Respiratory Physiology

Part I
Beth Israel Deaconess Medical Center
A member of CAREGROUP
Where the patient comes first
CASE

52 YEAR OLD M FOR LAPAROSCOPIC SIGMOID COLECTOMY UNDER GA
CASE

PMH: hyperlipidemia, COPD

PSH: wisdom teeth extraction

Social history: 2PPDX30 years, occasional alcohol, denies illicit drug use

Allergies: none

Height: 65 in  weight: 52 kg  BMI: 19

Medication: Simvastatin, Albuterol prn, Tylenol prn
Physical exam

VS: BP 105/65, HR 57, O2 sat (room air) 95%, afebrile

Gen: NAD

Heart: RRR, nl S1/S2, no m/g/r

Lungs: CTABL

Airway: MP I, HM>6, TM>3, neck: FROM, dentition: good

Upon questioning the patient states, that the last time he had anything to eat and drink was yesterday
QUESTION #1

JUST TO REFRESH OUR MEMORY:
WHERE IN THE RESPIRATORY TRACT
DOES GAS EXCHANGE TAKE PLACE?
Gas exchange starts taking place at the level of the respiratory bronchioles.

The pulmonary interstitial space, with a capillary passing between the two alveoli.

PRE-OP

WHILE DOING YOUR PRE-OPERATIVE EVALUATION YOU LOOK UP THE PATIENT’S PULMONARY FUNCTION TESTS.
QUESTION #2

WHAT ARE NORMAL LUNG VOLUMES?
LUNG VOLUMES

http://www.clevelandclinicmeded.com/medicalpubs/disease management/pulmonary/pulmonary-function-testing/
LUNG VOLUMES

- **Normal PFT values**: vary with age, sex, ethnicity, body size, posture
- **Total Lung Capacity (TLC)**: Volume of air in the lungs after maximal inspiration (nl 5.9l*)
- **Tidal Volume (TV)**: Volume of air moved during a normal breath (nl 0.5l*)
- **Vital Capacity (VC)**: Maximum volume of air that can be exhaled from the lungs after a maximal inspiration (nl 4.6l* or 60-70ml/kg)
- **Functional Residual Capacity (FRC)**: Volume of air in the lungs after a normal expiration (FRC = reserve volume + expiratory reserve volume) (nl 2.4l*)

* represents average values for adults
LUNG VOLUMES

• **Residual Volume (RV):** The volume of air remaining in the lungs at the end of a maximal exhalation (nl 1.2l*)

• **Expiratory Reserve Volume (ERV):** The amount of additional air that can be pushed out after the end expiratory level of normal breathing (nl 1.2l*)

• **Inspiratory Reserve Volume (IRV):** The additional air that can be inhaled after a normal tidal breath in (nl 3.0l*)

• **Forced Vital Capacity (FVC):** Maximum volume of air that can be forcibly expired after full inspiration (nl 4.7l*)

* represents average values for adults
QUESTION #3

DO YOU REMEMBER HOW THESE VOLUMES CHANGE IN OBSTRUCTIVE AND RESTRICTIVE PULMONARY DISEASE?
They indicate **Obstructive pulmonary diseases** like asthma, chronic bronchitis, emphysema and bronchiectasis if FEV$_1$/FVC ratio is $< 0.70$ (nl $> 0.8$)

They indicate **Restrictive pulmonary diseases** incl. interstitial pulmonary disease, diseases of the chest wall and neuromuscular disorders if FEV$_1$/FVC $\geq 0.8$ and FVC $<$ 80% predicted
## Pulmonary Function Tests

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<thead>
<tr>
<th>Test</th>
<th>Restrictive disease</th>
<th>Obstructive disease</th>
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<tr>
<td>FVC</td>
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Clinician's Pocket Reference > Chapter 18. Respiratory Care > Differential Diagnosis of PFTs
PRE-OP CONTINUED

OUR PATIENT’S SPIROMETRY RESULTS: FEV1/FVC<70%, FEV1>80% PREDICTED, WHICH CLASSIFIES HIM AS A PAT WITH MILD COPD*

*please also see Global Strategy for the Diagnosis, Management, and Prevention of COPD, 2006, www.goldcopd.com
INDUCTION

YOU ARE INDUCING GENERAL ANESTHESIA WITH PROPOFOL 140MG AND ROCURONIUM 40MG AND PLACE AN ENDOTRACHEAL TUBE WITHOUT COMPLICATIONS.
QUESTION #4

HOW DOES INDUCTION OF GENERAL ANESTHESIA CHANGE THE PATIENT’S FUNCTIONAL RESIDUAL CAPACITY?
With anesthesia induction in the supine position, the abdominal contents exert cephalad pressure on the diaphragm. At end-expiration, the dorsal portion of the diaphragm is more cephalad and the ventral portion is more caudal than when awake, the thoracic spine is more lordotic, and the rib cage moves inward, all secondary to loss of motor tone. These factors lead to a 15–20% reduction in FRC (400 ml in most patients) beyond what occurs with the supine position alone.

AFTER SUCCESSFUL INTUBATION THE SURGICAL TEAM SCRUBS IN. 30MINS AFTER INCISION THE PATIENT DESATURATES TO 88%.
QUESTION #5

WHY DO YOU START GETTING NERVOUS ONCE THE O2 SAT DROPS <90%?

WHAT IS THE HB OXYGEN DISSOCIATION CURVE?

HOW DOES IT LOOK LIKE AND WHICH FACTORS INFLUENCE IT?
The p50 of an adult is normally 27mmHg at 37°C and pH 7.4.
INTRA-OP CONTINUED

YOU DRAW AN ABG.
IT SHOWS THAT THE ARTERIAL OXYGEN PRESSURE IS LOW AND YOU CALCULATE THE ALVEOLAR-ARTERIAL OXYGEN GRADIENT WHICH IS NORMAL.
QUESTION #6
WHAT ARE THE 5 DIFFERENTIAL DIAGNOSES FOR HYPOXEMIA?
Hypoxemia = abnormally low arterial oxygen tension

1. **Hypoventilation**: associated with an increased PaCO$_2$; nl. A-a O$_2$ gradient.

2. **V/Q mismatch**: alteration of ventilation or perfusion; e.g. PE, pneumonia, asthma, COPD, extrinsic vascular compression; increased A-a gradient
DD HYPOXEMIA

3. **Low inspired FiO2**: high altitude or hypoxic gas mixture; nl. A-a gradient

4. **Right to left shunting**: etiologies include pulmonary consolidation, pulmonary atelectasis, and vascular malformations; increased A-a gradient

5. **Diffusion impairment**: regardless of the cause; increased A-a gradient
DD HYPOXEMIA

↓PaO₂

Check PaO₂

↑A-a

Give O₂

Improves

Check DLCO

Normal DLCO

↓DLCO

V/Q Mismatch

↓PCO₂

Hypoventilation

↓FiO₂

Doesn't Improve

Normal A-a

Check PCO₂

↑PCO₂

Normal PCO₂

Shunt

Diffusion impairment
CASE END

YOU ↑ THE FIO2 (22->40%) AND REMOVE A BIG MUCOUS PLUG VIA ENDOTRACHEAL SUCTIONING. HIS O2 SAT ↑ TO 98%.

THE REMAINDER OF THE CASE IS UNEVENTFUL AND YOU TRANSPORT THE PATIENT TO THE RECOVERY ROOM EXTRUBATED AND IN STABLE CONDITION.

GOOD JOB!!