pubmed/32847947>

Design	Retrospective analysis
Patients	104 patients with moderate-to-severe respiratory failure treated with high flow nasal cannula (HFNC)
Objectives	To assess if the treatment with HFNC was able to prevent the necessity for endotracheal intubation
Main Results	67 of 104 (64.42%) were able to avoid invasive mechanical ventilation. Incidence of hospital-associated/ventilator-associated pneumonia was 2.9%. Overall, mortality was 14.44% (n=15) with 13 (34.4%) in the progressed-to-intubation group and 2 (2.9%) in the non-intubation group. Mortality and incidence of pneumonia was statistically higher in the progressed-to-intubation group.
Conclusion	HFNC use is associated with a reduction in the rate of invasive mechanical ventilation and overall mortality in patients with COVID-19

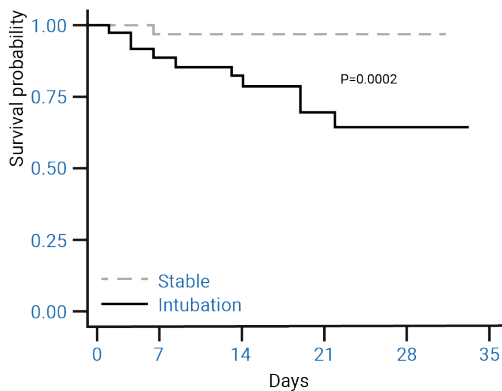


Figure 4: The figure shows better survival for the non-intubation group compared with the intubation group

Figure 4 Kaplan-Meier estimate of survival of high flow nasal therapy (HFNT) patients, comparing intubation with non-intubation (continued HFNT) groups.

Effects of High-Flow Nasal Cannula on the Work of Breathing in Patients Recovering from Acute Respiratory Failure

Delorme M, Bouchard PA, Simon M, Simard S, Lellouche F

Crit Care Med. 2017 Dec;45(12):1981-1988

PMID 28857852, <http://www.ncbi.nlm.nih.gov/pubmed/28857852>

Design	Randomized controlled crossover study: conventional oxygen therapy and HFNC at 20, 40, and 60 l/min
Patients	12 patients with moderate respiratory distress
Objectives	Assess the effects of HFNC on indexes of respiratory effort
Main Results	Esophageal pressure variations, esophageal pressure-time product/min, and work of breathing decreased from baseline (conventional oxygen therapy) up to 60 l/min, lung compliance increased, and inspiratory resistance decreased from baseline up to 60 l/min.
Conclusion	HFNC set at 60 l/min reduced the indexes of respiratory effort in patients recovering from acute respiratory failure. This effect is associated with an improvement in respiratory mechanics

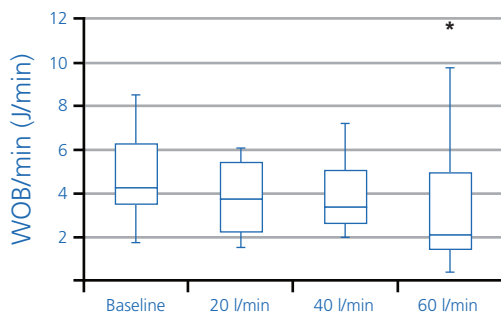


Figure 5: HFNC set at 60 l/min decreased WOB in comparison to standard oxygen

High-Flow Nasal Cannula Therapy Versus Intermittent Noninvasive Ventilation in Obese Subjects after Cardiothoracic Surgery

Stéphan F, Bérard L, Rézaiguia-Delclaux S, Amaru P; for the BiPOP Study Group

Respir Care. 2017 Sep;62(9):1193-1202

PMID 28807988, <http://www.ncbi.nlm.nih.gov/pubmed/28807988>

Design	Post-hoc analysis of a randomized, controlled trial
Patients	136 patients with NIV and 135 patients with HFNC
Objectives	Compare NIV and HFNC for preventing or resolving acute respiratory failure after cardiothoracic surgery in obese patients
Main Results	No differences were found for treatment failure (re-intubation, switch to the other treatment, or premature discontinuation), dyspnea and comfort scores. Skin breakdown was more common with NIV after 24 h. No differences for ICU mortality.
Conclusion	Among obese cardiothoracic surgery subjects, the use of HFNC compared to NIV did not result in a worse rate of treatment failure. As HFNC presents some advantages, it may be used instead of NIV in these patients

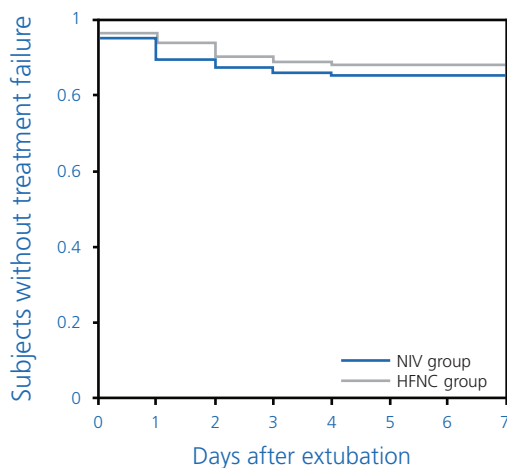


Figure 6: HFNC did not increase the number of treatment failures in comparison to NIV

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 Aug;4(8):646-652

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.

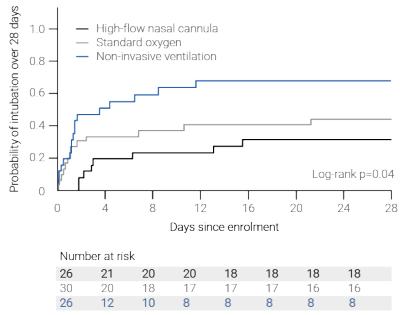
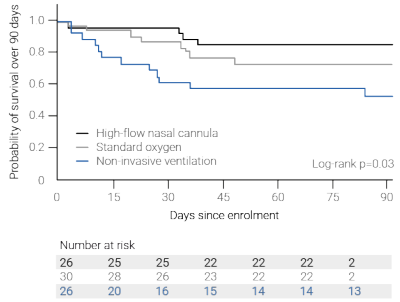


Figure 7: NIV increased intubation rate and decreased survival rate compared with HFNC



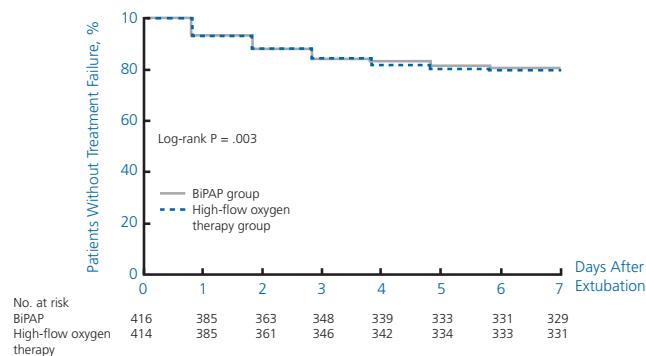
High-Flow Nasal Oxygen vs Noninvasive Positive Airway Pressure in hypoxemic patients after cardiothoracic surgery: A Randomized Clinical Trial

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 cmH ₂ O; PEEP = 4 cmH ₂ O)
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 91 of 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



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, Cottreau 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

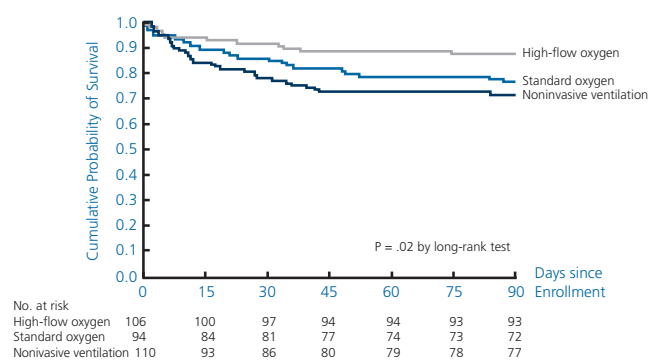
Patients 310 patients with acute hypoxemic respiratory failure without hypercapnia

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 $\text{PaO}_2:\text{FiO}_2$ 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.



FLORALI-IM study group and the REVA Research Network. High-flow nasal oxygen alone or alternating with non-invasive ventilation in critically ill immunocompromised patients with acute respiratory failure: a randomised controlled trial

Coudroy R, Frat JP, Ehrmann S, Pène F, Decavèle M, Terzi N, Prat G, Garret C, Contou D, Gacouin A, Bourenne J, Girault C, Vinsonneau C, Dellamonica J, Labro G, Jochmans S, Herbland A, Quenot JP, Devaquet J, Benzekri D, Vivier E, Nseir S, Colin G, Thevenin D, Grasselli G, Bougon D, Assefi M, Guérin C, Lherm T, Kouatchet A, Ragot S, Thille AW

Lancet Respir Med. 2022 Jul;10(7):641-649

PMID 35325620, <http://www.ncbi.nlm.nih.gov/pubmed/35325620>

Design	Multicenter, open-label, randomized clinical trial conducted in 29 ICUs
Patients	299 immunocompromised patients with acute respiratory failure, defined as RR \geq 25 breaths/min and P/F ratio \leq 300 mmHg. In the high flow nasal oxygen (HFNO) alone group, patients were continuously treated by HFNO with a gas flow rate of 60 l/min or the highest rate tolerated. In the noninvasive ventilation (NIV) group, patients were treated with NIV with a first session of at least 4 hours and then with sessions for a minimal duration of 12 hours a day; NIV sessions were interspaced with HFNO delivered as in the HFNO-alone group
Objectives	Determine whether HFNO alone could reduce the rate of mortality at day 28 compared with HFNO alternated with NIV
Main Results	154 assigned to the HFNO alone group and 145 assigned to NIV group. The mortality rate at day 28 was 56/154 (36%) in the HFNO alone group and 51/145 (35%) in the NIV group.
Conclusion	In critically ill immunocompromised patients with acute respiratory failure, the mortality rate did not differ between HFNO alone and NIV alternating with HFNO

Respiratory Drive in Patients with Sepsis and Septic Shock: Modulation by High-flow Nasal Cannula

Mauri T, Spinelli E, Pavlovsky B, Grieco DL, Ottaviani I, Basile MC, Dalla Corte F, Pintaudi G, Garofalo E, Rundo A, Volta CA, Pesenti A, Spadaro S.

2021 Dec 1;135(6):1066-1075. *Anesthesiology*. 2021;135(6):1066-1075

PMID 34644374, <http://www.ncbi.nlm.nih.gov/pubmed/34644374>

Design	Observational study
Patients	25 nonintubated patients with extrapulmonary sepsis or septic shock were enrolled. Each patient underwent three consecutive steps: low-flow oxygen at baseline, high-flow nasal cannula (HFNC), and then low-flow oxygen again
Objectives	Determine whether respiratory drive and effort may be increased in septic patients and correlated with extrapulmonary determinant, and whether HFNC may modulate drive and effort
Main Results	13 patients (52%) were in septic shock. During low-flow oxygen at baseline, respiratory drive and effort were elevated and correlated significantly with arterial lactate ($r = 0.46$, $p = 0.034$) and inversely with dynamic lung compliance ($r = -0.735$, $p < 0.001$). Respiratory effort assessed by ΔP_{es} and was elevated during low-flow oxygen baseline and low-flow oxygen end phases, and decreased significantly during the HFNC phase when compared with both low-flow oxygen steps (ANOVA $p < 0.001$). Support from HFNC was also associated with a decrease in respiratory drive: all three variables that were measured as a surrogate of central drive ($P_{0.5}$, $\Delta P_{es}/\Delta t$, and VT/Ti) fell significantly during HFNC. Oxygenation and arterial carbon dioxide levels remained stable during all study phases.
Conclusion	Patients with sepsis and septic shock of extrapulmonary origin present elevated respiratory drive and effort, which can be effectively reduced by HFNC

High-Flow Nasal Cannula Therapy in COVID-19: Using the ROX Index to Predict Success

Chandel A, Patolia S, Brown AW, Collins AC, Sahjwani D, Khangoora V, Cameron PC, Desai M, Kasarabada A, Kilcullen JK, Nathan SD, King CS

Respir Care. 2021 Jun;66(6):909-919

PMID 33328179, <http://www.ncbi.nlm.nih.gov/pubmed/33328179>

Design	Multicenter, retrospective, observational cohort study
Patients	272 patients with respiratory failure due to COVID-19 managed with HFNC
Objectives	To assess if the ROX index was able to predict HFNC success.
Main Results	164 (60.3%) were successfully weaned from HFNC. ROX index > 3.0 at 2, 6, and 12 hours after initiation of HFNC was 85.3% sensitive for identifying subsequent HFNC success. 108 subjects were intubated for failure of HFNC (61 early failures ≤ 48 h and 47 late failures). Mortality after HFNC failure was high (45.4%). There was no statistical difference in hospital mortality (39.3% vs 53.2%, P = 0.18) or any of the secondary end-points, including time-specific mortality, need for extracorporeal membrane oxygenation, and ICU length of stay, between early and late HFNC failure groups.
Conclusion	HFNC was a viable strategy and mechanical ventilation was unnecessary in the majority of subjects. In the minority that progressed to mechanical ventilation, duration of HFNC did not differentiate subjects with worse clinical outcomes. The ROX index was sensitive for the identification of subjects successfully weaned from HFNC

High-flow nasal oxygen in patients with COVID-19-associated acute respiratory failure

Mellado-Artigas R, Ferreyro BL, Angriman F, Hernández-Sanz M, Arruti E, Torres A, Villar J, Brochard L, Ferrando C; COVID-19 Spanish ICU Network

Crit Care. 2021 Feb 11;25(1):58

PMID 33573680, <http://www.ncbi.nlm.nih.gov/pubmed/33573680>

Design	Multicenter cohort study using a prospective collected database
Patients	122 patients with COVID-19 associated acute respiratory failure admitted to 36 Spanish and Andorran intensive care units (ICUs)
Objectives	Assess the effect of HFNC on ventilator-free days at 28 days compared to early initiation of invasive mechanical ventilation. ICU length of stay and all-cause in-hospital mortality served as secondary outcomes
Main Results	When compared to early intubation, the use of HFNC was associated with an increase in ventilator-free days (mean difference: 8.0 days) and a reduction in ICU length of stay (mean difference: - 8.2 days). No difference was observed in all-cause in-hospital mortality between groups.
Conclusion	The use of HFNC upon patients with COVID-19 related acute hypoxemic respiratory failure may lead to an increase in ventilator-free days and a reduction in ICU length of stay, when compared to early initiation of invasive mechanical ventilation.

High-Flow Nasal Oxygen in Coronavirus Disease 2019 Patients With Acute Hypoxemic Respiratory Failure: A Multicenter, Retrospective Cohort Study

Xia J, Zhang Y, Ni L, Chen L, Zhou C, Gao C, Wu X, Duan J, Xie J, Guo Q, Zhao J, Hu Y, Cheng Z, Zhan Q

Crit Care Med. 2020 Nov;48(11):e1079-e1086

PMID 32826432, <http://www.ncbi.nlm.nih.gov/pubmed/32826432>

Design	Multicenter, retrospective cohort study
Patients	43 confirmed Covid-19 patients with acute hypoxemic respiratory failure treated with high flow nasal cannula (HFNC)
Objectives	Analyze the effectiveness of HFNC and identify the variables predicting HFNC failure in Covid-19 patients with acute hypoxemic respiratory failure
Main Results	HFNC failure (defined as upgrading respiratory support to positive pressure ventilation or death) was observed in 20 patients (46.5%), of which 13 (30.2%) required intubation. Patients with HFNC success had a higher oxygen saturation (96.0% vs 93.0%; $p < 0.001$) at admission than those with HFNC failure. HFNC failure was more likely in patients who were older ($p = 0.030$) and male ($p = 0.037$), had a significant increase in respiratory rate and a significant decrease in the ratio of oxygen saturation/FIO ₂ to respiratory rate index within three days of HFNC treatment. In a multivariate logistic regression analysis model, male and lower oxygen saturation at admission remained independent predictors of HFNC failure. The hospital mortality rate of the cohort was 32.5%; however, the hospital mortality rate in patients with HFNC failure was 65%.
Conclusion	HFNC may be effective for treating Covid-19 patients with mild-to-moderate acute hypoxemic respiratory failure. However, HFNC failure was associated with a poor prognosis. Male and lower oxygenation at admission were the two strong predictors of HFNC failure

High-flow nasal cannula oxygen therapy versus non-invasive ventilation for chronic obstructive pulmonary disease patients after extubation: a multicenter, randomized controlled trial

Tan D, Walline JH, Ling B, Xu Y, Sun J, Wang B, Shan X, Wang Y, Cao P, Zhu Q, Geng P, Xu J

Crit Care. 2020 Aug 6;24(1):489

PMID 32762701, <http://www.ncbi.nlm.nih.gov/pubmed/32762701>

Design	Multicenter, randomized controlled trial high flow nasal cannula (HFNC) versus non-invasive ventilaton (NIV) at extubation
Patients	86 COPD patients with hypercapnic respiratory failure who were already receiving invasive ventilation
Objectives	Test whether HFNC is non-inferior to NIV in preventing post-extubation treatment failure in COPD patients previously intubated for hypercapnic respiratory failure
Main Results	The treatment failure rate, defined as either resumption of invasive ventilation or switching to the other study treatment modality (NIV for patients in the HFNC group or vice versa), was 22.7% in the HFNC group and 28.6% in the NIV group (risk difference of -5.8%), which was significantly lower than the non-inferior margin of 9%. Analysis of the causes of treatment failure showed that treatment intolerance in the HFNC group was significantly lower than that in the NIV group, with a risk difference of -50.0%. The average number of daily airway care interventions in the NIV group was 7 (5–9.3), which was significantly higher than 6 (4–7) times in the HFNC group ($p = 0.006$). The comfort score and incidence of nasal and facial skin breakdown of the HFNC group was significantly better than that of the NIV group.
Conclusion	Among COPD patients with severe hypercapnic respiratory failure who received invasive ventilation, the use of HFNC after extubation did not result in increased rates of treatment failure compared with NIV. HFNC had better tolerance and comfort than NIV

Non-invasive ventilation versus high-flow nasal cannula oxygen therapy with apnoeic oxygenation for preoxygenation before intubation of patients with acute hypoxaemic respiratory failure: a randomised, multicentre, open-label trial

Frat JP, Ricard JD, Quenot JP, Pichon N, Demoule A, Forel JM, Mira JP, Coudroy R, Berquier G, Voisin B, Colin G, Pons B, Danin PE, Devaquet J, Prat G, Clere-Jehl R, Petitpas F, Vivier E, Razazi K, Nay MA, Souday V, Dellamonica J, Argaud L, Ehrmann S, Gibelin A, Girault C, Andreu P, Vignon P, Dangers L, Ragot S, Thille AW; FLORALI-2 study group; REVA network

Lancet Respir Med. 2019 Apr;7(4):303-312

PMID 30898520, <http://www.ncbi.nlm.nih.gov/pubmed/30898520>

Design	Multicenter, open-label trial carried out in 28 intensive care units in France
Patients	313 patients during intubation
Objectives	Determine whether preoxygenation with NIV was more efficient than HFNC in reducing the risk of severe hypoxemia during intubation
Main Results	Severe hypoxemia occurred in 33 (23%) of 142 patients after preoxygenation with NIV and 47 (27%) of 171 with HFNC. In the 242 patients with moderate-to-severe hypoxaemia (PaO ₂ /FiO ₂ ≤200 mmHg), severe hypoxemia occurred less frequently after preoxygenation with NIV than with HFNC. Serious adverse events did not differ between groups (systolic arterial hypotension, death at day 28, and ventilator-associated pneumonia).
Conclusion	In patients with acute hypoxaemic respiratory failure, preoxygenation with NIV or HFNC did not change the risk of severe hypoxemia, except in the most severe patients where hypoxemia occurred less frequently with NIV

The effect of high-flow nasal oxygen on hospital length of stay in cardiac surgical patients at high risk for respiratory complications: a randomised controlled trial

Zochios V, Collier T, Blaudszun G, Butchart A, Earwaker M, Jones N, Klein AA

Anaesthesia. 2018 Dec;73(12):1478-1488

PMID 30019747, <http://www.ncbi.nlm.nih.gov/pubmed/30019747>

Design	Randomized controlled trial
Patients	100 adult patients with pre-existing respiratory disease undergoing elective cardiac surgery
Objectives	Compare HFNC and standard oxygen therapy after cardiac surgery
Main Results	The hospital length of stay was 7 (6-9) d in the HFNC group and 9 (7-16) d in the standard oxygen group ($p=0.012$). HFNC was associated with fewer intensive care unit re-admissions (1/49 vs. 7/45; $p = 0.026$).
Conclusion	After cardiac surgery, HFNC reduced the length of stay

Effect of High-Flow Nasal Oxygen vs Standard Oxygen on 28-Day Mortality in Immunocompromised Patients with Acute Respiratory Failure: The HIGH Randomized Clinical Trial

Azoulay E, Lemiale V, Mokart D, Nseir S, Argaud L, Pène F, Kontar L, Bruneel F, Klouche K, Barbier F, Reignier J, Berrahil-Meksen L, Louis G, Constantin JM, Mayaux J, Wallet F, Kouatchet A, Peigne V, Théodose I, Perez P, Girault C, Jaber S, Oziel J, Nyunga M, Terzi N, Bouadma L, Lebert C, Lautrette A, Bigé N, Raphalen JH, Papazian L, Darmon M, Chevret S, Demoule A

JAMA. 2018 Nov 27;320(20):2099-2107

PMID 30357270, <http://www.ncbi.nlm.nih.gov/pubmed/30357270>

Design	Multicenter randomized controlled trial
Patients	776 adult immunocompromised patients with acute hypoxemic respiratory failure (AHRF)
Objectives	Determine whether HFNC decreases mortality among immunocompromised patients with AHRF in comparison to standard oxygen therapy
Main Results	Mortality on day 28 was not different between groups (35.6% vs 36.1%; $p = 0.94$). The intubation rate was not significantly different between groups (38.7% vs 43.8%). There was no difference in ICU length of stay (8 vs 6 d), ICU-acquired infections (10.0% vs 10.6%), hospital length of stay (24 vs 27 d) or patient comfort and dyspnea scores.
Conclusion	HFNC did not change outcomes in immunocompromised patients in comparison to standard oxygen

Effect of Postextubation High-Flow Nasal Cannula vs Noninvasive Ventilation on Reintubation and Postextubation Respiratory Failure in High-Risk Patients: A Randomized Clinical Trial

Hernández G, Vaquero C, Colinas L, Cuenca R, González P, Canabal A, Sanchez S, Rodriguez ML, Villasclaras A, Fernández R

JAMA. 2016 Oct 18;316(15):1565-1574

PMID 27706464, <http://www.ncbi.nlm.nih.gov/pubmed/27706464>

Design	Multicenter randomized controlled trial
Patients	604 patients with at least one of the following high-risk factors for reintubation: > 65 years; APACHE II > 12 points on extubation day, BMI > 30; inadequate secretions management; difficult or prolonged weaning; more than 1 comorbidity; heart failure as the primary indication for mechanical ventilation; moderate to severe COPD; airway patency problems; or prolonged mechanical ventilation. 314 patients received NIV and 290 HFNC
Objectives	Test if high-flow conditioned oxygen therapy is noninferior to NIV for preventing postextubation respiratory failure and reintubation
Main Results	There was no difference regarding the reintubation rate or median time to reintubation. Median postrandomization ICU length of stay was lower in the high-flow group. Adverse effects requiring withdrawal of the therapy were observed in none of patients in the high-flow group vs 42.9% patients in the NIV group ($P < .001$).
Conclusion	Among high-risk patients, HFNC was not inferior to NIV for preventing reintubation and postextubation respiratory failure
Comment	Noninferiority study

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, Cuenca 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 SpO ₂ during intubation were 94% (83-98.5) with the standard oxygen therapy versus 100% (95-100) with HFNC oxygen ($p < 0.0001$). SpO ₂ 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 trial: HFNC versus Venturi mask
Patients	105 hypoxemic patients
Objectives	Compare the effects of the Venturi mask and the NHFC on PaO ₂ /FiO ₂ after extubation
Main Results	PaO ₂ /FiO ₂ 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 failure in critically ill cancer patients with acute respiratory failure: Moving from avoiding intubation to avoiding delayed intubation

Saillard C, Lambert J, Tramier M, Chow-Chine L, Bisbal M, Servan L, Gonzalez F, de Guibert JM, Faucher M, Sannini A, Mokart D

PLoS One. 2022 Jun 29;17(6):e0270138

PMID 35767521, <http://www.ncbi.nlm.nih.gov/pubmed/35767521>

Design	Retrospective study from 2012–2016 in a cancer referral center
Patients	202 onco-hematology patients treated with high flow nasal cannula (HFNC)
Objectives	Assess prognostic factors associated with mortality in ICU cancer patients requiring mechanical ventilation (MV) after HFNC failure and identify predictive factors for intubation
Main Results	104 patients were treated successfully with HFNC and 98 required intubation. ICU and hospital mortality rates were 26.2% (n = 53) and 42.1% (n = 85) respectively, and 53.1% (n = 52) and 68.4% (n = 67) in patients requiring MV. A multivariate analysis identified 4 prognostic factors for hospital mortality after HFNC failure: complete/partial remission compared to patients with refractory/relapse disease, intubation after day 3, number of pulmonary quadrants involved on chest X-ray, and SAPSII at ICU admission. Predictive factors for intubation were the absence of sepsis, SpO2 < 95% 15 minutes after HFNC initiation, number of quadrants on X-ray, FiO2 > 60% at HFNC initiation, and SAPSII at ICU admission.
Conclusion	The duration of HFNC may be predictive of excess mortality in acute respiratory failure cancer patients. Early warning scores to predict HFNC failure are needed to identify patients who would benefit from early intubation

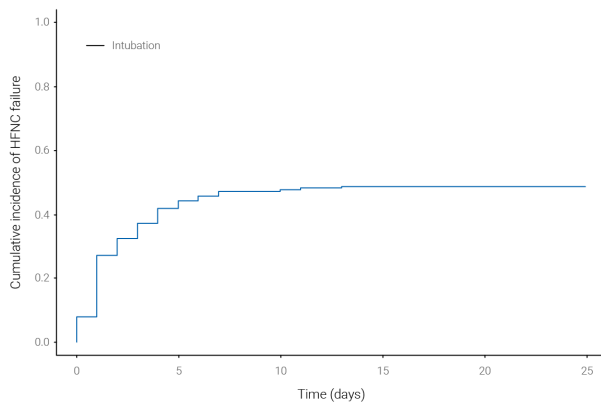


Figure 10: Kaplan Meier curve regarding intubation

Fig 3. Cumulative incidence of intubation in days.

High-flow nasal cannula for Acute Respiratory Distress Syndrome (ARDS) due to COVID-19

Panadero C, Abad-Fernández A, Rio-Ramirez MT, Acosta Gutierrez CM, Calderon-Alcala M, Lopez-Riolobos C, Matesanz-Lopez C, Garcia-Prieto F, Diaz-Garcia JM, Raboso-Moreno B, Vasquez-Gambasica Z, Andres-Ruzafa P, Garcia-Satue JL, Calero-Pardo S, Sagastizabal B, Bautista D, Campos A, González M, Grande L, Jimenez Fernandez M, Santiago-Ruiz JL, Caravaca Perez P, Alcaraz AJ

Multidiscip Respir Med. 2020 Sep 16;15(1):693

PMID 32983456, <http://www.ncbi.nlm.nih.gov/pubmed/32983456>

Design	Single-centre, retrospective observational study
Patients	40 patients with COVID-19 pneumonia were treated with high flow nasal cannula (HFNC)
Objectives	Describe the utility of HFNC as a therapy for the treatment of ARDS caused by SARS-CoV-2
Main Results	The intubation rate at day 30 was 52.5%, and overall mortality was 22.5%. After initiating HFNC, the SpO ₂ /FiO ₂ ratio was significantly better in the group that did not require intubation, as was the ROX index. A ROX index less than 4.94 measured 2 to 6 h after the start of therapy was associated with increased risk of intubation.
Conclusion	HFNC is a useful treatment in COVID-19 ARDS to avoid intubation or as a bridge therapy, and no increased mortality was observed secondary to the delay in intubation. After initiating HFNC, a ROX index below 4.94 predicts the need for intubation

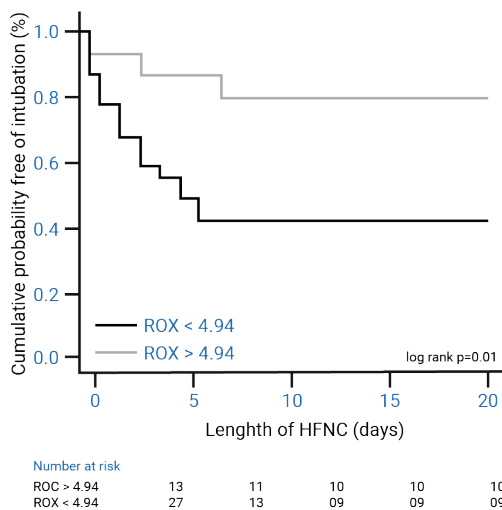


Figure 11: The figure shows the accumulated probability of remaining intubation-free in patients with HFNC, according to ROX index; a value less than 4.94 was associated with an increased risk of intubation

Figure 2 Kaplan-Meier curve showing the accumulated probability of remaining intubation-free in patients with high-flow nasal cannula according to ROX index.

High-flow nasal oxygen reduces endotracheal intubation: a randomized clinical trial

Andino R, Vega G, Pacheco SK, Arevalillo N, Leal A, Fernández L, Rodriguez MJ

Ther Adv Respir Dis. 2020 Jan-Dec;14:1753466620956459

PMID 32976085, <http://www.ncbi.nlm.nih.gov/pubmed/32976085>

Design	An open-label, controlled and single-center clinical trial
Patients	46 patients with acute hypoxemic respiratory failure
Objectives	Compare high flow nasal cannula (HFNC) therapy versus conventional oxygen therapy in the prevention of endotracheal intubation in patients with acute hypoxemic respiratory failure (AHRF)
Main Results	Intubation occurred significantly later in the HFNC group. Estimated PaO ₂ /FIO ₂ , respiratory rate, and dyspnea were significantly better in the HFNC group. Patients treated with HFNC who required intubation presented significant worsening after the first 8 h, as compared with non-intubated HFNC group patients. Mortality was 22% with no differences. The HFNC group patients were hospitalized for almost half of the time in the ICU and in the ward, with a significantly lower hospital length of stay. A total of 14 patients in the HFNC group (58%) complained of excessive heat and 17% of noise; three patients did not tolerate HFNC.
Conclusion	Patients with severe acute hypoxemic respiratory failure who tolerate HFNC present a significantly lower need for endotracheal intubation compared with conventional oxygen therapy

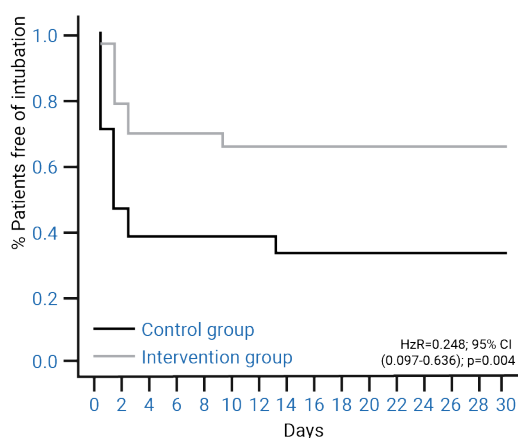


Figure 12: Intubation occurred later in the HFNC group and patients who tolerated HFNC presented a significantly lower need for endotracheal intubation compared with conventional oxygen therapy

Figure 2 Kaplan-Meier plot of patients free of endotracheal intubation.

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.

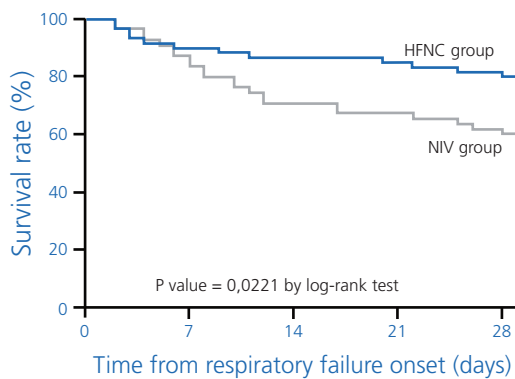


Figure 13: Survival was higher with HFNC alone than with NIV

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 cmH ₂ O. 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

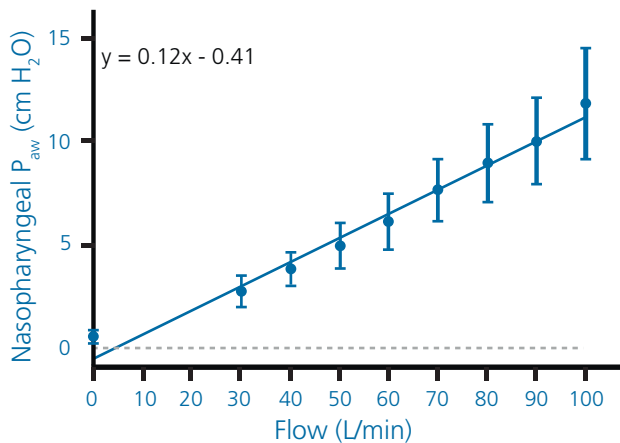


Figure 14: Airway pressure increased with flow

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

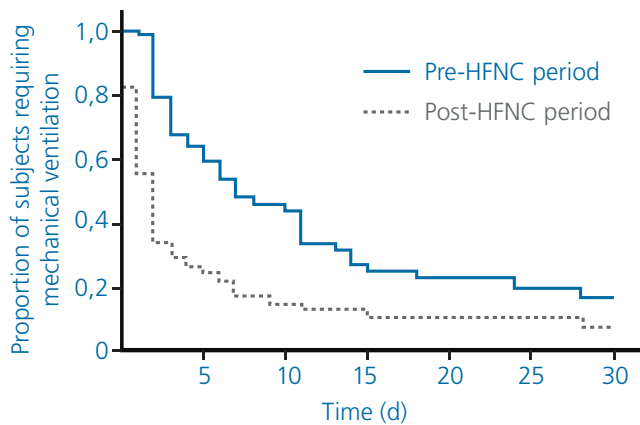


Figure 15: Mechanical ventilation before and after HFNC introduction

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 \pm 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

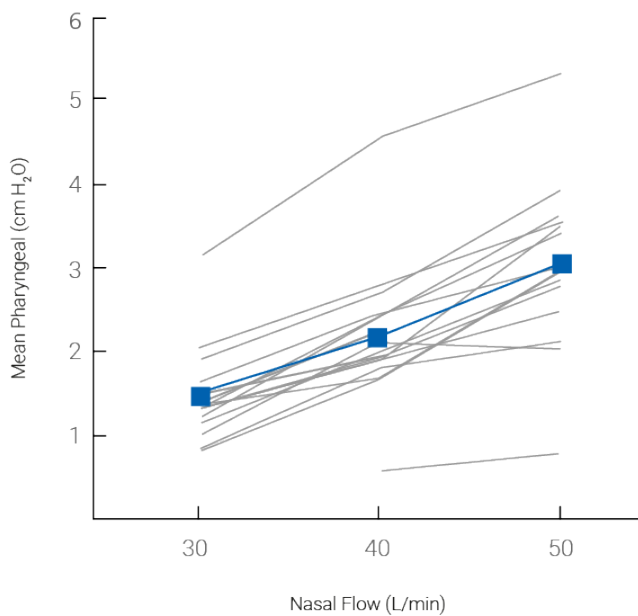


Figure 16: Increasing flow increased airway pressure

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 cmH2O.
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

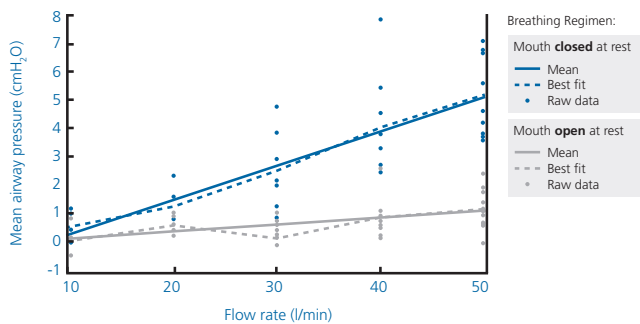


Figure 17: Paw increase with the flow rate when mouth is closed

High-flow nasal oxygenation or standard oxygenation for gastrointestinal endoscopy with sedation in patients at risk of hypoxaemia: a multicentre randomised controlled trial (ODEPHI trial)

Nay MA, Fromont L, Eugene A, Marcueyz JL, Mfam WS, Baert O, Remerand F, Ravry C, Auvet A, Boulain T

Br J Anaesth. 2021 Jul;127(1):133-142

PMID 33933271, <http://www.ncbi.nlm.nih.gov/pubmed/33933271>

Design	Multicenter, randomized controlled trial with blinded assessment of the primary outcome
Patients	379 patients at risk of hypoxemia (i.e., > 60 yrs old, or with underlying cardiac or respiratory disease, or with ASA physical status > 1, or with obesity or sleep apnea syndrome) undergoing gastrointestinal endoscopy
Objectives	Determine whether high flow nasal cannula (HFNC) (gas flow 70 L/min, inspired oxygen fraction 0.50) could reduce the incidence of decreased SpO ₂ ($\leq 92\%$ compared with standard oxygen delivered via nasal cannula or face mask (6 L/min) or nasopharyngeal tube (5 L/min) during gastrointestinal endoscopy under deep sedation
Main Results	A decrease in SpO ₂ $\leq 92\%$ occurred in 9.4% (18/191) for the HFNC group, and 33.5% (63/188) for the standard oxygen groups ($p < 0.001$). Prolonged desaturation (> 1 min) and maneuvers to maintain free upper airways were less frequent in the HFNC group than in the standard oxygen group (7.3% vs 14.9%, $P = 0.02$, and 11.1% vs 32.4%, $P < 0.001$).
Conclusion	In patients at risk of hypoxemia undergoing gastrointestinal endoscopy under deep sedation, use of HFNC significantly reduced the incidence of peripheral oxygen desaturation

High-flow nasal cannula oxygen therapy decreases postextubation neuroventilatory drive and work of breathing in patients with chronic obstructive pulmonary disease

Di Mussi R, Spadaro S, Stripoli T, Volta CA, Trerotoli P, Pierucci P, Staffieri F, Bruno F, Camporota L, Grasso S
Crit Care. 2018 Aug 2;22(1):180

PMID 30071876, <http://www.ncbi.nlm.nih.gov/pubmed/30071876>

Design	Single-center, unblinded, crossover study: 1 h of HFNC(1), then 1 h of conventional oxygen via a face mask, then 1 h of HFNC(2)
Patients	14 postextubation COPD patients who had received mechanical ventilation for hypercapnic respiratory failure
Objectives	Compare the effects of HFNC and conventional low-flow O ₂ therapy on the neuroventilatory drive and work of breathing
Main Results	EAdi peak and PTPDI/min increased with the transition from HFNC(1) to conventional oxygen, and then decreased during HFNC(2).
Conclusion	In patients with COPD, the application of HFNC after extubation decreased the neuroventilatory drive and work of breathing when compared with conventional oxygen

A randomised controlled trial comparing high-flow nasal oxygen with standard management for conscious sedation during bronchoscopy

Douglas N, Ng I, Nazeem F, Lee K, Mezzavia P, Krieser R, Steinfors D, Irving L, Segal R
Anaesthesia. 2018 Feb;73(2):169-176

PMID 29171661, <http://www.ncbi.nlm.nih.gov/pubmed/29171661>

Design	Parallel-group randomised controlled trial: HFNC at a flow rate of 30–70 l/min, compared with standard oxygen therapy at 10 l/min
Patients	60 adult patients; 30 in each group
Objectives	Compare oxygenation during conscious sedation for bronchoscopy
Main Results	Desaturation occurred in 4 out of 30 patients allocated to the HFNC group compared with 10 out of 30 allocated to the standard oxygenation group ($p = 0.047$ using a per-protocol analysis). Oxygen saturation after pre-oxygenation and the lowest oxygen saturation during the procedure were higher in the HFNC group.
Conclusion	HFNC may prevent desaturation during bronchoscopy

Hypoxemic Patients With Bilateral Infiltrates Treated With High-Flow Nasal Cannula Present a Similar Pattern of Biomarkers of Inflammation and Injury to Acute Respiratory Distress Syndrome Patients

García-de-Acilu M, Marin-Corral J, Vázquez A, Ruano L, Magret M, Ferrer R, Masclans JR, Roca O
Crit Care Med. 2017 Nov;45(11):1845-1853
PMID 28806218, <http://www.ncbi.nlm.nih.gov/pubmed/28806218>

Design	Prospective, multicenter study
Patients	170 patients with acute hypoxemia ($\text{PaO}_2/\text{FIO}_2 \leq 300$) and bilateral opacities, 127 intubated and 43 nonintubated patients
Objectives	Examine whether patients with acute hypoxemia and bilateral opacities treated with HFNC and ARDS patients mechanically ventilated are similar in terms of lung epithelial, endothelial, and inflammatory biomarkers
Main Results	No differences were observed in any of the biomarkers, nor in mortality or length of stay.
Conclusion	Patients treated with HFNC should be considered as ARDS patients

Physiologic Effects of High-Flow Nasal Cannula in Acute Hypoxemic Respiratory Failure

Mauri T, Turrini C, Eronia N, Grasselli G, Volta CA, Bellani G, Pesenti A
Am J Respir Crit Care Med. 2017 May 1;195(9):1207-1215
PMID 27997805, <http://www.ncbi.nlm.nih.gov/pubmed/27997805>

Design	Prospective randomized crossover study: HFNC set at 40 l/min compared with a standard, nonocclusive facial mask
Patients	15 nonintubated patients with acute hypoxemic respiratory failure (AHRF) ($\text{PaO}_2/\text{setFiO}_2 \leq 300$ mm Hg)
Objectives	Assess the effects of HFNC on gas exchange, inspiratory effort, minute ventilation, end-expiratory lung volume, dynamic compliance, and ventilation homogeneity in patients with acute hypoxemic respiratory failure
Main Results	HFNC improved oxygenation, lowered the respiratory rate, minute ventilation, ΔPes , and pressure time product, and increased end-expiratory lung volume in comparison to the facial mask. The tidal volume did not change, but the ratio of tidal volume to ΔPes (an estimate of lung compliance) increased; ventilation distribution was more homogeneous.
Conclusion	In patients with AHRF, HFNC exerts multiple beneficial physiologic effects, including less inspiratory effort, and improved lung volume and compliance

High-Flow Nasal Cannula Oxygenation in Immunocompromised Patients with Acute Hypoxemic Respiratory Failure: A Groupe de Recherche Respiratoire en Réanimation Onco-Hématologique Study

Lemiale V, Resche-Rigon M, Mokart D, Pène F, Argaud L, Mayaux J, Guitton C, Rabbat A, Girault C, Kouatchet A, Vincent F, Bruneel F, Nyunga M, Seguin A, Klouche K, Colin G, Kontar L, Perez P, Meert AP, Benoit DD, Papazian L, Demoule A, Chevret S, Azoulay E

Crit Care Med. 2017 Mar;45(3):e274-e280

PMID 27655324, <http://www.ncbi.nlm.nih.gov/pubmed/27655324>

Design	Post-hoc analysis of a randomized controlled trial
Patients	353 immunocompromised patients with hypoxemic acute respiratory failure: 127 treated with HFNC, 226 treated with standard oxygen
Objectives	Assess outcomes in immunocompromised patients with hypoxemic acute respiratory failure treated with HFNC
Main Results	HFNC was associated with neither a lower intubation rate nor day 28 mortality
Conclusion	In immunocompromised patients with hypoxemic acute respiratory failure, HFNC did not reduce intubation or survival rates when compared with standard oxygen

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 PaO ₂ /FiO ₂ 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 PaO ₂ /FiO ₂ (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 (Δ 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 Δ 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 O ₂ 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 SpO ₂ 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 PaO ₂ from 8.73 (7.13-11.13) to 15.27 (9.66-25.6) kPa ($p = 0.001$) and moderately increased PaCO ₂ , 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 cmH ₂ O. 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

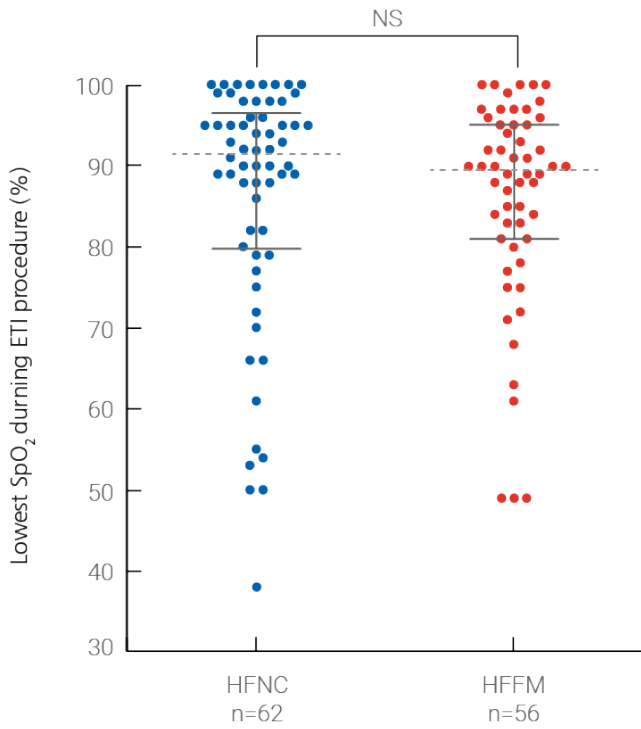


Figure 18: HFNC did not increase the saturation during intubation

--- Median

┌─┐ Interquartile Range

Median (IQR)	91.5 (80-96)	89.5 (81-95)	p= 0.44
Mean (SD)	86.2 (15.2)	85.9 (12.9)	

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

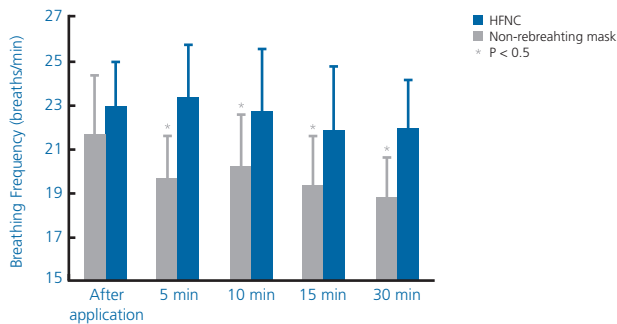


Figure 19: HFNC decreased respiratory rate during its application compared with conventional oxygen therapy

High-flow nasal cannula oxygen therapy to treat acute respiratory failure in patients with acute exacerbation of idiopathic pulmonary fibrosis

Vianello A, Arcaro G, Molena B, Turato C, Braccioni F, Paladini L, Vio S, Ferrarese S, Peditto P, Gallan F, Saetta M
Ther Adv Respir Dis. 2019 Jan-Dec;13:1753466619847130
PMID 31170875, <http://www.ncbi.nlm.nih.gov/pubmed/31170875>

Design	Retrospective cohort analysis
Patients	17 patients with acute exacerbation of idiopathic pulmonary fibrosis admitted to a respiratory intensive care unit
Objectives	Assess how a treatment algorithm incorporating high flow nasal cannula (HFNC) affects the short-term mortality of patients with acute exacerbation of idiopathic pulmonary fibrosis who develop acute respiratory failure
Main Results	Implementation of the treatment algorithm led to a successful outcome in nine patients and to a negative one in eight patients who died. The survival rate was 70.6% ($\pm 0.1\%$) at 15 days, 52.9% ($\pm 0.1\%$) at 30 days, 35.3% ($\pm 0.1\%$) at 90 days, and 15.6% ($\pm 9.73\%$) at 365 days. Overall, four out of ten patients who did not respond to conventional oxygen therapy showed a satisfactory response to HFNC.
Conclusion	Short-term mortality fell to below 50% when a treatment algorithm incorporating HFNC was implemented in a group of patients with acute exacerbation of idiopathic pulmonary fibrosis admitted to a ICU for acute respiratory failure. Patients not responding to conventional oxygen therapy seemed to benefit from HFNC

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 immunocompromised 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 SpO ₂ /FiO ₂ ≥ 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 \pm SD airway pressures at 30, 40, and 50 l/min were 1.93 \pm 1.25 cmH ₂ O, 2.58 \pm 1.54 cmH ₂ O, and 3.31 \pm 1.05 cmH ₂ O, 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 PaO ₂ (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 PaCO ₂ .
Conclusion	HFNC was better tolerated and more comfortable than HFFM, associated with better oxygenation and lower RR

Additional files

High-flow nasal cannula reduces intubation rate in patients with COVID-19 with acute respiratory failure: a meta-analysis and systematic review

Li Y, Li C, Chang W, Liu L

BMJ Open. 2023 Mar 0;13(3):e067879

PMID 36997243, <http://www.ncbi.nlm.nih.gov/pubmed/36997243>

Design	Meta-analysis and systematic review
Patients	Nine studies involving 3370 patients (1480 received HFNC)
Objectives	Investigate the effect of high-flow nasal cannula therapy (HFNC) versus conventional oxygen therapy (COT)
Main Results	HFNC reduced the intubation rate compared with COT (OR 0.44, 95% CI 0.28 to 0.71, $p = 0.0007$), decreased 28-day ICU mortality (OR 0.54, 95% CI 0.30 to 0.97, $p = 0.04$) and improved 28-day ventilator-free days (VFDs) (mean difference 2.58, 95% CI 1.70 to 3.45, $p < 0.00001$). However, HFNC had no effect on ICU length of stay (LOS) versus COT (MD 0.52, 95% CI -1.01 to 2.06, $p = 0.50$).
Conclusion	In patients with acute respiratory failure due to COVID-19, HFNC may reduce intubation rate and 28-day ICU mortality, and improve 28-day VFDs compared with COT

The effects of flow settings during high-flow nasal cannula support for adult subjects: a systematic review

Li J, Albuainain FA, Tan W, Scott JB, Roca O, Mauri T

Crit Care. 2023 Feb 28;27(1):78

PMID 36855198, <http://www.ncbi.nlm.nih.gov/pubmed/36855198>

Design	Systematic review
Patients	44 studies
Objectives	Provide evidence-based guidance on optimal high flow nasal cannula (HFNC) flow settings for various clinical conditions
Main Results	In-vitro studies evaluated the effects of flow settings on FiO ₂ , PEEP, and CO ₂ washout. These effects are flow-dependent and are maximized when the flow exceeds the patient peak inspiratory flow, which varies between patients and disease conditions. In-vivo studies report that higher flows result in improved oxygenation and dead-space washout, and can reduce the work of breathing. Higher flows also lead to alveolar overdistension in non-dependent lung regions, as well as patient discomfort. The impact of flows on different patients is largely heterogeneous.
Conclusion	Individualizing flow settings during HFNC treatment is necessary, and titrating flow based on clinical findings like oxygenation, respiratory rates, ROX index, and patient comfort represents a pragmatic way forward

ERS clinical practice guidelines: high-flow nasal cannula in acute respiratory failure

Oczkowski S, Ergan B, Bos L, Chatwin M, Ferrer M, Gregoretti C, Heunks L, Frat JP, Longhini F, Nava S, Navalesi P, Ozsancak U, Uurlu A, Pisani L, Renda T, Thille AW, Winck JC, Windisch W, Tonia T, Boyd J, Sotgiu G, Scala R
Eur Respir J. 2022 Apr 14;59(4):2101574

PMID 34649974, <http://www.ncbi.nlm.nih.gov/pubmed/34649974>

Design	Guidelines
Objectives	Provide evidence-based recommendations for the use of high-flow nasal cannula (HFNC) alongside other noninvasive forms of respiratory support in adults with acute respiratory failure (ARF)
Main Results	The task force developed eight conditional recommendations, suggesting the use of 1) HFNC over conventional oxygen therapy (COT) in hypoxemic ARF; 2) HFNC over noninvasive ventilation (NIV) in hypoxemic ARF; 3) HFNC over COT during breaks from NIV; 4) either HFNC or COT in post-operative patients at low risk of pulmonary complications; 5) either HFNC or NIV in post-operative patients at high risk of pulmonary complications; 6) HFNC over COT in nonsurgical patients at low risk of extubation failure; 7) NIV over HFNC for patients at high risk of extubation failure unless there are relative or absolute contraindications to NIV; and 8) trialling NIV prior to use of HFNC in patients with COPD and hypercapnic ARF.
Conclusion	HFNC is a valuable intervention in adults with ARF. These conditional recommendations can assist clinicians in choosing the most appropriate form of noninvasive respiratory support to provide to patients in different acute settings

High-flow nasal cannulae for respiratory support in adult intensive care patients

Lewis SR, Baker PE, Parker R, Smith AF

Cochrane Database Syst Rev. 2021 Mar 4;3(3):CD010172

PMID 33661521, <http://www.ncbi.nlm.nih.gov/pubmed/33661521>

Design	Systematic review
Patients	31 studies (22 parallel-group and nine cross-over designs) with 5136 participants; this update included 20 new studies
Objectives	To assess the effectiveness of high flow nasal cannula (HFNC) compared to standard oxygen therapy, non-invasive ventilation (NIV), or non-invasive positive pressure ventilation (NIPPV), for respiratory support in adults in the ICU
Main Results	HFNC versus standard oxygen therapy: HFNC probably makes little or no difference in mortality. HFNC probably results in little or no difference to cases of pneumonia, and it was uncertain of its effect on nasal mucosa or skin trauma. Low-certainty evidence was found that HFNC may make little or no difference to the length of ICU stay according to the type of respiratory support used. It was uncertain whether HFNC made any difference to PaO ₂ /FiO ₂ ratio within 24 hours of treatment. It was uncertain whether HFNC made any difference to short-term or to long-term comfort. HFNC versus NIV: No evidence was found of a difference between HFNC and NIV groups in terms of treatment failure when HFNC was used post-extubation or without prior use of mechanical ventilation, nor was there a difference in terms of in-hospital mortality. The effect of using HFNC on incidence of pneumonia was very uncertain, and HFNC may result in little or no difference to barotrauma. HFNC may make little or no difference to the length of ICU stay. The PaO ₂ /FiO ₂ ratio for the first 24 hours may be lower with HFNC use. It was uncertain whether HFNC improved short-term comfort when measured using comfort scores and responses to questionnaires; evidence for short-term comfort was very low certainty. No studies reported on nasal mucosa or skin trauma.
Conclusion	HFNC may lead to less treatment failure when compared to standard oxygen therapy, but probably makes little or no difference to treatment failure when compared to NIV. For most other review outcomes, no evidence was found of a difference in effect. However, the evidence was often of low certainty. No studies reported on nasal mucosa or skin trauma.

Use of nasal high flow oxygen during acute respiratory failure

Ricard JD, Roca O, Lemiale V, Corley A, Braunlich J, Jones P, Kang BJ, Lellouche F, Nava S, Rittayamai N, Spoletini G, Jaber S, Hernandez G

Intensive Care Med. 2020 Dec;46(12):2238-2247

PMID 32901374, <http://www.ncbi.nlm.nih.gov/pubmed/32901374>

Design	Panel of experts review
Patients	Analyses of the physiological effects of HFNC indicate flow-dependent improvement in various respiratory function parameters.
Objectives	To assess potential benefits of high flow nasal cannula (HFNC) in different areas of acute respiratory failure management
Main Results	<p>Analyses of the physiological effects of HFNC indicate flow-dependent improvement in various respiratory function parameters. These beneficial effects allow some patients with severe acute hypoxemic respiratory failure to avoid intubation and improve their outcome. They require close monitoring to not delay intubation. Such a delay may worsen outcome. The ROX index may help clinicians decide when to intubate. In immunocompromised patients, nasal high flow (NHF) reduces the need for intubation but does not impact mortality.</p> <p>Beneficial physiological effects of HFNC have also been reported in patients with chronic respiratory failure, suggesting a possible indication in acute hypercapnic respiratory failure. When intubation is required, NHF can be used to pre-oxygenate patients either alone or in combination with non-invasive ventilation (NIV). Similarly, NHF reduces reintubation alone in low-risk patients and in combination with NIV in high-risk patients.</p>
Conclusion	In every segment of acute hypoxemic respiratory failure management (first-line ventilatory support, preoxygenation, post-extubation, palliative care), evidence suggests that HFNC has the potential to benefit the patient. Beneficial effects also seem to be seen in patients with chronic respiratory disease

The role for high flow nasal cannula as a respiratory support strategy in adults: a clinical practice guideline

Rochweg B, Einav S, Chaudhuri D, Mancebo J, Mauri T, Helviz Y, Goligher EC, Jaber S, Ricard JD, Rittayamai N, Roca O, Antonelli M, Maggiore SM, Demoule A, Hodgson CL, Mercat A, Wilcox ME, Granton D, Wang D, Azoulay E, Ouanes-Besbes L, Cinnella G, Rauseo M, Carvalho C, Dessap-Mekontso A, Fraser J, Frat JP, Gomersall C, Grasselli G, Hernandez G, Jog S, Pesenti A, Riviello ED, Slutsky AS, Stapleton RD, Talmor D, Thille AW, Brochard L, Burns KEA

Intensive Care Med. 2020 Dec;46(12):2226-2237

PMID 33201321, <http://www.ncbi.nlm.nih.gov/pubmed/33201321>

Design	Guidelines for clinical practice
Patients	Guideline panel composed of clinicians, methodologists, and experts in respiratory medicine
Objectives	Develop evidence-based recommendations regarding use of high flow nasal cannula (HFNC) in various clinical settings
Main Results	The guideline panel made a strong recommendation for HFNC in hypoxemic respiratory failure compared to conventional oxygen therapy, a conditional recommendation for HFNC following extubation, no recommendation regarding HFNC in the peri-intubation period, and a conditional recommendation for postoperative HFNC in high risk and/or obese patients following cardiac or thoracic surgery.
Conclusion	A strong recommendation for HFNC in hypoxemic respiratory failure (moderate certainty), a conditional recommendation for HFNC following extubation (moderate certainty), no recommendation regarding HFNC in the peri-intubation period (moderate certainty), and a conditional recommendation for postoperative HFNC in high risk and/or obese patients following cardiac or thoracic surgery (moderate certainty)

The effect of high-flow nasal oxygen therapy on postoperative pulmonary complications and hospital length of stay in postoperative patients: A Systematic Review and Meta-Analysis

Lu Z, Chang W, Meng S, Xue M, Xie J, Xu J, Qiu H, Yang Y, Guo F

J Intensive Care Med. 2020 Oct;35(10):1129-1140

PMID 30587060, <http://www.ncbi.nlm.nih.gov/pubmed/30587060>

Design	Literature summary of randomized controlled trials (RCTs) comparing high flow nasal oxygen (HFNO) with conventional oxygen therapy or noninvasive mechanical ventilation in adult postoperative patients
Patients	14 randomized controlled trials including 2,568 patients
Objectives	Evaluate the effect of HFNO on hospital length of stay (LOS) and postoperative pulmonary complications in adult postoperative patients
Main Results	HFNO was associated with a shorter hospital length of stay ($p = 0.002$), but not mortality. Weak evidence of a reduction in reintubation rate and rate of postoperative pulmonary complications with HFNC was recorded.
Conclusion	Among the adult postoperative patients, HFNC significantly reduced hospital LOS compared to the control group

Effect of high-flow nasal cannula oxygen therapy compared with conventional oxygen therapy in postoperative patients: a systematic review and meta-analysis.

Lu Z, Chang W, Meng SS, Zhang X, Xie J, Xu JY, Qiu H, Yang Y, Guo F

BMJ Open. 2019 Aug 2;9(8):e027523

PMID 31377696, <http://www.ncbi.nlm.nih.gov/pubmed/31377696>

Design	Systematic review and meta-analysis
Conclusion	HFNC is associated with a significantly lower reintubation rate and rate of escalation of respiratory support compared with conventional oxygen therapy in postextubation adult surgical patients, but there is no difference in the incidence of postoperative pulmonary complications or mortality.

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 Sep;42(9):1336-49

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

The efficacy of high-flow nasal cannula (HFNC) versus non-invasive ventilation (NIV) in patients at high risk of extubation failure: a systematic review and meta-analysis

Wang Q, Peng Y, Xu S, Lin L, Chen L, Lin Y

Eur J Med Res. 2023 Mar 14;28(1):120

PMID 36915204, <http://www.ncbi.nlm.nih.gov/pubmed/36915204>

Design	Systematic review and meta-analysis
Patients	13 randomized clinical trials with 1457 patients
Objectives	Compare the efficacies of high-flow nasal cannula (HFNC) and non-invasive ventilation (NIV) in patients at high risk of extubation failure
Main Results	13 randomized clinical trials with 1457 patients were included. The HFNC and NIV groups showed no differences in reintubation (RR 1.10, 95% CI 0.87-1.40, I2 = 0%, p = 0.42), mortality (RR 1.09, 95% CI 0.82-1.46, I2 = 0%, p = 0.54), and respiratory function indices (PaCO ₂ , P/F, RR). However, HFNC reduced adverse events (abdominal distension, aspiration, facial injury, delirium, pulmonary complications, intolerance) and may have shortened length of stay (p = 0.02).
Conclusion	In patients at a high risk of extubation failure, HFNC reduced the incidence of adverse events, but did not affect reintubation or mortality

Effect of high-flow nasal cannula oxygen therapy vs conventional oxygen therapy on adult postcardiothoracic operation: A meta-analysis

Wu X, Cao W, Zhang B, Wang S

Medicine (Baltimore). 2018 Oct;97(41):e12783

PMID 30313100, <http://www.ncbi.nlm.nih.gov/pubmed/30313100>

Design	Meta-analysis
Patients	4 studies, 649 patients
Main Results	Compared with conventional oxygen treatment, HFNC was associated with a reduction in the escalation of respiratory support and pulmonary complications. There were no differences in reintubation rate, ICU length of stay or hospital length of stay.
Conclusion	HFNC could reduce respiratory support and pulmonary complications in postcardiothoracic surgery, and could be safely administered for adult postcardiothoracic surgery

High-Flow Nasal Cannula Oxygen in Adults: An Evidence-based Assessment

Drake MG

Ann Am Thorac Soc. 2018 Feb;15(2):145-155

PMID 29144160, <http://www.ncbi.nlm.nih.gov/pubmed/29144160>

Design	Review
Conclusion	This review examines the evidence for HFNC, with a focus on the effects on respiratory physiology and keys to tailoring the flow for specific clinical scenarios

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
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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 PaO ₂ , PaO ₂ /FiO ₂ , and SpO ₂ 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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