Respiratory failure and Oxygen Therapy

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Guideline for emergency oxygen use in adult patients

British Thoracic Society
Emergency Oxygen Guideline Group

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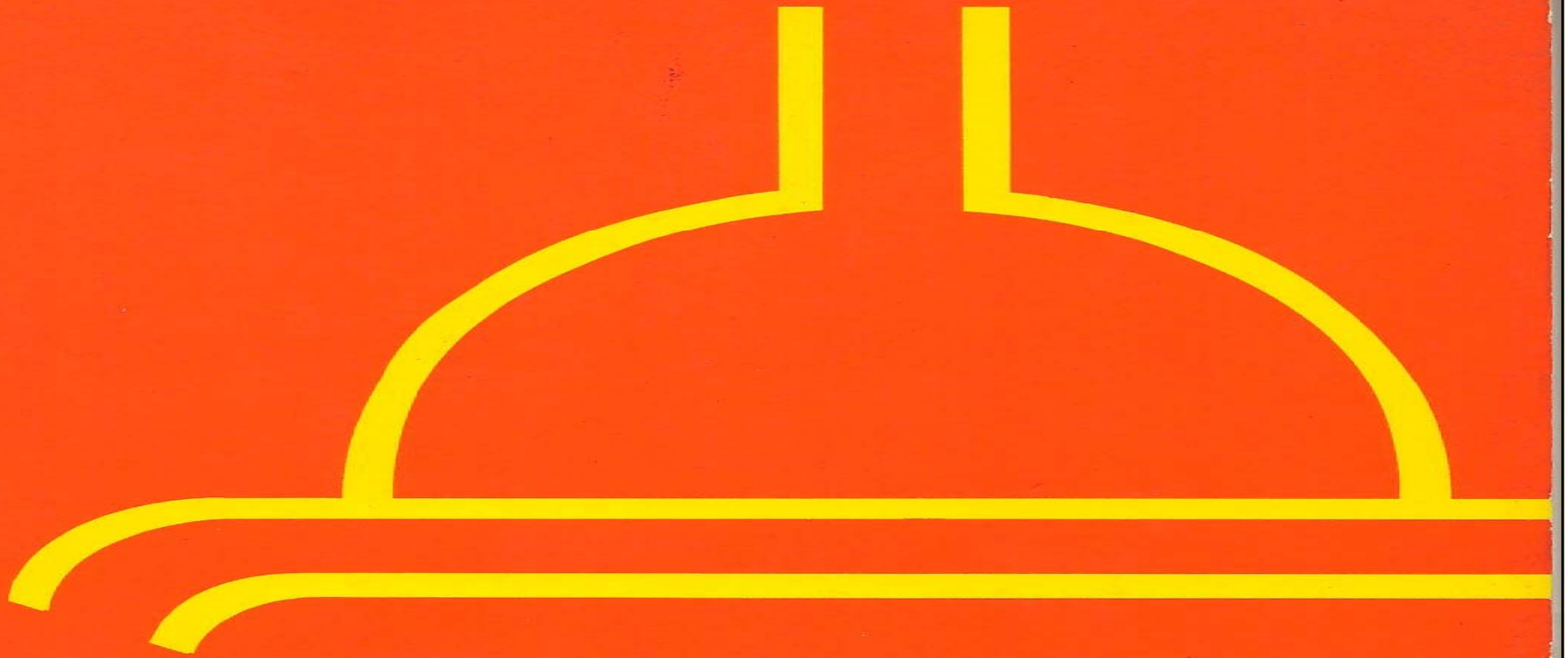


Respiratory Physiology

— *the essentials*

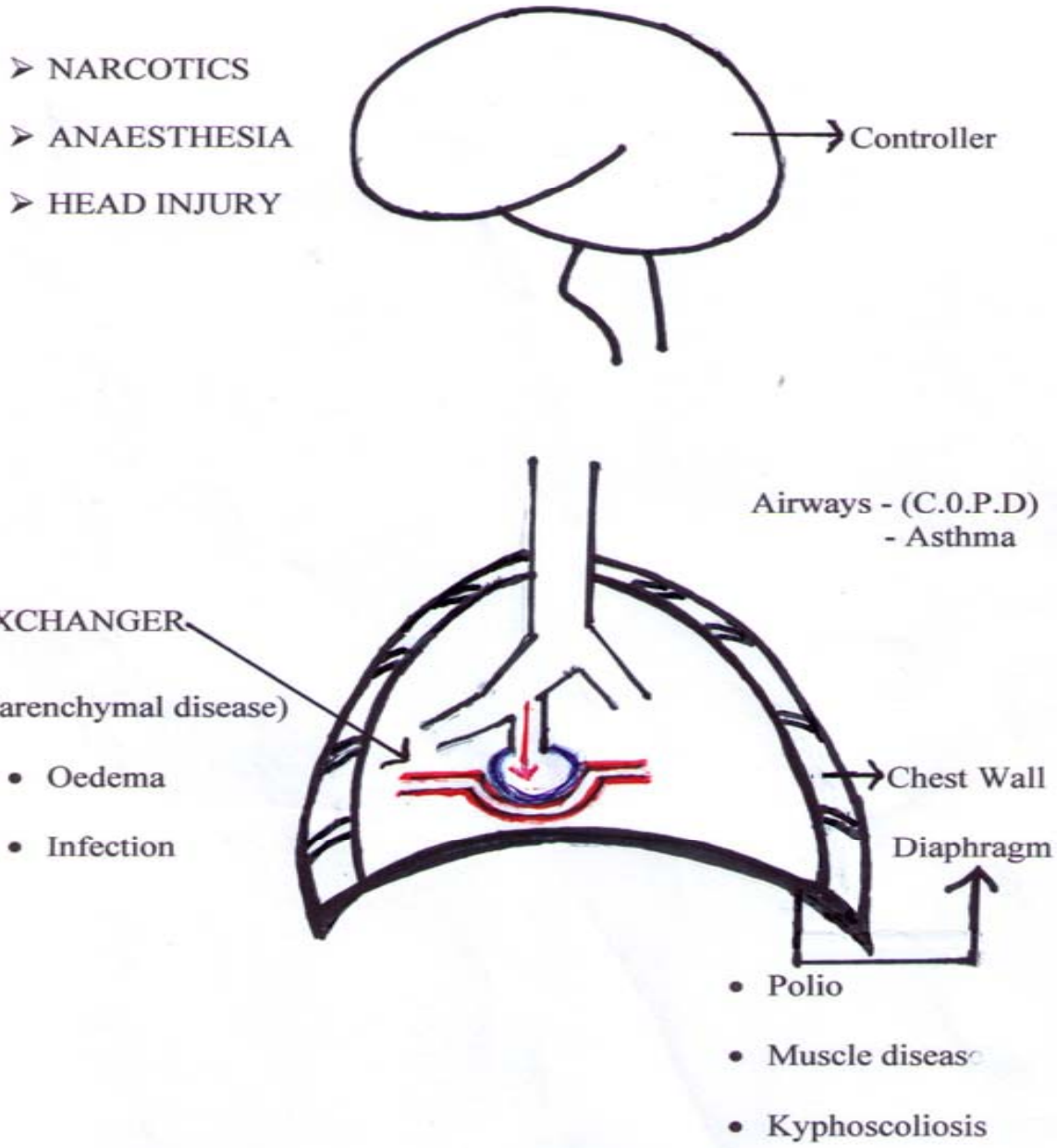
2nd Edition

John B. West, M.D., Ph.D.

Williams & Wilkins

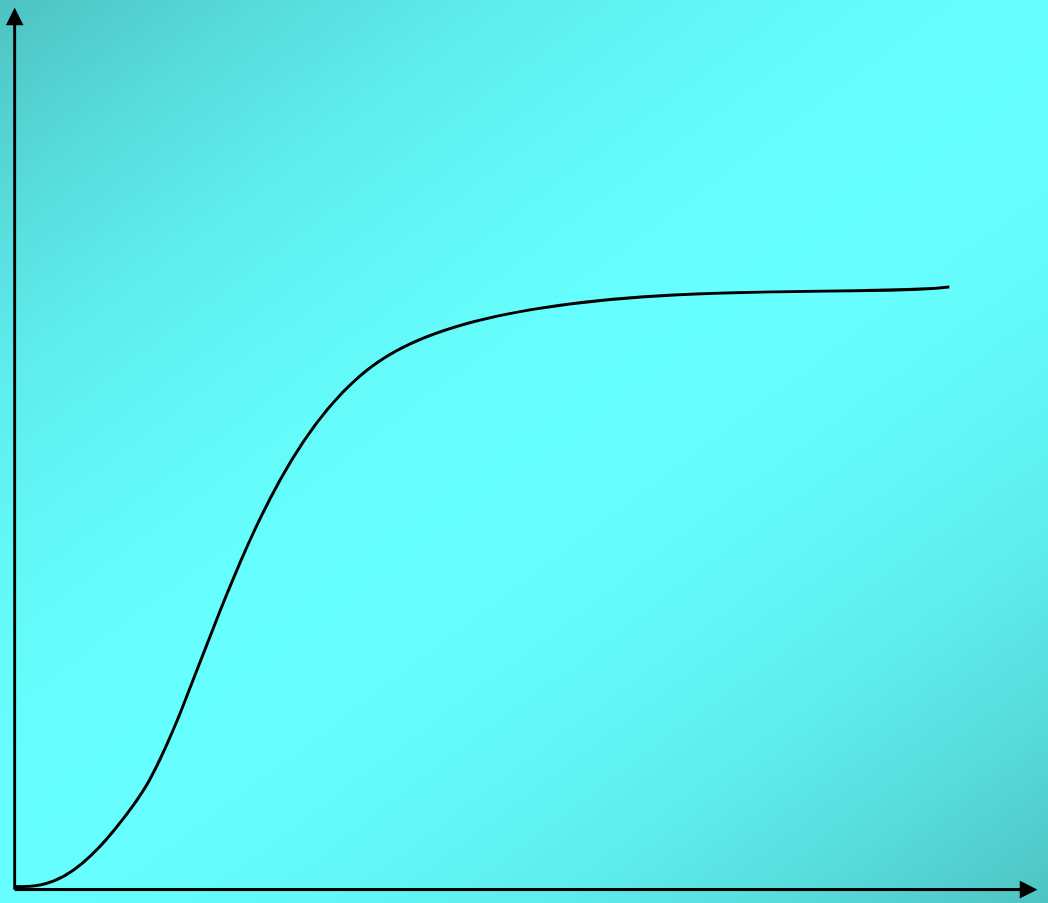
- A patient with Hb 15 G % will carry 3X more O_2 in his blood than someone with Hb 5G %
- Give Controlled O_2 treatment in acute pulmonary oedema to avoid CO_2 retention
- Exacerbation of COPD is a classical example of type 1 respiratory failure
- 24 – 28 % FIO_2 should be given in COPD exacerbation
- Oxygen is routinely recommended for AMI patient
- Oxygen is routinely recommended for acute stroke patient

RESPIRATORY FAILURE



Based on J B WEST

O2 dissociation curve



Essential pressure concepts

- Partial pressure = % $_x$ (total pressure)
- Room Air = 21%
- P(atmos) =760 mm Hg
- Partial pressure O_2 in room air
- =760 $_x$ (21/100)=159 mm Hg

More pressure concepts

- In airways water vapour Pressure
  =47 mm Hg
- Dry gas pressure =760 – 47
  =713 mm Hg
- PO_2 inspired air =713 x 21%
- $P_I(O_2)$ =149 mm Hg

Finally!

- Alveolar Gas Equation

$$P_AO_2 = P_IO_2 - (P_ACO_2)/(0.8)$$

$$=149 - 49$$

$$=100$$

O_2 dissociation curve

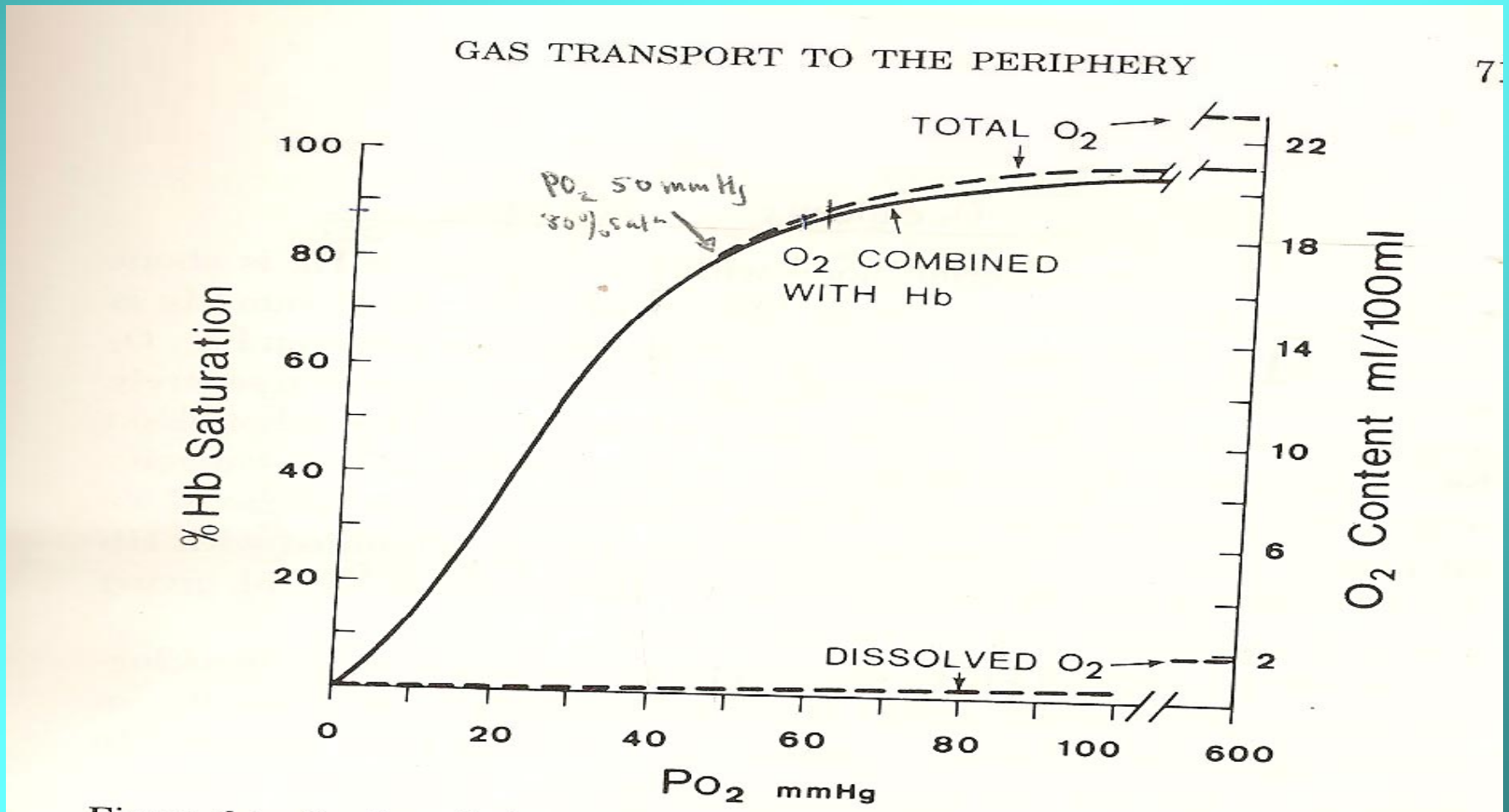


Figure 6.1. O_2 dissociation curve (*solid line*) for pH 7.4, P_{CO_2} 40 mm Hg and 37°C. The total blood O_2 content is also shown for a hemoglobin concentration of 15 gm/100 ml of blood.

Haemoglobin and O_2 Carriage

- Dissolved O_2 =0.3ml in 100ml blood
- 1G Hb = 1.4ml O_2
- 15G Hb = 20ml O_2 (un 100 ml blood)
- i.e Hb ↑ O_2 carriage X 70-fold

Importance of anaemia

- 15 G Hb = 20ml O_2
- 10 G Hb = 13.3ml O_2
- 5G Hb = 6.6ml O_2

Hb level and O_2 transport

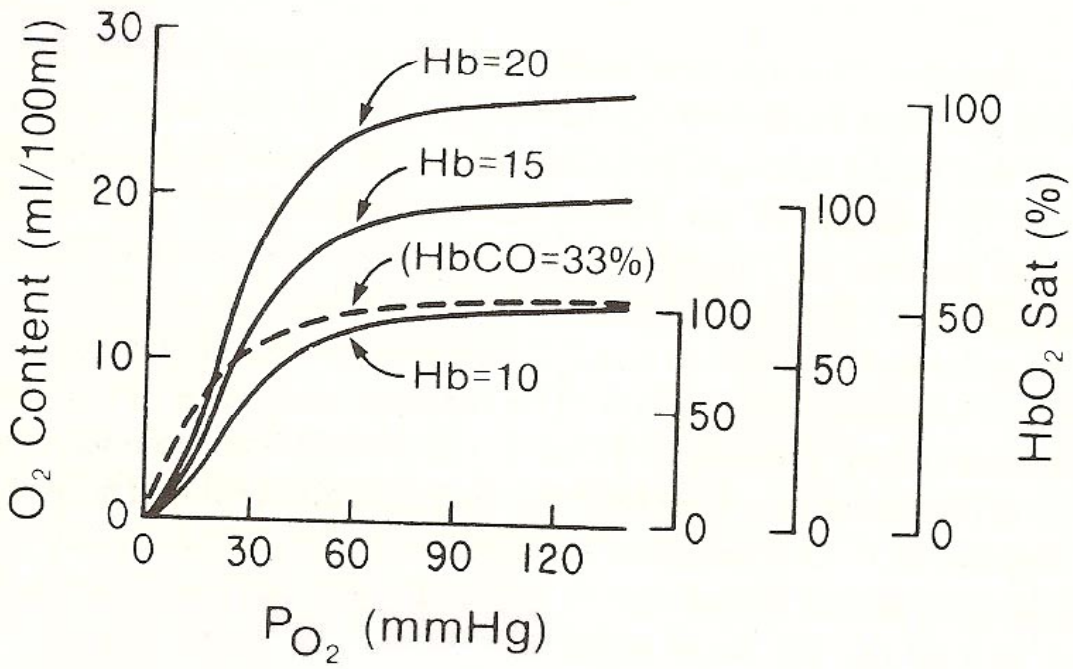
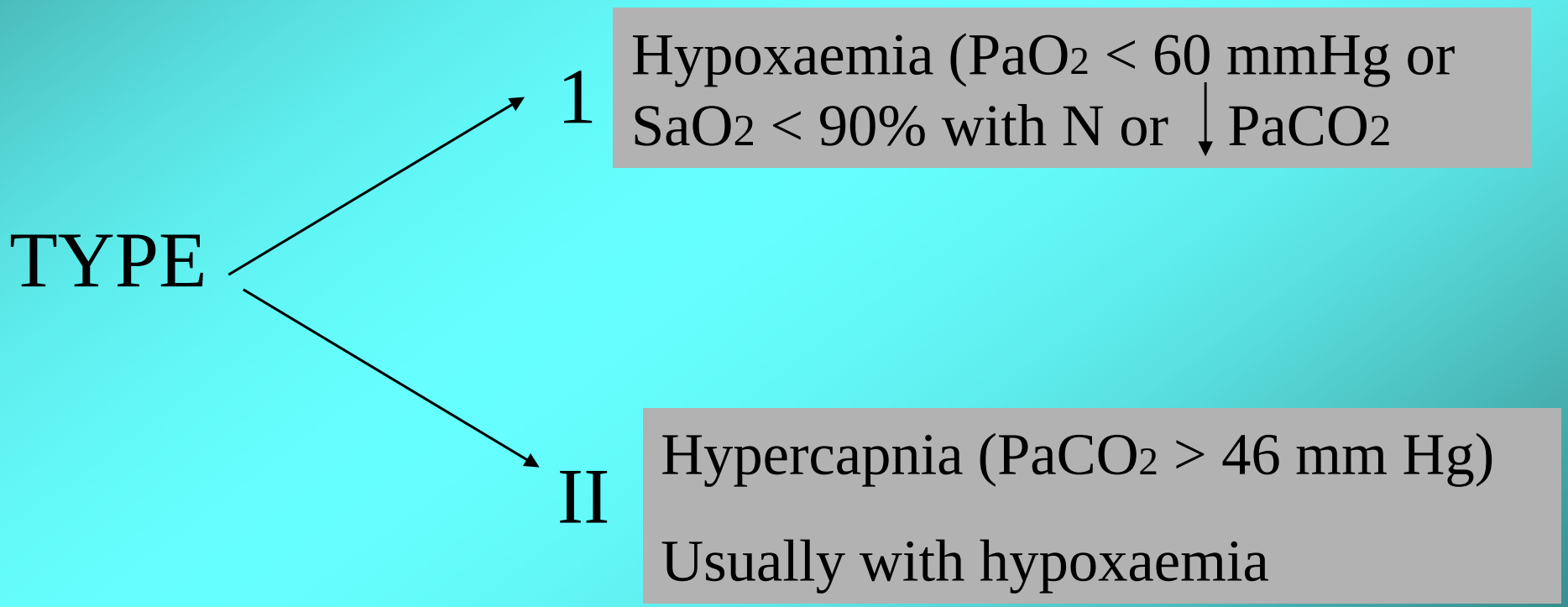


Figure 6.2. Effects of anemia and polycythemia on O_2 content and saturation. In addition, the *broken line* shows the O_2 dissociation curve when one-third of the normal hemoglobin is bound to CO. Note that the curve is shifted to the left.

Respiratory Failure



Type I

- Parenchymal disease
- Hypoxic environments

Type II

- COPD
- Obesity hypoventilation syndrome
- Neuromuscular disease
- Kyphoscoliosis

Hypoxaemia assessment - pitfalls

- Detection of cyanosis -fraught with error ie hypoxaemia often missed specially if anaemic – oximetry much better
- Tachypnoea, tachycardia often present but not always so

Hypoxaemia assessment- pitfalls

- Confusion, restlessness maybe more prominent especially in the elderly

- ↑ respiratory rate is the single best predictor of severe illness- but beware the calm patient hypoventilating from opiates!

Assessment of hypoxaemia

- Hx and examination
- Previously healthy or features of COPD
- Other illnesses predisposing to CO_2 retention
- Clinical picture will usually point towards correct diagnosis
- In dire emergencies resuscitate first then go through above steps

Pulse Oximetry

- Principle : differential absorption of Infrared light by HbO_2 and deoxy Hb
- Accurate at SPO_2> 88% (cf ABGs)
- THE FIFTH VITAL SIGN


Ohmeda Biox 3740 Pulse Oximeter
SpO2%
Pulse
NO PROBE
CONNECTED TO UNIT
Display Select
Menu Enter
BOC Health Care


Ohmeda
Biox 3740 Pulse Oximeter
SpO2%
Pulse
99
Menu
Select


99
83
Heal Force

Pulse Oximetry-Disadvantages

- Inaccurate when poor perfusion, shock
- Does not measure Hb, pH, $PaCO_2$
- Normal reading with COHb and metHb

Pulse Oximetry-Disadvantages

- Dark skinned subjects (overestimates SpO_2)
- Sickle cell crisis (underestimates)
- Nail varnish, false nails
- Thick fingers

Pulse Oximetry

- Does not mean Arterial blood gases should not be done

Arterial blood gases: indications

- All critically ill patient
- Unexpected hypoxaemia
- Worsening hypoxaemia
- Any patient at risk of type II respiratory failure who worsens
- Breathless patient who could be metabolic
- Unable to obtain reliable pulse oximetry

How to give O_2

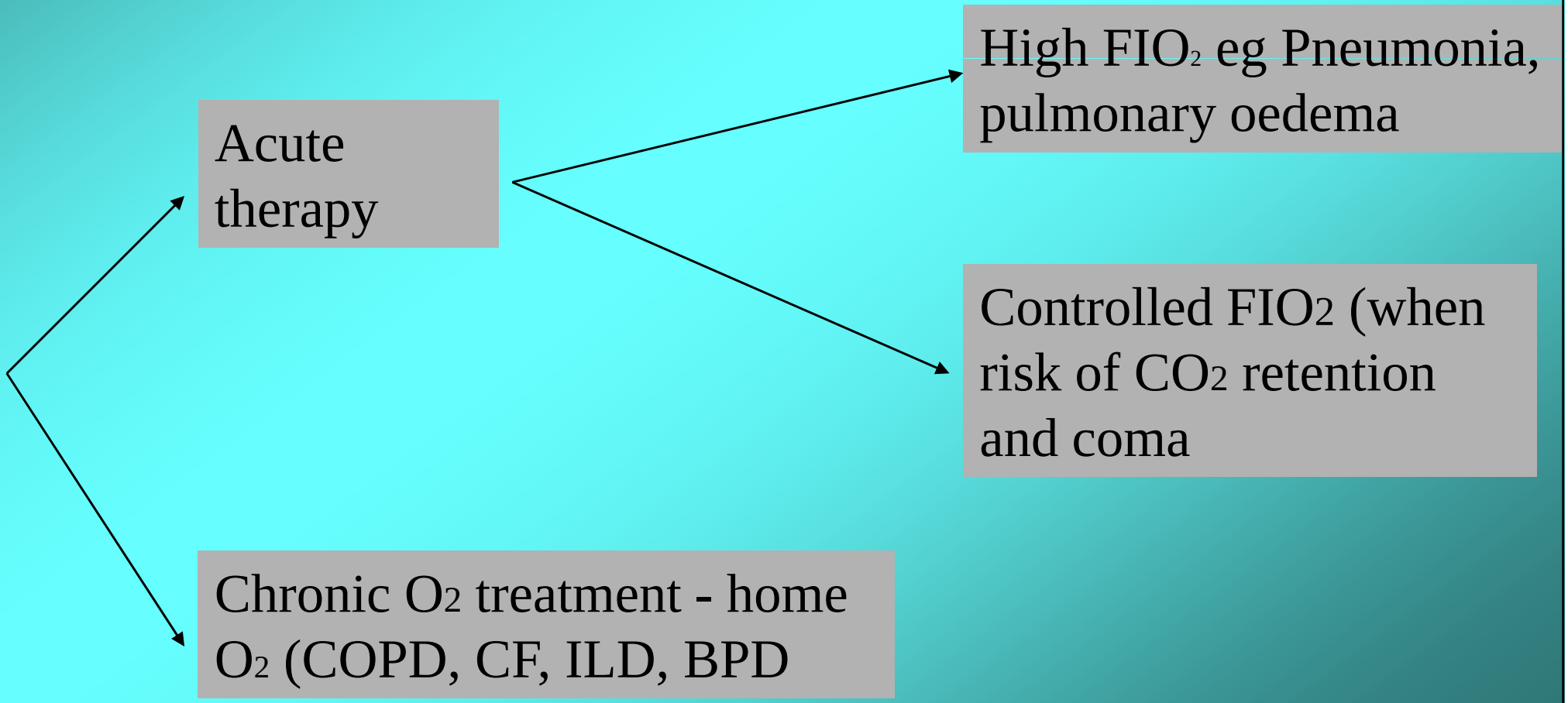
- Set a target
- 94- 98% SpO_2 in those without hypercapnic risk
- 88- 92% when risk of CO_2 retention exists

O_2 administration

- Administering O_2 via most appropriate device
- 24- 28% if risk of CO_2 retention
- Monitor(pulse oximetry) O_2 saturation
- Do ABG after 1hr if risk of retention
- Careful clinical observation

Essentials of O_2 treatment

- Aim at ↑ PaO_2 and Sa O_2



- Remember – O_2 delivery to tissues is what matters
- SaO_2 is important
- But so are [Hb] and Cardiac output

COPD dx. - pointers

- Age > 50 yrs
- > 10 pack yr smoking
- Chronic cough , Sputum
- Pre existing exertional dyspnoea
- Previous exacerbations

O_2 - dangers

- CO_2 retention (hypercapnia)
- Respiratory Acidosis (pH decreased)
- Occurs in pathology associated with hypoventilation
- Commonest: COPD
- Also
  - Morbid Obesity
  - Neuromuscular disease
  - Kyphoscoliosis

Mechanism of CO_2 retention

- Classically ‘ loss of hypoxic drive’
- Current favourite – V/Q mismatch (loss of hypoxic vasoconstriction)

CO_2 retention: Symptom and signs

- Headache
- Tremor (flap)
- Confusion
- COMA ($PaCO_2$ > 90mmHg)
- Flushed
- Bounding pulse

Rebound Hypoxaemia

	Room Air	Excess Air	O_2 Stopped
PaO_2	6.5 (49)	32(240)	3.4 (255)
$PaCO_2$	7.5 (56)	10(75)	10(75)
PAO_2	11.6 (87)		8.5 (64)

O_2 - Dangers

- Paraquat poisoning
- Bleomycin lung injury

Oxygen- Potentially dangerous

- Post MI (normoxaemic)
- Post Stroke
- Paediatric resuscitation

Hyperoxaemia - beneficial

- CO poisoning
- Pneumothorax
- 2hr Post-op bowel surgery
- ? Diabetic foot ulcers
- ? Cluster headaches

Oxygen cylinders

- Size C (170 L) G (3400) J(6800)
- Black cylinder with white shoulder
- Check label
- Check state of filling


OXYGEN
MEDICAL OXYGEN REGULA
SERIES 0
0-400


OXYGEN
OXYGEN REGULATO

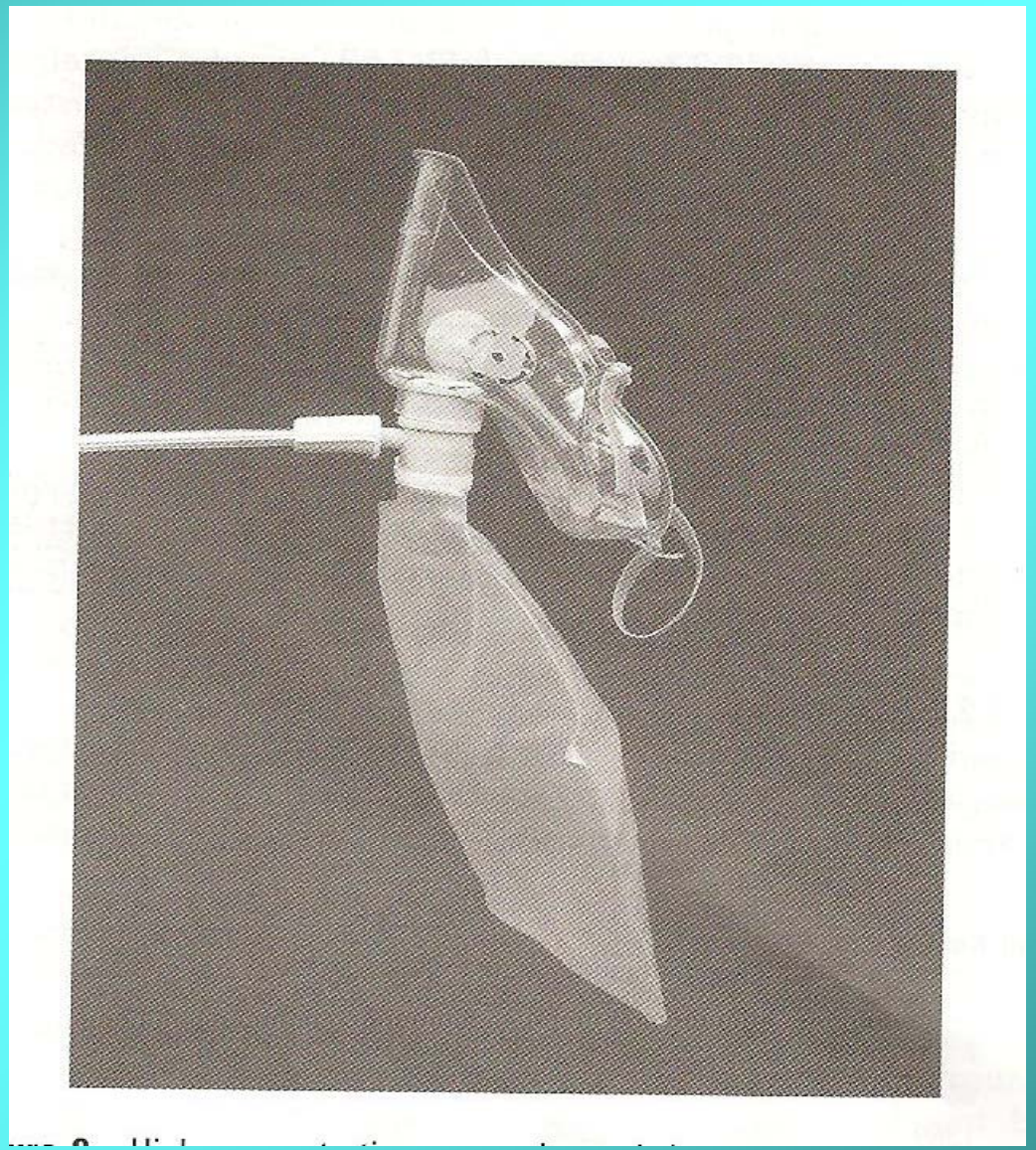
- Oxygen Concentration →
  - Air intake
  - Filter out non- O_2 gases
  - 95-99% pure O_2 out
  - Up to 6 Lpm

High FIO_2

- High reservoir mask 60-90% O_2

  10- 15 L/min

  - Major trauma
  - ER when no CO_2 retention likely

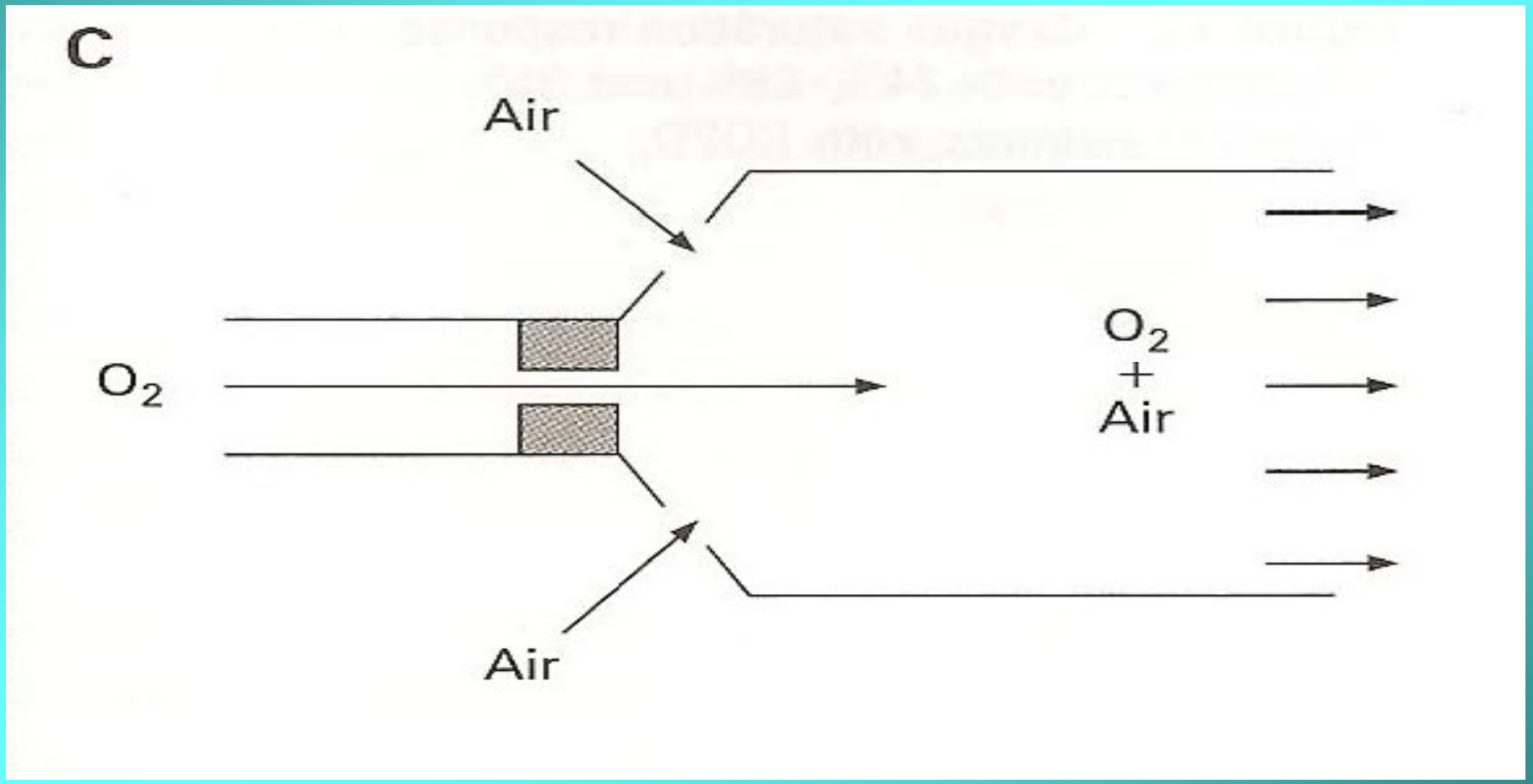


- Simple face mask
  - O_2 concentration 40 – 60%
  - Never use O_2 flow < 5l/min
    * inappropriate for COPD

Venturi principle

- Gas flowing out from small orifice will lead to a fall in pressure

Venturi principle



Venturi masks

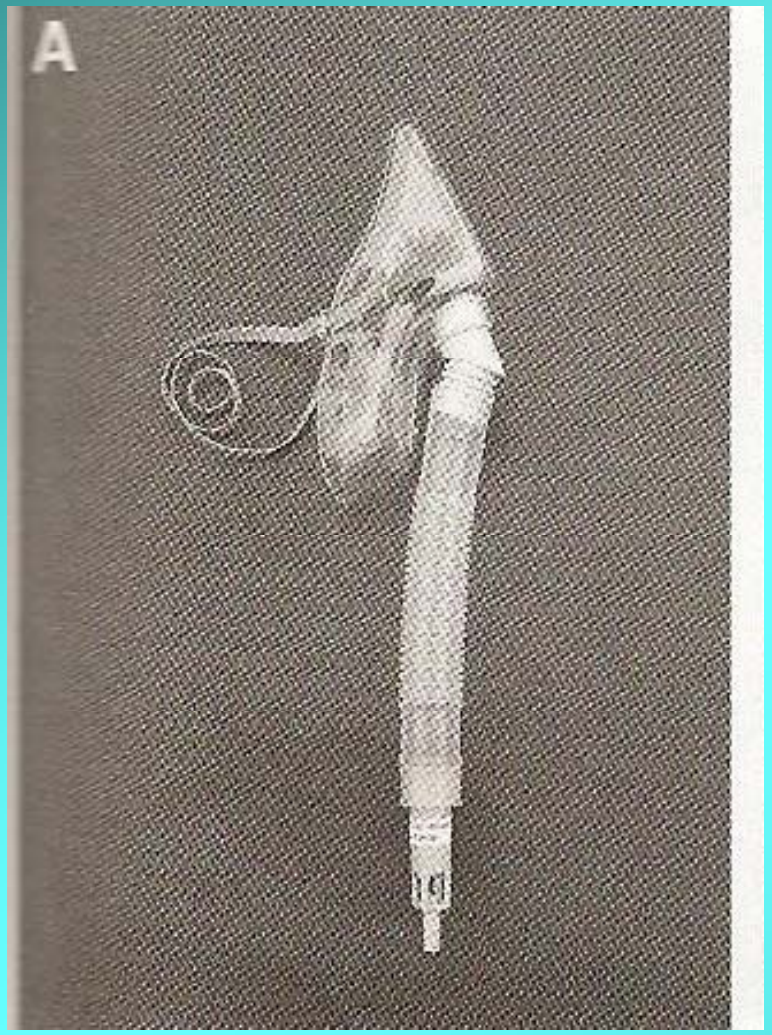


Table 11 Total gas flow rate (l/min) from Venturi masks at different oxygen flow rates

	Venturi values				
Oxygen flow (l/min)	24% oxygen	28% oxygen	35% oxygen	40% oxygen	60% oxygen
15			84	82	30
12			67	50	24
10			56	41	
8		89	46		
6		67			
4	102	44			
2	51				

Fixed O_2 conc provided minimum O_2 flow rate

Venturi masks

- Most suitable for controlled O_2 in COPD
- Also if RR > 30 Lpm with very high inspiratory flow rate

Nasal Cannulae

- Low to medium O_2 concentration
- 1 – 4 Lpm = 24% - 40 % O_2
- Breathing pattern dependent
  - thus , monitor oximetry

Nasal cannulae vs Simple face mask

- Comparable efficacy to deliver 0_2 around 40%
- NC mm appropriate for low concentration O_2 cf. simple mask
- NC better than venturi to achieve longer periods > 90% saturation

Nasal cannulae v face mask

- Advantages
  - Comfort
  - Adjustable flow gives wide oxygen dose range
  - Patient preference
  - No claustrophobic sensation
  - Not taken off to eat or speak
  - Less affected by movement of the face
  - Less inspiratory resistance than simple face masks
  - No risk of rebreathing of Carbon dioxide
  - cheaper

Nasal cannulae v face mask

- Disadvantages
  - May cause nasal irritation or soreness
  - Will not work if nose is severely congested or blocked

Humidification

- Not required for low flow O_2
- Possibly required for high flow O_2 >24 hrs
- Needed for tracheotomy mask
- May be of value to assist clearance of secretions

Humidification devices

- Bubble humidification
- No benefit re:comfort
- Infection risk

Large volume nebulisation based humidifier

- Used in patients with viscid sputum

Nebulisation

- Asthma: Use O_2
- COPD: Use compressed air or electrical nebuliser