

Photo: Paul Sonenthal/Partners In Health

Medical Oxygen Therapy

A review of best practices



**Partners
In Health**
Inpatient Medicine

Acknowledgements

Illustrations by The OpenCriticalCare.org Project & Holly Sullivan at sulscientific.com

To say that you are not prepared to administer it is no excuse when death is imminent, for every physician is as well prepared as I was, or soon can be at little expense.

VOLUME XLVI.

JULY TO DECEMBER, 1887, INCLUSIVE.



NEW YORK:
D. APPLETON AND COMPANY,
1, 3, AND 5 BOND STREET.
1887.

ported by the lymph-vessels. So much, then, is the evidence as to the way of access of these micro-organisms to the nervous system. As regards cerebro-spinal meningitis and pneumonia, taken separately or together, we must regard Koch's postulates as demonstrated.

The clinical evidence as to the occurrence of cerebro-spinal meningitis and pulmonary disease is equally widespread. Jürgensen notes that in epidemics of cerebro-spinal meningitis, pneumonia cases are often complicated by it. Immermann and Heller, in post-mortem examinations in thirty cases of death from pneumonia, found evidences of meningitis in nine, and this was during an epidemic of cerebro-spinal meningitis. Githens, in ninety-eight cases of cerebro-spinal meningitis, found nine cases of pneumonia, and seven of bronchitis, and says that "many had more or less tendency to irritation of the air-passages."

De Willich notes a case where the symptoms were meningeal until the fourth day, when pneumonia became evident. Lewis Smith also cites a similar case where the diagnosis was not made until the sixth day. Rothman cites analogous cases. Lewis Smith has remarked the prevalence

merely cerebral excitement; and, as in the cases of De Willich and Lewis Smith, only as the meningeal symptoms subsided did the pulmonary become marked, thus showing that the brunt of the disease fell upon the lungs.

THE USES AND EFFECTS OF OXYGEN GAS AND NUX VOMICA IN THE TREATMENT OF PNEUMONIA.*

By GEORGE E. HOLTZAPPLE, M. D.,
LOGANVILLE, PA.

MEDICAL literature does not inform us of much advancement having been made in the treatment of pneumonia for some years. I think there are certain agents which, from their physiological effects, should have a place in the armamentarium of this disease. I refer to the use of oxygen gas and nux vomica.

Studying closely the physiological effects of each, and the pathological conditions and clinical phenomena of pneumonia, it seems to me there are stages in this disease when

had been previously injured, meningitis was more easily produced by injection of micrococci, is confirmed by clinical evidence. One of Immermann and Heller's patients was insane; one third of all who died were alcoholic subjects. Of Barth's cases, three out of four were alcoholic. Grobe's patient had suffered from great disappointment.

So, if the brain has been before diseased, it is the organ of least resistance, and cerebro-spinal meningitis is likely to occur. Nearly all observers note that the onset of the disease follows severe mental or nervous strain.

I believe that we may agree with Bozzolo and Barth and Greenfield and M. Sée and Netter in concluding that both cerebro-spinal meningitis and pneumonia are due to the same micro-organisms, the relative frequency of the diseases being determined by the factors above noted. The grounds for this belief are the morphological identity of the micro-organisms, their habitat in living and dead bodies, the results of cultivations and inoculations, and the clinical evidence of the occurrence of the two diseases together.

That the four cases cited above are cases of the pulmonary form of cerebro-spinal meningitis is shown by the precedence of an undoubted case of cerebro-spinal meningitis, and by the meningeal symptoms being too severe for

cardiac ganglia, the pneumogastric, the accelerator nerves of the heart, the vaso-motor center in the medulla, and the vaso-motor functions generally" (Bartholow). Larger doses will paralyze the very structures that full doses will stimulate. There are stages in this disease when life depends upon stimulating the very structures which I have so far enumerated. The difference of effect depends on the dose administered. It is a powerful remedy and has to be administered with care. Yet, if only half enough is administered and no favorable effects are produced, or if entirely too much is administered and unfavorable effects are produced, it is not the fault of the remedy, but of the one who administered it. According to some observers, strychnine diminishes the amount of carbonic acid formed in the blood.

I am not aware that strychnine or nux vomica was ever administered in acute disease with a view of obtaining the useful effects on the circulation and respiration above enumerated, and the stimulant effects upon the functions generally which must then result.

When hepatization is extensive, the patient craves for oxygen. He may even do so when hepatization is less ex-

* Read before the York County Medical Society, August 4, 1887.

Objectives

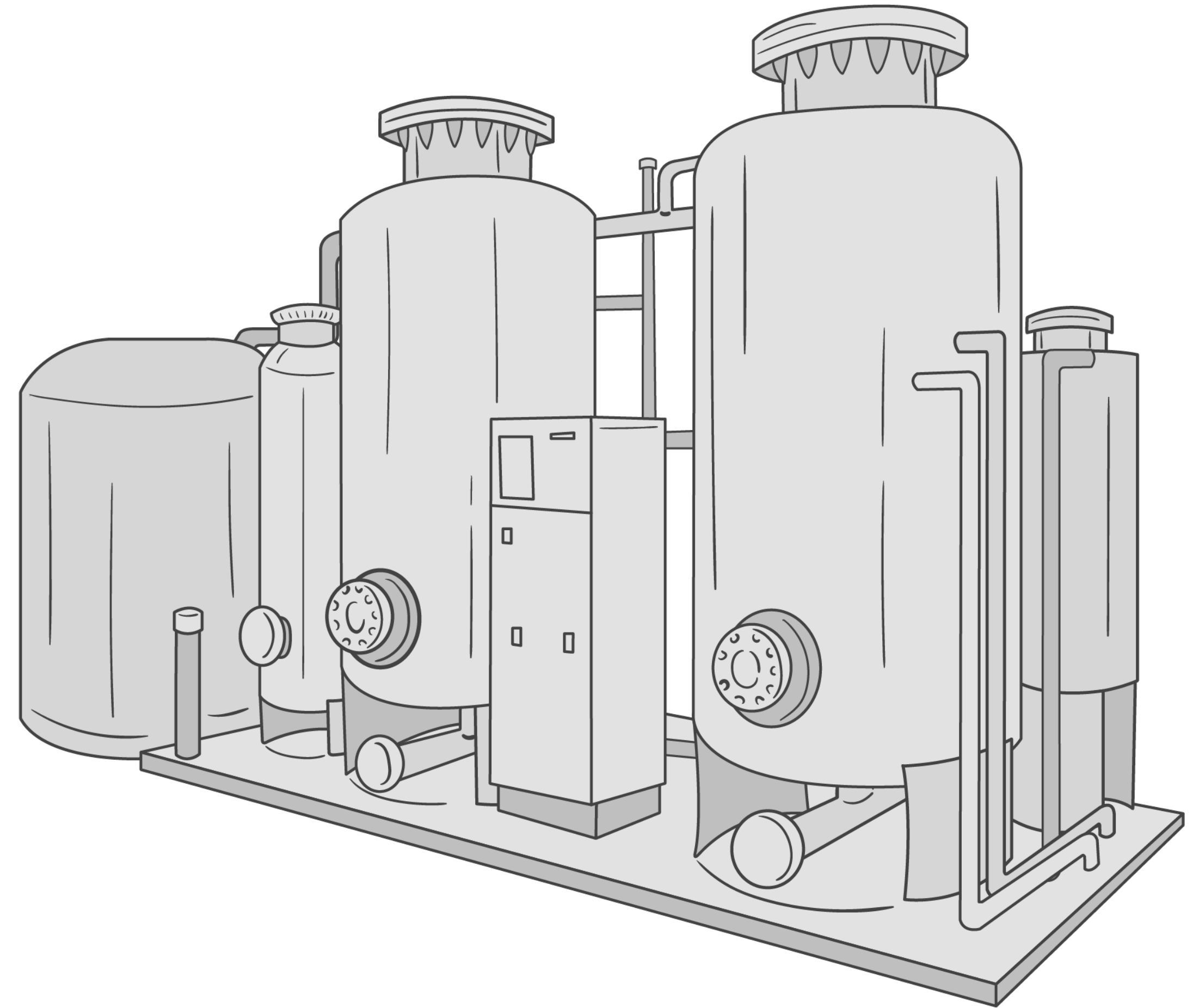
1. Improve ability to provide high quality care for patients with hypoxemia
2. Better understand oxygen interfaces & sources
3. Learn techniques to reduce unnecessary oxygen use



Photo: Paul Sonenthal/Partners In Health

Outline

- Case presentation
- Oxygen interfaces
- Oxygen sources
- Matching interfaces & sources
- Optimizing oxygen use
- Review & conclusions



Case presentation

Case presentation

65 year old male with COVID-19 pneumonia arrives on the COVID ward with shortness of breath and fevers for 5 days

Vitals:

Oxygen saturation: 84% on room air

Respiratory rate: 24

Heart rate: 117

Blood pressure: 137/92

Exam: Bilateral rales and scattered rhonchi

Diagnostics: Chest xray shown on the right



After arrival to COVID unit

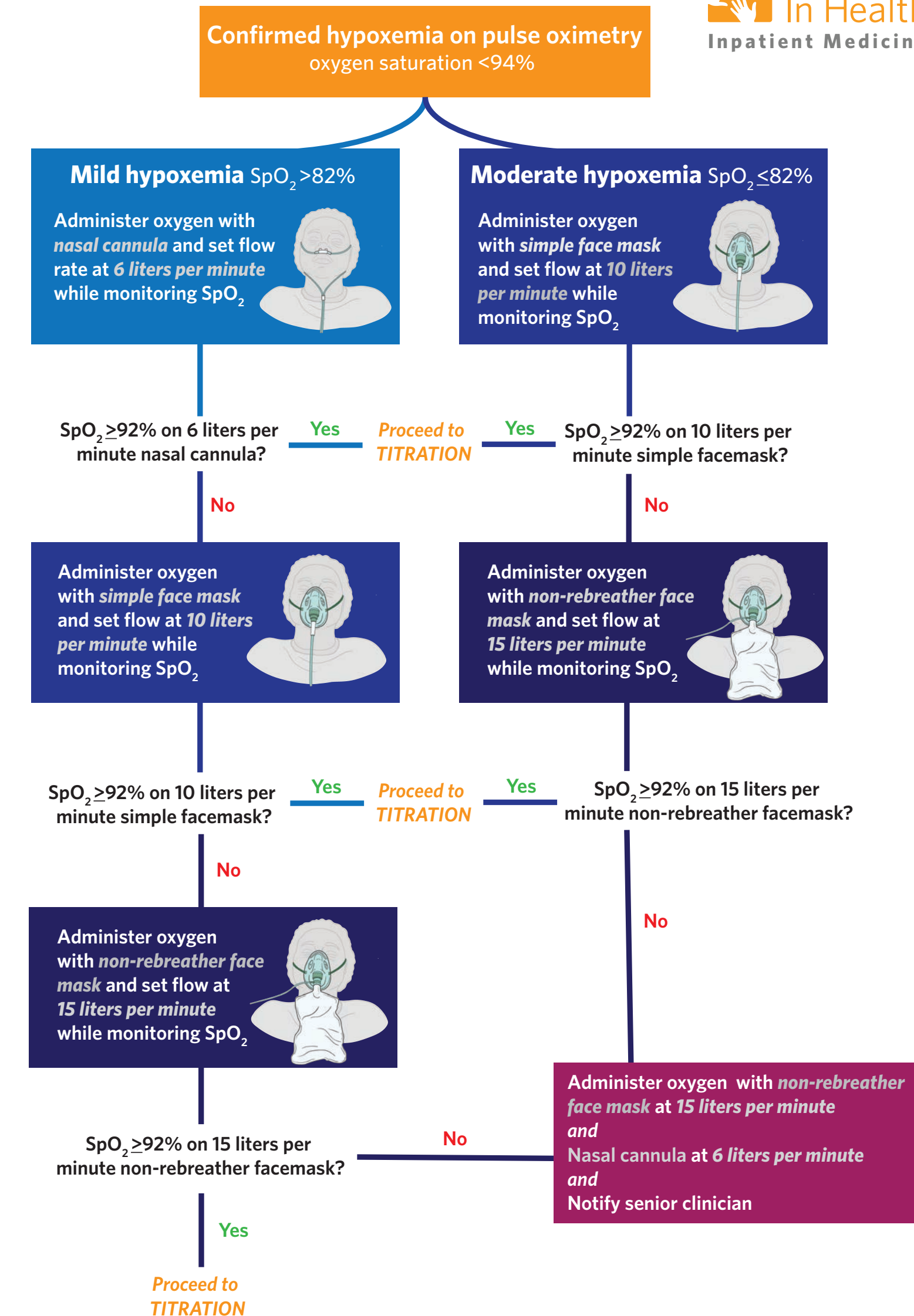
An oxygen cylinder is transported to bedside

He is given oxygen via nasal cannula at 6L/min

Oxygen saturation 1 minute later is 96%

The clinician continues to round on other patients...

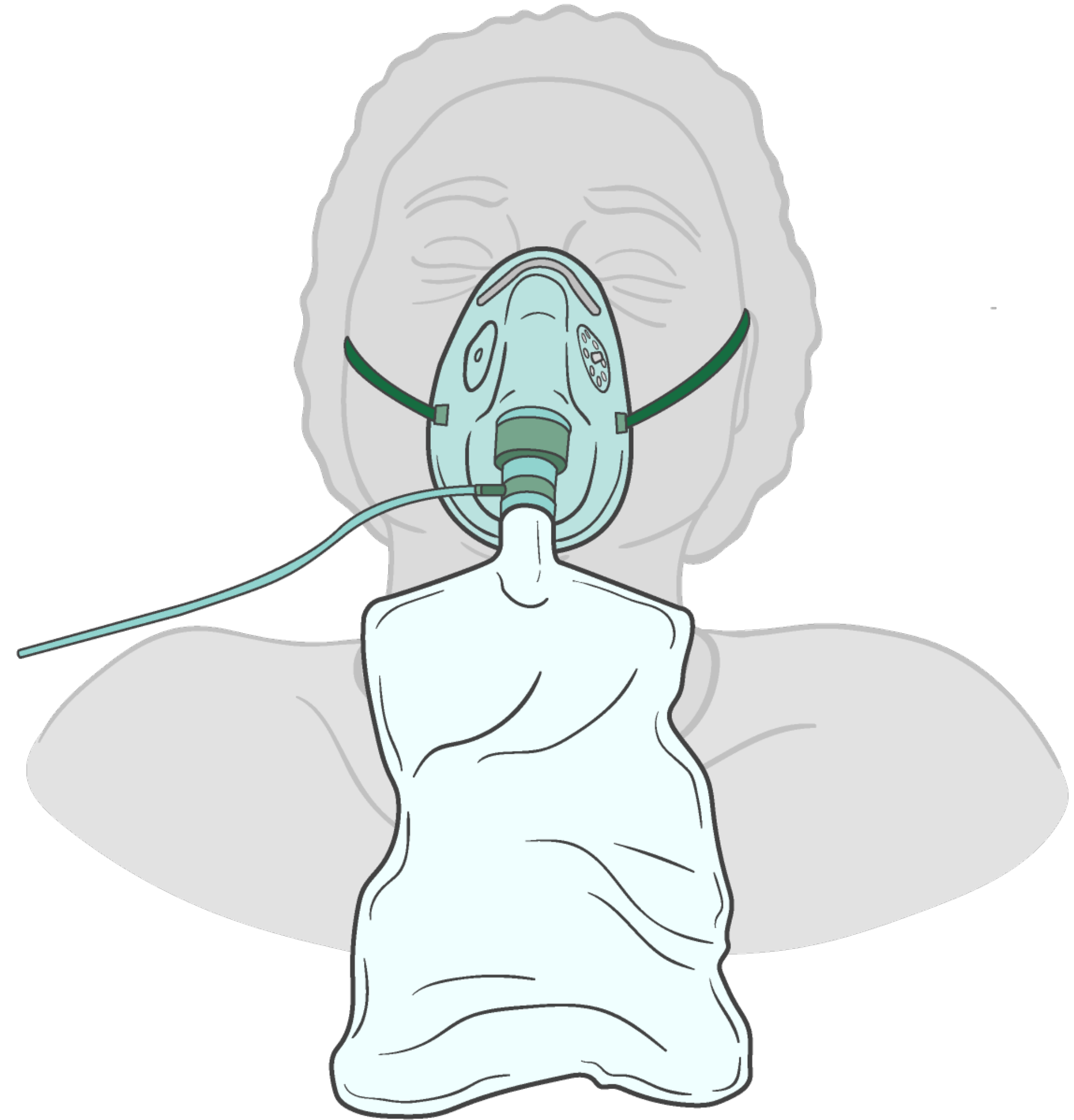
Stabilization

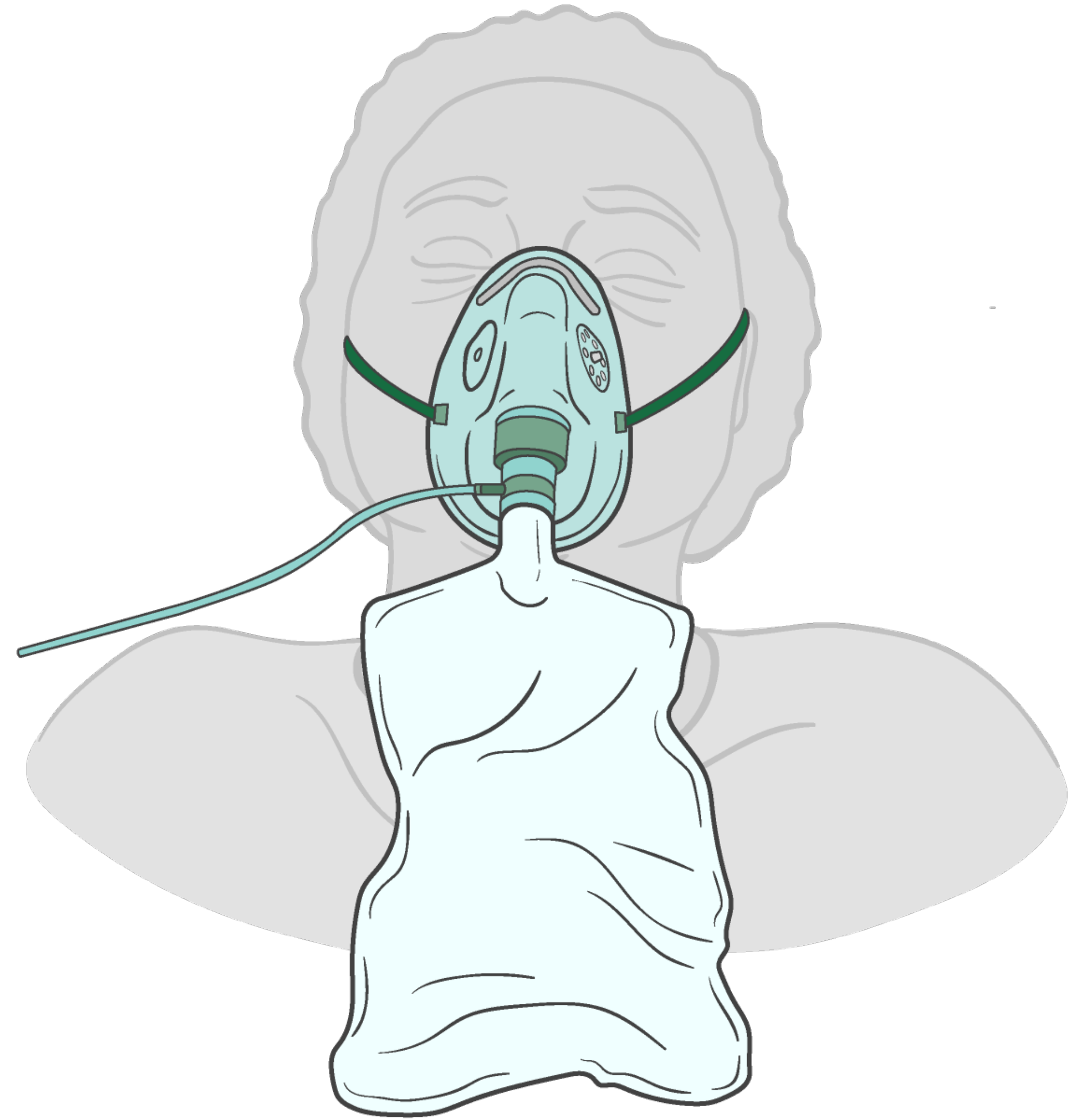
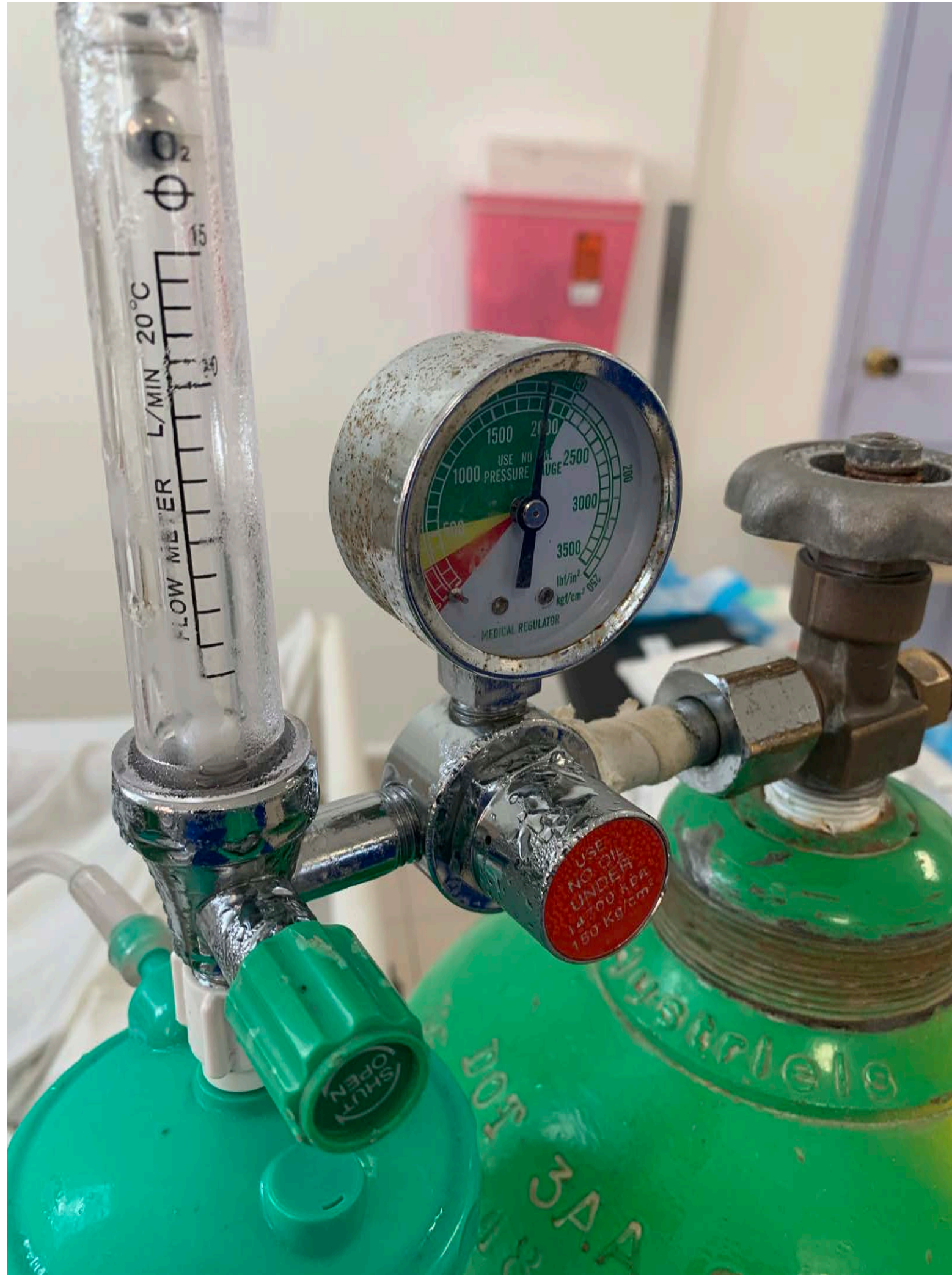


...Two hours later

The patient is comfortable with an oxygen saturation of 100%, but now on a reservoir facemask

Earlier, the patient became tachypneic and someone adjusted the oxygen



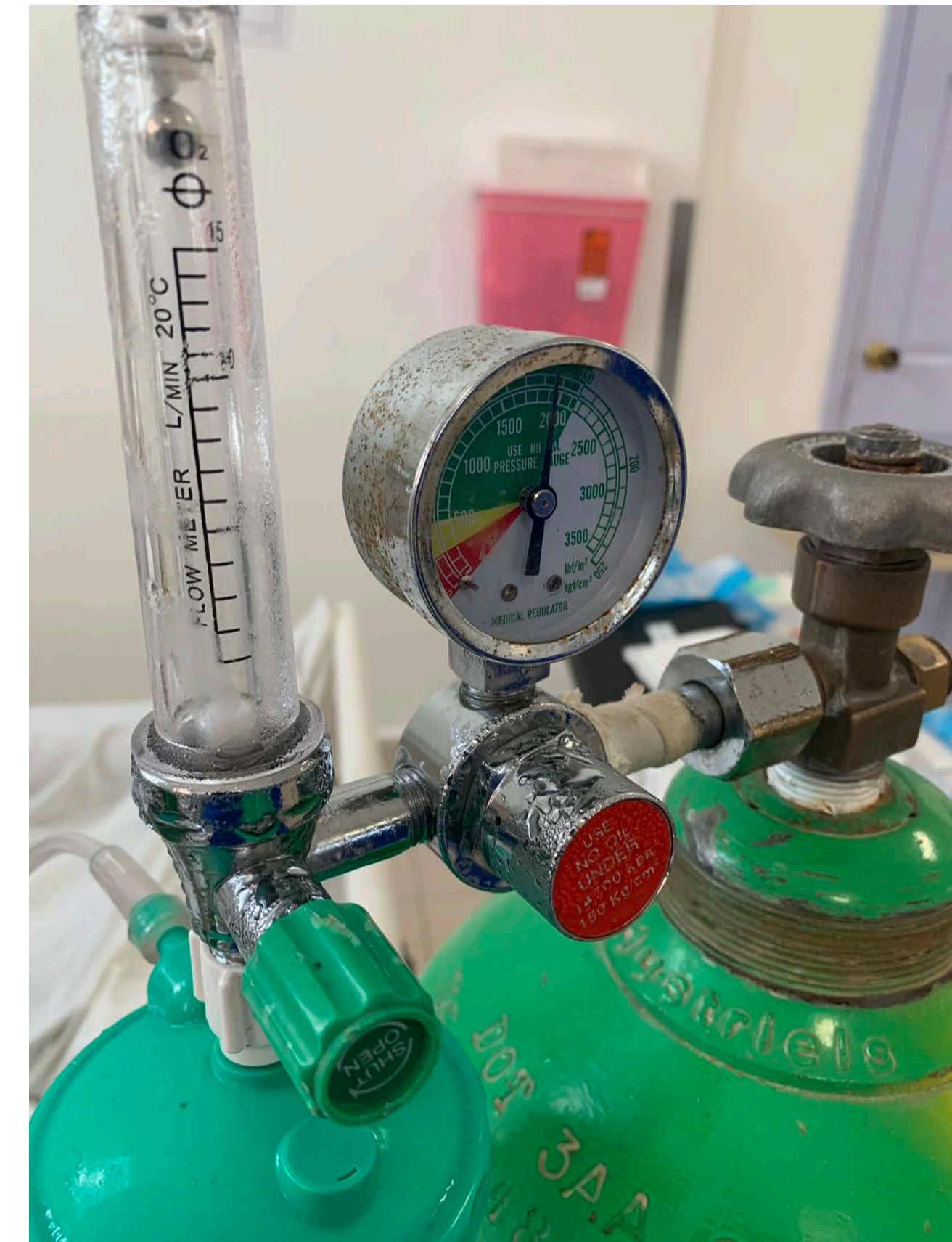


What flow of oxygen is the patient receiving?



“Flush” setting on flowmeters

*Flush settings vary from
40L/min to **75L/min** or
more*



Case lessons

Use of pulse oximeters

Importance of regular titration of oxygen

Avoid leaving patients on “flush” if they do not need it

Oxygen weaning trials should be performed regularly on all stable patients with SpO₂ >94%

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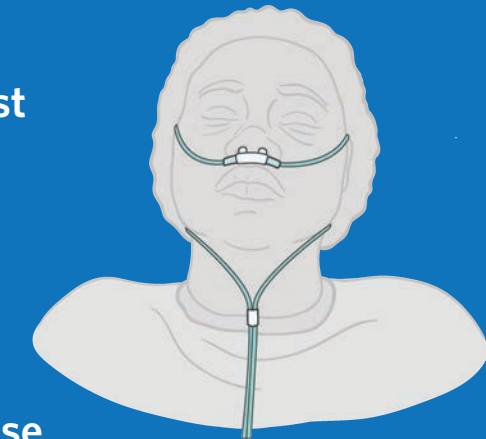
Nasal cannula

Oxygen flow 1 to 3 L/min

Turn off oxygen while continuously monitoring SpO₂ for at least 5 minutes. If SpO₂ drops below 92%, increase oxygen to the lowest flow necessary to maintain SpO₂ > 92%

Oxygen flow 4 to 6 L/min

Reduce oxygen to 3 L/min while continuously monitoring SpO₂ for at least 5 minutes. If SpO₂ drops below 92%, increase oxygen to the lowest flow necessary to maintain SpO₂ > 92%



Simple facemask

Reduce oxygen to 6 L/min while continuously monitoring SpO₂ for at least 5 minutes

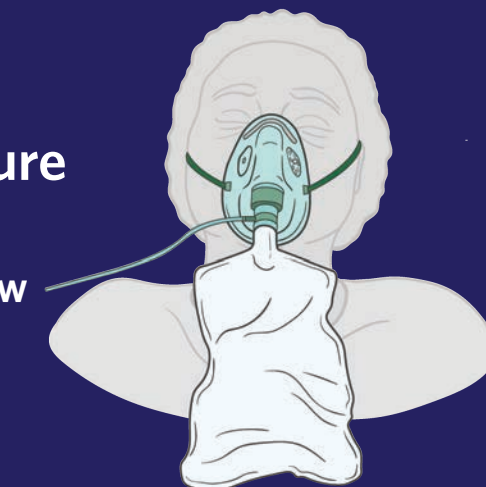
- If SpO₂ drops below 92%, increase oxygen to the lowest flow necessary to maintain SpO₂ > 92%
- If SpO₂ remains above 92%, change the patient to a nasal cannula at 6 L/min.



Reservoir facemask

Reduce oxygen to 6 L/min while continuously monitoring SpO₂ for at least 5 minutes (make sure the reservoir remains inflated)

- If SpO₂ drops below 92%, increase oxygen to the lowest flow necessary to maintain SpO₂ > 92%
- If SpO₂ remains above 92% change the patient to a simple facemask at 10 L/min



Objective 3

Learn techniques to reduce unnecessary oxygen use

Estimated daily savings from respiratory interventions

Intervention	Reduced demand	Full cylinders saved^	Cost savings* (USD)
Titrating flowmeter on flush (75 L/min) down to 15L/min	60 L/min	14	\$322 to \$1568

^ Assumes J-type cylinder with safe residual pressure of 200psi and 6,120L of effective oxygen

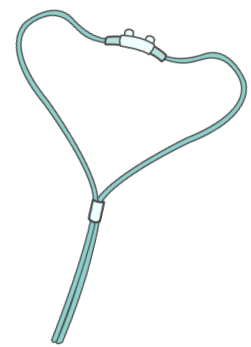
*Cylinder price estimates form: <https://www.thebureauinvestigates.com/stories/2020-08-09/lack-of-oxygen-leaves-covid-19-patients-in-africa-gasping-for-air>

Oxygen interfaces

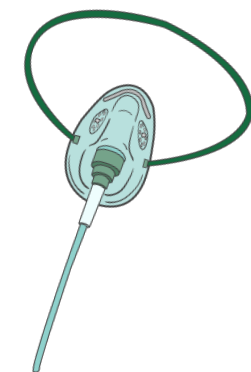
Oxygen interfaces



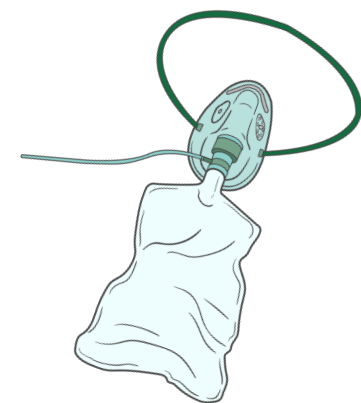
Room air



Nasal cannula



Simple facemask



Reservoir facemask (non-rebreather)

Understanding oxygen interfaces

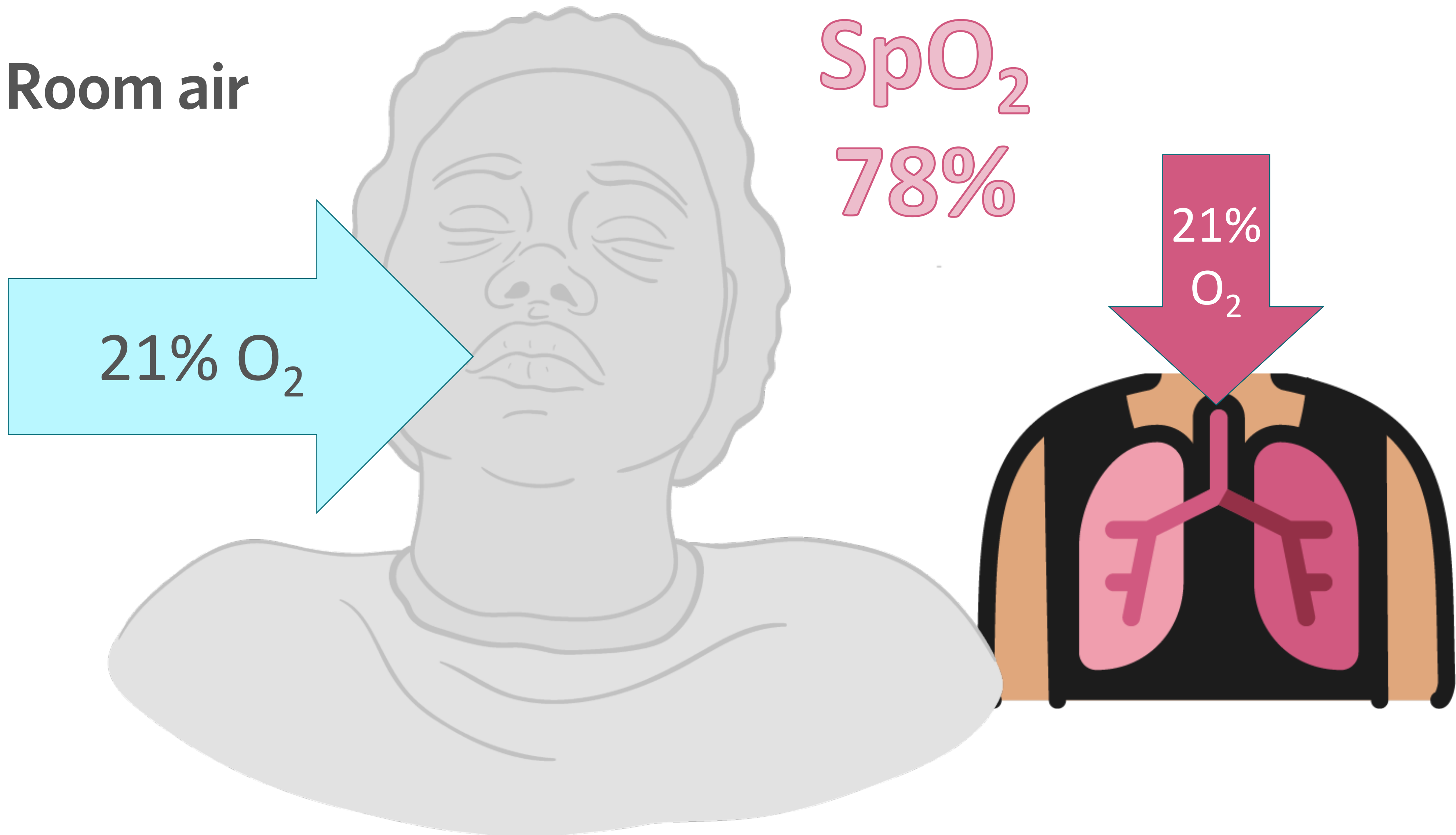
1. Oxygen flow delivered through interface
2. Room air entrained
3. Oxygen content of gas entering the lungs

Room air

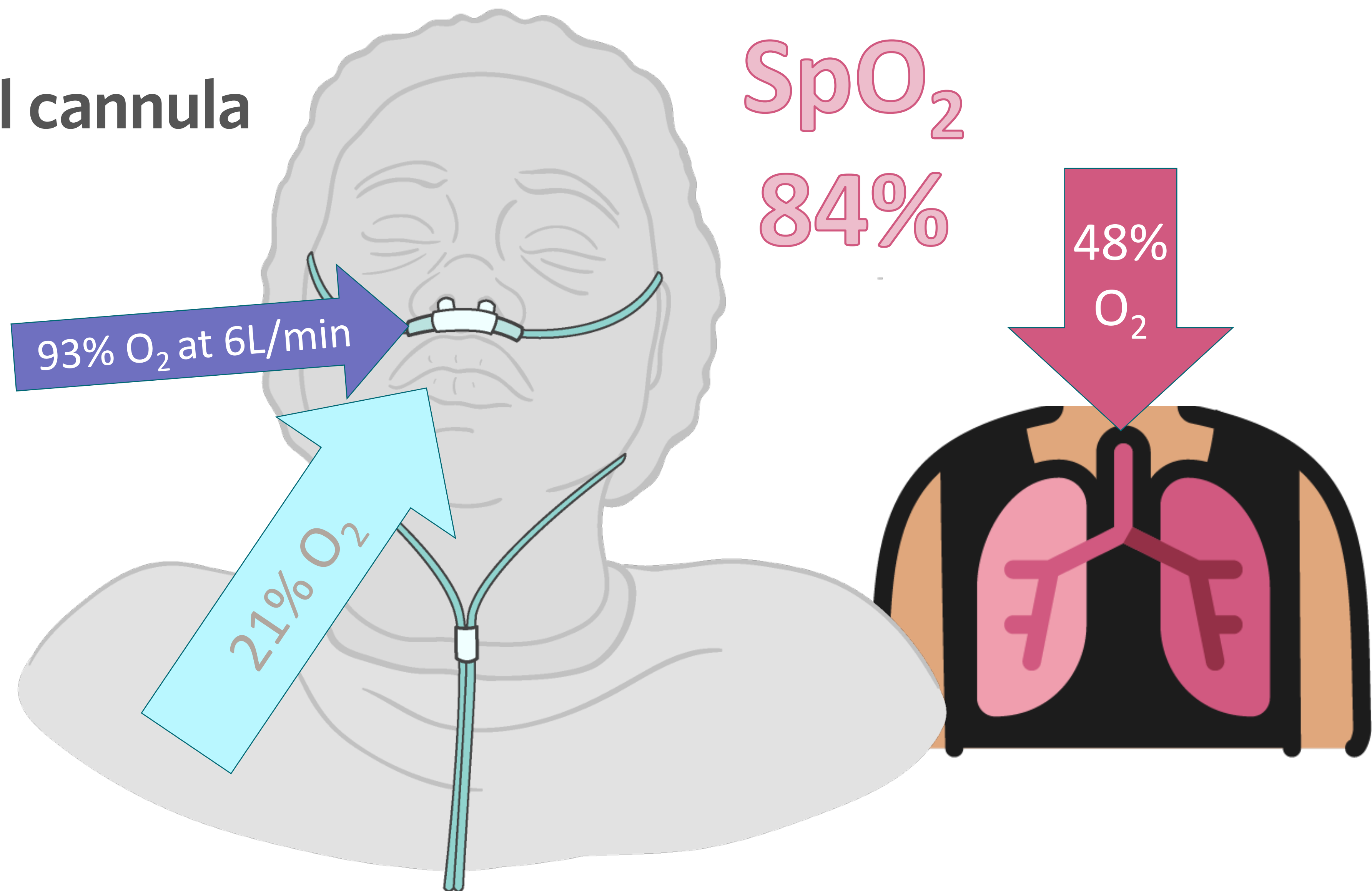
21% O₂

SpO₂
78%

21%
O₂

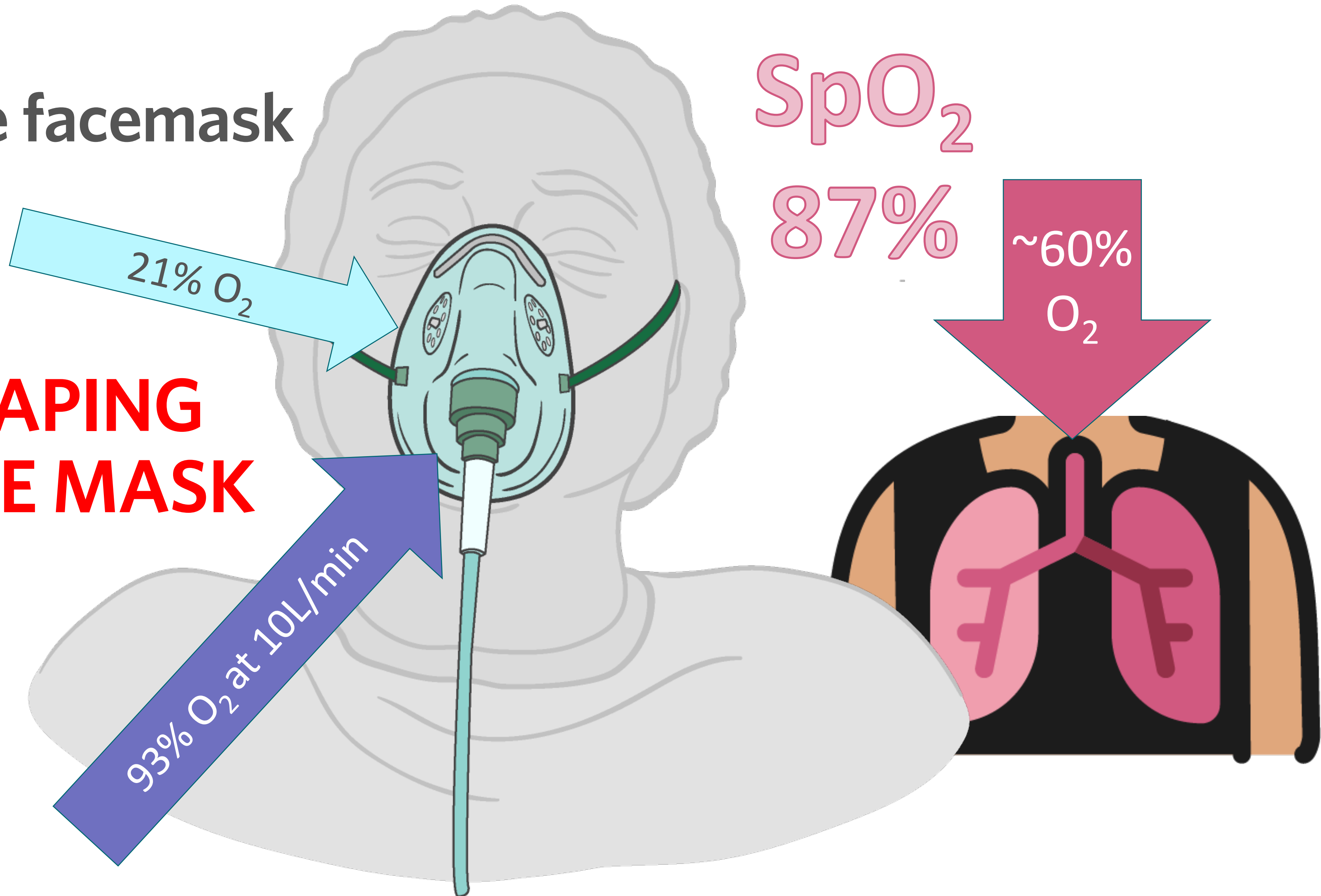


Nasal cannula



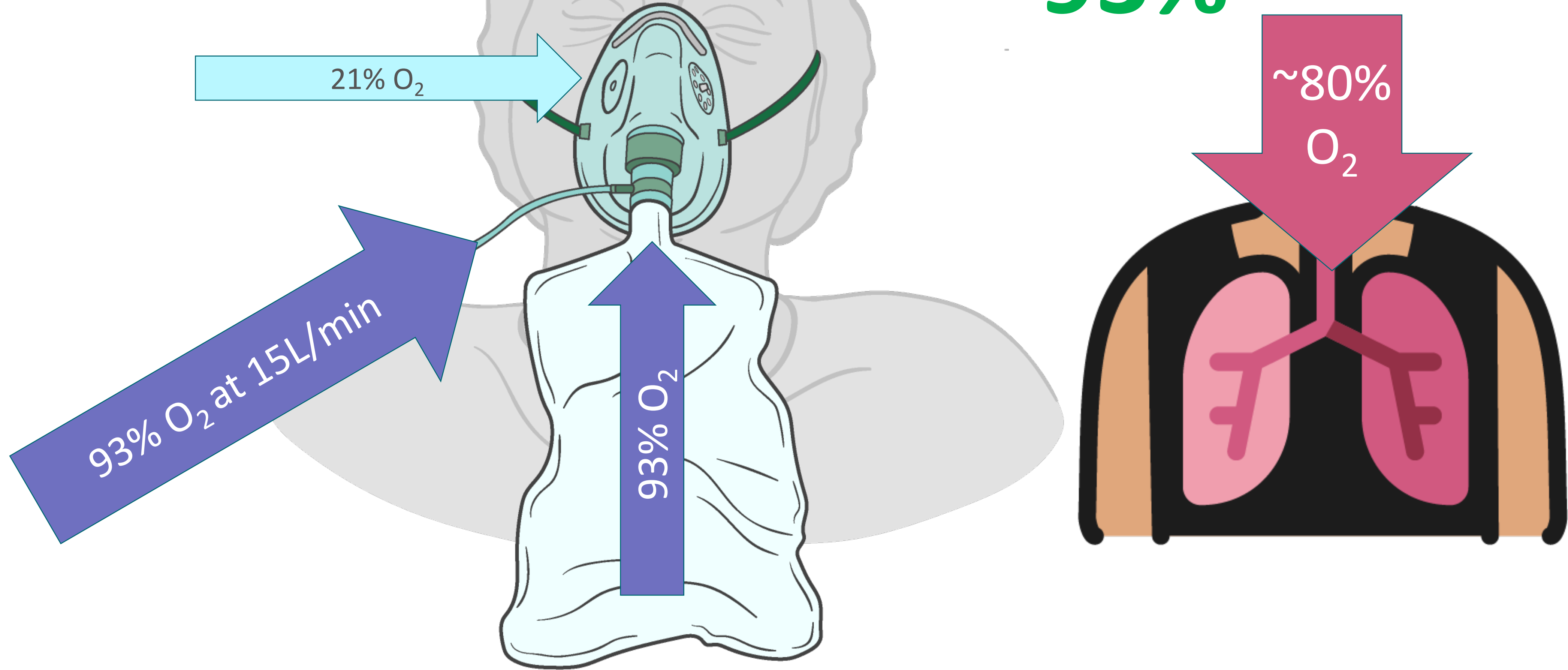
Simple facemask

**AVOID TAPING
OVER THE MASK
HOLES**

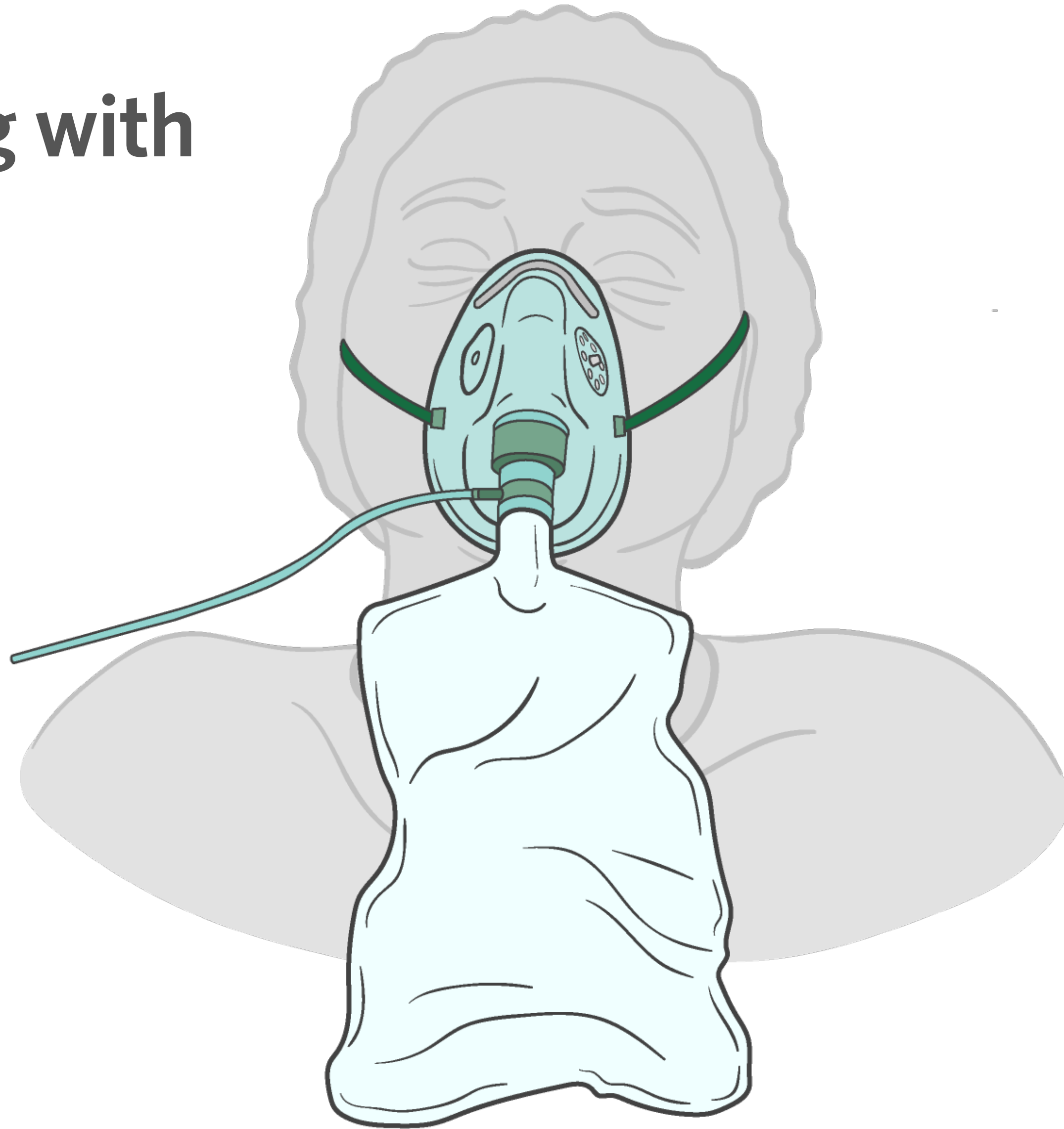


Non-rebreather facemask

SpO₂
93%

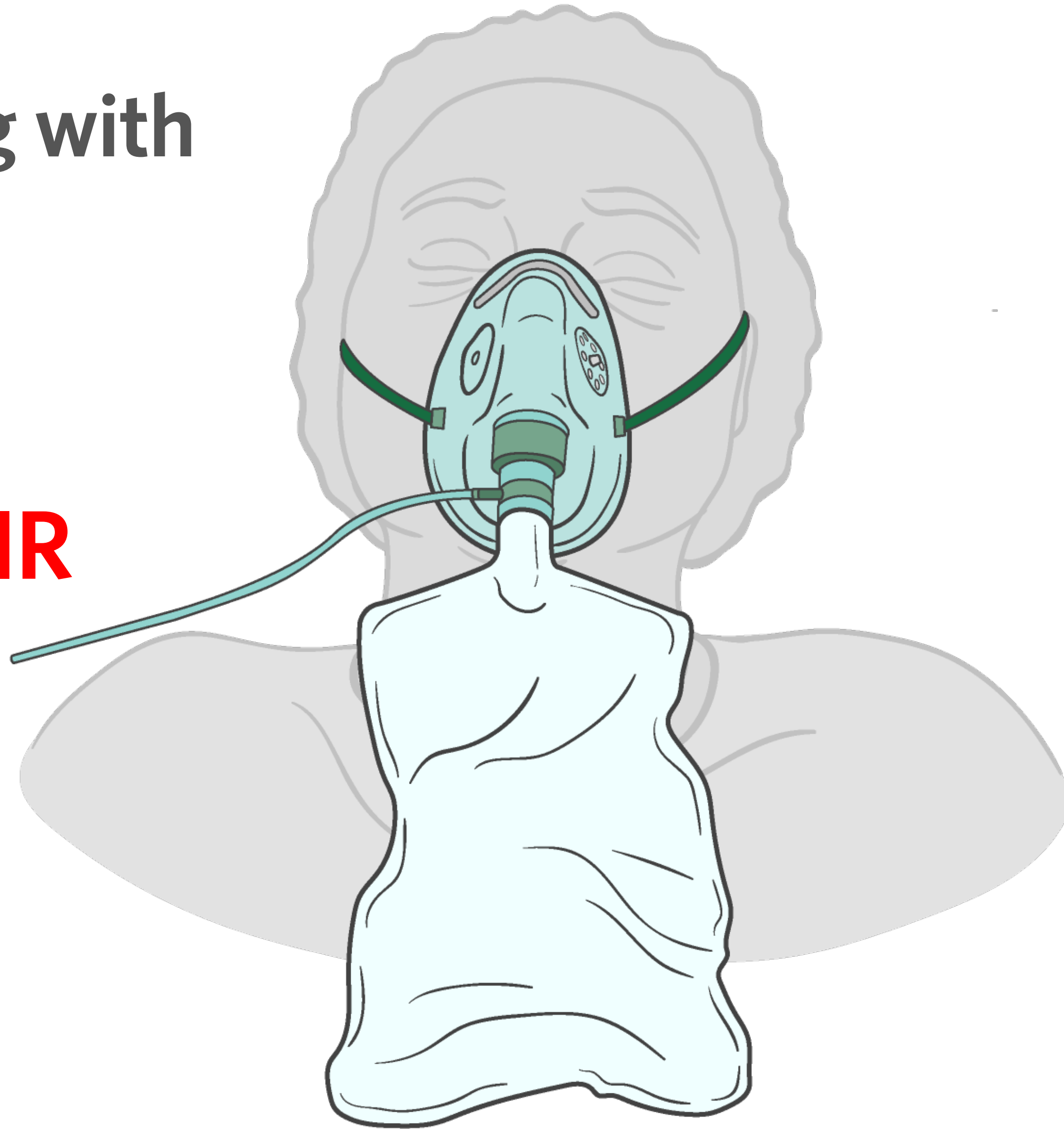


What is wrong with
this picture?



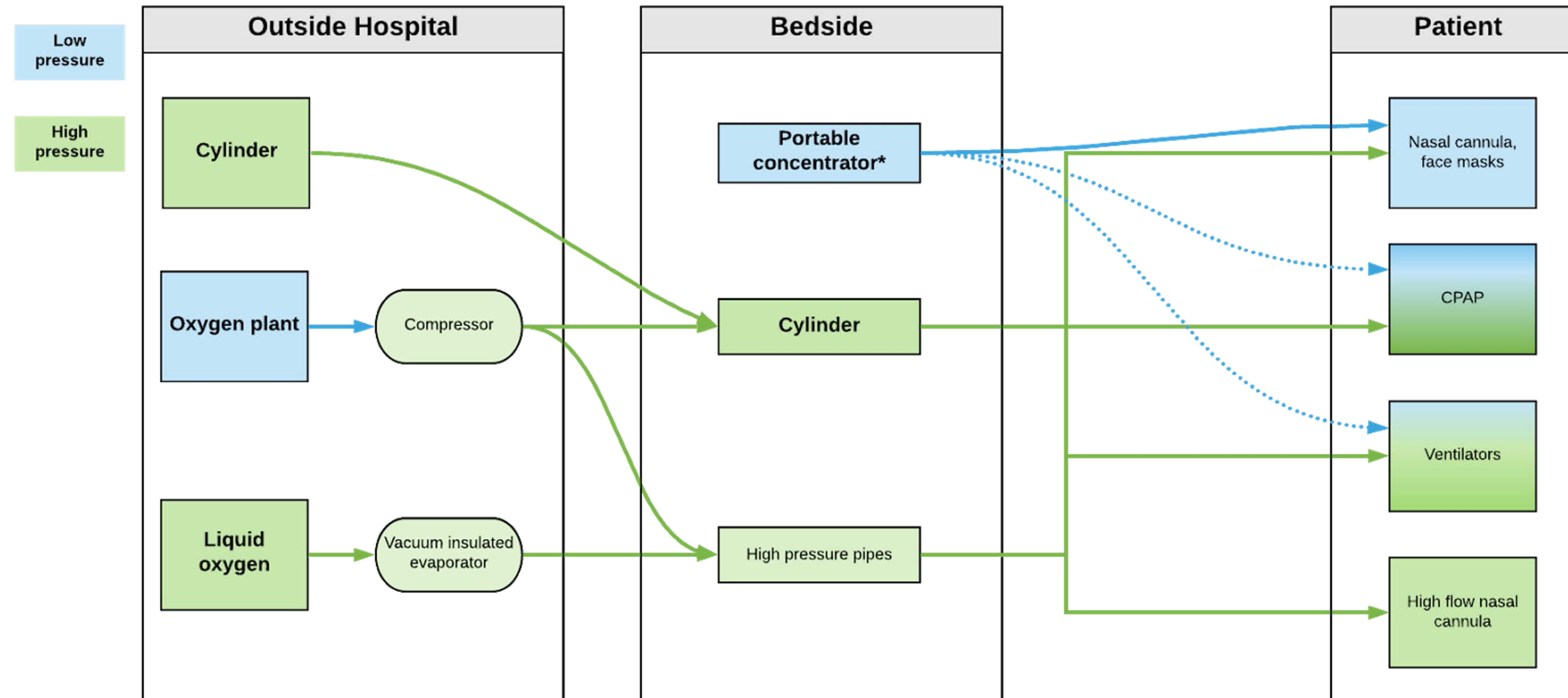
What is wrong with
this picture?

**THE RESEVOIR
MUST BE
INFLATED!!**



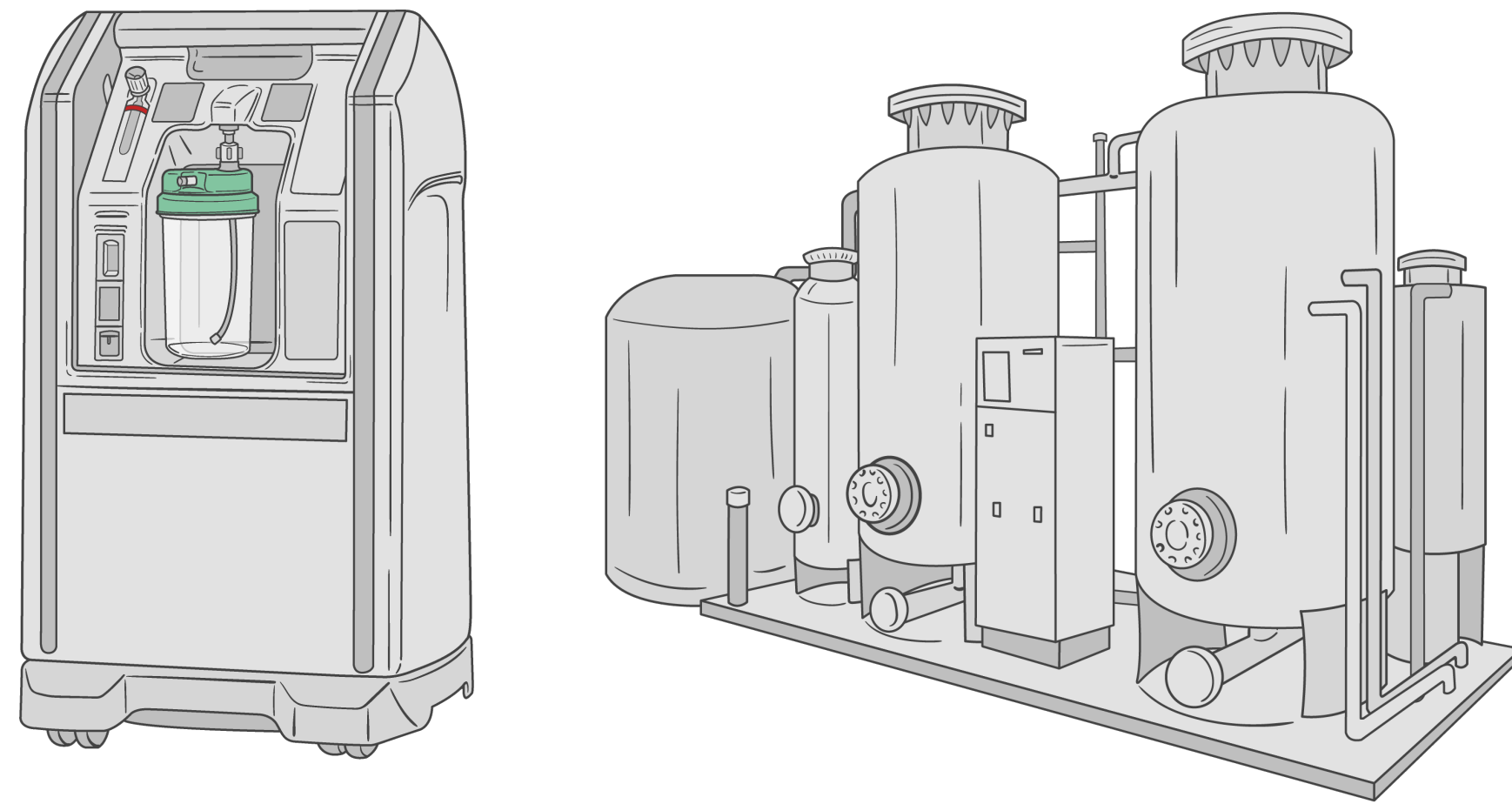
Oxygen sources

Oxygen sources

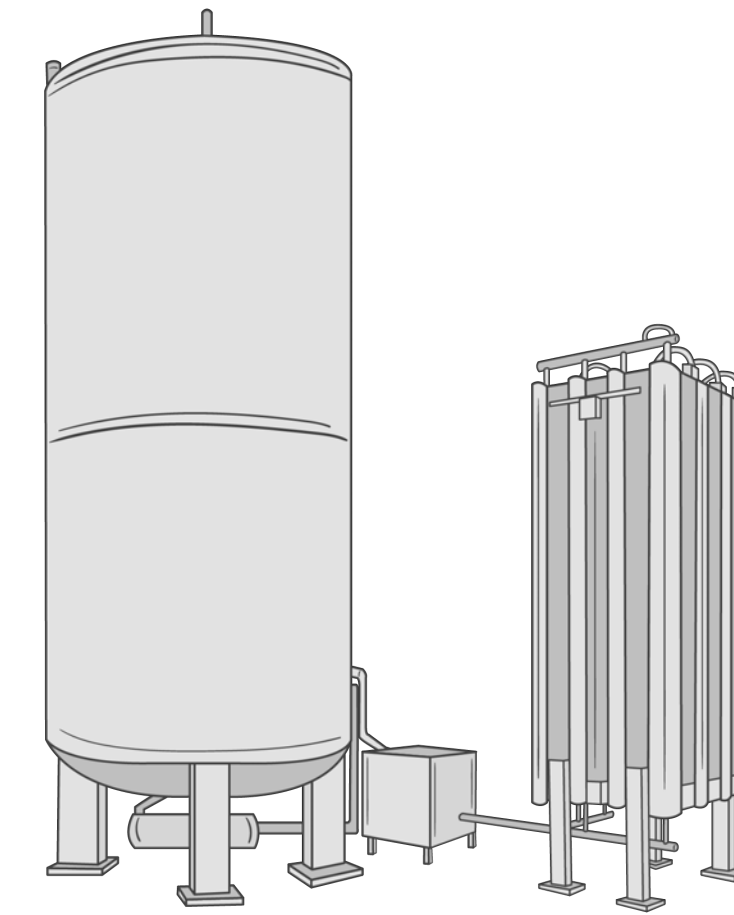


Generating oxygen

Oxygen from PSA plants and concentrators is safe and effective



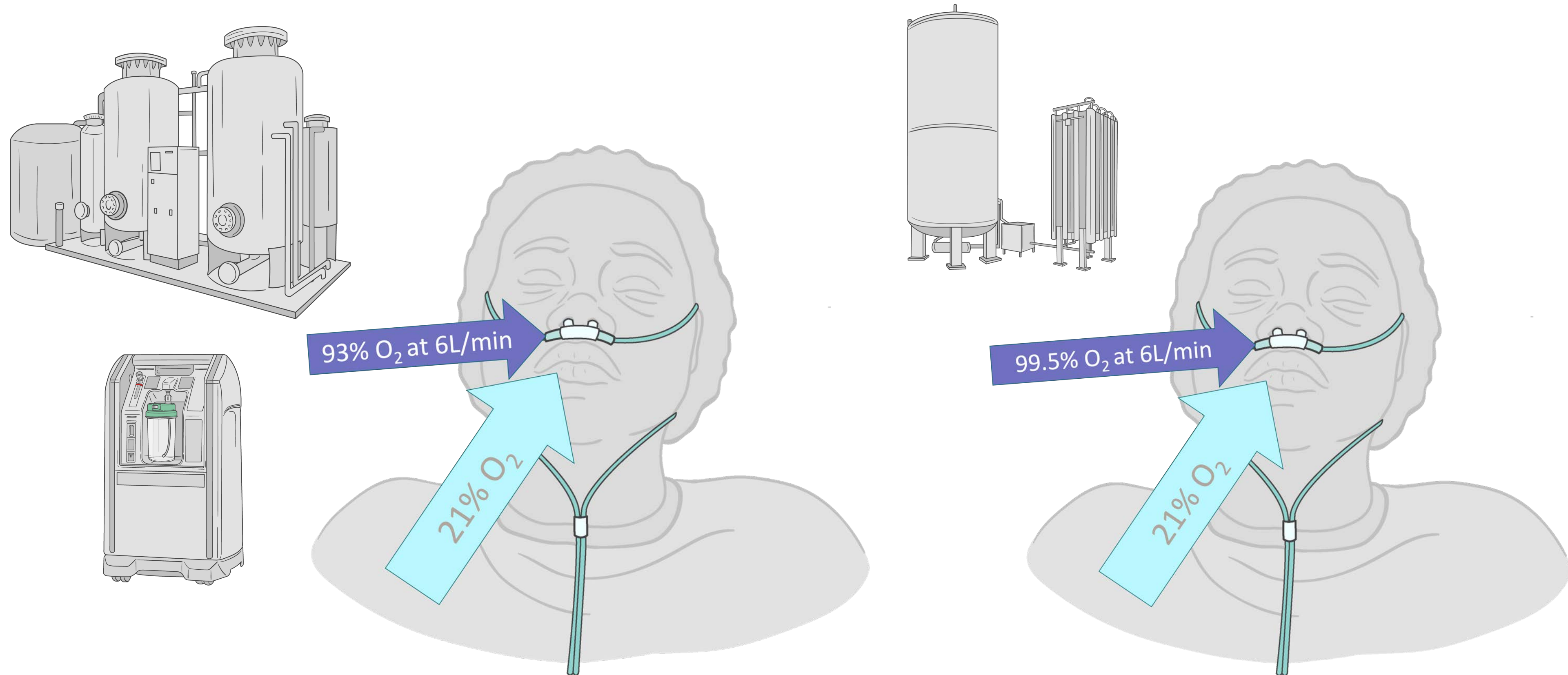
93% O₂



99.5% O₂

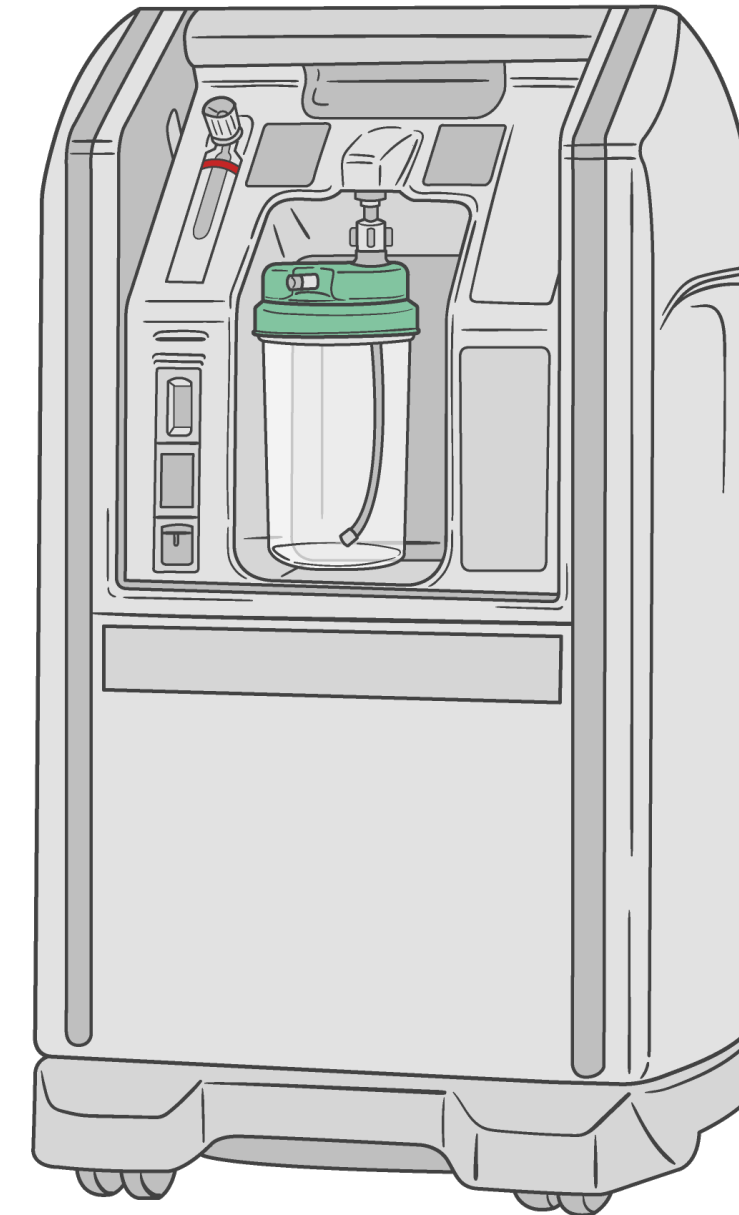
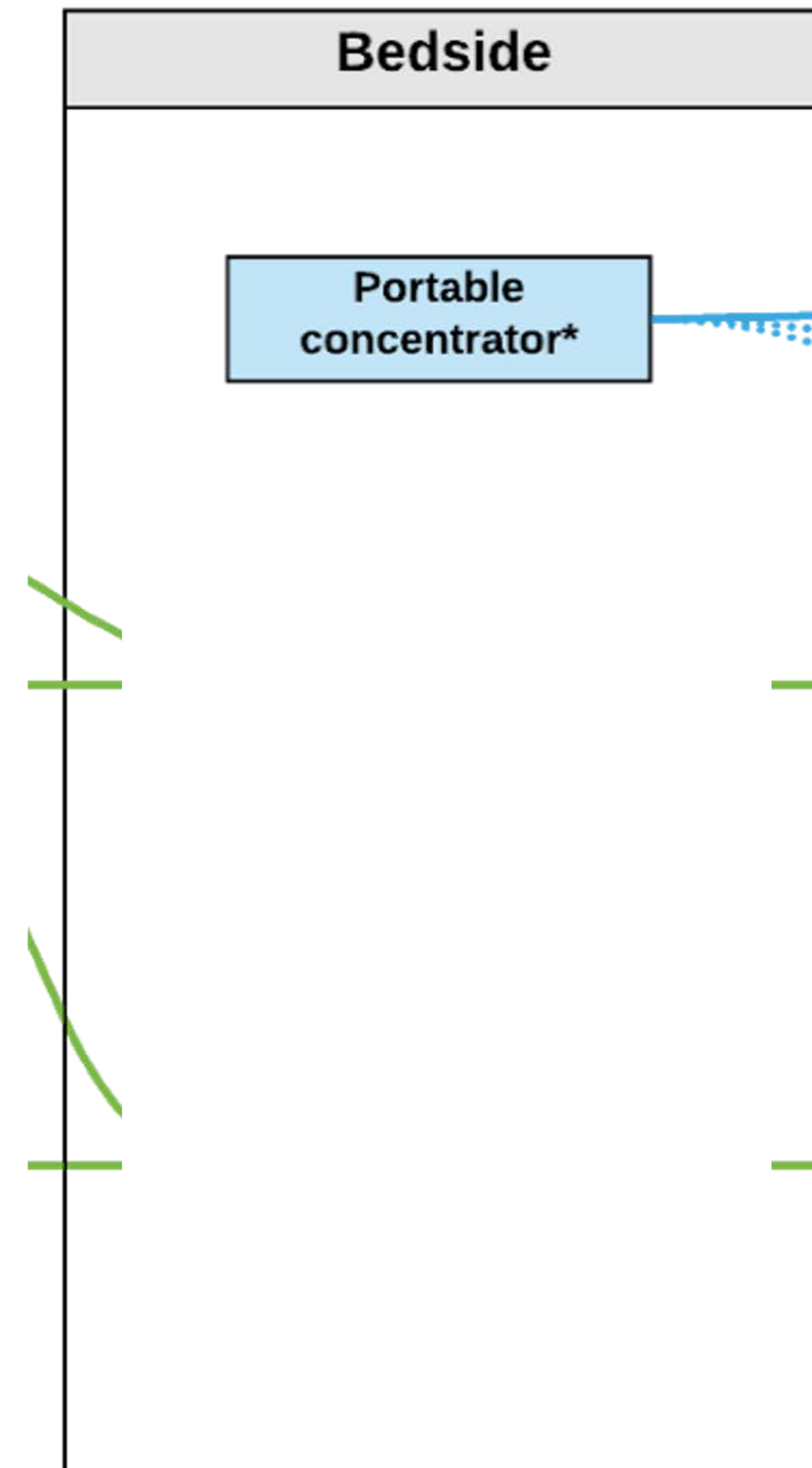
Generating oxygen

Oxygen from PSA plants and concentrators is safe and effective



Bedside oxygen sources

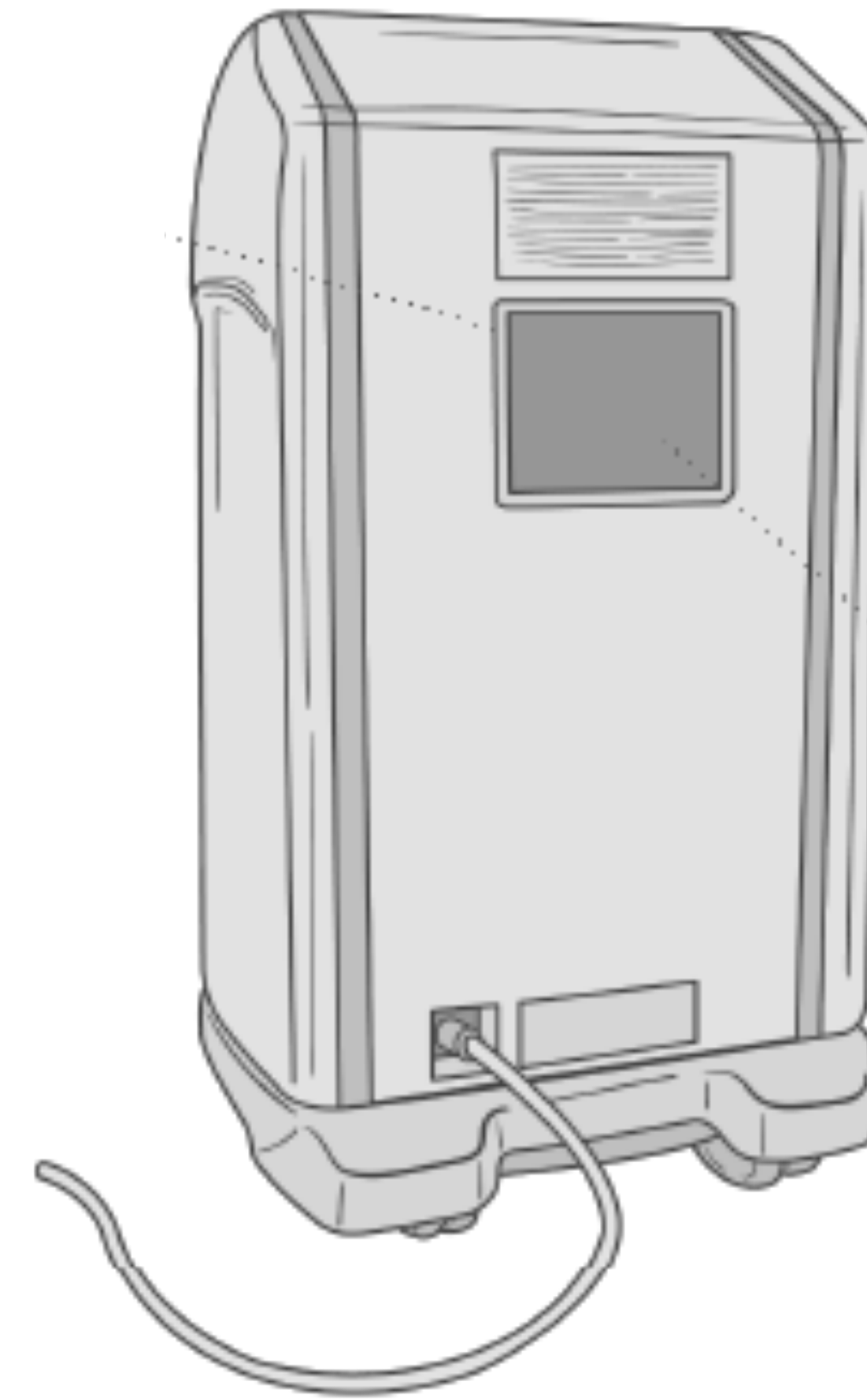
Low pressure sources



Concentrators



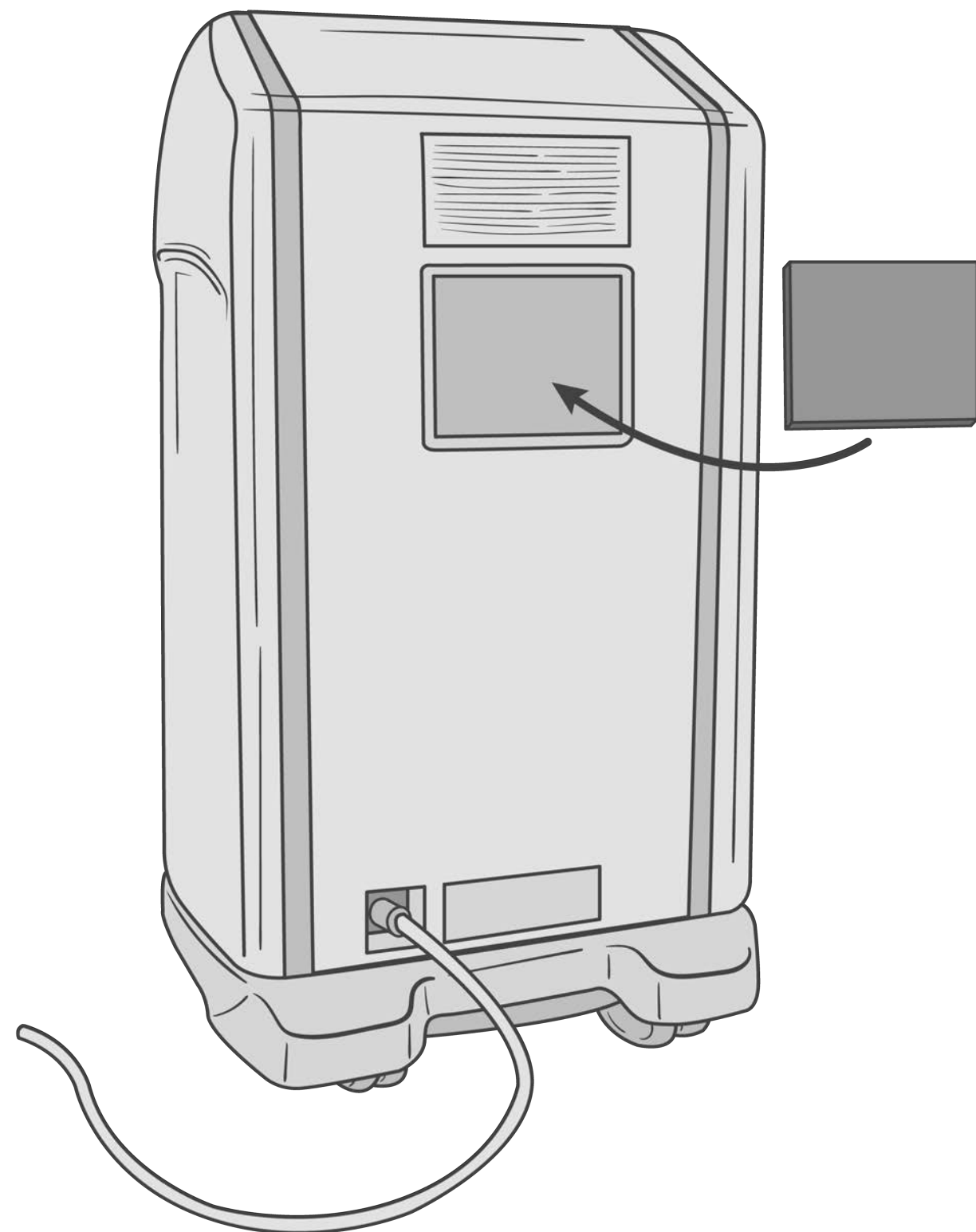
Cleaning the filter



Position

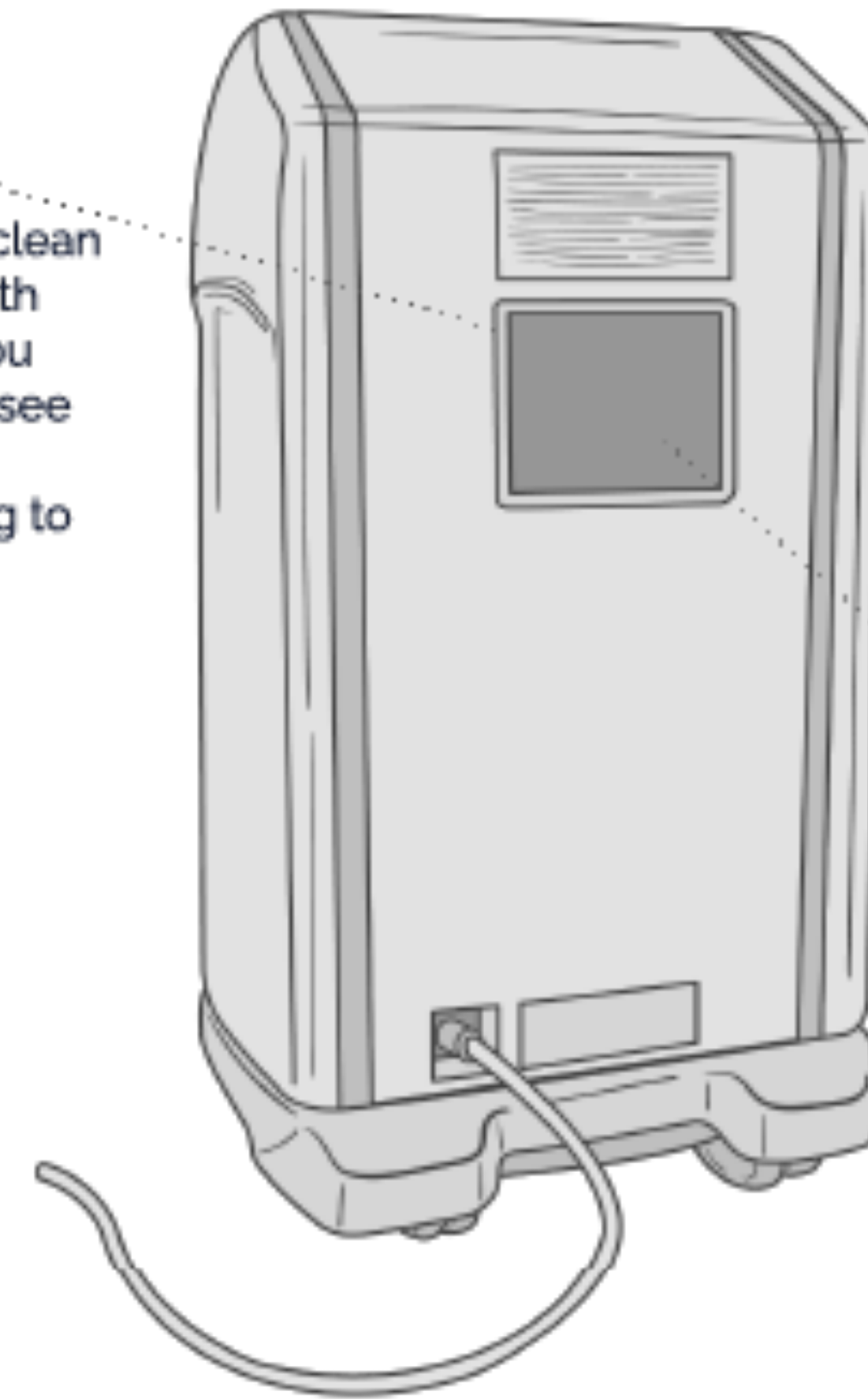
Always position the unit upright and keep the inlet filter away from walls, curtains and obstruction.

Cleaning the filter



Air Inlet filter

Inspect daily and clean at least weekly with soap and water. You should be able to see through it when removed & holding to light. Must be dry before use.

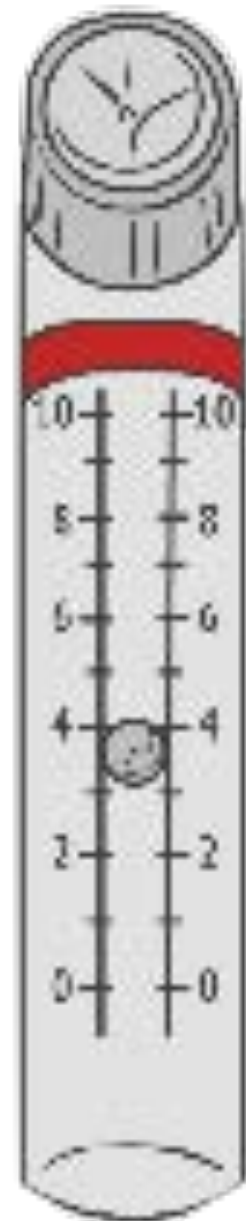


Position

Always position the unit upright and keep the inlet filter away from walls, curtains and obstruction.

Inspect & clean air inlet filter 1-2x **weekly**
(A second air filter is needed to ensure continuous use while cleaning and drying one air filter)

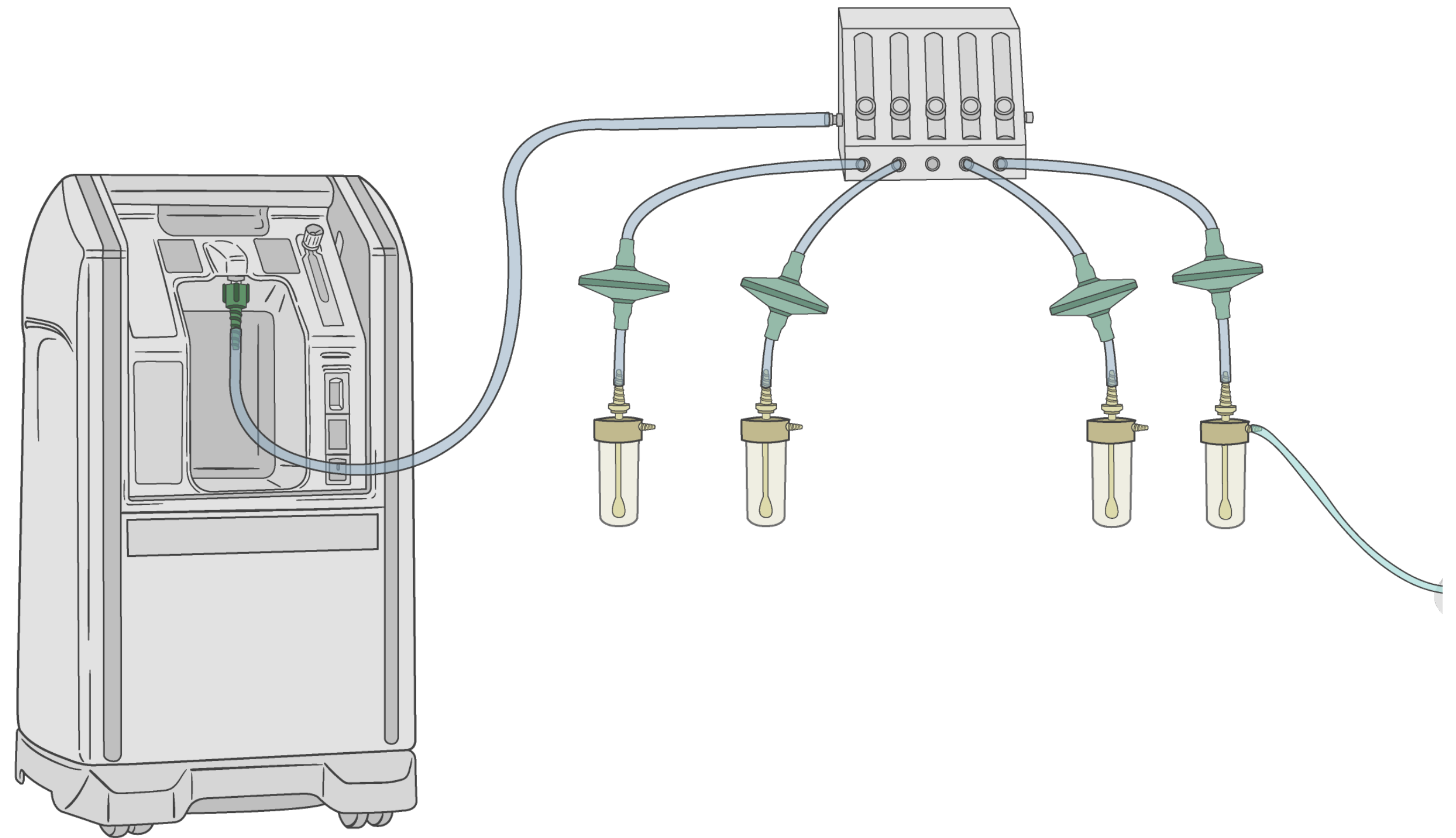
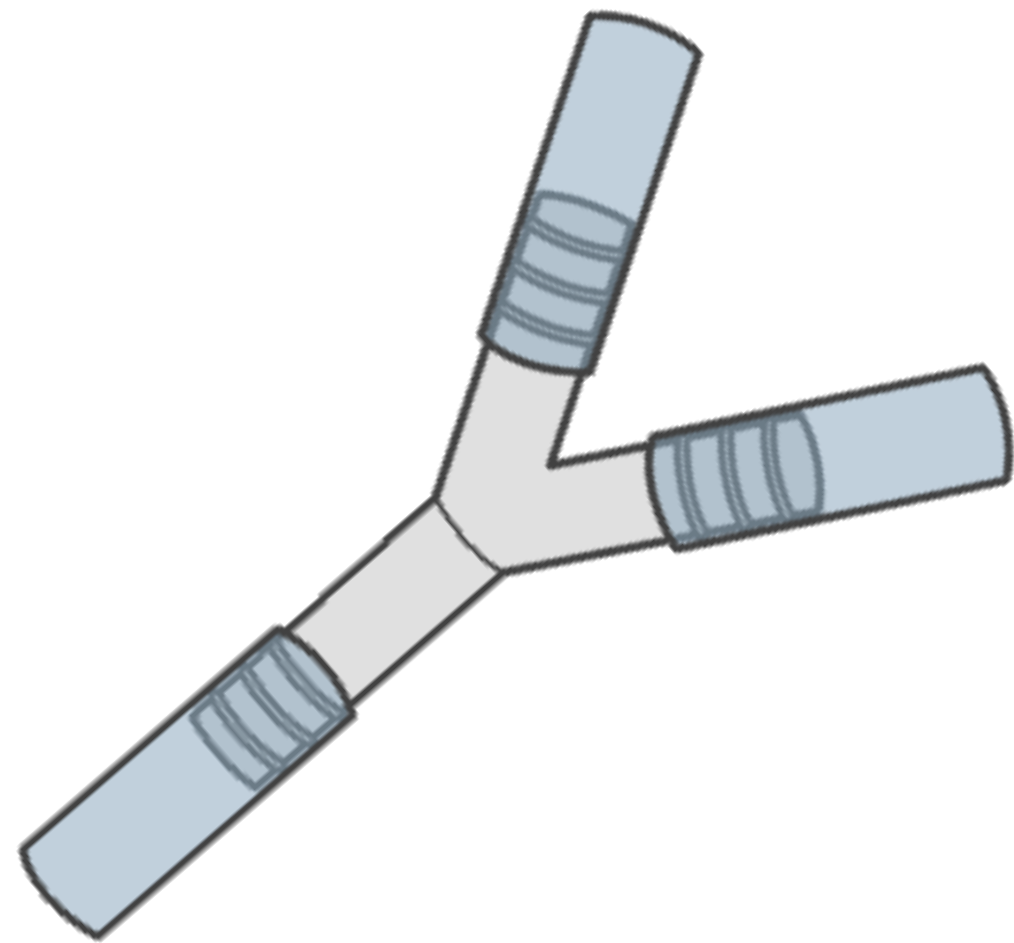
Maximum flow



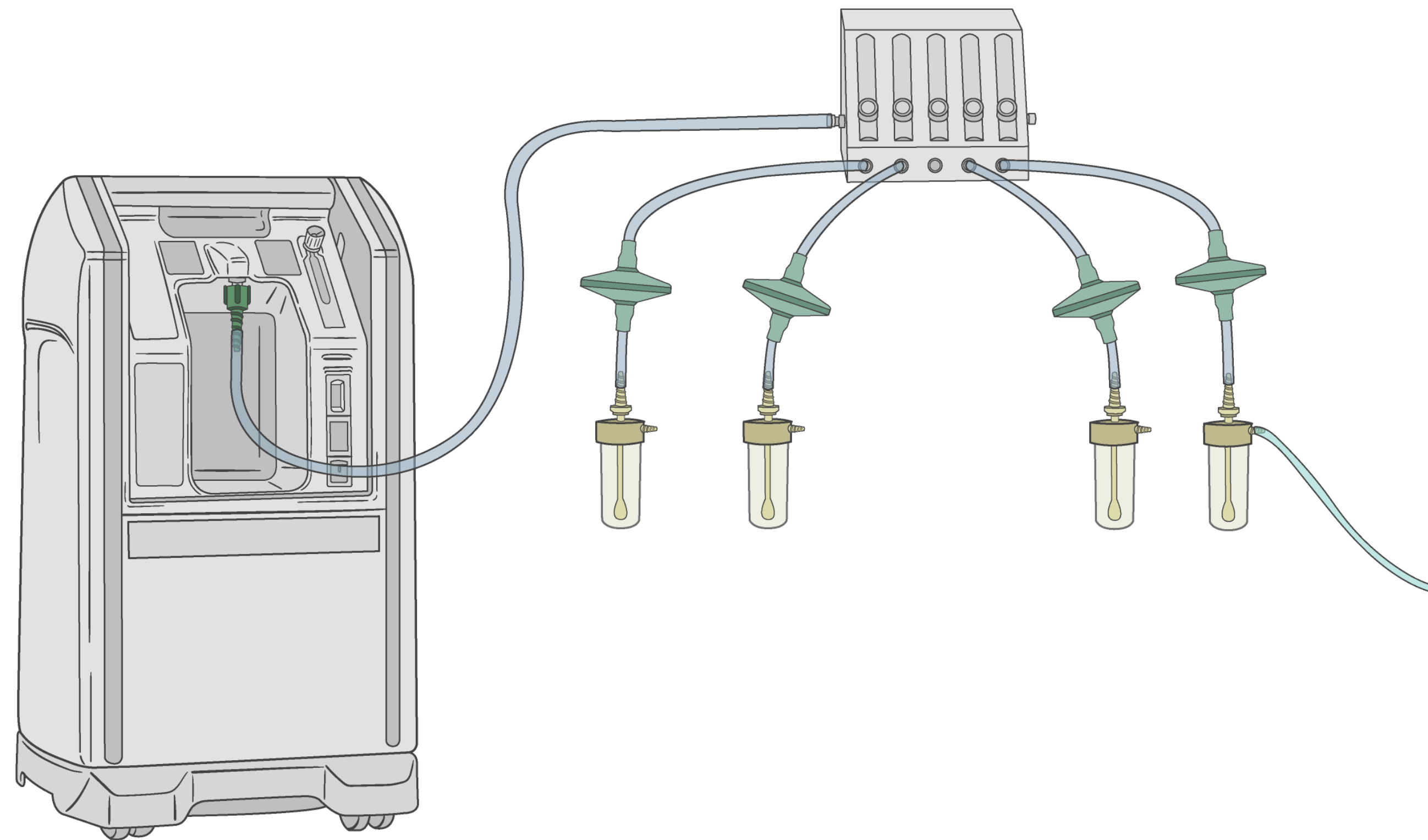
Flowmeter
DO NOT adjust
flow above max
rated output.



Splitting concentrators



How much oxygen can each patient use?



Flowmeter
DO NOT adjust
flow above max
rated output.

Objective 3

Learn techniques to reduce unnecessary oxygen use

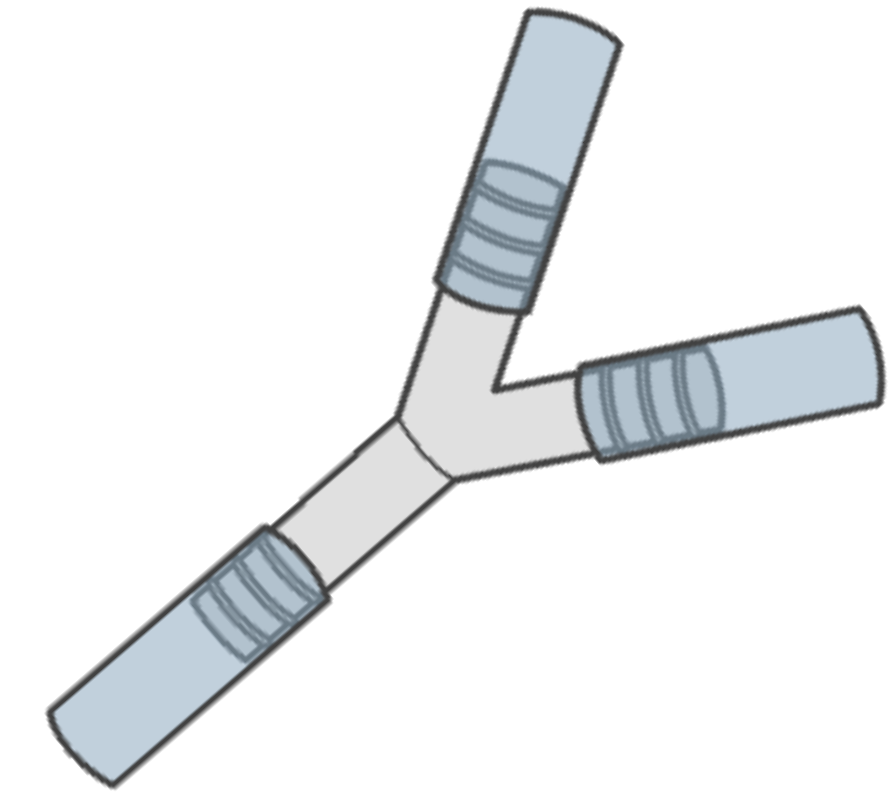
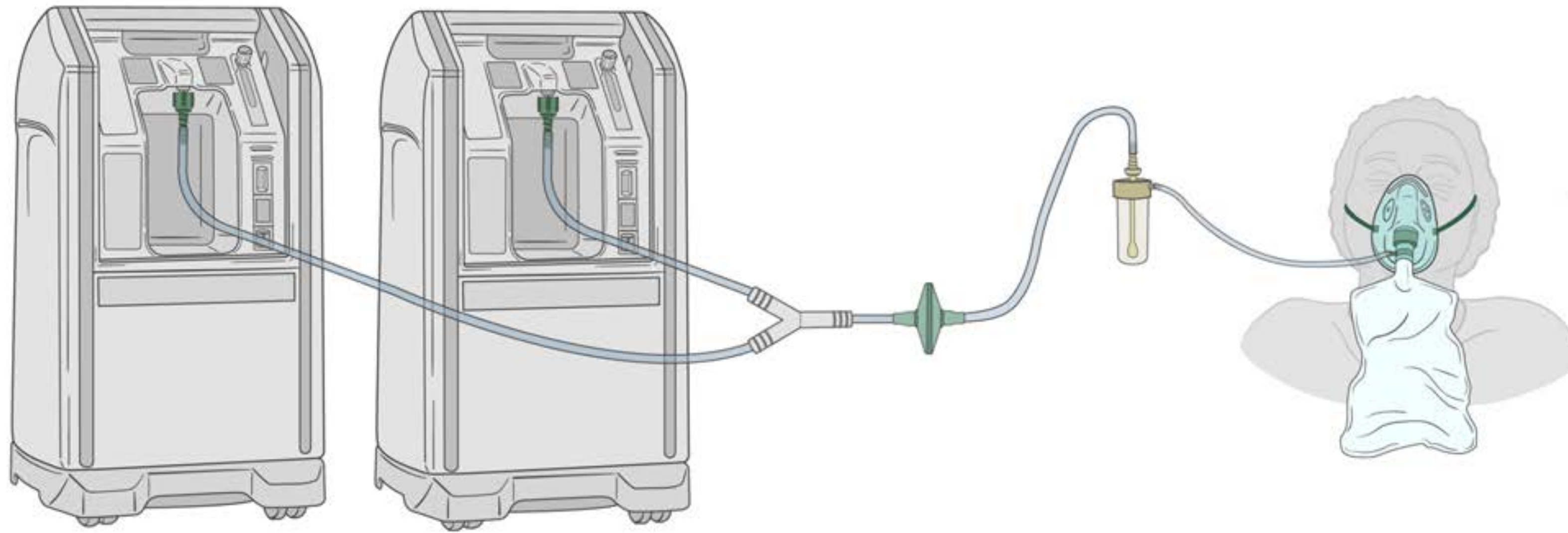
Estimated daily savings from respiratory interventions

Intervention	Reduced demand	Full cylinders saved^	Cost savings* (USD)
Titrating flowmeter on flush (75 L/min) down to 15L/min	60 L/min	14	\$322 to \$1568
Splitting a concentrator for two patients on 5L/min	5 L/min	1	\$23 to \$112

^ Assumes J-type cylinder with safe residual pressure of 200psi and 6,120L of effective oxygen

*Cylinder price estimates form: <https://www.thebureauinvestigates.com/stories/2020-08-09/lack-of-oxygen-leaves-covid-19-patients-in-africa-gasping-for-air>

Combining concentrators



Objective 3

Learn techniques to reduce unnecessary oxygen use

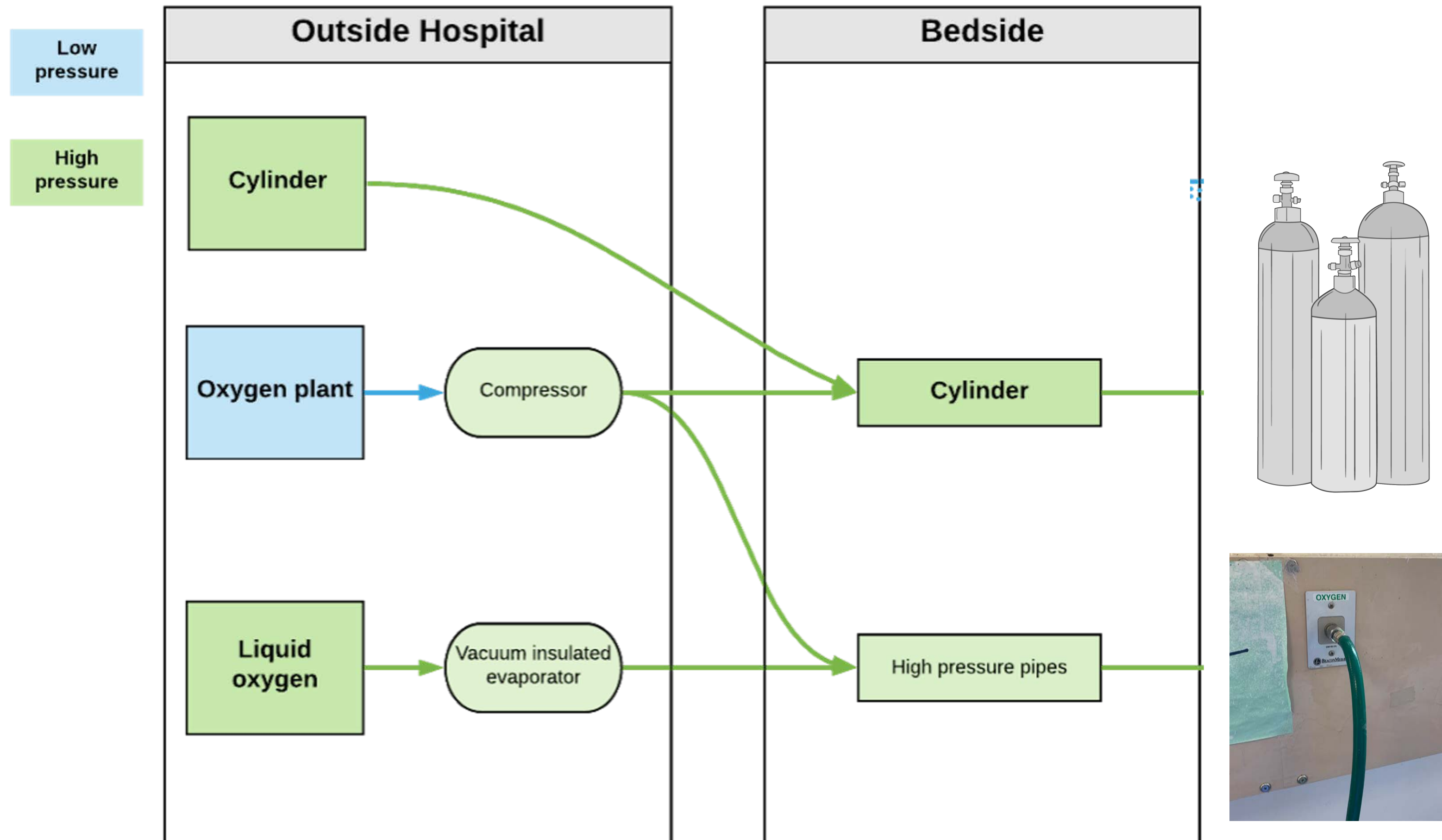
Estimated daily savings from respiratory interventions

Intervention	Reduced demand	Full cylinders saved^	Cost savings* (USD)
Titrating flowmeter on flush (75 L/min) down to 15L/min	60 L/min	14	\$322 to \$1568
Splitting a concentrator for two patients on 5L/min	5 L/min	1	\$23 to \$112
Using two concentrators for a patient on reservoir mask	15 L/min	3	\$69 to \$336

^ Assumes J-type cylinder with safe residual pressure of 200psi and 6,120L of effective oxygen

*Cylinder price estimates form: <https://www.thebureauinvestigates.com/stories/2020-08-09/lack-of-oxygen-leaves-covid-19-patients-in-africa-gasping-for-air>

High pressure sources



Which setups are delivering high pressure oxygen?



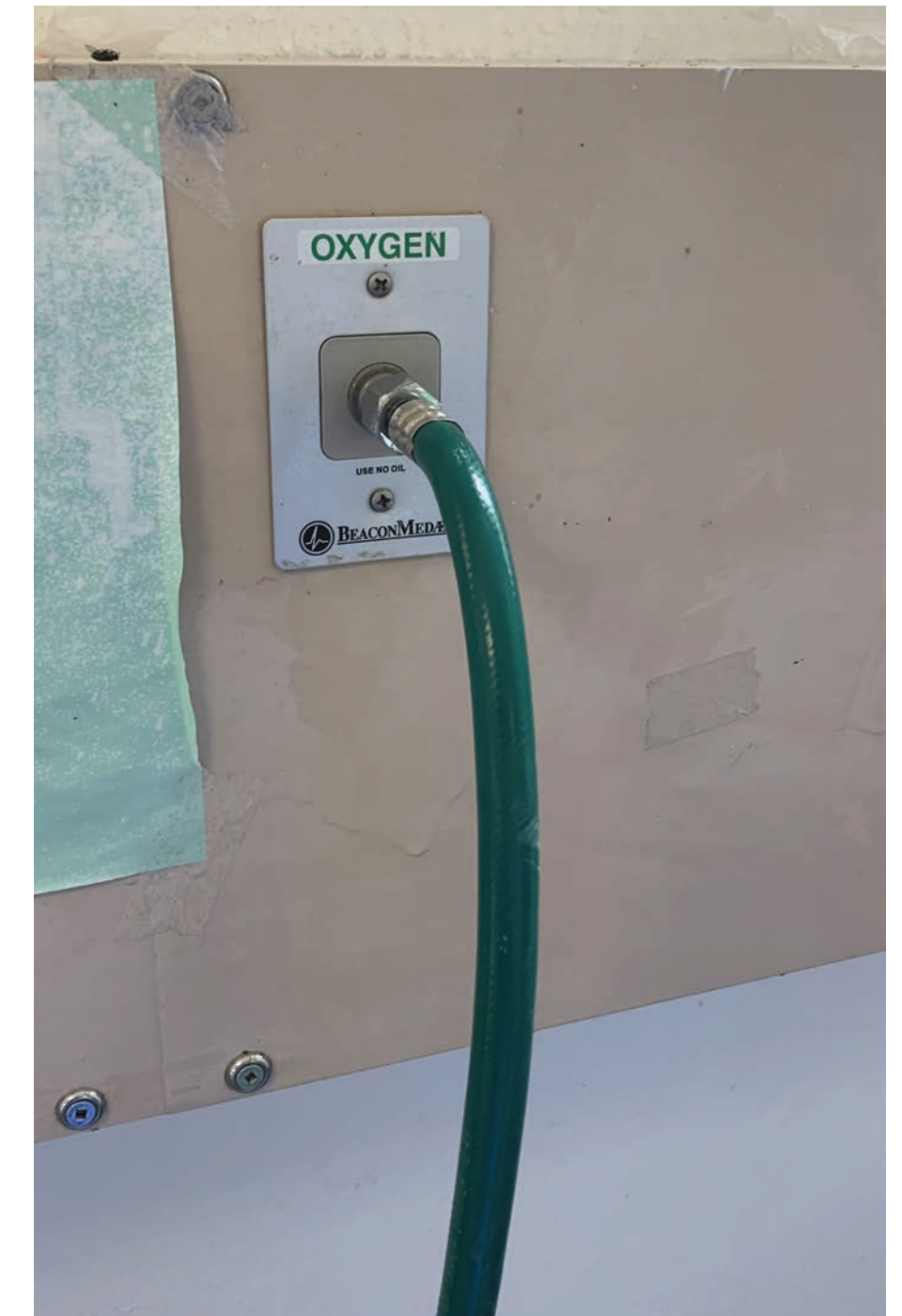
A



B



C



D

Which setups are delivering high pressure oxygen?



A



B



C

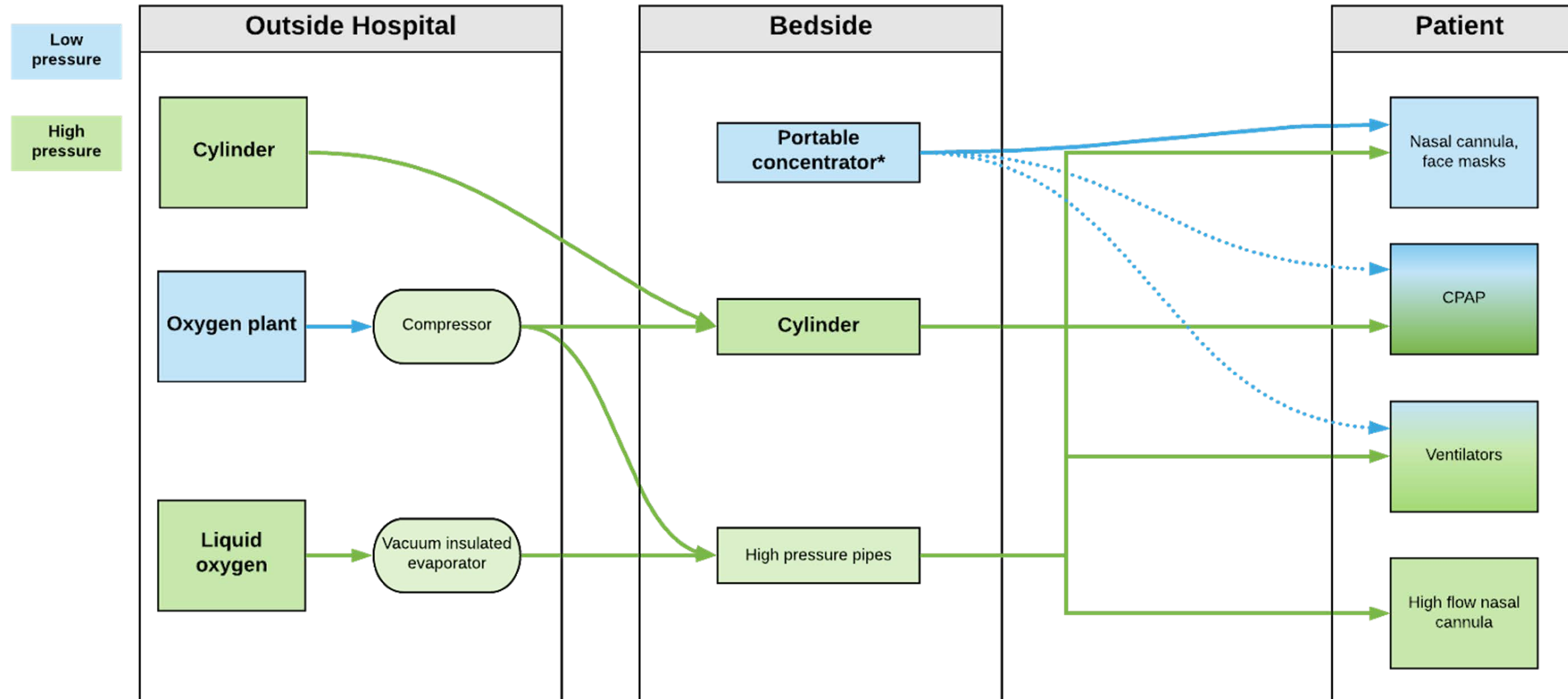


D

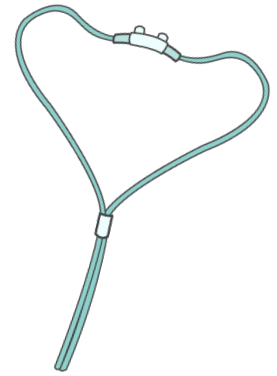
Matching interfaces & sources

Matching source and interface

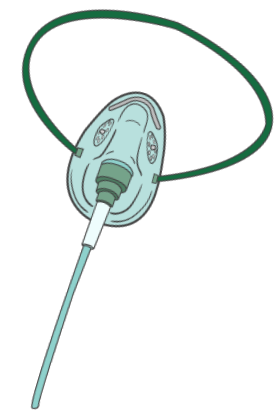
Consider pressure and flow



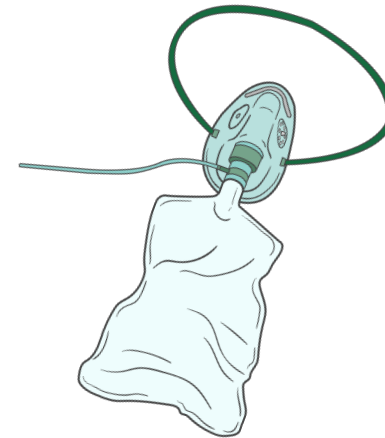
Low pressure interfaces



Nasal cannula

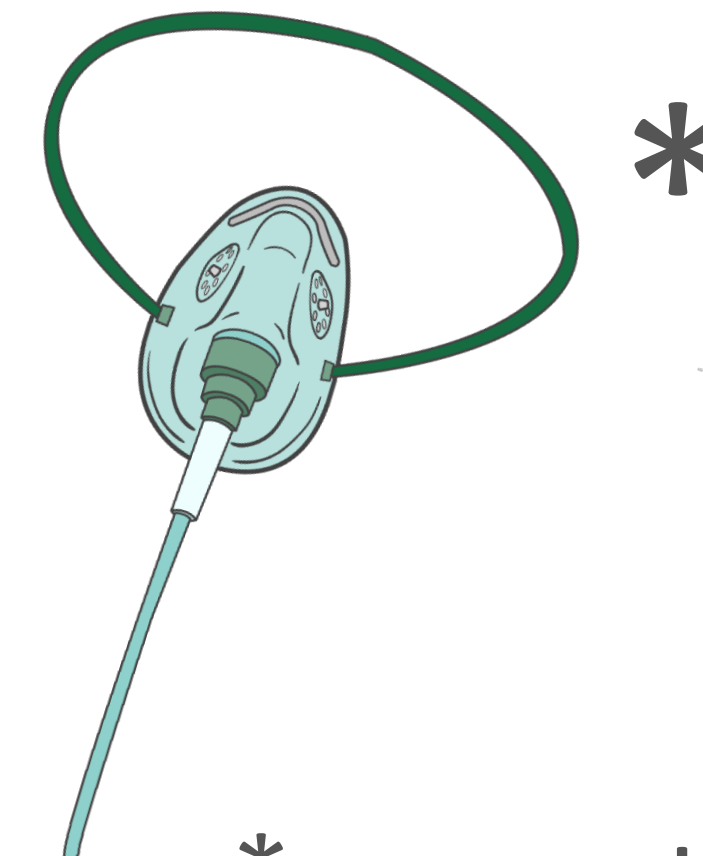
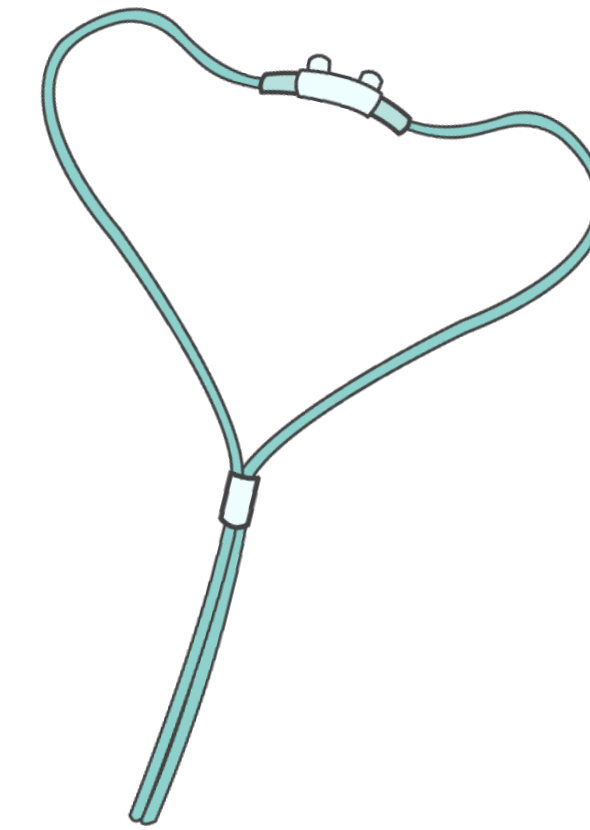
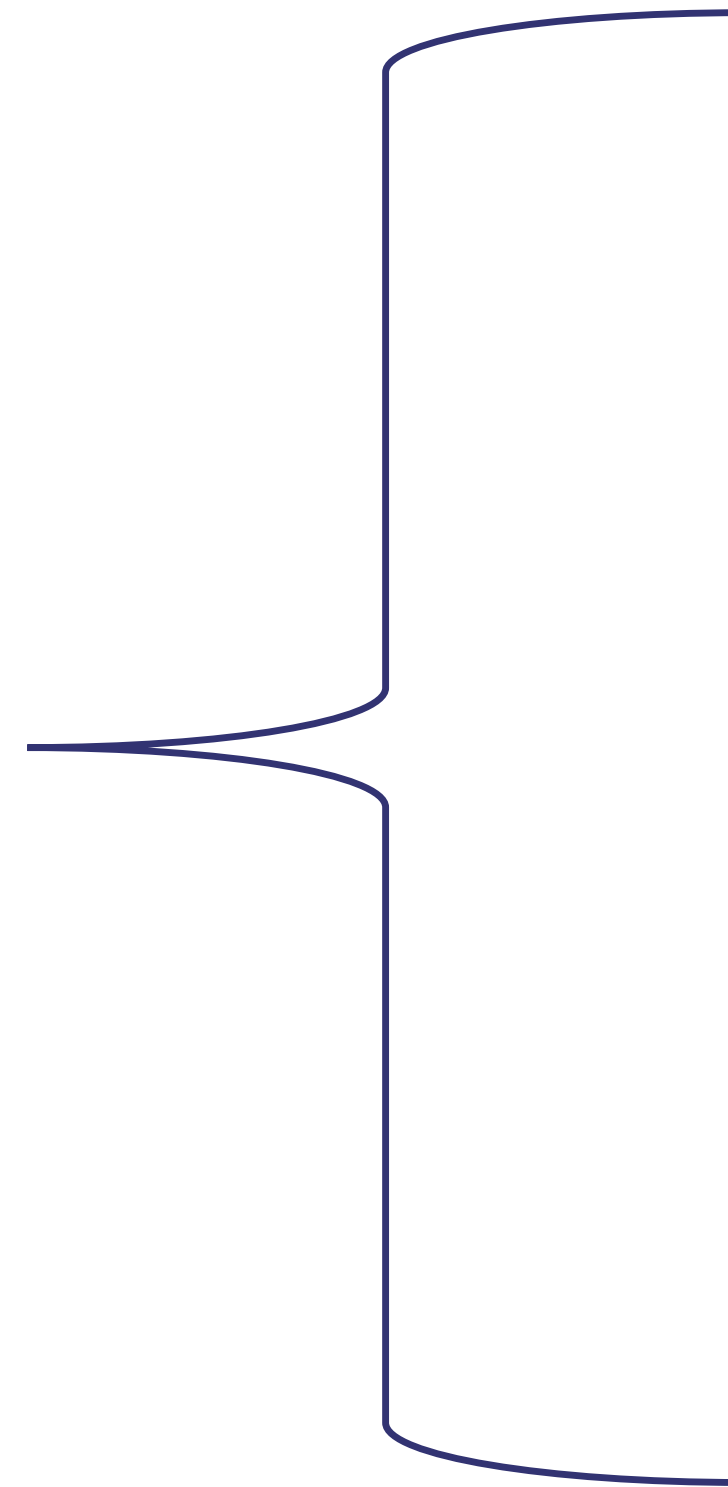
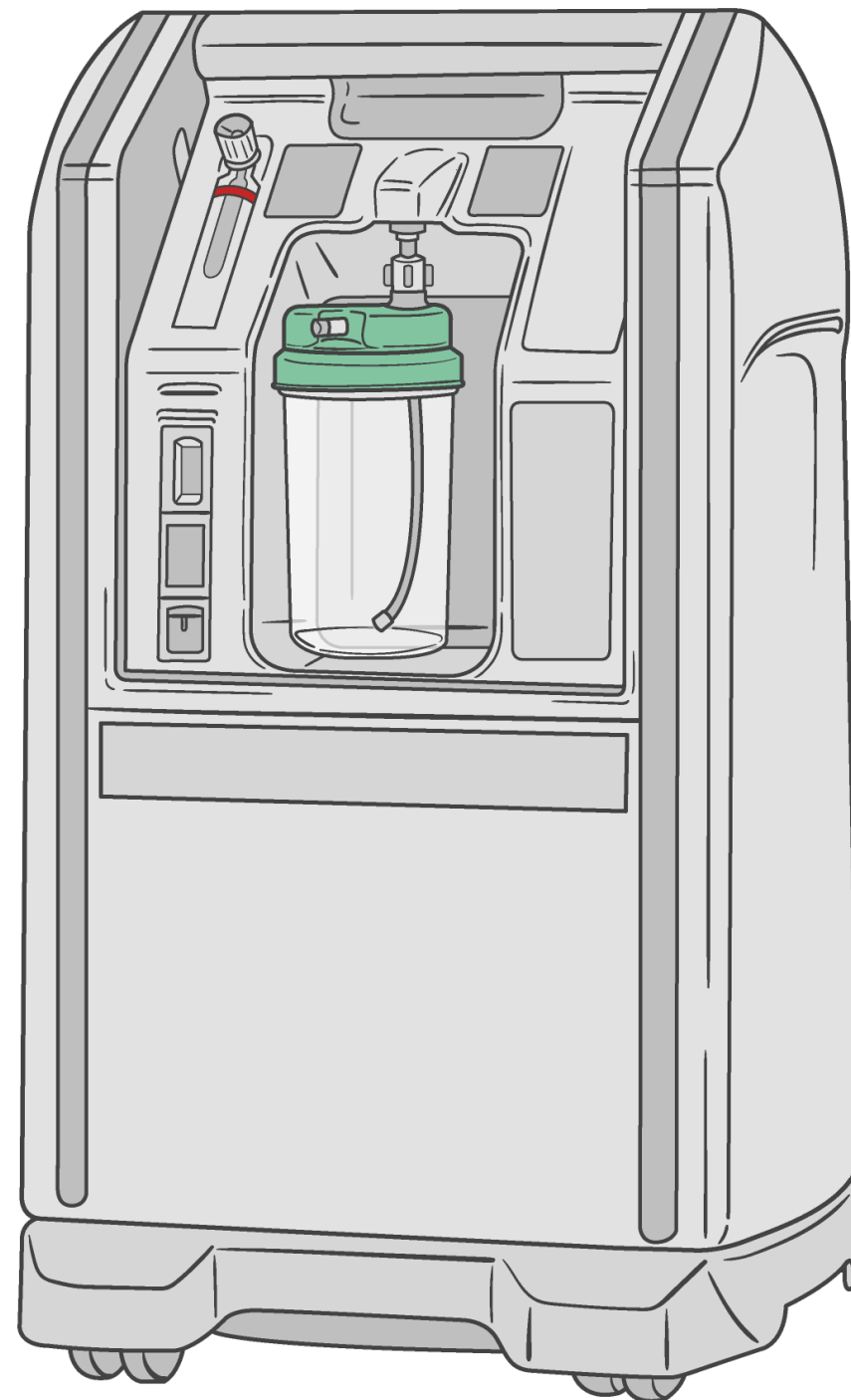


Simple facemask



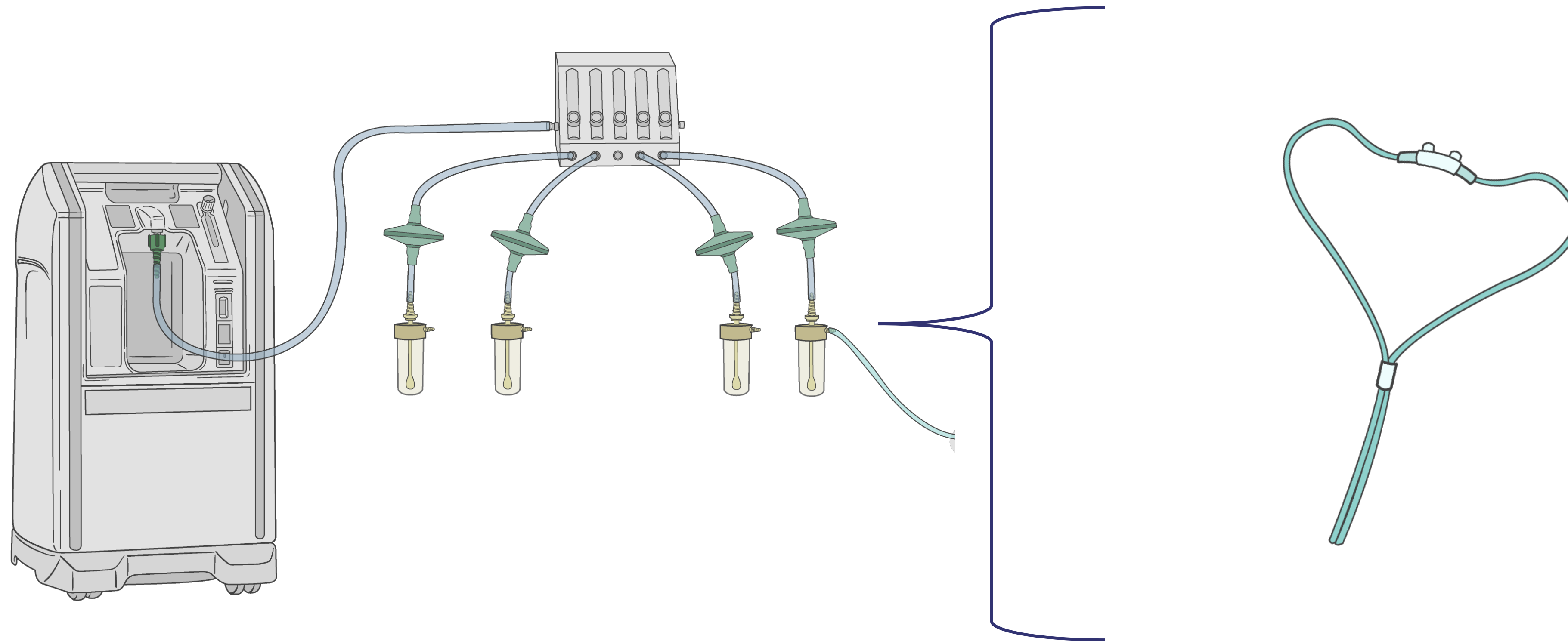
Reservoir facemask (non-rebreather)

Low pressure & low flow

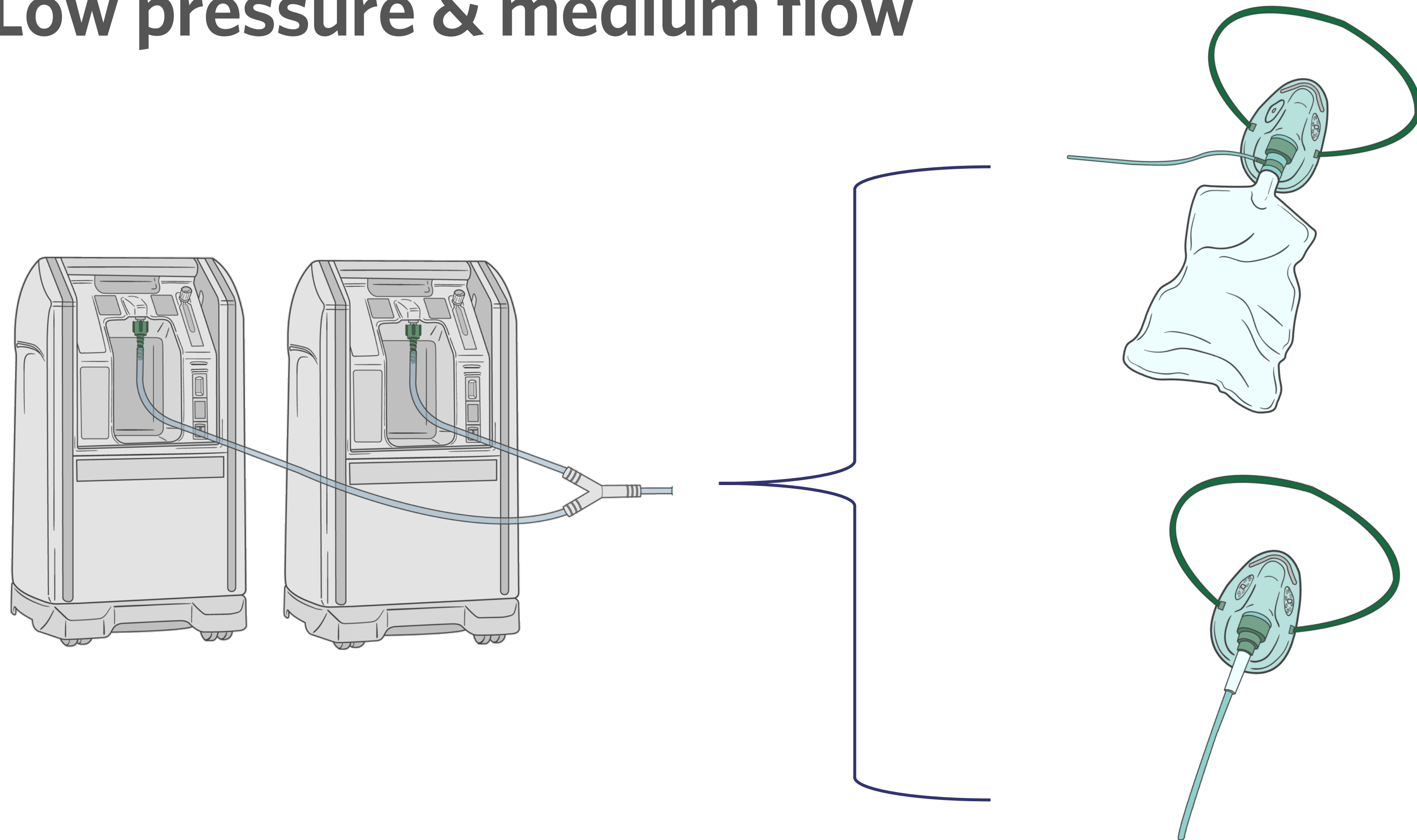


*concentrator capacity must be more than 5L/min

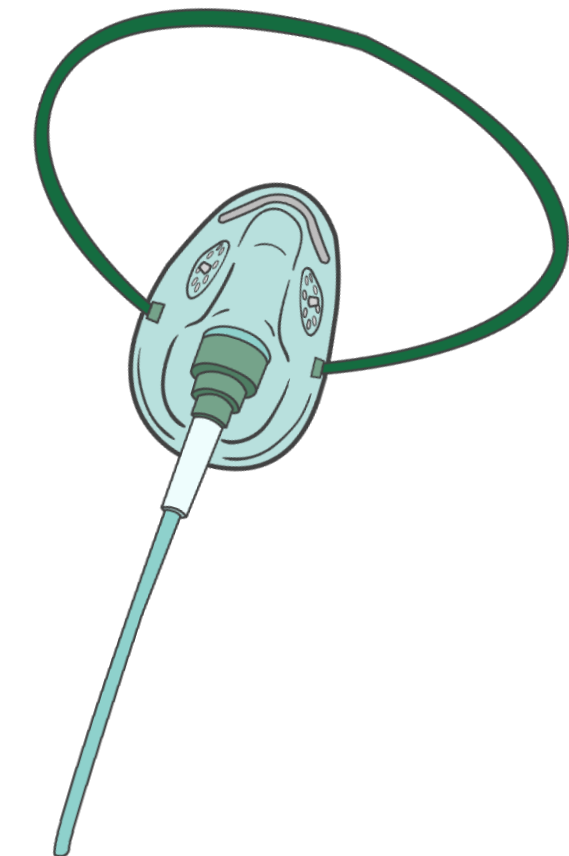
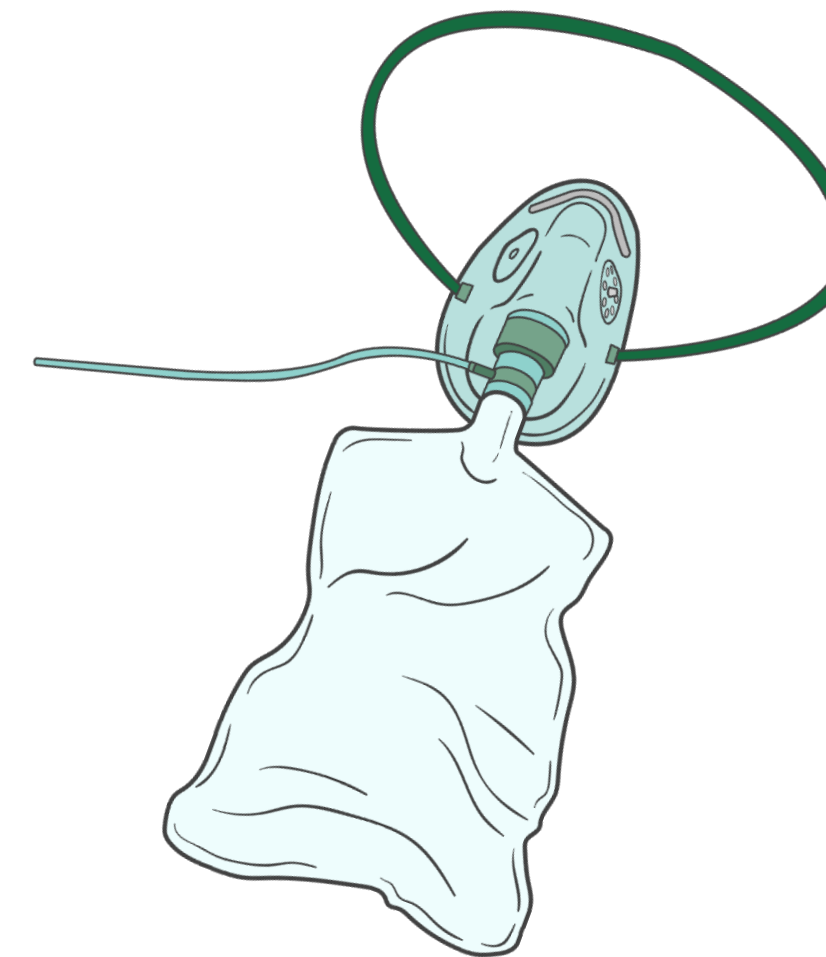
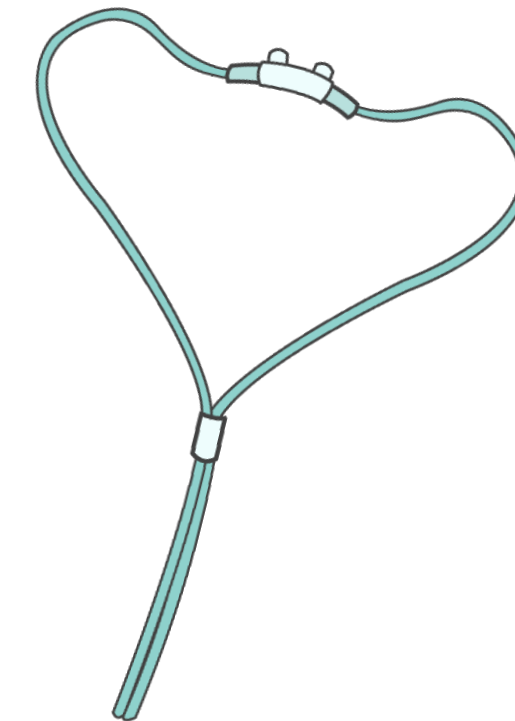
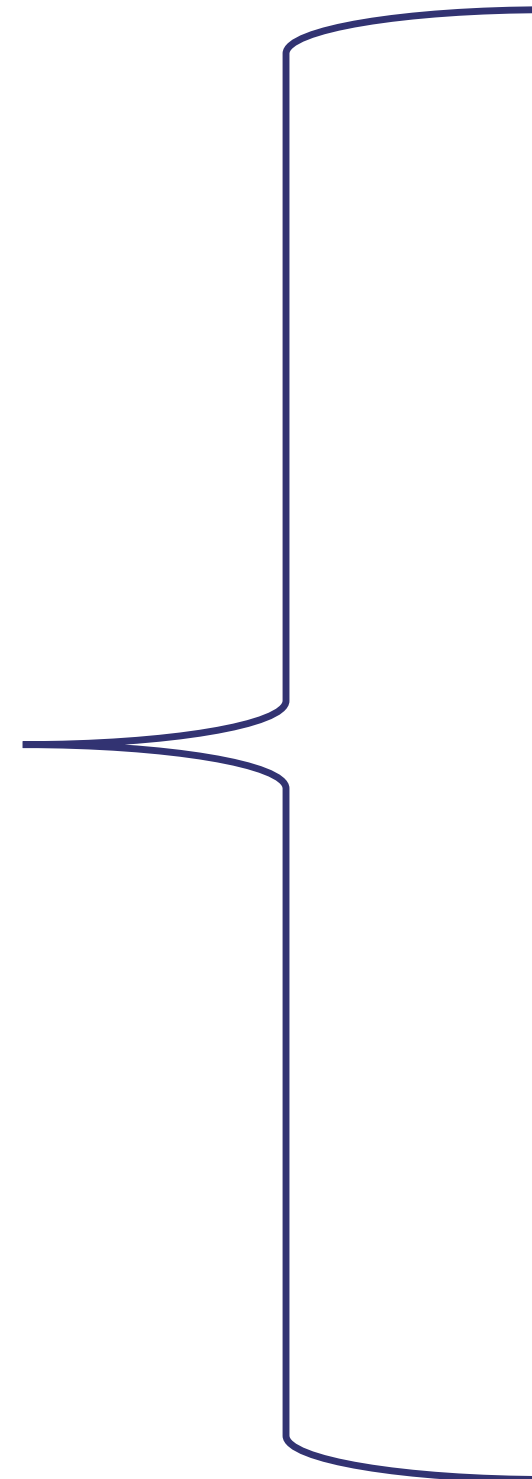
Low pressure & very low flow



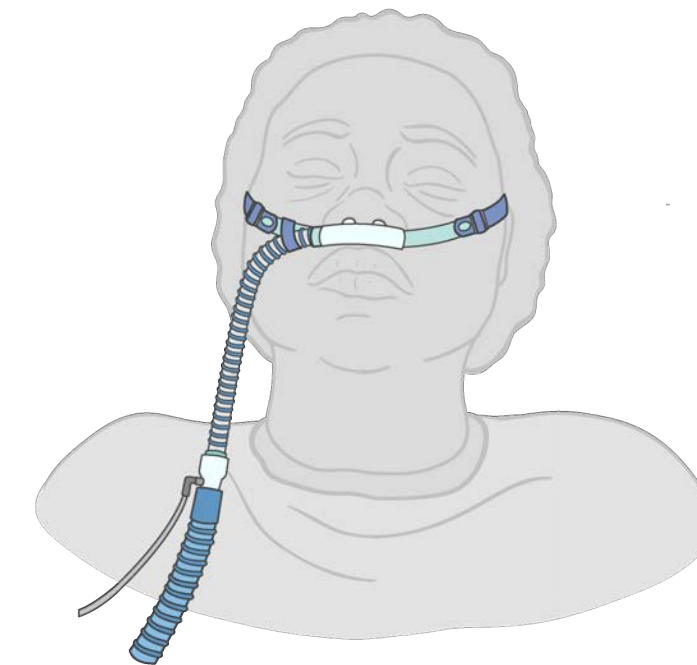
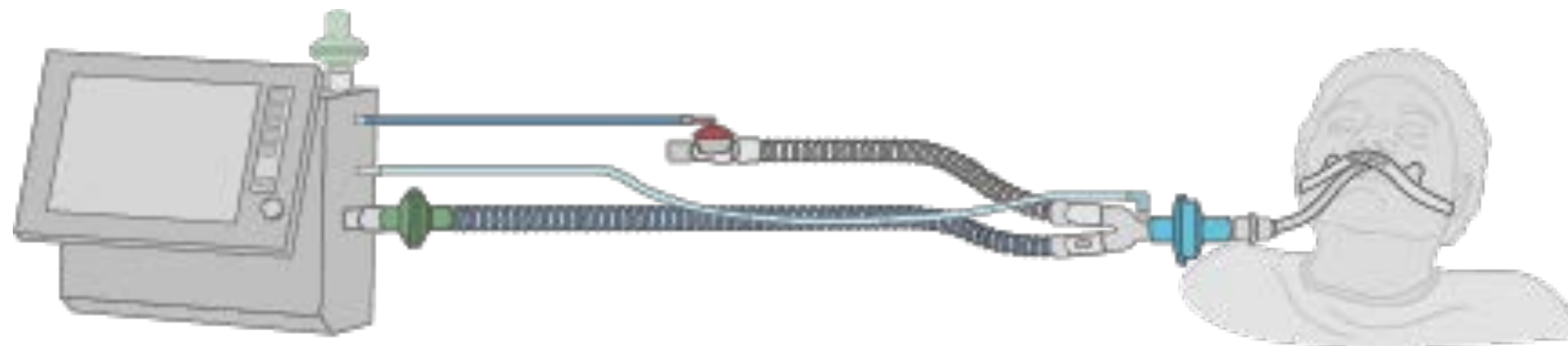
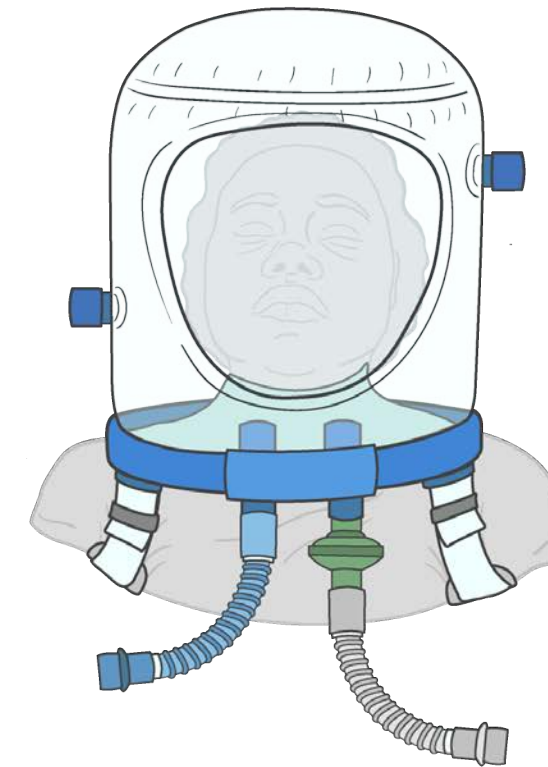
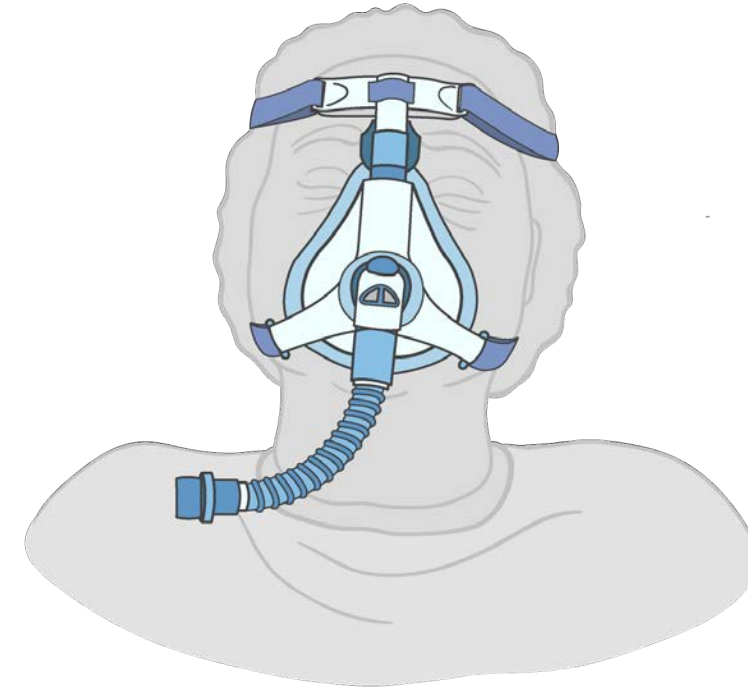
Low pressure & medium flow



Low pressure & medium/high flow

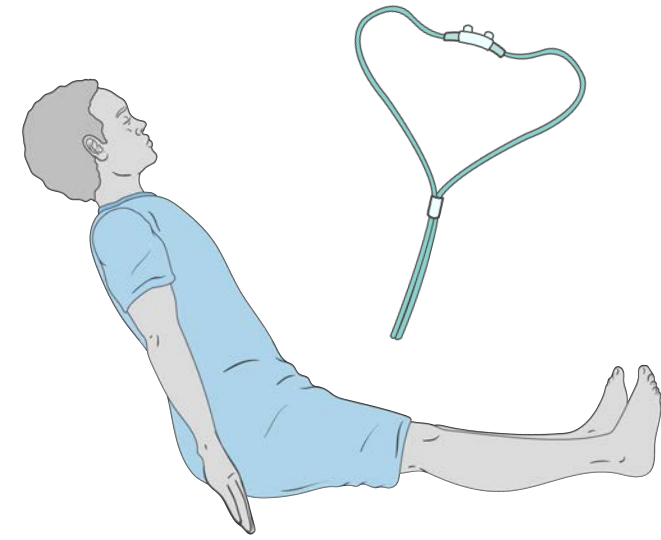


Advanced interfaces

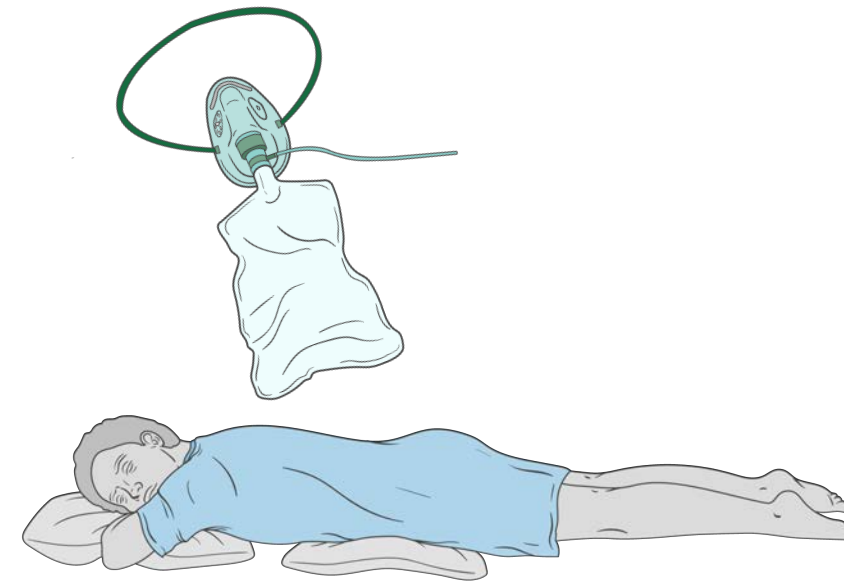


Optimizing oxygen supply

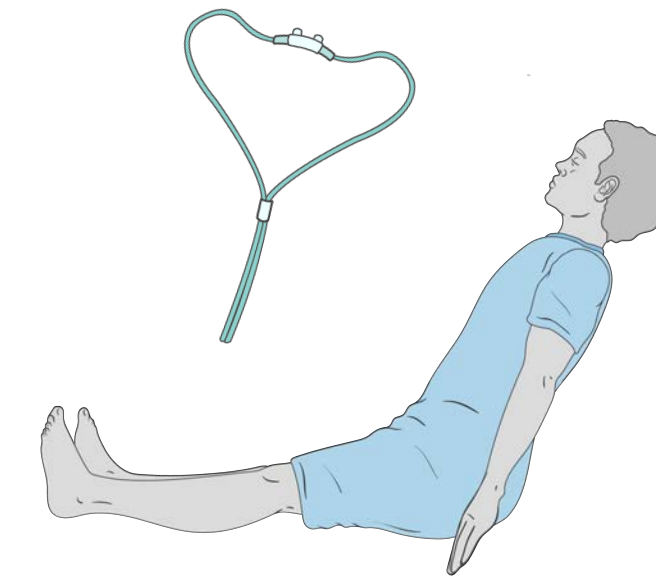
Ward scenario



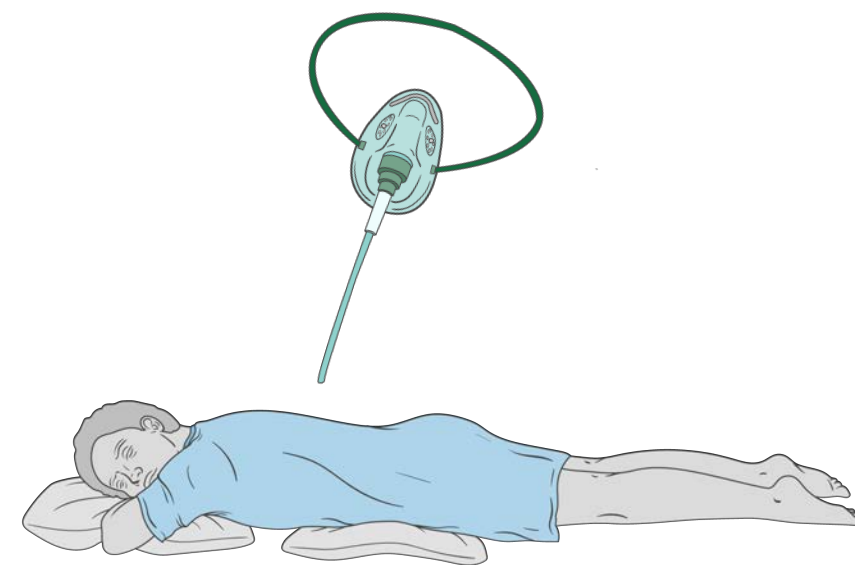
2L/min



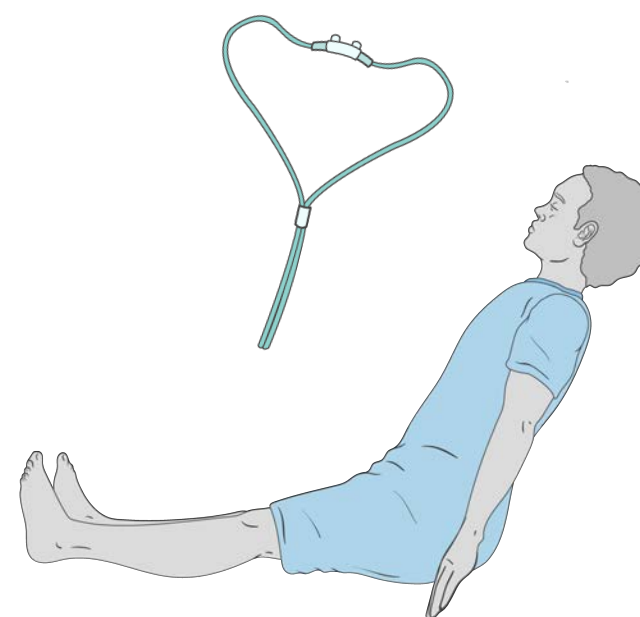
15L/min



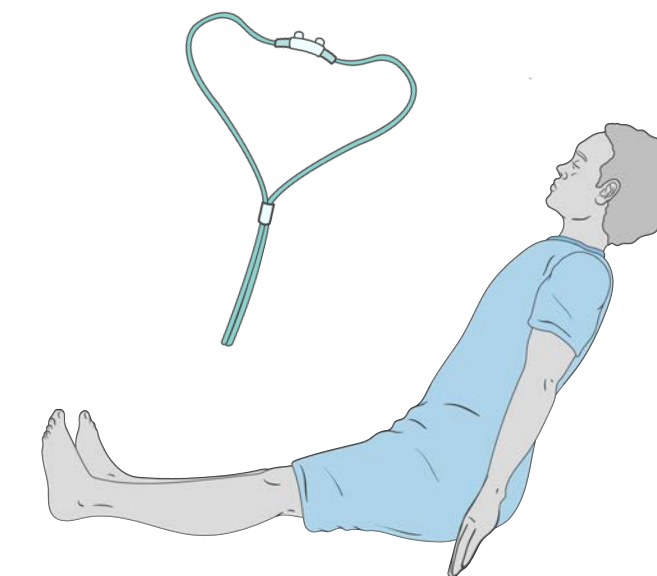
2L/min



10L/min

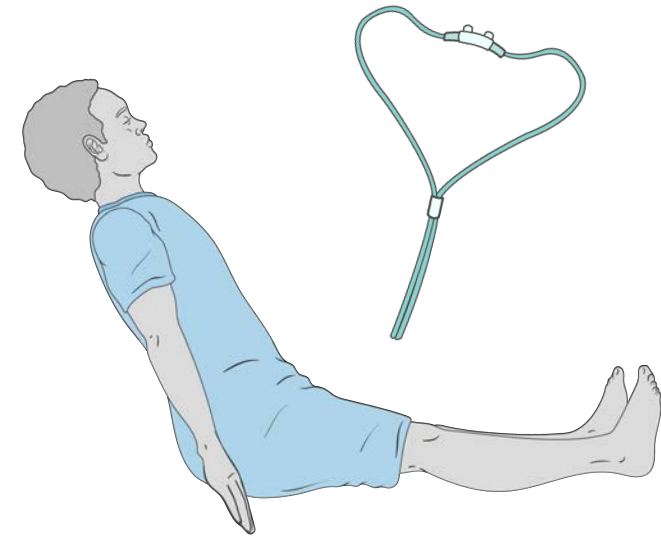


5L/min

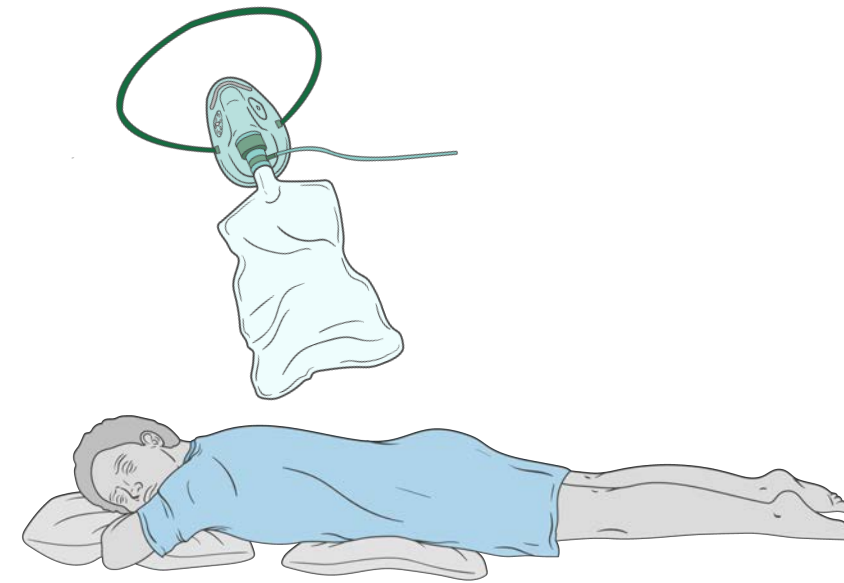


3L/min

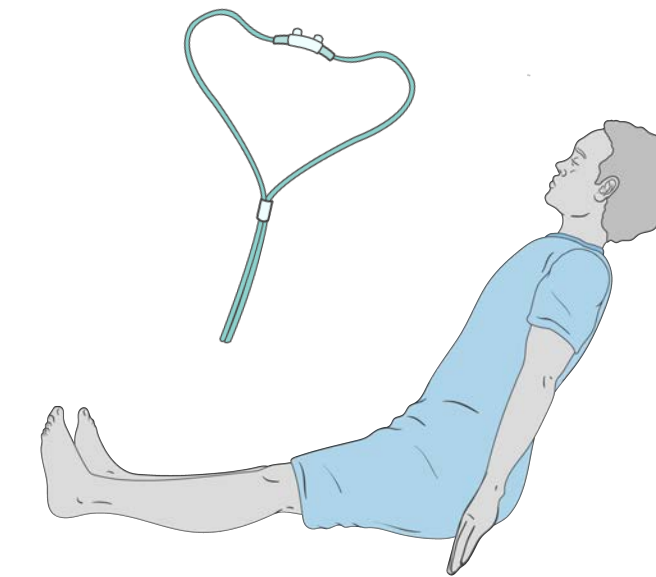
Ward scenario



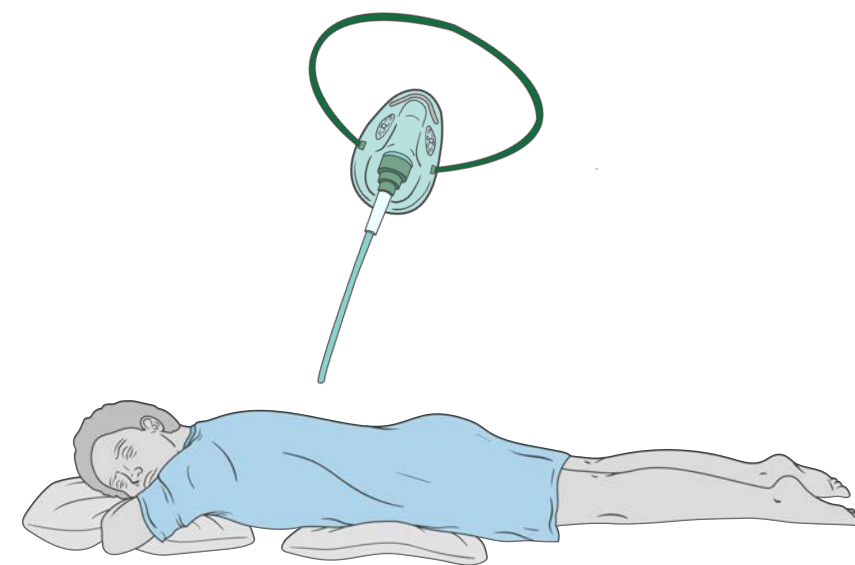
2L/min



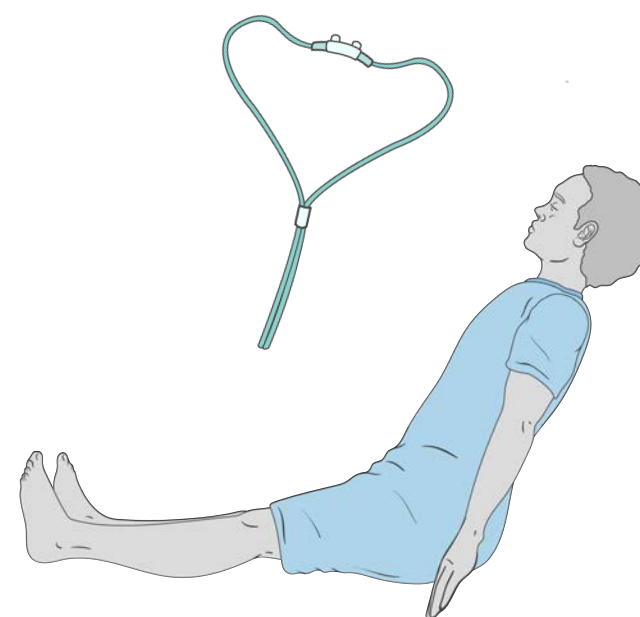
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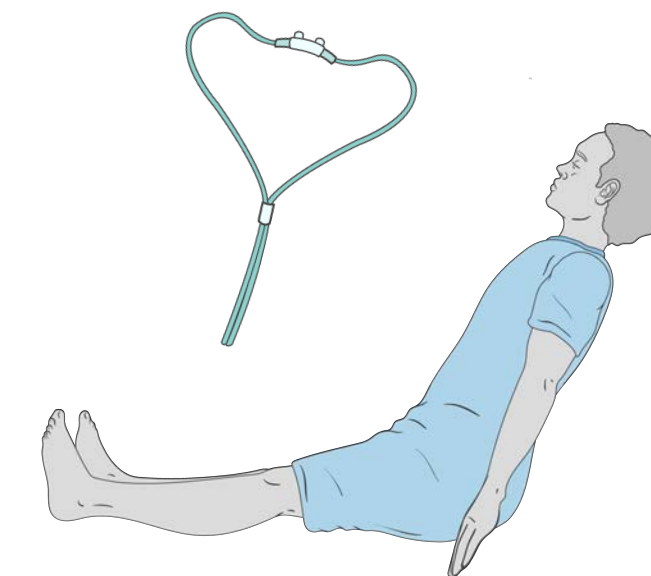
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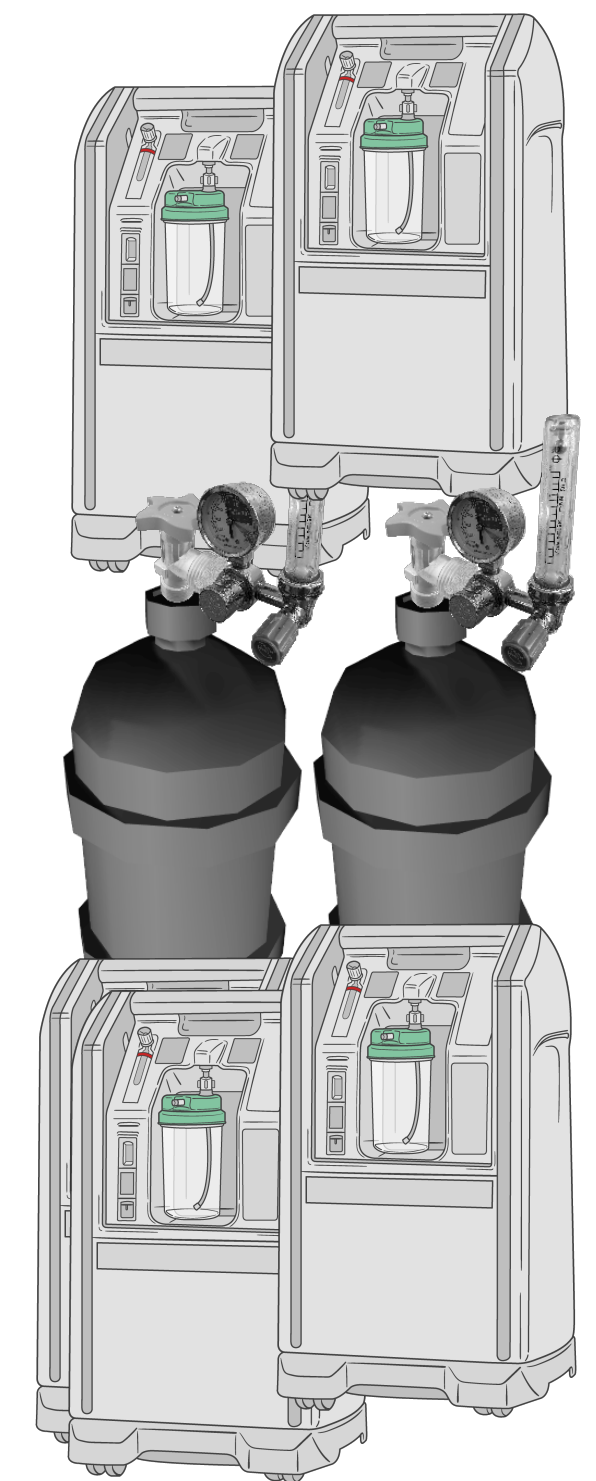
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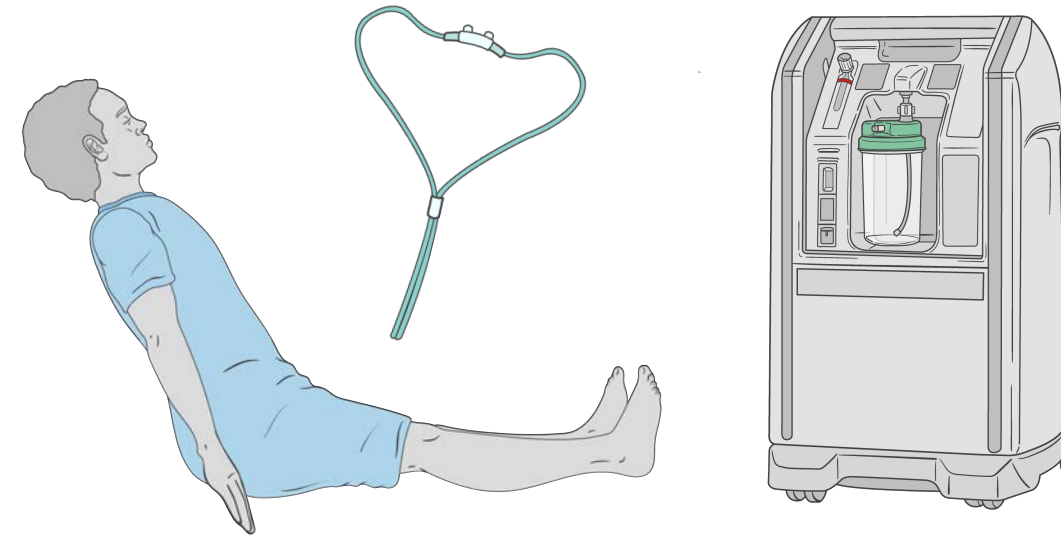
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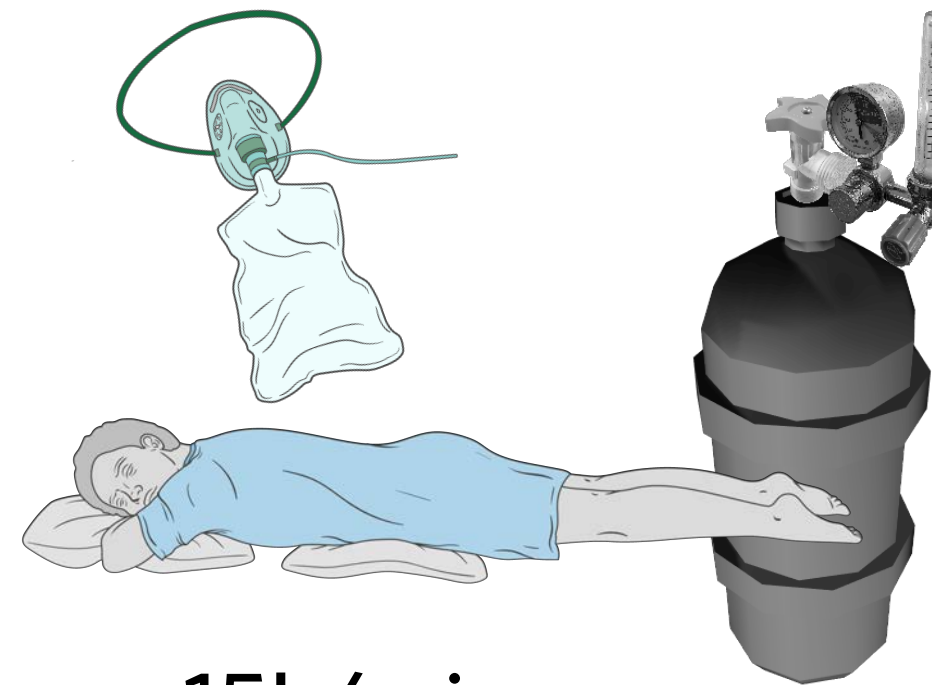
3L/min



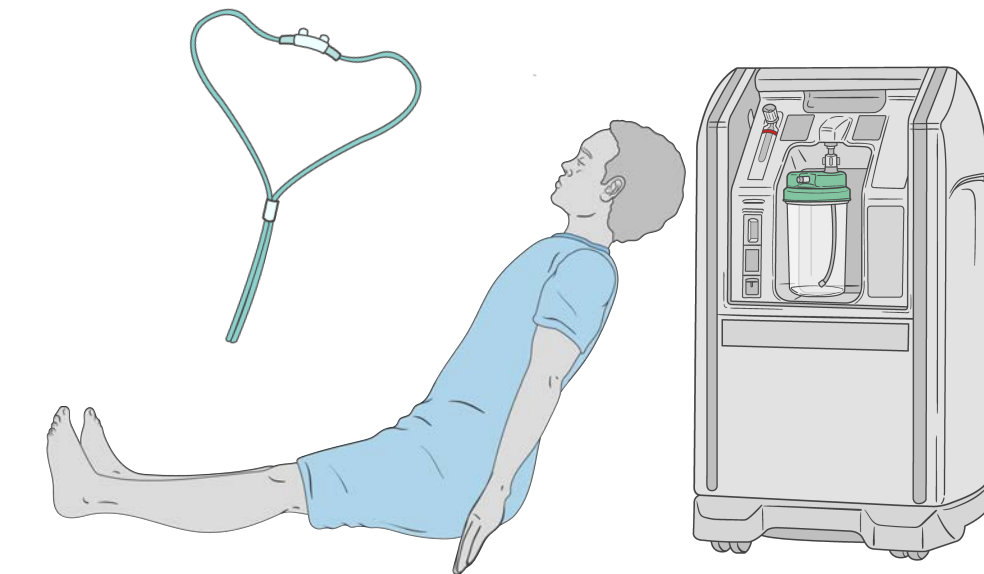
Ward scenario



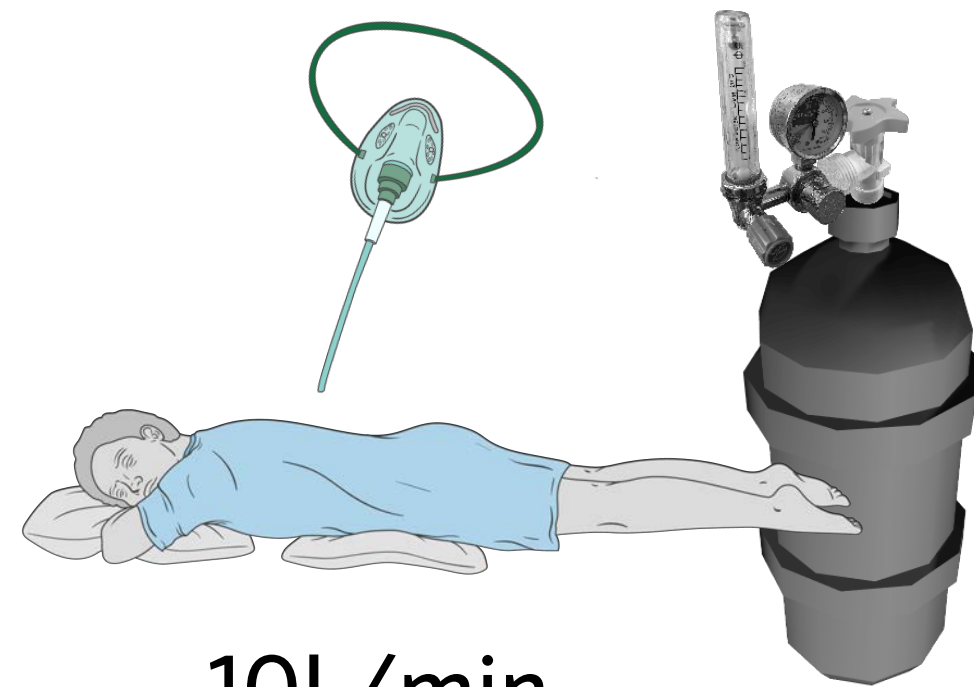
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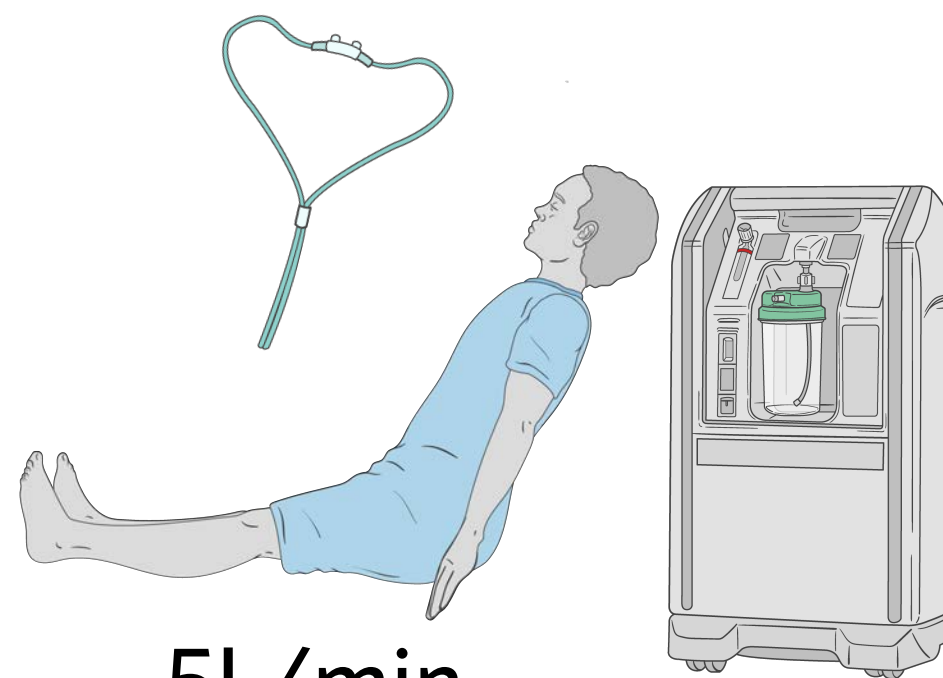
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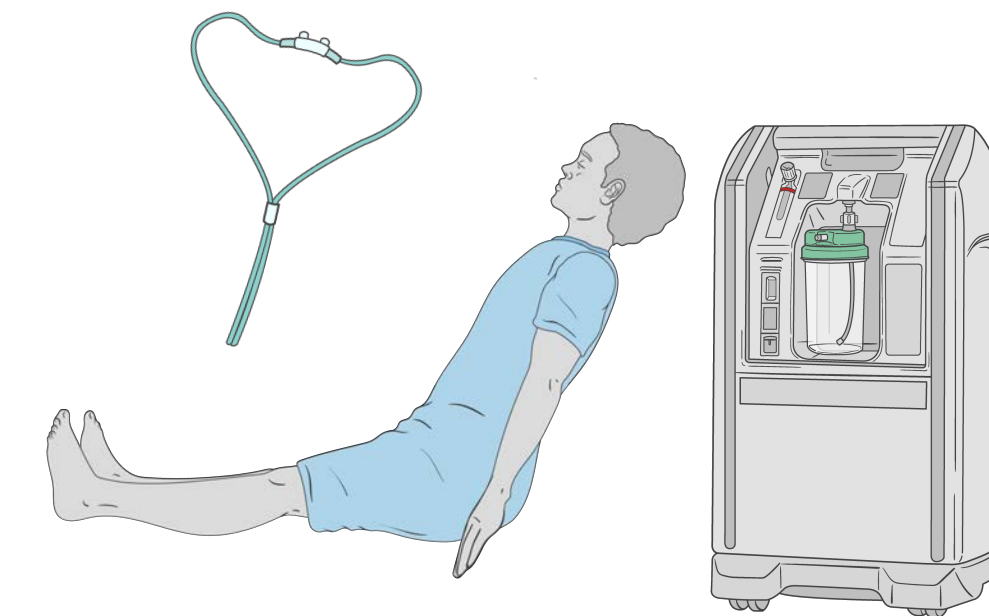
2L/min



10L/min

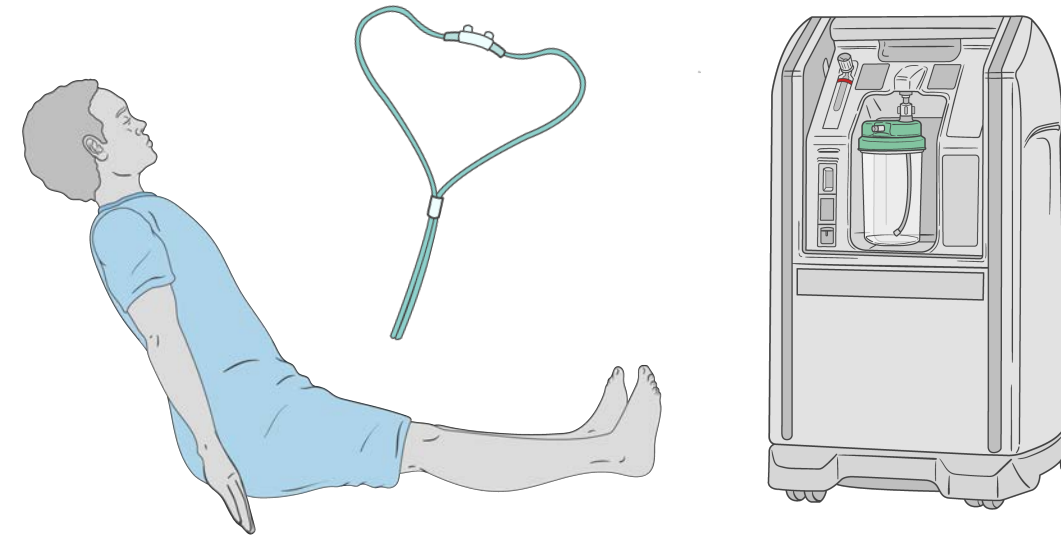


5L/min

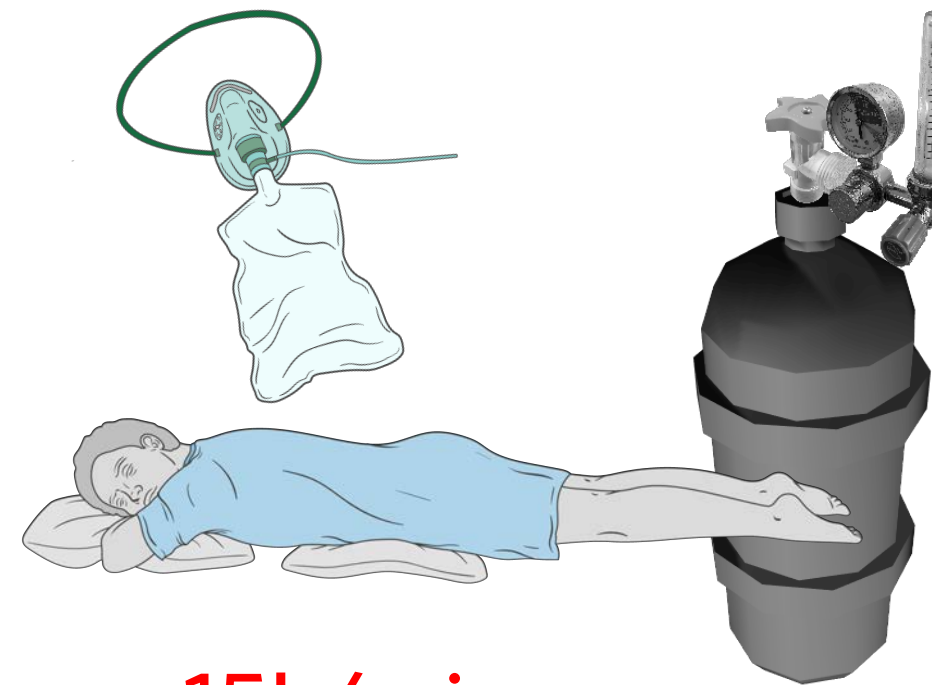


3L/min

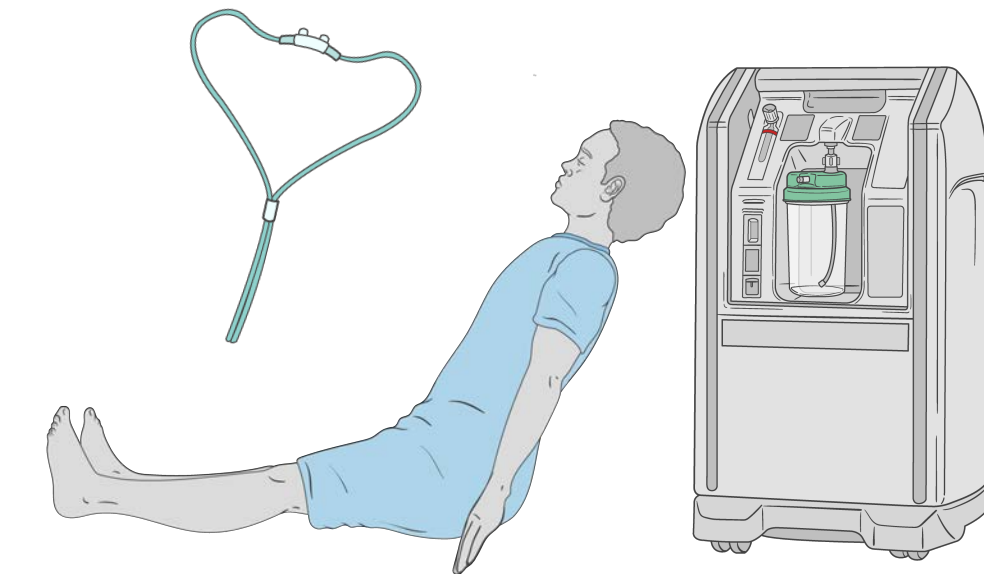
Ward scenario



2L/min

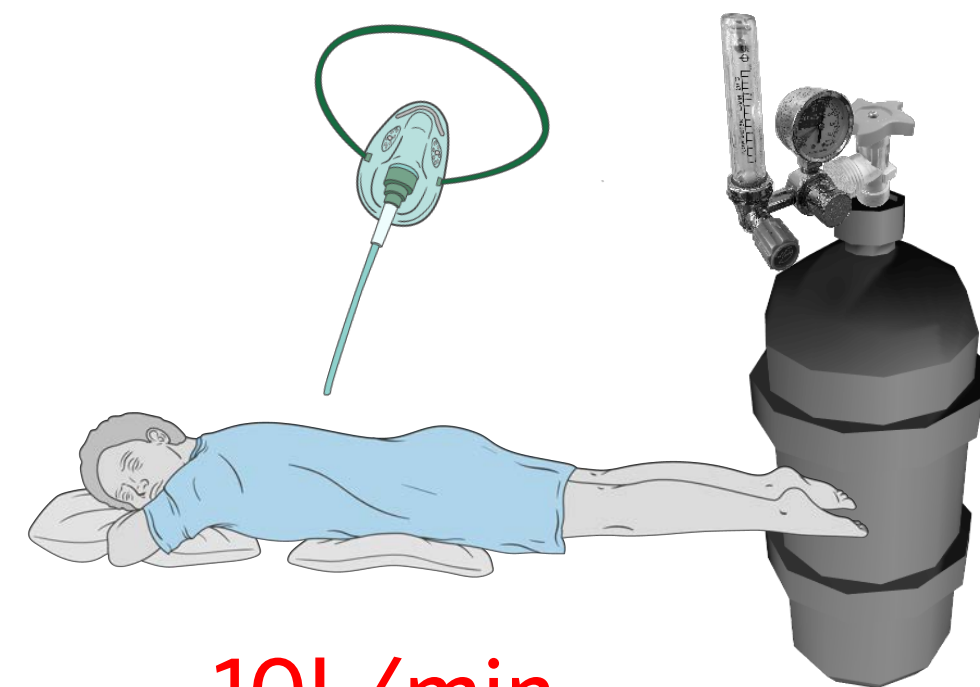


15L/min

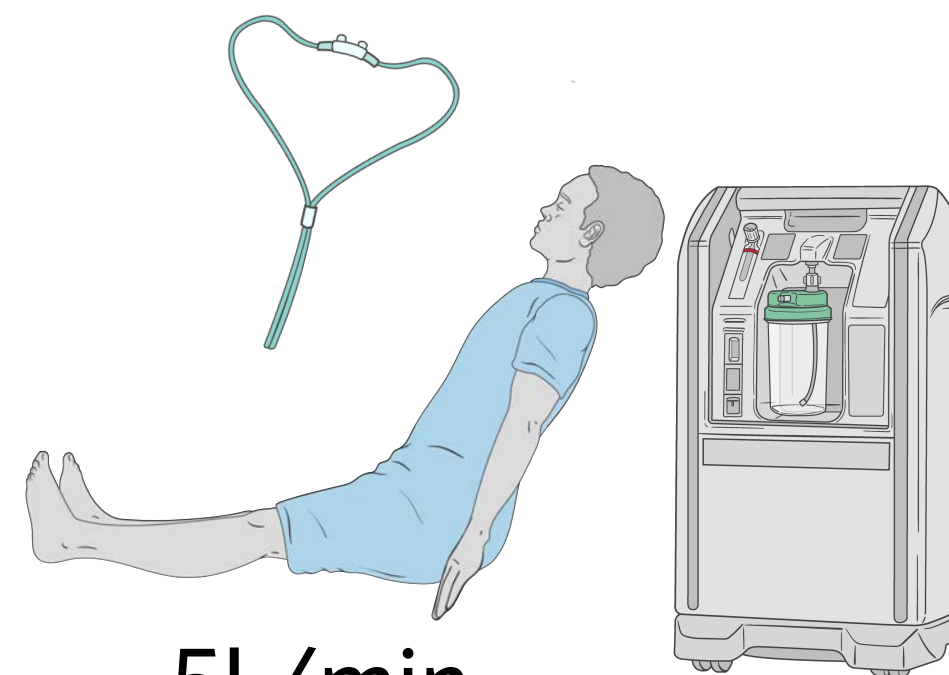


2L/min

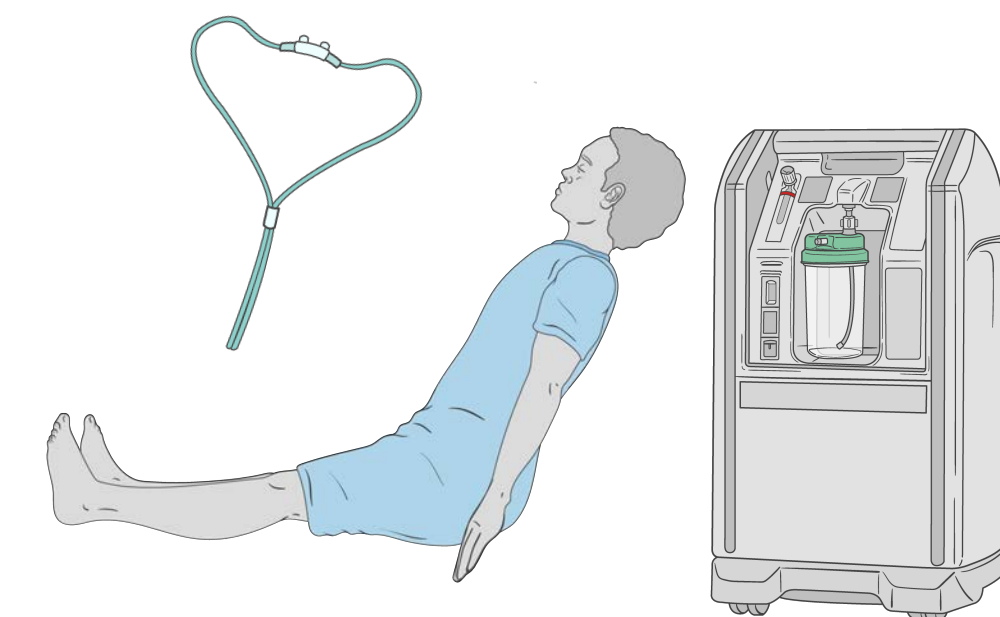
25 L/min



10L/min

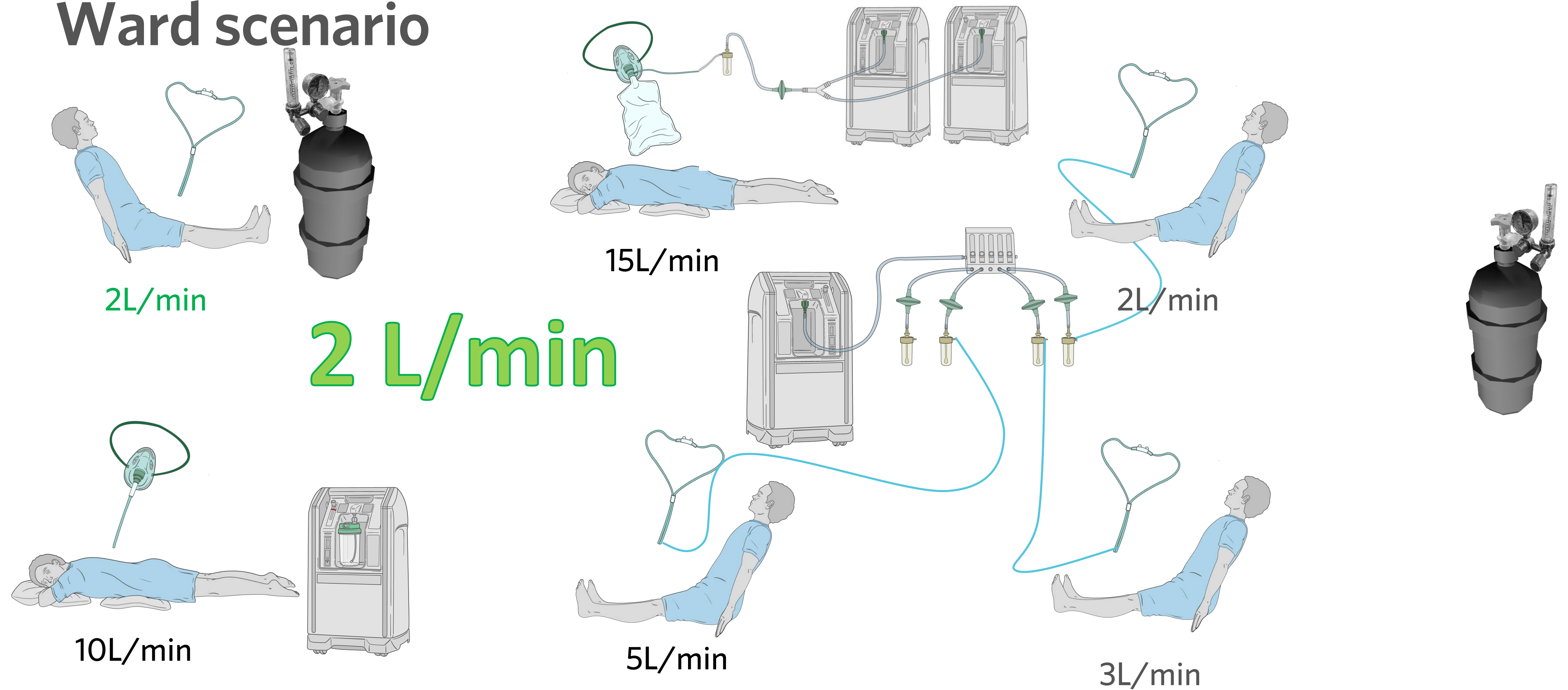


5L/min



3L/min

Ward scenario



Review & conclusions

Review of objectives

1. Improve ability to provide high quality care for patients with hypoxemia
2. Better understand oxygen interfaces & sources
3. Learn techniques to reduce unnecessary oxygen use



Objective 1

Improve ability to provide high quality care for patients with hypoxemia

- Avoid giving patients too much oxygen
- Avoid taping over the holes on simple facemasks
- Ensure non-rebreather mask reservoirs are inflated
- Regularly reassess patients on oxygen and titrate using pulse oximetry

Objective 2

Better understand oxygen interfaces & sources

- Spare concentrator filters are an important commodity
- Avoid increasing concentrator flow above the maximum level
- Consider flow and pressure when matching oxygen source and interface
- Y connectors can be helpful
- Oxygen from PSA plants and concentrators is safe and effective

Objective 3

Learn techniques to reduce unnecessary oxygen use

Estimated daily savings from respiratory interventions

Intervention	Reduced demand	Full cylinders saved^	Cost savings* (USD)
Titrating flowmeter on flush (75 L/min) down to 15L/min	60 L/min	14	\$322 to \$1568
Splitting a concentrator for two patients on 5L/min	5 L/min	1	\$23 to \$112
Using two concentrators for a patient on reservoir mask	15 L/min	3	\$69 to \$336

^ Assumes J-type cylinder with safe residual pressure of 200psi and 6,120L of effective oxygen

*Cylinder price estimates form: <https://www.thebureauinvestigates.com/stories/2020-08-09/lack-of-oxygen-leaves-covid-19-patients-in-africa-gasping-for-air>

How can we implement oxygen best practices?

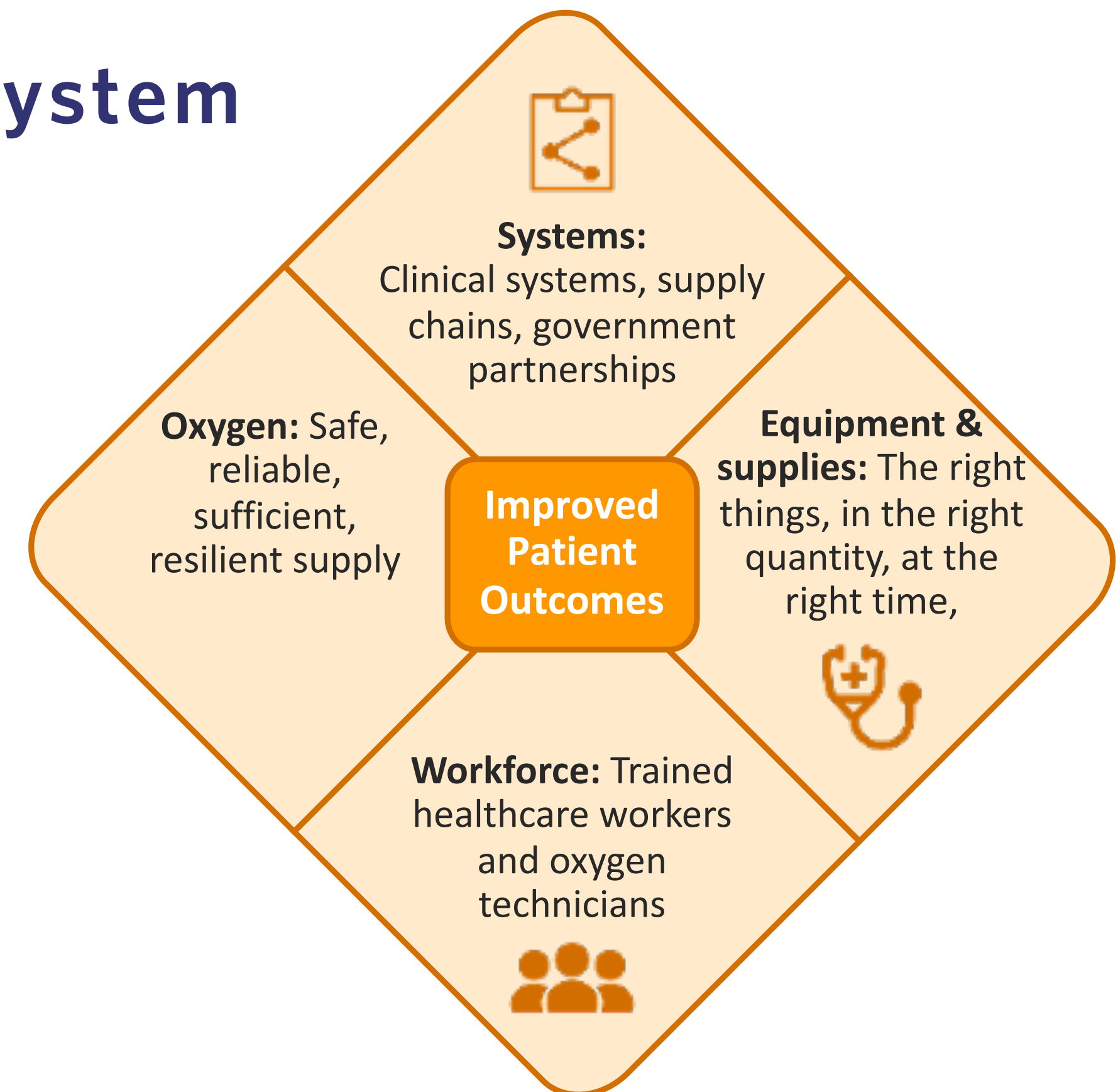
Oxygen isn't a commodity, its an ecosystem

To build a strong oxygen ecosystem we need **trained maintenance technicians** and **clinical safety protocols** to guarantee continuity and safe use.

We need **clinical protocols** implemented by **trained healthcare workers** with access to **adequate supplies**.

We need **production plants, cylinders, piping, and portable concentrators** to ensure a sufficient oxygen supply.

This is how we ensure the success of short-term efforts while building long-term health system capacity



How can we implement oxygen best practices?

- Systems
- Stuff
- Staff
- Space
- Social support

How can we implement oxygen best practices?

- Systems
- Stuff
- Staff
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Respiratory Flowsheet

Today's Date / /	Surname/Family Name				Name								
Admit Date / /	Patient MRN / Registration Number				Age		Sex		Ward		Bed #		

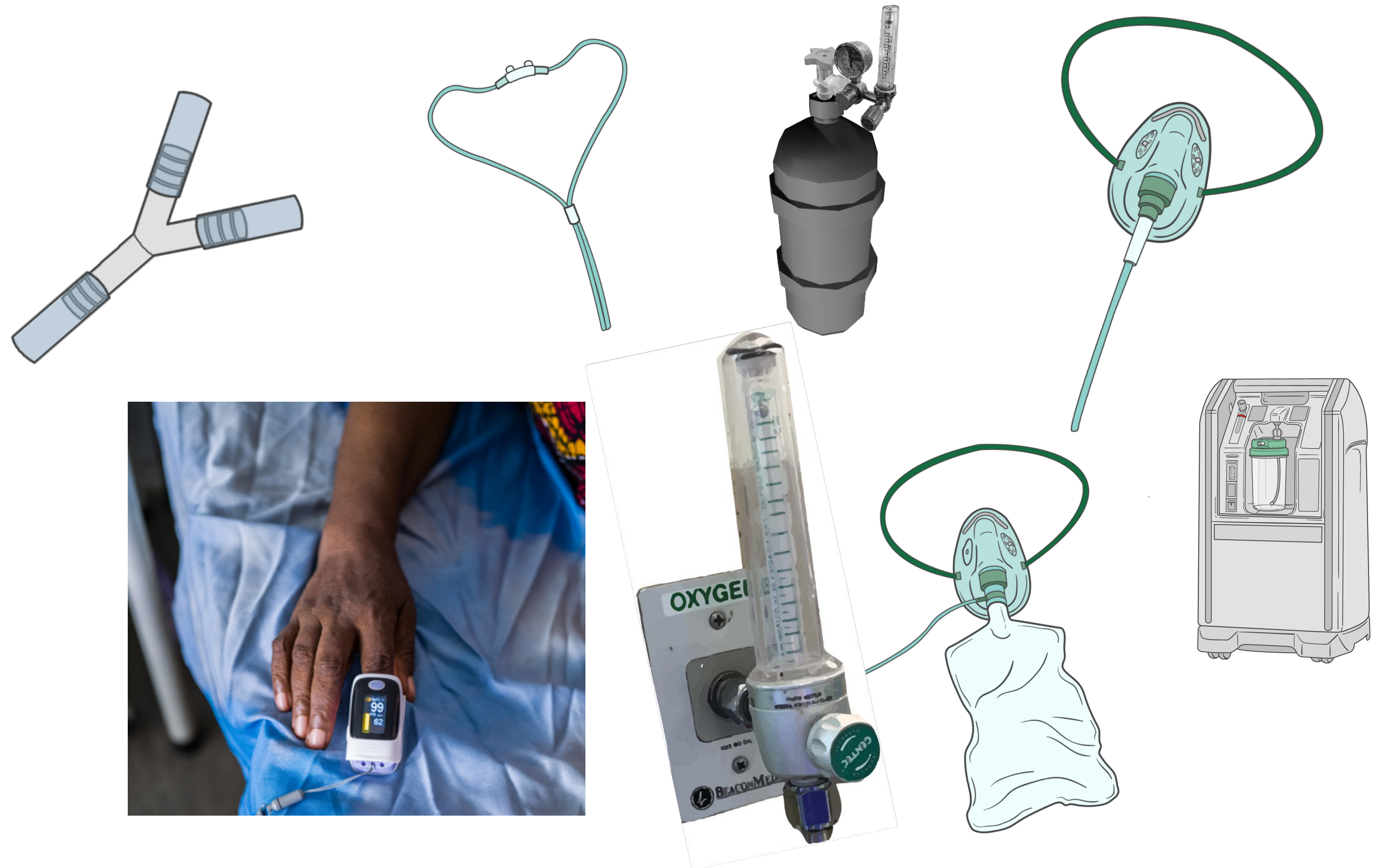
Time	:	:	:	:	:	:	:	:	:	:	:	:	:
O2 Delivery Device #1													
O2 L/min (or FiO2) #1													
O2 Source #1													
Humidification	Y / N	Y / N	Y / N	Y / N	Y / N	Y / N	Y / N	Y / N	Y / N	Y / N	Y / N	Y / N	Y / N
O2 Delivery Device #2													
O2 L/min (or FiO2) #2													
O2 Source #2													
Humidification	Y / N	Y / N	Y / N	Y / N	Y / N	Y / N	Y / N	Y / N	Y / N	Y / N	Y / N	Y / N	Y / N
SpO2													
Respiratory rate													
Accessory muscle use	Y / N	Y / N	Y / N	Y / N	Y / N	Y / N	Y / N	Y / N	Y / N	Y / N	Y / N	Y / N	Y / N
Patient Position (Prone/Supine/Left/Right)													
Switch to concentrator?	Y / N / NA	Y / N / NA	Y / N / NA	Y / N / NA	Y / N / NA	Y / N / NA	Y / N / NA	Y / N / NA	Y / N / NA	Y / N / NA	Y / N / NA	Y / N / NA	Y / N / NA

O2 Delivery Devices			
NC: Nasal Cannula	SM: Simple facemask		
NRB: nonrebreather	NIV: BIPAP/CPAP		

O2 Sources	
CYL: Cylinder	CON: Concentrator
WL: Wall	

How can we implement oxygen best practices?

- Systems
- Stuff
- Staff
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- Social support



How can we implement these practices?

- Systems
- Stuff
- Staff
- Space
- Social support



Photo: Paul Sonenthal/Partners In Health

How can we implement oxygen best practices?

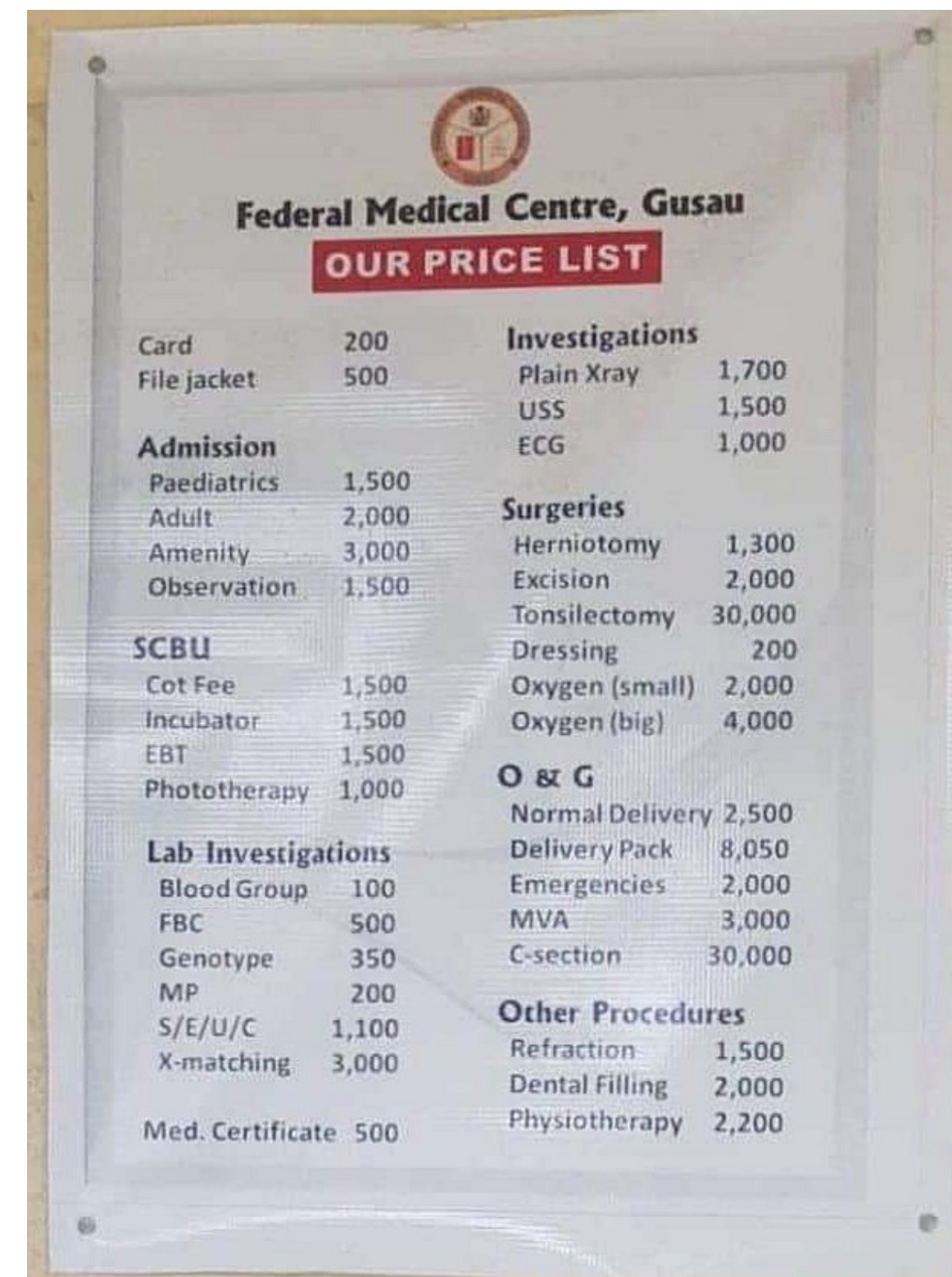
- Systems
- Stuff
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Photo: Paul Sonenthal/Partners In Health

How can we implement oxygen best practices?

- Systems
- Stuff
- Staff
- Space
- Social support



Federal Medical Centre, Gusau	
OUR PRICE LIST	
Card	200
File jacket	500
Admission	
Paediatrics	1,500
Adult	2,000
Amenity	3,000
Observation	1,500
SCBU	
Cot Fee	1,500
Incubator	1,500
EBT	1,500
Phototherapy	1,000
Lab Investigations	
Blood Group	100
FBC	500
Genotype	350
MP	200
S/E/U/C	1,100
X-matching	3,000
Med. Certificate	500
Investigations	
Plain Xray	1,700
USS	1,500
ECG	1,000
Surgeries	
Herniotomy	1,300
Excision	2,000
Tonsilectomy	30,000
Dressing	200
Oxygen (small)	2,000
Oxygen (big)	4,000
O & G	
Normal Delivery	2,500
Delivery Pack	8,050
Emergencies	2,000
MVA	3,000
C-section	30,000
Other Procedures	
Refraction	1,500
Dental Filling	2,000
Physiotherapy	2,200

<https://www.thebureauinvestigates.com/stories/2020-08-09/lack-of-oxygen-leaves-covid-19-patients-in-africa-gasping-for-air>

Clinical resources



covidprotocols.org



opencriticalcare.org



postgraduateeducation.hms.harvard.edu/covid-19-clinical-education-series



Thank you

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**Partners
In Health**
Inpatient Medicine