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A Manual for House Staff on Pulmonary Service at PCOM

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<table>
<thead>
<tr>
<th>Topic</th>
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<tbody>
<tr>
<td>Pulmonary Topics</td>
<td>1</td>
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<tr>
<td>Arterial Blood Gases</td>
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<tr>
<td>Use of term regarding pCO₂, HCO₃, PaO₂, A-a Gradient</td>
<td>1</td>
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<tr>
<td>Calculation of A-a Gradient</td>
<td>2</td>
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<tr>
<td>Oxygen in General</td>
<td>3</td>
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<tr>
<td>Clinical Use of Shunt Chart</td>
<td>4</td>
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<tr>
<td>Shunt Chart</td>
<td>5</td>
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<tr>
<td>Acid Base Diagnosis</td>
<td>6</td>
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<tr>
<td>Acid Base Effects on Electrolytes</td>
<td>6</td>
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<tr>
<td>Common Causes of Acidosis and Alkalosis</td>
<td>7</td>
</tr>
<tr>
<td>Correction of Metabolic Acidemia</td>
<td>8-9</td>
</tr>
<tr>
<td>Correction of Metabolic Alkalemia</td>
<td>9-10</td>
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<tr>
<td>Ventilators</td>
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<tr>
<td>CO₂ Control</td>
<td>12</td>
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<td>Pressure versus Volume Ventilators</td>
<td>12</td>
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<td>Modes of Volume Ventilation</td>
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<tr>
<td>CMV and SIMV</td>
<td>13</td>
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<tr>
<td>Correction of Respiratory Acidosis and Alkalosis on Ventilator</td>
<td>14</td>
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<tr>
<td>Setting up the Volume Ventilator</td>
<td>15</td>
</tr>
<tr>
<td>Hyperventilation on the Ventilator</td>
<td>16</td>
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<td>Compliance</td>
<td>17</td>
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<td>Oxygen Control</td>
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<td>Oximetric Swan</td>
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<td>Best Compliance</td>
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<td>VC/VT</td>
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<td>Pulmonary Consult</td>
<td>21</td>
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<tr>
<td>Who Should Receive INH</td>
<td>22</td>
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<tr>
<td>Auscultation</td>
<td>22</td>
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<td>Atypical Mycobacterium</td>
<td>23</td>
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<td>Common X-Ray Diagnosis</td>
<td>24-25</td>
</tr>
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<td>Signs of Inoperability</td>
<td>26</td>
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<tr>
<td>Bronchodilation/Bronchospasm Diagram</td>
<td>27</td>
</tr>
<tr>
<td>Physiologic Parameters for ICU Patients</td>
<td>28</td>
</tr>
<tr>
<td>Pulmonary Service Note</td>
<td>29-30</td>
</tr>
<tr>
<td>Pulmonary Function Tests</td>
<td>31</td>
</tr>
<tr>
<td>Classification of Tuberculosis</td>
<td>32-33</td>
</tr>
<tr>
<td>Pleural Effusion</td>
<td>34</td>
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<td>Chest Tube</td>
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ARTERIAL BLOOD GASES

\[ \begin{align*}
\text{ph} & = 7.38 \text{ to } 7.42 \\
\text{pCO}_2 & = 40 \text{ mmHg} \\
\text{pO}_2 & = 70 \text{ to } 100 \text{ mmHg} \\
\text{HCO}_3 & = 23 \text{ to } 25 \text{ meq./liters}
\end{align*} \]

\text{ph}

1. Definition: A measure of acidity in relation to body gases.
2. Determined by the Henderson-Hasslebach relationship.
   \[ \text{ph} + \text{HCO}_3 = \text{kidney} \]
   \[ \text{pCO}_2 = \text{lung} \]

\text{pCO}_2

1. Definition: Pressure exerted by CO\(_2\)
   (not a direct measurement of amount)
2. Determined by and is equal to the Alveolar Ventilation Equation:
   \[ \text{A} = (\text{T.V.} - \text{D.S.}) \times \text{R} \]
   Where \( \text{A} \) = alveolar ventilation or that volume of air reaching the alveoli
   \( \text{T.V.} \) = tidal volume
   \( \text{D.S.} \) = dead space, the volume of air in the tracheobronchial tree which is not available for gas exchange
   \( \text{R.} \) = rate

USEFUL TERMS REGARDING THE pCO\(_2\):

1. Hyperventilation: \( \text{pCO}_2 \downarrow 35 \text{ mmHg} \)
2. Hypoventilation: \( \text{pCO}_2 \uparrow 45 \text{ mmHg} \)

These are blood gas diagnoses (lab), do not confuse with “TACHYPNEA” which means an increase in respiratory rate and is a physical diagnosis.
**BICARBONATE ION HCO₃**

1. Definition: Direct measurement of base solute in a solvent (blood) . . . . a measurement of amount

2. Control of this ion is by the kidney which excretes or retains it

**pₐO₂ (determined by Blood Gas Analysis)**

1. Definition: The pressure exerted by O₂ in the blood, is not a direct measurement of amount (Small “a” means arterial)

**pA₀₂ (Calculated by the physician)**

1. Definition: The pressure exerted by O₂ in the alveolus, is not a direct measurement of amount

**A-a Gradient:** The difference between the O₂ pressure in the alveolus and the capillary

**CALCULATION OF THE A-a GRADIENT**

\[
p_{AO₂} = p_lO₂ - \frac{pCO₂}{.8}
\]

\[
p_lO₂ = (pB - 47) \cdot fiO₂
\]

- \(p_lO₂\) = pressure of inspired O₂
- \(pB\) = barometric pressure
- \(47\) = pressure of water vapor
- \(fiO₂\) = the fraction of inspired O₂ (express as decimal)
CALCULATION OF THE A-a GRADIENT

What is the A-a Gradient if the fIO₂ = .21 (air) - pₐCO₂ = 40 and the PₐO₂ = 60?

\[
p_{A\text{-}O₂} = p\text{I}_O₂ - p\text{CO₂} \div .8
\]

\[
= (760 - 47) \div .21 - 40 \div .8
\]

\[
= 150 - 50
\]

\[
p_{A\text{-}O₂} = 100
\]

\[
A\text{-}a = 100 - 60
\]

\[
= 40
\]

O₂ in General

Carried in the blood in two forms: dissolved and in combination with Hb.

1. Dissolved: Obey Henry’s Law – the amount dissolved is proportional to the partial pressure. There is .003 ml O₂/100 ml blood for each mmHg pₐO₂ so that arterial blood with a pₐO₂ of 100 mmHg contains .3 ml O₂/100 ml (or .3 vols%).

2. In combination with Hb:  
   1 gm Hb can combine with 1.39 ml O₂, so  
   15 gm Hb can combine with 20.8 ml O₂/100 ml blood

O₂ Terms:

1. O₂ Capacity: max amount of O₂ that can combine with Hb at full saturation

2. % Saturation: equals \( \frac{O₂ \text{ combined with Hb}}{O₂ \text{ Capacity}} \) x 100

3. O₂ Content: O₂ combined with Hb plus O₂ dissolved in the plasma
CLINICAL APPLICATION:

Anemic patient with 7.5 gm Hb but a $P_aO_2$ of 100 mmHg

\[
\begin{align*}
O_2 \text{ combined} & = 7.5 \times 1.39 = 10.4 \\
O_2 \text{ dissolved} & = 100 \times 0.003 = 0.3 \\
O_2 \text{ content} & = 10.7
\end{align*}
\]

SHUNT

The amount of blood expressed as a % coming from the right heart through the lungs which is unoxygenated in returning to the left heart.

\[
\begin{align*}
O_s &= Cc’O_2 - CaO_2 \\
Q_t &= Cc’ - CvO_2
\end{align*}
\]

TOO CUMBERSOME?? – Use the chart on the next page.

CLINICAL USE OF THE SHUNT CHART

1. Now able to reduce $fiO_2$ to a precalculated $PaO_2$. This helps avoid oxygen toxicity at high $fiO_2$.

2. Locate $fiO_2$ (fraction of Inspired Oxygen or Percentage of $O_2$), then locate $PaO_2$. Where the two parameters intersect is the percentage shunt.

3. As long as there are no major hemodynamic changes such as cardiopulmonary arrest, hemorrhagic shock, etc., the shunt will hold.

4. Please note, this is a calculated value and not a true value but can be utilized quite well in clinical practice.

5. EXAMPLE:
   Patient is on a ventilator and the $fiO_2$ is 1.00 (100%). The $PaO_2$ is 400. the calculated shunt is 17%. Now, suppose we want a $PaO_2$ of 100. All you do is locate the $PaO_2$ of 100 and read horizontally until you get the shunt of 17%, then read vertically to $fiO_2$ of 0.39. So, in effect, you have decreased the $fiO_2$ from 1.0 to 0.39.
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<td>18</td>
<td>18</td>
<td>19</td>
<td>19</td>
<td>20</td>
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</tr>
</tbody>
</table>

**TABLE OF SHUNTS - Hb. = 15;  A.V. O₂ = 4;  pH = 7.5**
ACID BASE DIAGNOSIS
DEFINITIONS:

- **Respiratory Acidosis**
- **Respiratory Alkalosis**
- **Metabolic Acidosis**
- **Metabolic Alkalosis**

**Key**
- A1: K+ loss is
- Compensatory mechanisms are opposite so alkalosis corrects by acidosis and vice versa.
- Na+ exchanges for H+ or K+ in the kidney
- pCO₂ regulated by alveolar ventilation of the lung

ACID BASE EFFECT ON ELECTROLYTES

<table>
<thead>
<tr>
<th>pH</th>
<th>H⁺</th>
<th>Na⁺</th>
<th>K⁺</th>
<th>Cl⁻</th>
<th>HCO₃⁻</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Alkalosis</th>
<th></th>
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<tbody>
<tr>
<td></td>
<td>▲</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Acidosis</th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>▼</td>
<td>▲</td>
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<td>▼</td>
</tr>
</tbody>
</table>
COMMON CAUSES OF RESPIRATORY ACIDOSIS

1. COPD – asthma, bronchitis, emphysema
2. Depression of the respiratory center – anesthesia, drugs
3. Traumatic – flair chest
4. Polio

COMMON CAUSES OF METABOLIC ALKALOSIS

1. Vomiting
2. N G Suction
3. Drugs (diuretics, steroids, antacids)
4. Hypokalemia Al K+ loss

COMMON CAUSES OF RESPIRATORY ALKALOSIS

1. Emotion or pain
2. Pneumonia
3. CHF
4. Pulmonary Embolism

COMMON CAUSES OF METABOLIC ACIDOSIS

1. Diabetes
2. Renal Failure
3. Lactic Acidosis
4. Diarrhea
CORRECTION OF METABOLIC ACIDEMIA

\[ \text{Meq of NaHCO}_3 = 0.2 \times \text{kg (body weight)} \times \text{Base} \]

EXAMPLE:

\[
\begin{align*}
\text{pH} & = 7.02 \\
\text{HCO}_3^- & = 10 \\
\text{pCO}_2 & = 40
\end{align*}
\]

Question: Correct the pH to calculated 7.4.

Patient weighs 70 kg.

DETERMINATION OF THE \( B \) FROM SIGGARD-ANDERSON ALIGNMENT NOMOGRAM

1. Draw a straight line between the above blood gas parameters.
2. Draw a straight line from the pCO\(_2\) through the pH you want the patient to have – say for example, 7.4. The line will intersect an HCO\(_3^-\) level of 23.8.
3. You have 10 meq./liters of HCO\(_3^-\) on board for a pH of 7.02 and you want to increase the level of HCO\(_3^-\) to 23.8 for planned pH of 7.4.

So:

\[
\begin{align*}
\text{HCO}_3^- \text{ desired} & = 23.8 \\
\text{HCO}_3^- \text{ on board} & = 10 \\
\text{B} & = 13.8
\end{align*}
\]

And: \[ \text{Meq of NaHCO}_3 = 0.2 \times 70 \times 13.8 \]
\[ = 193 \text{ meq. needed to correct to a pH of 7.4.} \]
CORRECTION OF METABOLIC ACIDEMIA

pH 7.02
HCO₃ 10
pCO₂ (N) 40
HCO₃ desired 23.8
HCO₃ measured 10

(=) 13.8
CORRECTION OF METABOLIC ALKALEMIA

Meq. of Arginine $\times$ HCl = 0.2 $\times$ kg (body weight) $\times$ Base

Example:

$\text{pH} = 7.67$
$\text{HCO}_3^- = 45$
$\text{pCO}_2 = 40$

Question: Correct the pH to calculated 7.4.

Patient weighs 70 kg.

Determination of the Base from the Siggard-Anderson Alignment Nomogram:

1. Draw a straight line between the above blood gas parameters.
2. Draw a straight line from the pCO$_2$ through the pH you want the patient to have – for example, 7.4. The line will intersect an HCO$_3^-$ level of 23.8.
3. You have 45 meq./liters on board for a pH of 7.67 and you want to decrease the level of HCO$_3^-$ to 23.8 for a planned pH of 7.4.

So:

\[
\begin{align*}
\text{HCO}_3^- \text{ on board} & = 45.0 \\
\text{HCO}_3^- \text{ desired} & = 23.8 \\
\text{Base} & = 21.2
\end{align*}
\]

And: Meq. of Arginine $\times$ HCl = 0.2 $\times$ 70 $\times$ 21.2

= 296.8 meq. of Arginine $\times$ HCl

needed to correct to a pH of 7.4.
pH = 7.67
pCO₂ = 40
HCO₃ = 45

\[ \text{HCO}_3 \text{ measured} - 45.0 \]
\[ \text{HCO}_3 \text{ measured} - 23.8 \]
\[ \Delta \beta = 21.2 \]
A. CO₂ Control
   1. pCO₂ is controlled by the alveolar gas equation
      \[ pCO₂ \approx A = (TV - DS) R \]

   a. Four factors which influence A
      1. Volume (TV)
      2. Rate (R)
      3. Pressure
      4. Flow

2. Ideal Ventilator

3. Difference between Volume and Pressure Ventilator

<table>
<thead>
<tr>
<th></th>
<th>TV</th>
<th>Rate</th>
<th>Pressure</th>
<th>Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure Vent.</td>
<td>Varies</td>
<td>Set</td>
<td>Set</td>
<td>Set</td>
</tr>
<tr>
<td>Vol. Vent.</td>
<td>Set</td>
<td>Set</td>
<td>Varies</td>
<td>Set</td>
</tr>
</tbody>
</table>
4. Modes of Ventilation on Volume Ventilator

CMV - patient gets same dialed in volume whether he breathes or not

\[ CMV = (TVm \times RVm) + (TVm \times Rpt) \]

SIMV - Patient breathes on his own and ventilator signs patient at frequent intervals

- (A Bionic Nurse) S stands for synchronous - ventilator will not cycle if patient has not exhaled.

USE: Hard Weaning problems
- Patient with severe emphysema who needs to be signed so as to lower the pCO₂.

Remember \[ pCO₂ = (TV - DS) \times R \]

TVm - Tidal Volume Machine
TVpt - Tidal Volume Patient
Rm - Rate on Machine
Rpt - Rate of Patient
5. Correction of Respiratory Acidosis and Alkalosis while on the Ventilator

The CO₂ Adjust Equation
Since A Ventilation produces a certain CO₂ as determined by blood gas analysis then it is possible to calculate what new A is necessary to produce a new CO₂.

\[ p \text{CO}_2 \times TV_1 \times R_1 = p \text{CO}_2 \times TV_2 \times R_2 \]

Example: \[ p \text{CO}_2 = 50 \quad \text{Need} \quad p \text{CO}_2 = 40 \]

1

\[ TV_1 = 500 \quad TV_2 = ? \]

\[ R_1 = 10 \quad R_2 = ? \]

\[ 50 \times 500 \times 10 = 6250 = TV_2 \times R_2 \]

Plug in TV and solve for R or plug in R and solve for TV

\[ 625 \times 10 = TV_2 \times R_2 \]

\[ 520 \times 12 = TV_2 \times R_2 \]

\[ 415 \times 15 = TV_2 \times R_2 \]

**NOTE:** \[ R_1 \text{ is the total rate of machine set plus patient triggering rate or } R_1 = (Rm + Rpt) \]
This formula is very accurate in apenic patients.
Setting Up the Volume Ventilator

TV - 10 to 15 ml/kg of body weight

R - normal rate 10 to 20

P - This is an alarm (cannot set pressure on volume ventilator)

A. Turn up pressure alarm to 100 cm

B. Read pressure patient needs for desired volume from gauge or digital display, add 10 and dial down pressure alarm
   i.e. meter needs 30 cm - so add 10 cm and set pressure alarm at 40 cm

FLOW - Depends on Ventilator - usually around 40 liters/min

NOTE: In all PCOM books, flow is expressed in ml/sec - less confusing better understood when looking at illustrative Volume, Pressure, Flow, Rate, Graphs
FLOW (continued)
- Check I:E (Inspiratory/Expiratory light) - if on, patient needs more flow

- If you desire a low flow ventilation for better air dispersion, turn down flow until the red light or indicator comes on and then add 10 liters/min

7. Hyperventilation on Ventilator - patient with a low CO$_2$ and high respiratory rate
   A. Low Flow Trick - you cannot take a deep breath while you are inspiring because you are all ready doing it.

   ![Graph showing flow calculation]

   Flow \( \frac{750}{2} = 375 \text{ ml/seg} \)

   Flow \( \frac{750}{3} = 250 \text{ ml/seg} \)

   B. Pavulon - paralyzes respiratory muscles

   C. Add Dead Space - patient rebreathes his own expired air

   ![Dead Space Tube Diagram]  
   Dead Space Tube  
   Start at 6”
COMPLIANCE MEASUREMENT ON VENTILATOR

\[ C = \frac{\text{Tidal Volume}}{\text{Plateau Pressure} - \text{PEEP}} \]

Example:

\[ C = \frac{800}{20 - 0} \]

\[ C = 40 \]

Normal: 40 plus or minus 5

NB
1. Turn on expiratory resistance control
or
2. Obstruct the expiratory hose
3. Read the dial gauge or digital display for \( P_2 \)

1. Respiratory Cycle

TIME
B. O₂ Control on Ventilator

1. Shunt Chart - see page 5

2. CPAP (continuous positive airwave pressure)
   To maintain positive pressure during inspiration and expiration.

   Patient must breathe on his own - he must be able to control his pCO₂

   USE: Oxygenation Problems Only

   EXAMPLE: P.E.

   ![Diagram of O₂ Control on Ventilator]

   **IPEEP**
   Compliance =

   - Wall Flow - Extremely High Flow
     Air or Air + O₂ or O₂
     30 - 50 liters/min

   **3. PEEP** (Positive and Expiratory Pressure)

   A. Oximetric Swan Ganz - measure SVO₂ at different levels of PEEP, Highest SVO₂ corresponds to best PEEP
B. Compliance Best PEEP

**Best PEEP** - PEEP at which compliance is closest to 40

Example:

<table>
<thead>
<tr>
<th>PEEP</th>
<th>Compliance</th>
<th>T.V.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>( \frac{500}{20} - 0 )</td>
<td>25</td>
</tr>
<tr>
<td>2</td>
<td>( \frac{500}{18} - 2 )</td>
<td>31</td>
</tr>
<tr>
<td>4</td>
<td>( \frac{500}{16} - 2 )</td>
<td>40</td>
</tr>
<tr>
<td>6</td>
<td>( \frac{500}{22} - 6 )</td>
<td>30</td>
</tr>
<tr>
<td>8</td>
<td>( \frac{500}{26} - 8 )</td>
<td>27</td>
</tr>
</tbody>
</table>

**VD/VT RATIOS:**

During each breath a certain volume of air ventilates the dead space and the remainder the alveolar space where gas exchange occurs. The ratio of dead space ventilation to total ventilation (VD/VT) is a reflection of efficiency of ventilation. Normally, the VD/VT = .35 or less. When the dead space increases so there are abnormally large areas which are being ventilated but which are not exchanging gas, the VD/VT increases. VD/VT is calculated from the following equation:

\[
\frac{VD}{VT} = \frac{PaCO_2 - PeCO_2}{PaCO_2} = \frac{PaCO_2}{PaCO_2} = \text{artrial carbon dioxide tension} = \text{carbon dioxide tension in expired air}
\]

Above VD/VT of .6 patient cannot be weaned off ventilator.
EXAMPLE:

What is the VD in a patient who has a tidal volume of 800, PaCO₂ of 50 and PeCO₂ of 30?

What is the VD/VT?

\[
\frac{VD}{VT} = \frac{50 - 30}{800} = \frac{320}{800} = 0.4
\]
I. HISTORY OF CHIEF COMPLAINT
   Includes six major symptoms

   1. Cough and time cough occurs
   2. Sputum
      a. amount
      b. color
      c. odor
      d. frothiness
   3. Hemoptysis
   4. Chest Pain
   5. Dyspnea
   6. Wheezing

II. PAST HISTORY
   1. Tuberculosis – active disease, exposure, previous PPD results
   2. Smoking – age when began, packs per day
   3. Occupations
   4. COPD, asthma, past hospitalization

III. PHYSICAL
   1. Heart
      a. rhythm
      b. cervical venous distension
   2. Lungs
      a. see auscultation flow chart
      b. percussion
      c. tactile fremitus
      d. vocal fremitus
   3. Extremities
      a. cyanosis
      b. clubbing
      c. edema
   4. Thorax
      a. deformities
      b. spinal and lesion complex
      c. distended veins
      d. adenopathy

IV. LAB
   1. Pulmonary function testing, arterial blood gases, other pertinent results

V. IMPRESSION

VI. RECOMMENDATIONS
AUSCULTATION

ADVENTITIOUS SOUNDS

PULMONARY

DISCONTINUOUS (INTERRUPTED) CONTINUOUS (UNINTERRUPTED)

RALES RHONCHI

COURSE MEDIUM FINE* SIBILANT SONOROUS

*Fine rales – crepitations
Sibilant rhonchi – high pitched and musical
Sonorous rhonchi – low pitched

PLEURAL

FRICTION RUB CLICKING OR CRUNCHING SOUND OF PNEUMOTHORAX OR PNEUMOMEDIASTINUM

WHO SHOULD RECEIVE INH

1. House contacts and newly developed cases
2. Patients with old tuberculosis but inadequately treated
3. Positive PPD with abnormal chest film
4. Positive PPD adolescents with or without normal chest films
5. PPD reactors who have diabetes, reticuloendothelial disease, silicosis, gastrectomy, or receiving steroids or other immunosuppressive therapy.
<table>
<thead>
<tr>
<th>Runyan Group</th>
<th>Synonym</th>
<th>Rate of Growth</th>
<th>Disease</th>
<th>Therapy</th>
<th>Antigen</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Photochromogen (Pigment in light)</td>
<td>3-4 weeks</td>
<td>Pulmonary, adenitis</td>
<td>Surgery</td>
<td>Non-pathogens</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>M. kansasii</td>
<td></td>
<td>M. aquae</td>
</tr>
<tr>
<td>II</td>
<td>Scochromogen (Pigment in dark)</td>
<td>2-3 weeks</td>
<td>Swimming pool granuloma</td>
<td>M. marinum (bairi)</td>
<td>M. flavescens</td>
</tr>
<tr>
<td>III</td>
<td>Non-photochromogen</td>
<td>3-4 weeks</td>
<td>Adenitis</td>
<td>M. scrofulaceum</td>
<td>M. gastri</td>
</tr>
<tr>
<td>IV</td>
<td>Rapid growers</td>
<td>3-4 days</td>
<td>Pulmonary, miliary</td>
<td>M. avium</td>
<td>M. intracellulare (Battey)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>M. xenopei</td>
<td></td>
<td>M. xenopei</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>M. terrae</td>
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<td>M. terrae</td>
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<td></td>
<td>M. smegmatis</td>
<td></td>
<td>M. smegmatis</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>M. phlei</td>
<td></td>
<td>M. phlei</td>
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</tr>
</tbody>
</table>

- 75% INH responsive
- (Pigment in light)
- (Pigment in dark)
- (Gauss)
- (Battey)
COMMON X-RAY DIAGNOSES

I. DIFFUSE RETICULAR OR NODULAR
   A. Infectious – Tuberculosis, Staphylococcus, Pneumocystis
   B. Neoplastic – Alveolar Carcinoma
   C. Cardiovascular – Interstitial Pulmonary Edema, Fibrosis, Hemosiderosis
   D. Immunologic – Collagen
   E. Inhalation – Organic and Inorganic Dusts
   F. Idiopathic – Sarcoid, Hamman-Rich, DIP

II. DIFFUSE ACINAR
    A. Infectious – Viral
    B. Neoplastic – Alveolar Carcinoma, Metastasis
    C. Cardiovascular – Pulmonary Edema
    D. Immunologic – Necrotizing Alveolitis
    E. Inhalation – Aspiration, Noxious Gases
    F. Idiopathic – Sarcoid, Hyaline Membrane, Shock Lung, Goodpasture’s

III. DIFFUSE MIXED ACINAR – RETICULONODULAR
     A. Infectious – Viral, PPLO
     B. Neoplastic – Bronchoalveolar
     C. Inhalation
     D. Idiopathic – Goodpasture’s

IV. HILAR AND MEDIASTINAL LYMPH NODE ENLARGEMENT
    A. Infectious – Tuberculosis, PPLO
    B. Neoplastic – Bronchogenic, Hodgkin’s, Metastasis
    C. Inhalation – Silicosis
    D. Idiopathic – Sarcoid

V. PLEURAL EFFUSION
    A. Infectious – Klebsiella, Staphylococcus, Tuberculosis, Pseudomonas, E. Coli
    B. Neoplastic – Bronchogenic, Mesothelioma, Meig’s Syndrome
    C. Thromboembolis – P.E. with infarction
    D. Cardiovascular – CHF
    E. Immunologic
    F. Traumatic
    G. Incidental – Peritoneal Dialysis
VI. CYST WITH CAVITY
   A. Developmental
   B. Infectious
      1. Bacterial: Staphylococcus, Klebsiella, Tuberculosis, Pseudomonas, E. Coli, Bacteroides, Proteus
      2. Fungal: Aspergillosis, Nocardia, Blastomycetes
   C. Neoplastic – Bronchogenic carcinoma, Metastasis
   D. Thromboembolic – P.E. with infarction
   E. Immunologic
   F. Inhalation
   G. Traumatic

VII. SOLITARY NODULES LESS THAN 6 CM
   A. Developmental – Cyst, sequestration, A-V fistula
   B. Infectious – Tuberculosis
   C. Neoplastic – Adenoma, OMA, Bronchogenic Carcinoma
   D. Immunologic – Rheumatoid Nodule

VIII. MULTIPLE PULMONARY NODULES
   A. Developmental – A-V fistula
   B. Infectious
   C. Neoplastic – Metastasis
   D. Immunologic – Wegener’s

IX. SOLITARY MASSES GREATER THAN 6 CM
   A. Developmental – Sequestration
   B. Infectious – Abscess
   C. Neoplastic – Bronchogenic carcinoma

X. Mediastinal widening
   A. Developmental – Cyst
   B. Infectious
   C. Neoplastic – Thyroid, thymoma, germinal cell, metastasis
   D. Trauma – Pneumomediastinum
   E. Incidental – Esophageal hiatal hernia, Morgagni hernia (anterior), Bochdalek hernia (posterior)
SIGNS OF INOPERABILITY

1. Metastasis – brain, bone, other organs

2. Lymph Nodes

3. Superior Vena Caval Obstruction

4. Recurrent Laryngeal Nerve Paralysis

5. Phrenic Nerve Paralysis

6. Pancoast Syndrome (Superior Sulcus Tumor Syndrome): Low grade squamous cell carcinoma of the apex of the lung which spreads to the lower cords of the brachial plexus. Gives rise to Horner’s syndrome and wasting of the small muscles of the hand.
1. Bronchial Smooth Muscle has both:

   - alpha receptors — increase bronchomotor tone (constrict)
   - beta receptors — decrease bronchomotor tone (dilate)

2. Beta receptor is probably the enzyme adenyl cyclase (asthmatics may have decreased adenyl cyclase)
<table>
<thead>
<tr>
<th>Volume-Related Variables</th>
<th>Abbreviation</th>
<th>Formulas</th>
<th>Units</th>
<th>Normal Values</th>
<th>Optimal Goals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean arterial pressure</td>
<td>MAP</td>
<td></td>
<td>mm Hg</td>
<td>90 ± 5</td>
<td>90</td>
</tr>
<tr>
<td>Central venous pressure</td>
<td>CVP</td>
<td></td>
<td>cm water</td>
<td>5 ± 2</td>
<td>10</td>
</tr>
<tr>
<td>Central blood volume</td>
<td>CBV</td>
<td>CBV = CI x MTT x 16.7</td>
<td>ml · m⁻²</td>
<td>830 ± 60</td>
<td>750</td>
</tr>
<tr>
<td>Stroke index</td>
<td>SI</td>
<td></td>
<td>ml · m⁻²</td>
<td>46 ± 5</td>
<td>50</td>
</tr>
<tr>
<td>Hemoglobin</td>
<td>Hb</td>
<td></td>
<td>g · 100 ml⁻¹</td>
<td>14 ± 1</td>
<td>12</td>
</tr>
<tr>
<td>Mean pulmonary arterial pressure</td>
<td>MPAP</td>
<td></td>
<td>mm Hg</td>
<td>13 ± 1</td>
<td>15</td>
</tr>
<tr>
<td>Pulmonary wedge pressure</td>
<td>PWP</td>
<td></td>
<td>cm water</td>
<td>6 ± 3</td>
<td>12</td>
</tr>
<tr>
<td>Red cell mass</td>
<td>RCM</td>
<td></td>
<td>liter M⁻²</td>
<td>1.2 ± 1.0</td>
<td>1.2 ± 1.0</td>
</tr>
<tr>
<td>Blood volume</td>
<td>BV</td>
<td></td>
<td>liter M⁻²</td>
<td>2.74 ± 3.7</td>
<td>3.0 ± 2.7</td>
</tr>
</tbody>
</table>

| Flow-Related Variables                   |              |          |           |               |               |
| Cardiac index                            | CI           | CI = CO / SA | liter · min⁻¹ · m⁻² | 3.2 ± 0.2     | 4.5           |
| Mean transit time                        | MTT          |          | sec       | 15 ± 1.4      | 16            |
| Left ventricular stroke work             | LVSV         | LVSV = SI x MAP .0136 | g · m · m⁻² | 56 ± 6     | 60            |
| Left cardiac work                        | LCW          | LCW = CI x MAP .0136 | kg · m · m⁻² | 3.8 ± 0.4    | 4.0           |
| Mean systolic ejection rate              | MSER         | MSER = SI / time of systole | ml · sec⁻¹ · m⁻² | 370 ± 50  | 360           |
| Tension time index                       | TTI          | TTI = MAP x time of systole x HR | mm Hg · sec · cm⁻¹ | 780 ± 100 | 1200          |
| Right Ventricular stroke work            | RVSW         | RVSW = SI x MAP x .0136 | g · m · m⁻² | 8.8 ± 0.9    | 10.5          |
| Right cardiac work                       | RCW          | RCW = CI x MAP x .0136 | kg · m · m⁻² | 0.6 ± 0.06  | 1.15          |

| Bodily Responses                         |              |          |           |               |               |
| Systemic vascular resistance             | SVR          | SVR = (MAP — CVP) / Cl | dyne · sec/cm²/M² | 2180 ± 210  | 1400          |
| Pulmonary vascular resistance            | PVR          | PVR = (MPAP — WP) / Cl | dyne · sec/cm²/M² | 270 ± 45   | 350           |
| Heart rate                               | HR           |          | beats · min⁻¹ | 71 ± 4      | 86            |
| Temperature, rectal                      | Temp         |          | ° F       | 98 ± 0.2     | 100           |

| O₂ Related Variables                     |              |          |           |               |               |
| Arterial pH                               | pHₐ          |          |           | 7.4 ± 0.02    | 7.45          |
| Arterial O₂ tension                      | PaCO₂        |          | torr      | 40 ± 2        | 36            |
| Mixed Venous                              | PvO₂         |          | torr      | 38 ± 4        | 40            |
| O₂ tension                               | SaO₂         |          | %         | 97 ± 1        | 97            |
| Arterial venous O₂ content difference    | axDO₂        | axDO₂ = CaO₂ — CV_o₂ | ml · 100⁻¹ | 4.6 ± 0.4    | 4.5           |
| O₂ availability                          | O₂ Avail     | O₂ Avail = CaO₂ · Cl · 10 | ml · min⁻¹ · m⁻² | 600 ± 50  | 600           |
| O₂ consumption                           | V̇O₂         | V̇O₂ = axDO₂ · Cl · 10 | ml · min⁻¹ · m⁻² | 140 ± 25  | 160           |
| O₂ extraction                             | O₂ Ext       | O₂ Ext = (CaO₂ — CV_o₂) / CaO₂ | % | 26 ± 2 | 24            |

| Perfusion Indices                        |              |          |           |               |               |
| Red cell flow rate                       | RCFR         | RCFR = Cl x Hct | liter · min⁻¹ · m⁻² | 1.2 ± 0.3 | 1.2          |
| Blood flow/                               | BFVR         | BFVR = CI / BV | ----- | 1.2 ± 0.3 | 1.6          |
| volume ratio                             | OTRM         | OTRM = vO₂ / RCM | ----- | 0.12 ± 0.03 | 0.25         |
| O₂ transport/red                         | TOEI         | TOEI = axDO₂ · RCFR | ----- | ± 4.15 | 4.5          |
| cell mass ratio                          | ETOE         | ETOE = axDO₂ · RCM | ----- | 4.2 ± 1.2 | 5             |
| Tissue O₂ extraction index               | OTRF         | OTRF = vO₂ / RCFR | ----- | 120 ± 34 | 130           |

† — Direct Measurement ‡ — Mean = SD ᵀ — Venous Pressure expressed in mm Hg ᵃ — Hematocrit
Example: A patient with pulmonary edema on MA-1 weighing 70 kg.

\[
\begin{align*}
\text{pH} &= 7.14 \\
\text{pCO}_2 &= 80 \\
\text{pO}_2 &= 180 \\
\text{HCO}_3 &= 25 \\
\end{align*}
\]

\[
\begin{align*}
\text{MA-1} &\quad \text{Severe} \\
\text{TV} &= 400 \\
\text{Rate} &= 12 \\
\text{fiO}_2 &= 1.00 \\
\text{P}_{c+R} &= 40 \\
\text{P}_c &= 20 \\
\end{align*}
\]

(Shunt)

\[
\frac{Q_s}{Q_t} \times 100 = 30\% 
\]

\[
\begin{align*}
PAP &= 40 \\
\text{Wedge} &= 25 \\
\text{A-a gradient} &= 613 - 180 = 433 \\
\text{PAO}_2 &= 613 \\
\text{Compliance} &= \frac{V}{P_c} = \frac{400}{20} = 20 \\
\text{PaO}_2 &= 180
\end{align*}
\]
LUNGS – bilateral end-inspiratory crepitant rales

Chest Film

1. Bilateral pulmonary vascular engorgement
2. Cardiomegaly

Plan –

1. Increase RV to 800
2. Rate: 12

Why?

\[
pCO_2 \times RV_1 \times R_1 = pCO_2 \times RV_2 \times R_2
\]

\[
80 \times 400 \times 12 = 9600 = (TV_2 \times R_2)
\]

\[
800 \times 12 = (TV_2 \times R_2)
\]

\[
960 \times 10 = (TV_2 \times R_2)
\]

3. Decrease fIO₂ to 0.56 for calculated paO₂ of 80.
PULMONARY FUNCTION TESTS

IN OBSTRUCTIVE DISEASE:

FEV1%

Mild  70% – 55%
Moderate  54% – 45%
Severe  less than 45%

IN RESTRICTIVE DISEASE:

All lung volumes decreased (FVC, FRC or RV)

<table>
<thead>
<tr>
<th></th>
<th>FVC</th>
<th>FRC or RV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild</td>
<td>79%-65%</td>
<td>+</td>
</tr>
<tr>
<td>Moderate</td>
<td>64%-50%</td>
<td>+</td>
</tr>
<tr>
<td>Severe</td>
<td>less than 50%</td>
<td>+</td>
</tr>
</tbody>
</table>

RV above 125% – – – – – – – Hyperinflation

BRONCHODILATORS:  Increase of 25% in volumes or flows is a good response.
CLASSIFICATION OF TUBERCULOSIS
AND OTHER MYCOBACTERIAL DISEASES

Summarized from Diagnostic Standards and Classification of Tuberculosis and Other Mycobacterial Disease, American Thoracic Society, Medical Section of American Lung Association, 1981.

TUBERCULOSIS
0. No Tuberculosis Exposure. Not Infected.
   (no history of exposure, reaction to tuberculin skin test not significant)
1. Tuberculosis Exposure. No Evidence of Infection (history of exposure, reaction to tuberculin skin test not significant)
2. Tuberculosis Infection. No Disease. (significant reaction to tuberculin skin test, negative bacteriologic studies (if done), no clinical and/or roentgenographic evidence of tuberculosis).

CHEMOTHERAPY STATUS (preventive)
   None
   On chemotherapy since (date)
   Chemotherapy terminated (date)
   Complete (prescribed course of therapy)
   Incomplete

3. Tuberculosis: Current Disease (M. Tuberculosis cultured [if done], otherwise both a significant reaction to tuberculin skin test and clinical and/or roentgenographic evidence of current disease).

LOCATION OF DISEASE
   Pulmonary
   Pleural
   Lymphatic
   Bone and/or Joint
   Genitourinary
   Disseminated (Miliary)
   Meningeal
   Peritoneal
   Other

The predominant site shall be listed. Other sites may also be listed. Anatomic sites may be specified more precisely.

BACTERIOLOGIC STATUS
   Positive by
   Microscopy only (date)
   Culture only (date)
   Microscopy and Culture (date)
   Negative (date)
   Not done

CHEMOTHERAPY STATUS
   On chemotherapy since (date)
   Chemotherapy terminated, incomplete (date)

The following data are necessary in certain circumstances:

ROENTGENOGRAM FINDINGS
   Normal
   Abnormal
   Cavitary or noncavitary
   Stable or worsening or improving

(continued)
TUBERCULIN SKIN TEST REACTION
Significant
Not significant

4. Tuberculosis: No current disease (history of previous episode(s) of tuberculosis, or abnormal stable roentgenographic findings in a person with a significant reaction to tuberculin skin test, negative bacteriologic studies (if done), no clinical or roentgenographic evidence of current disease).

CHEMOTHERAPY STATUS
None
On chemotherapy since (date)
Chemotherapy terminated (date)
Complete
Incomplete

5. Tuberculosis Suspect (diagnosis pending)

CHEMOTHERAPY STATUS
None
On chemotherapy since (date)

OTHER MYCOBACTERIAL DISEASES
Mycobacterial disease caused by (organism)

LOCATION OF DISEASE
Pulmonary
Genitourinary
Other
Pleural
Disseminated (Miliary)
Lymphatic
Meningeal
Bone and/or Joint
Peritoneal

BACTERIOLOGIC STATUS
Positive by
Culture only (date)
Microscopy and Culture (Date)
Negative

CHEMOTHERAPY STATUS
None
On chemotherapy since (date)
Complete
Incomplete

ROENTGENOGRAM FINDINGS
Normal
Abnormal

cavitary or noncavitary
Stable or worsening or improving
ETIOLOGIES OF PLEURAL EFFUSION

A. Transudates
1. Congestive heart failure
2. Cirrhosis of the liver
3. Nephrotic syndrome
4. Atelectasis, early
5. Myxedema
6. Peritoneal dialysis

B. Exudates
1. Parapneumonic effusion
2. Pulmonary infarction
3. Neoplasm
4. Viral disease
5. Collagen disease
   (rheumatoid arthritis, lupus erythematosus)
6. tuberculosis
7. Fungal disease
8. Parasitic disease
9. Rickettsial disease
10. Gastrointestinal disease
   (pancreatitis, subphrenic abscess)
11. Drug reaction (e.g., nitrofurantoin, methysergide)
12. Asbestosis
13. Meigs’ syndrome
14. Postmyocardial infarction syndrome
15. Trapped lung
16. Lymphatic abnormality
17. Uremic pleurisy
18. Atelectasis, late
19. Chylothorax

Labs – What to Order

WBC increased 1000 Exudate: pneumonia infarction, pancreatitis, subphrenic abscess

Lymphys increased in tuberculosis, carcinoma, uremic pleurisy

RBC increased 5000 hemorrhagic
increased 100,000 carcinoma, trauma, infarction

Glucose decreased 30 rheumatoid
0-60 empyema, carcinoma tuberculosis, rheumatoid

Amalase – 2 times serum – pancreatitis, pseudocyst esophageal rupture, metastasis or carcinoma

Lipids – tuberculosis, carcinoma, rheumatoid

pH – decreased 7.3 empyema

Cytology

Gram Stain – AFB stain and cultures

Exudate versus Transudate: (Light’s criteria)
1. pleural fluid protein divided by serum protein greater than 0.5
2. pleural fluid LDH divided by serum LDH greater than 0.6
3. pleural fluid LDH greater than two-thirds the upper limit of normal for the serum LDH.
CHEST TUBE

Pleur-evac pleural drainage system. Air vent is shown.