Clinical Communication

Indigenous adaptor for high flow nasal oxygen delivery

INTRODUCTION

High flow nasal cannula (HFNC) is a relatively newer non-invasive ventilation therapy that is well tolerated both in paediatric and adult care settings and was increasingly used during third wave of coronavirus disease–2019 (COVID–19).[1] Studies in newborn and children have suggested that HFNC may reduce the need for continuous positive airway pressure (CPAP) and invasive ventilation.[2]

Initial flow rate recommendation begins with 2 litres/kg/min. Flow rates can be increased to a maximum of 60 litres/min.[2,3]

HFNO acts by washout of nasopharyngeal dead space, increasing pulmonary compliance, functional residual capacity and airway pressure.[4]

Management of COVID-19 patients entails administration of oxygen by various methods and the use of devices which might not be available in all locations.[5] Hence, there is a need for innovative products to ensure oxygen therapy that can be provided even at primary health centre level for better patient care. One such adaptation is the use of two sources of oxygen flow combined by a "Y-Connector" device. One limb of the device is connected to a Venturi adaptor for providing large total gas flows and the second limb is used for providing higher oxygen concentration.

METHODS

The study was conducted in a medical college and super speciality hospital. The HFNO therapy was instituted by designing a simple prototype (Defence Research and Development Organisation, Hyderabad) of the mechanism described above [Figure 1a].[6] The adaptor [Figure 1b] has two ports, both of which were connected to two sources of oxygen.

One end of the adaptor was connected to an oxygen source using a Venturi connector, while the side port was directly connected to oxygen tubing and patient end connected via a heat and moisture exchanger (HME) filter to nasal prongs. Passive humidification could be provided if the oxygen tubings were connected to flow meters with humidifier bottles.

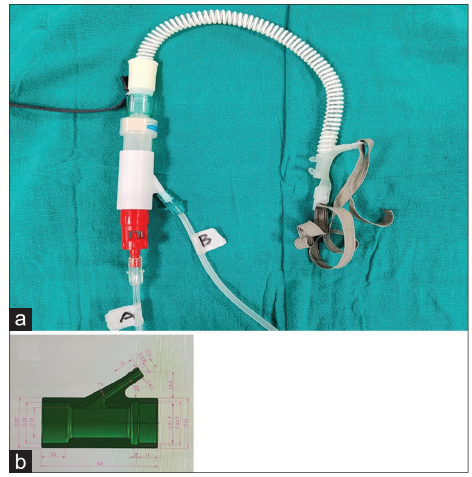

Figure 1: (a) Indigenous adaptor with nasal cannula for high flow oxygen delivery. (b) 3D printed template design of adaptor

Validation of the device

Peak flows: Mindray® flow pressure monitor device.

Fraction of inspired oxygen (FiO2): Side-stream analyser of Spacelab Blease Sirius (model: 700/900 series)

RESULTS

Table 1a: Shows net peak flow and net FiO_2 delivered to the patient with the adaptor using various color-coded Venturi connectors. Standard flow rates as recommended for the Venturi device were used in oxygen tubing 'A' and varying flow rates from 6 to 15 litres with 3 litre increments were used in oxygen tubing 'B'. Highest peak flows delivered and FiO_2 achieved are marked and highlighted.

Table 1b: Shows net peak flow and FiO_2 delivered when variable flow rates were used in both the oxygen tubings. Oxygen flow rates were increased incrementally from 4 to 15 litres/min in both tubings 'A' and 'B'. Highest peak flow delivered and FiO_2 achieved are marked and highlighted.

DISCUSSION

The Surviving Sepsis Campaign guidelines for COVID-19 have suggested the benefit of HFNC device over non-invasive ventilation to obtain oxygen saturation (SpO_2) above 90%.[7] The commercially available standard HFNO oxygen therapy equipments allow warm and humidified oxygen with a maximum flow of 60 litres/min and positive end-expiratory pressure of up to 7.2 cm of water.

Table 1a: Final peak flows and FiO_2 delivered with standard flow rates using various Venturi connectors

Venturi connector (FiO_2, flow in Litres/min)	Oxygen flow settings (Litres/min)		Net peak flow delivered to patient (Litres/min)	Net FiO_2 delivered at patient end (%)
	Venturi tubing (A)	Non-Venturi tubing (B)		
Blue	4	6	26	58%
	4	9	32	62%
	4	12	38	65%
(24%, 4 L/min)	4	15	43	72%
White	4	6	25	67%
	4	9	30	71%
	4	12	35	73%
(28%, 4 L/min)	4	15	39	74%
Red	9	6	28	85%
	9	9	33	86%
	9	12	39	86%
(40%, 8 L/min)	9	15	44	86%

Table 1b: Final peak flows generated and FiO_2 delivered when variable flow rates were used in both the oxygen tubings

Type of Venturi connector	Oxygen flow settings (Litres/min)	Net peak flow delivered to patient (Litres/min) with Non-Venturi tubing (B) (Litres/min)				Net FiO_2 delivered at Patient end (%)			
	Venturi tubing (A) (Litres/min)	4	8	12	15	4	8	12	15
Blue	4	20	28	33	36	52	58	59	59
	8	49	52	56	61	41	48	52	53
	12	65	68	70	72	39	45	49	50
(24%, 4 L/min)	15	79	83	86	90	39	43	45	48
White	4	21	28	33	34	48	56	58	60
	8	50	53	56	59	42	47	50	53
	12	64	67	70	72	41	45	47	50
(28%, 4 L/min)	15	80	82	85	88	40	43	45	47
Red	4	11	21	26	29	70	67	65	65
	8	24	31	34	37	62	66	66	67
	12	32	37	41	43	59	64	66	66
(40%, 8 L/min)	15	40	45	49	51	57	62	64	65

FiO_2: Fraction of inspired oxygen

Our indigenous adaptor is lightweight, cost-effective and easy to make. It might be useful as a rescue oxygen therapy in resource limited settings where commercial HFNO devices are not available, and this device can provide high peak flows in the current COVID-19 pandemic with the help of oxygen cylinders.

Multiple prototypes of adaptors with various inner to outer diameters ratios were tested for generation of maximum peak flows. The inner to outer diameter ratios of various adaptors used were 1:5.3, 1:1.47, 1:1.37, 1:1.22. Of all the prototypes, the inner to outer diameter ratio of 1:1.37 generated the maximum peak flows and FiO_2.

With fixed flows through the Venturi, increasing the flow through the oxygen tubing, connected directly to the adaptor, did not yield higher peak flows but increased the FiO_2 by 2–3 times from the expected values of the Venturi adaptors. Whereas, by increasing the oxygen flow connected to the Venturi, peak flows were increased by 2–3 times and FiO_2 was increased only by 1.5–2 times.

This indigenous adaptor can only provide passive humidification when oxygen is supplied through flow meters with water-filled humidifier bottles. Absence of heating is the only limitation with the adaptor.

CONCLUSION

We conclude that variable combination of flow rates with passive humidification would be practical and useful in remote/resource limited settings. The adaptor, by providing high flows of oxygen can be used where standard HFNO machines are not available.

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Conflicts of interest

There are no conflicts of interest.

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