High Flow Nasal Cannula Therapy

T Townend
Christchurch Hospital



Rationale

- Non-invasive respiratory support
- Delivery of prescribed FiO2
  - ↓air entrainment (dilution)
- Humidification (≥95%)
- Comfortable nasal interface
- Low-level CPAP

- Easier application and better facial access than nasal CPAP



Mechanisms of action

- Washout of nasopharyngeal deadspace
- Reduced WOB
- Improved mechanics
- Reduced metabolic expense
- Distending pressure

Dysart et al, Respiratory Medicine 2009; 103:1400-1405

Applications

- High O_2 requirements or WOB
- Need for humidification (secretions)
- Poor tolerance of mask

Paucity of evidence

- Cochrane review 2014
  - To determine whether HFNC therapy is more effective than other forms of non-invasive therapy in paediatric patients who require respiratory support
  - Content to 1st April 2013
  - No study matched inclusion criteria

- Neonatal evidence not much better

Neonates

- Most studies have focused on respiratory support during post-extubation period in premature infants
- RCT of 432 infants 28-42 weeks gestation comparing nCPAP and HFNC
  - Primary therapy or post-extubation
  - Primary outcome: need for intubation within 72hrs of applied non-invasive therapy
- No difference in:
  - Early failure HFNC vs nCPAP
  - Subsequent need for any intubation
  - Duration on oxygen
  - Rates of BPD

Bradley et al, *Pediatrics* 2013;131;e1482

TABLE 4 Respiratory Support Outcomes Among Infants Randomly Assigned to nCPAP Compared With HHHFNC

	nCPAP (*n* = 216)	HHHFNC (*n* = 211)	*P*
Days on study mode	2 (1–4)	4 (2–7)	<.001
Delayed use of other study mode, *n* (%)	31 (14)	19 (9)	.096
Days ventilated	2 (1–4)	2 (1–5)	.476
Days any positive pressure support	4 (2–8)	6 (3–11)	<.001
Days supplemental O_2	8 (5–24)	10 (5–27)	.357
BPD,[a] *n* (%)	12/73 (16)	15/75 (20)	.575
Home oxygen, *n* (%)	38 (18)	40 (19)	.698
Age at discharge	25 (13–47)	25 (14–49)	.756

Data are shown as medians (25%–75%) unless otherwise indicated.

[a] Only surviving infants <32 weeks' gestational age at birth.

TABLE 5 Occurrence Rates for Secondary Outcomes in the nCPAP Compared With the HHHFNC Study Group

	nCPAP (*n* = 220)	HHHFNC (*n* = 212)
Any adverse event	46 (21)	52 (25)
Air leak	5 (2)	1 (<1)
Increased apnea	15 (7)	23 (11)
Confirmed sepsis	7 (3)	7 (3)
Confirmed NEC	4 (2)	2 (1)
Reintubation, any	25 (11)	32 (15)
<72 hours	18 (8)	23 (11)
<7 days	21 (10)	23 (11)
No nasal trauma	180 (84)	187 (91)*
Abdominal distention	17 (8)	21 (10)
Days to full oral feedings, median (25%–75%)	17 (8–35)	18 (8–41)
Death	4 (2)	1 (<1)

Data are shown as *n* (%) unless otherwise indicated. **P* = .047. NEC, necrotizing enterocolitis.



Paediatrics

- Most studies have focused on infants with bronchiolitis
- Efficacy of HFNC yet to be demonstrated in other paediatric conditions

- Retrospective case-control study, Brisbane 2011
  - Reduced intubation rates in infants with bronchiolitis when HFNC introduced in the PICU
  - No direct comparison with nasal CPAP
  - Clinical effects need to be reassessed at 60-90min as most improvement (in RR and HR) will be seen in this time

- French study 2014, compared HFNC and nCPAP in bronchiolitis
  - No difference in LOS, oxygen requirement, RR, HR

Schibler et al. *Intensive Care Medicine* 2011; DOI 10.1007/s00134-2177-5
Metge et al. *Eur J Pediatr* (2014) 173;953-958

- HFNC use in PICU transports
  - Pre-HFNC 7% NIV 49% IV
  - Post-HFNC 33% HFNC 2% NIV 35% IV

Schlapbach et al. *Intensive Care Medicine* (2014) 40; 592-599

Physiological effect of HFNC

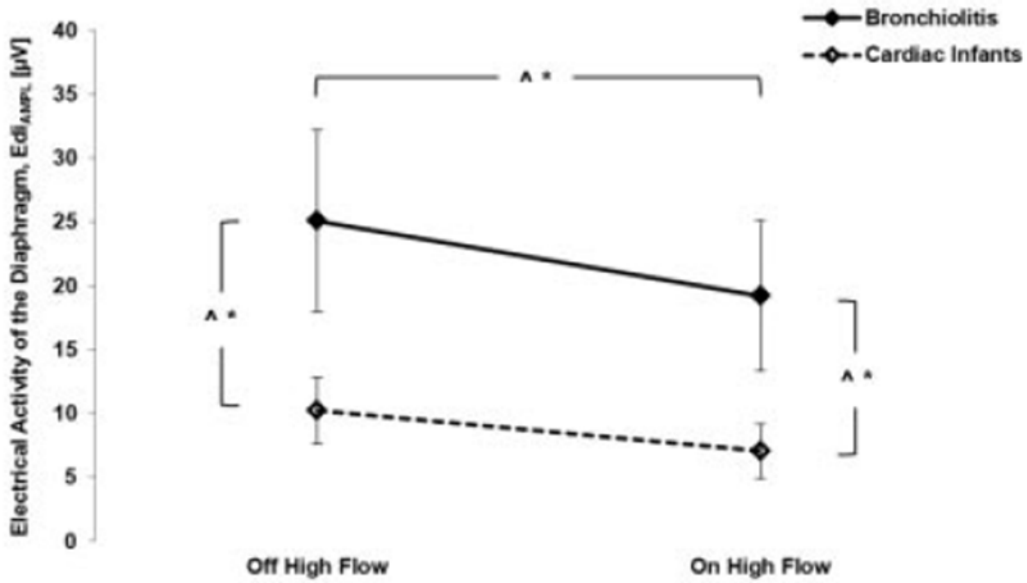


Fig. 2. Amplitude of the electrical activity of the diaphragm (Edi) for infants with bronchiolitis and cardiac infants, off and on HFNC. Both groups were significantly different, off and on HFNC (^ bronchiolitis, * cardiac infants, $P < 0.001$). Edi_{AMPL} decreased significantly between HFNC states for both groups (^ bronchiolitis, * cardiac infants, $P = 0.021$ and $P = 0.001$, respectively). Mean and 95% confidence intervals are shown.

Pham et al. *Pediatric Pulmonology* 2014

Outside PICU?

- Pilot study 2014, Mater Children's, Ward setting
- 61 infants
  - <12m, bronchiolitis, oxygen requirement in ED
  - HFNC 2L/kg/min, FiO_2 to keep sats >94%
- Control group low-flow nasal O_2

- Responders identified within 60min

- HFNC 4 times less likely to require PICU admission

Mayfield et al, *Journal of Paediatrics and Child Health* 50; (2014) 373-378

HFNC Distending Pressure

- Pressure generated is inconsistent and unpredictable
  - Affected by mouth opening and size of leak at nares
- Reported pressures range from 2-8 cmH_2O
- Prospective study 2013
  - 21 infants <6m, RSV bronchiolitis
  - Flow ≥2L/kg/min achieved a clinically relevant mean pharyngeal pressure ≥4cmH2O
    - Associated with improved breathing pattern and rapid unloading of respiratory muscles

Milesi et al. *Intensive Care Medicine* 2013 39:1088-1094

- Study of 18 preterm infants NICU Melbourne
  - Median age 34/40
  - Catheter tip pressure transducer in nasopharynx

Wilkinson et al, *Journal of Perinatology (2008) 28, 42–47*

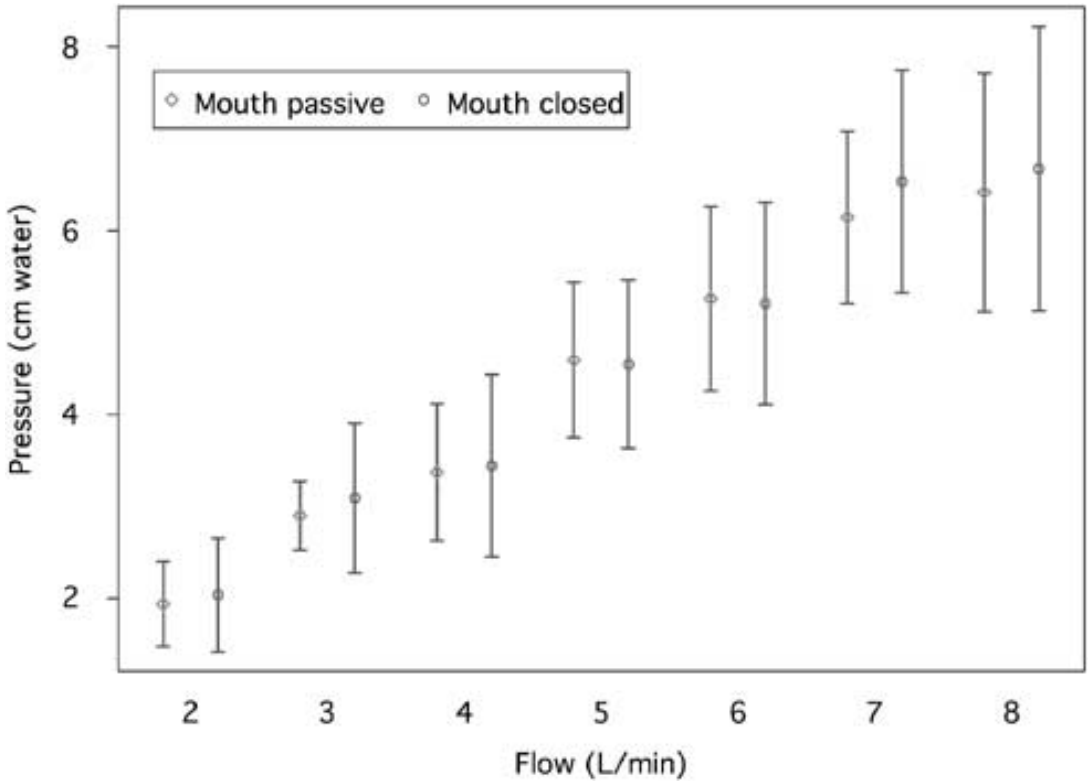


Figure 2 Mean pharyngeal pressure (with 95% confidence intervals) recorded at flow rates 2 to 8 l min^{-1}.

- Study of 18 preterm infants NICU Melbourne
  - Median age 34/40
  - Catheter tip pressure transducer in nasopharynx

- Mouth leak may be less important than nasal leak

Wilkinson et al, *Journal of Perinatology (2008) 28, 42–47*

Contraindications

- Maxillofacial trauma
- Choanal atresia or nasal obstruction
- Suspected base of skull fracture
- Risk of air leak

- Noise?
- Too sick for HFNC?

Complications

- Case series published 2013, all with serious air leak
  - 2m RSV bronchiolitis
  - 16y cerebral palsy, post-surgical/extubation
  - 22m NAI, post-extubation

- Use is “off label”

Hegde and Prodhan, *Pediatrics* 2013;131;e939

Flow rate

- 2L/kg/min
- Children >20kg 40-50L/min
- Adult 40-60L/min

2L/kg/min?

Table 3: Comparison of TB parameters between both patient groups ordered according to the p-value of the ANOVA (Presented are group means ± SD, statistically significant p-values after Bonferroni correction (p < 0.0028) are printed in bold)

Parameter	Healthy neonates (n = 48)	CLD infants (n = 48)	p-value CLD
t_I(s)	0.65 ± 0.14	0.45 ± 0.11	**p < 0.0001**
RR (min^{-1})	39.2 ± 8.6	55.4 ± 14.2	**p < 0.0001**
(PTIF+PTEF)/V_T (s^{-1})	0.27 ± 0.06	0.37 ± 0.09	**p < 0.0001**
t_E (s)	0.98 ± 0.24	0.72 ± 0.22	**p < 0.0001**
V_T/t_I($mL \cdot s^{-1} \cdot kg^{-1}$)	8.9 ± 2.2	11.6 ± 2.8	**p < 0.0001**
V'_E($mL \cdot min^{-1} \cdot kg^{-1}$)	215 ± 51.7	276 ± 76.8	**p < 0.0001**
TIF 50 ($L \cdot min^{-1} \cdot kg^{-1}$)	0.75 ± 0.21	0.98 ± 0.26	**p < 0.0001**
PTIF ($L \cdot min^{-1} \cdot kg^{-1}$)	0.83 ± 0.20	1.05 ± 0.28	**p < 0.0001**
PTEF/t_{PTEF} ($L \cdot s^{-2} \cdot kg^{-1}$)	2.90 ± 1.68	5.25 ± 3.66	**p = 0.0001**
PTEF ($L \cdot min^{-1} \cdot kg^{-1}$)	0.64 ± 0.19	0.82 ± 0.29	**p = 0.0006**
t_{ptef} (s)*)	0.24 ± 0.09	0.18 ± 0.11	**p = 0.001**
TEF75 ($L \cdot min^{-1} \cdot kg^{-1}$)	0.60 ± 0.20	0.76 ± 0.29	p = 0.003
TEF50 ($L \cdot min^{-1} \cdot kg^{-1}$)	0.52 ± 0.17	0.66 ± 0.25	p = 0.003
TEF25 ($L \cdot min^{-1} \cdot kg^{-1}$)	0.38 ± 0.11	0.46 ± 0.16	p = 0.006
V_{ptef} (mL/kg)*)	1.68 ± 0.52	1.37 ± 0.44	p = 0.006
V_T ($mL \cdot kg^{-1}$)	5.57 ± 1.06	5.15 ± 1.35	p = 0.09
V_{PTEF}/V_T(%)*)	29.4 ± 6.6%	27.2 ± 6.1%	p = 0.13
t_{PTEF}/t_E (%)*)	25.8 ± 9.7%	23.2 ± 7.8%	p = 0.20

*)Loops with flow limitations, grunting or other deformations were excluded from the evaluation (6 controls, 8 CLD infants)

Abbreviations: $t_{I,E}$-inspiratory, expiratory time, RR-respiratory rate, PTIF, PTEF-peak tidal inspiratory and expiratory flow, V_T-tidal volume, TIF 50-tidal inspiratory flow when 50% of V_T is inspired, TEF 75, TEF 50, TEF 25-expiratory flow when 75%, 50% and 25% of tidal volume remains in the lung, V'_E-minute ventilation, t_{PTEF},V_{PTEF}-time and volume to peak tidal expiratory flow

Schmalisch et al. *BMC Pediatrics* 2005, **5**:36

- 2L/kg/min ensures flow higher than peak inspiratory flow rate (SSH)

- Alternatives:
  - 2L/kg/min up to 10kg, plus 0.5L/kg/min for each kg above 10kg to max 50L/min (RCH)
  - Flow (L/min) = maintenance fluid rate (ml/hr) / 2















Optiflow Junior



Optiflow Junior Nasal Cannula	Approx. Weight Range	Max. Flow
Premature size nasal cannula	<2 kg	8 L/min
Neonatal size nasal cannula	1-8 kg	8 L/min
Infant size nasal cannula	3-15 kg	20 L/min
Pediatric size nasal cannula	12-22 kg	25 L/min

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Optiflow Junior



Optiflow Junior Nasal Cannula	Approx. Weight Range	Max. Flow
Premature size nasal cannula	<2 kg	8 L/min
Neonatal size nasal cannula	~~1-8 kg~~ 1-4kg	8 L/min
Infant size nasal cannula	~~3-15 kg~~ 3-10kg	20 L/min
Pediatric size nasal cannula	~~12-22 kg~~ 10-12.5kg	25 L/min

Nasal Prong sizing

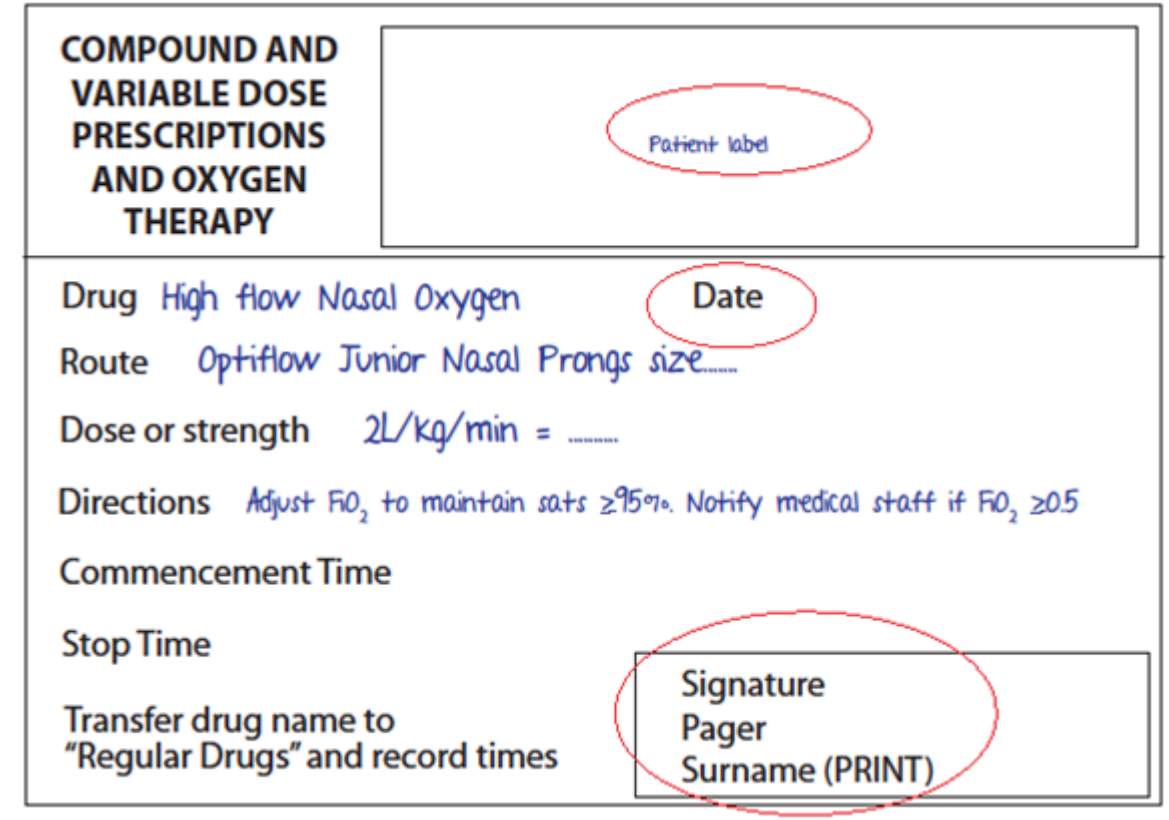
- Optiflow Junior ≤12.5kg
- Optiflow >12.5kg

Adult Optiflow



Prescribing

- Stipulate FiO_2 and Flow Rate



COMPOUND AND VARIABLE DOSE PRESCRIPTIONS AND OXYGEN THERAPY

Patient label

Drug High flow Nasal Oxygen

Date

Route Optiflow Junior Nasal Prongs size.....

Dose or strength 2L/kg/min = ...

Directions Adjust FiO_2 to maintain sats ≥95%. Notify medical staff if FiO_2 ≥0.5

Commencement Time

Stop Time

Transfer drug name to "Regular Drugs" and record times

Signature
Pager
Surname (PRINT)

Weaning (Acute Paeds)

- Titrate FiO_2, weaning to 40%
  - Then trial Low Flow oxygen at 1-2L/min (wall, not mixer)

- Don't wean flow ie. 'High' or 'Low'
  - No need to change cannula (Optiflow Junior)

Nebulising via HFNC

- No paediatric data of effectiveness

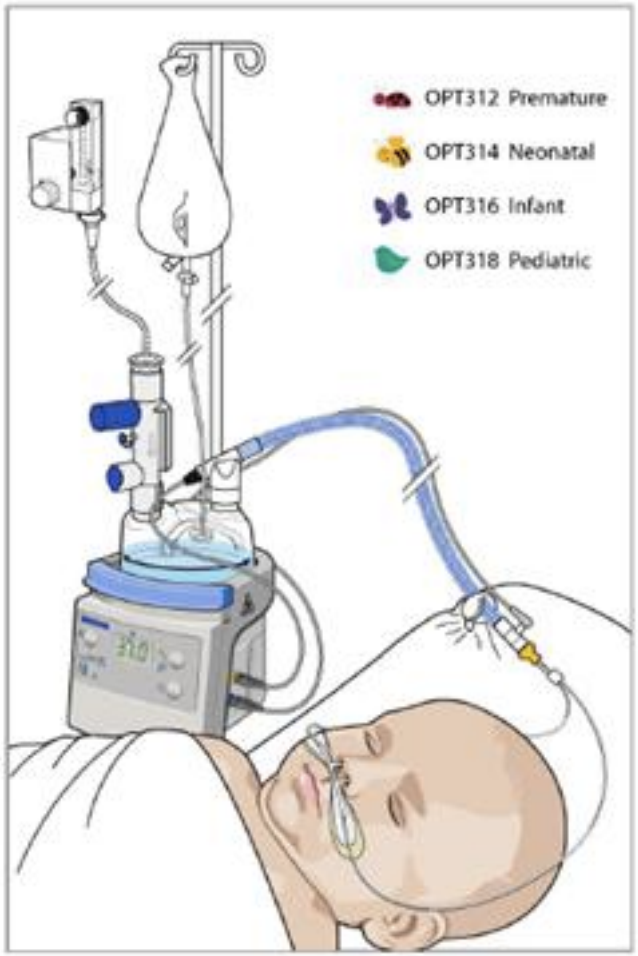
- In vitro study nebulised albuterol via Vapotherm:
  - 3 sizes cannulae
    - Adult 5-40L/min
    - Pediatric 3-20L/min
    - Infant 3-8L/min
  - Inadequate delivery to achieve a clinical response
    - 0-2.5% of nominal dose
  - Delivery inversely proportional to flow rate
  - Delivery proportional to cannula size

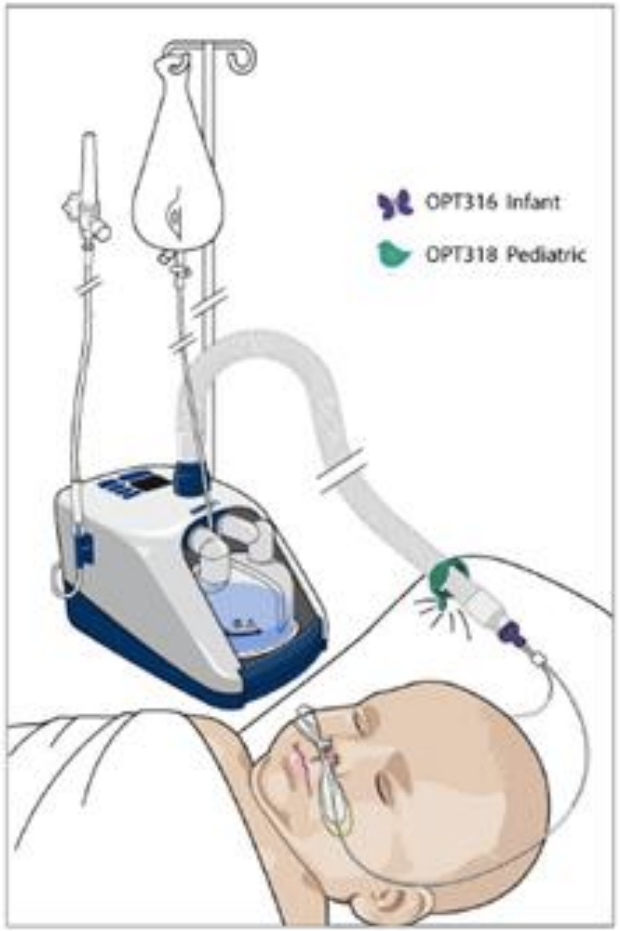
Perry et al. *Pediatric Critical Care Medicine* 14(5);e250-e256, June 2013

- Limited adult data suggest pulmonary deposition of aerosol through High Flow circuit similar to level obtained by direct inhalation from nebuliser



Dhand R. Journal of Aerosol Medicine and Pulmonary Drug Delivery 2012; 25(2): 63-78


OPT312 Premature
OPT314 Neonatal
OPT316 Infant
OPT318 Pediatric


OPT316 Infant
OPT318 Pediatric

Questions?