# Emergencies at 35,000 Feet

## *Is There a Medical Provider on Board?*

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By MICHELLE

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THE WALL STREET JOURNAL.



U.S. EDITION | Wednesday, May 29, 2013 As of 9:00 PM EDT

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# Medical Care's Flight Status

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By MELINDA BECK CONNECT

It happens on about one in 600 flights: an onboard medical emergency requires help and sometimes an unscheduled landing. Passengers are often left wondering what happened.

Melinda Beck reveals the numbers behind in-flight medical emergencies, including types of illnesses, who treats sick passengers while mid-flight and methods of treatment. Photo: Getty Images.

A new study in the New England Journal of Medicine opens a window into some 12,000 in-flight medical emergencies on five airlines over a three-year period. Dramatic or serious incidents—pregnancy complications, psychiatric episodes, cardiac arrest—were relatively rare, the researchers found. The most common problems: fainting, followed by difficulty breathing; gastrointestinal problems and cardiac symptoms.

# In-flight Medical Emergencies (IMEs)

- 3 billion commercial airline passengers per year

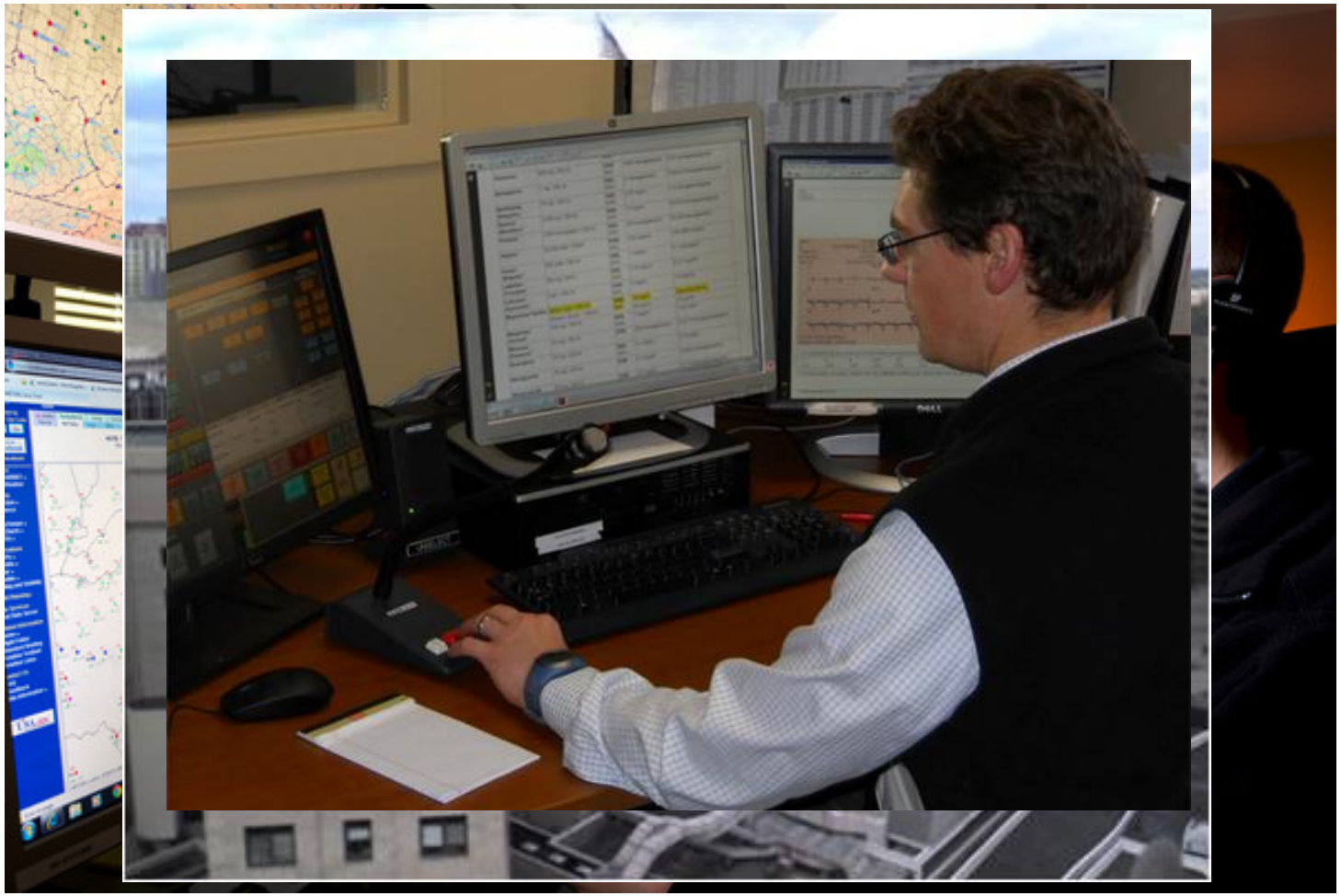
- Reported incidence of 24 to 130 IMEs per 1 million passengers
  - Up to 1,068 IMEs per day

# Objectives

- Medical care with limited resources
- Altitude physiology
- Responding as an EMS provider aboard a commercial airline
- Responding to medical issues before or after commercial airline travel

Why am I talking to you about this?

# STAT-MD Communications Center



# STAT-MD Communications Center

- Staffed by an Emergency Physician from the Division of EMS 24/7
- ~12 EMS Communications Specialists per shift
- Medical Consultation for:
  - Ground EMS
  - 18 STAT MedEvac Helicopter Bases
  - 20 Commercial US and International airlines

# STAT-MD Communications Center

- 27,000+ airline medical consultations in 2018
- All consultations handled by a physician and transport specialist

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

# Outcomes of Medical Emergencies on Commercial Airline Flights

Drew C. Peterson, M.D., Christian Martin-Gill, M.D., M.P.H., Francis X. Guyette, M.D., M.P.H., Adam Z. Tobias, M.D., M.P.H., Catherine E. McCarthy, B.S., Scott T. Harrington, M.D., Theodore R. Delbridge, M.D., M.P.H., and Donald M. Yealy, M.D.

ABSTRACT

**BACKGROUND**

Worldwide, 2.75 billion passengers fly on commercial airlines annually. When in-flight medical emergencies occur, access to care is limited. We describe in-flight medical emergencies and the outcomes of these events.

**METHODS**

We reviewed records of in-flight medical emergency calls from five domestic and international airlines to a physician-directed medical communications center from January 1, 2008, through October 31, 2010. We characterized the most common medical problems and the type of on-board assistance rendered. We determined the incidence of and factors associated with unscheduled aircraft diversion, transport to a hospital, and hospital admission, and we determined the incidence of death.

**RESULTS**

There were 11,920 in-flight medical emergencies resulting in calls to the center (1 medical emergency per 604 flights). The most common problems were syncope or presyncope (37.4% of cases), respiratory symptoms (12.1%), and nausea or vomiting (9.5%). Physician passengers provided medical assistance in 48.1% of in-flight medical emergencies, and aircraft diversion occurred in 7.3%. Of 10,914 patients for whom postflight follow-up data were available, 25.8% were transported to a hospital by emergency-medical-service personnel, 8.6% were admitted, and 0.3% died. The most common triggers for admission were possible stroke (odds ratio, 3.36; 95% confidence interval [CI], 1.88 to 6.03), respiratory symptoms (odds ratio, 2.13; 95% CI, 1.48 to 3.06), and cardiac symptoms (odds ratio, 1.95; 95% CI, 1.37 to 2.77).

**CONCLUSIONS**

Most in-flight medical emergencies were related to syncope, respiratory symptoms, or gastrointestinal symptoms, and a physician was frequently the responding medical volunteer. Few in-flight medical emergencies resulted in diversion of aircraft or death; one fourth of passengers who had an in-flight medical emergency underwent additional evaluation in a hospital. (Funded by the National Institutes of Health.)

From the Department of Emergency Medicine, University of Pittsburgh School of Medicine, Pittsburgh (D.C.P., C.M.-G., F.X.G., A.Z.T., C.E.M., S.T.H., D.M.Y.); and the Department of Emergency Medicine, Brody School of Medicine at East Carolina University, Greenville, NC (T.R.D.). Address reprint requests to Dr. Martin-Gill at Iroquois Bldg., Suite 400A, 3600 Forbes Ave., Pittsburgh, PA 15261, or at martingillc2@upmc.edu.

N Engl J Med 2013;368:2075-83.
DOI: 10.1056/NEJMoa1212052

# UPMC In-Flight Emergencies Study

- Review of 11,920 in-flight physician consultations over 34 month period, 2008-2010
  - Domestic and international cases
  - Excluded cases occurring at the terminal or taxiing
- 16 IMEs with consultation per 1 million passengers
- One IME per 604 flights

JAMA | Review

# In-Flight Medical Emergencies
## A Review

Christian Martin-Gill, MD, MPH; Thomas J. Doyle, MD, MPH; Donald M. Yealy, MD

**IMPORTANCE** In-flight medical emergencies (IMEs) are common and occur in a complex environment with limited medical resources. Health care personnel are often asked to assist affected passengers and the flight team, and many have limited experience in this environment.

**OBSERVATIONS** In-flight medical emergencies are estimated to occur in approximately 1 per 604 flights, or 24 to 130 IMEs per 1 million passengers. These events happen in a unique environment, with airplane cabin pressurization equivalent to an altitude of 5000 to 8000 ft during flight, exposing patients to a low partial pressure of oxygen and low humidity. Minimum requirements for emergency medical kit equipment in the United States include an automated external defibrillator; equipment to obtain a basic assessment, hemorrhage control, and initiation of an intravenous line; and medications to treat basic conditions. Other countries have different minimum medical kit standards, and individual airlines have expanded the contents of their medical kit. The most common IMEs involve syncope or near-syncope (32.7%) and gastrointestinal (14.8%), respiratory (10.1%), and cardiovascular (7.0%) symptoms. Diversion of the aircraft from landing at the scheduled destination to a different airport because of a medical emergency occurs in an estimated 4.4% (95% CI, 4.3%-4.6%) of IMEs. Protections for medical volunteers who respond to IMEs in the United States include a Good Samaritan provision of the Aviation Medical Assistance Act and components of the Montreal Convention, although the duty to respond and legal protections vary across countries. Medical volunteers should identify their background and skills, perform an assessment, and report findings to ground-based medical support personnel through the flight crew. Ground-based recommendations ultimately guide interventions on board.

**CONCLUSIONS AND RELEVANCE** In-flight medical emergencies most commonly involve near-syncope and gastrointestinal, respiratory, and cardiovascular symptoms. Health care professionals can assist during these emergencies as part of a collaborative team involving the flight crew and ground-based physicians.

*JAMA*. 2018;320(24):2580-2590. doi:10.1001/jama.2018.19842

Author Audio Interview

Supplemental content

CME Quiz at jamanetwork.com/learning

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**Section Editors:** Edward Livingston, MD, Deputy Editor, and Mary McGrae McDermott, MD, Senior Editor.

# In-Flight Medical Emergencies: A Review

*Martin-Gill et al. JAMA 2018;320(24):2580-2590.*

- Literature review (Jan 1990 – Jun 2018)
  - N=765 relevant articles
  - N=317 articles included in the review

- N=14 articles reporting:
  - Frequency of IMEs
  - Medical conditions encountered
  - Incidence of diversions

# IN-FLIGHT EMERGENCIES

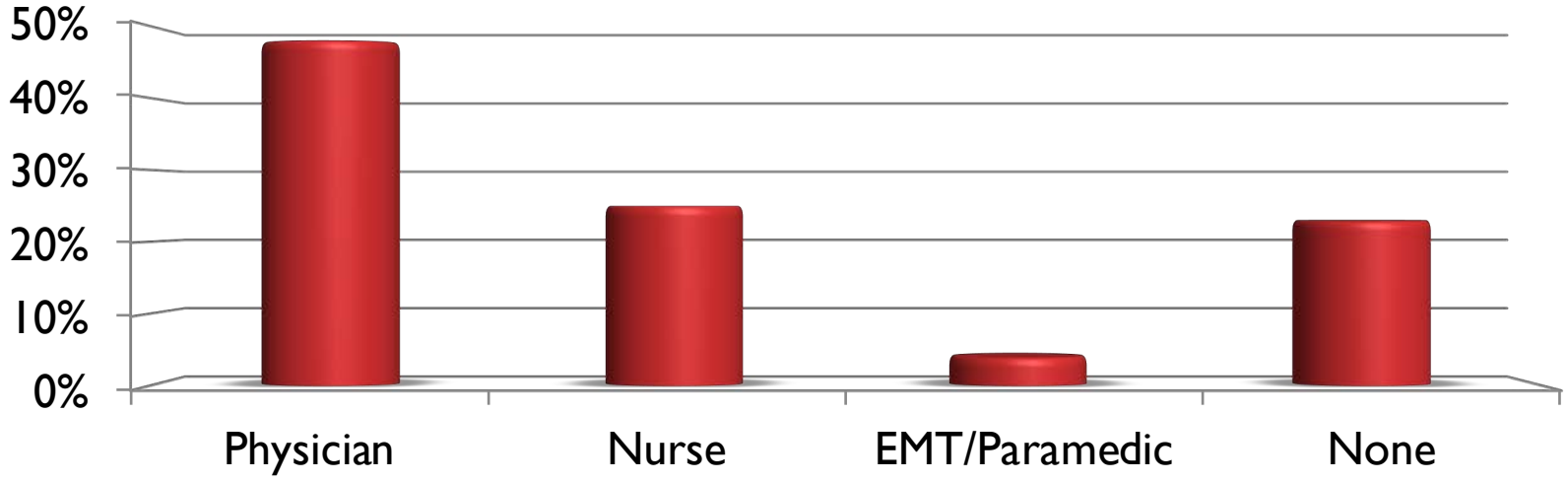
# Airline Medical Consultation

Who's involved?

- Pilot
- Flight attendant
- Radio Communications Center
- Airline Dispatch
- UPMC Medical Communications Center
  - Physician
  - Communications Specialist

# RESOURCES ON BOARD

# Who is available on board to assist?




- Health professionals responding for assistance
  - Physician: 48% (5,742 cases)
  - Nurse: 25% (3,033 cases)
  - EMT or Paramedic: 4% (535 cases)
  - None: 23% (2,813 cases)

# Equipment available on board

- Airline medical kits vary by airline
- All aircraft must have an AED

# AEDs & Monitors


Phillips Heart Stream DL Aircraft
(can see rhythm)

LifePac 500 NW aircraft
(cannot see rhythm)

Biolog Heart Monitor
NW Aircraft XMK (outside pocket)
Cable & leads or place on bare chest
Visual EKG; no printout

# Basic Emergency Medical Kit (EMK)

- Diagnostic Equipment
  - BP Cuff
  - Stethoscope
- IV Equipment
  - Needles (18G, 20G, 22G)
  - IV Catheters
  - Tourniquet
  - IV tubing, connectors
  - Alcohol, tape, gloves, etc
  - IV Fluids (NS 500 ml)
- Airway
  - BVM
  - OPA's
- Medications
  - Acetaminophen (Tylenol)
  - Aspirin
  - Nitroglycerin tablets
  - Altuberol inhaler
  - Benadryl
  - Epinephrine IM
  - Epinephrine 1:1000
  - Atropine
  - Lidocaine
  - Dextrose

# Enhanced EMK (XMK)

- Additional Medications:
  - Calcium chloride
  - Diazepam (Valium)
  - Digoxin
  - Lasix
  - Hydrocortisone
  - Metoprolol
  - Nalbuphine
  - Naloxone
  - Promethazine (Phenergan)
  - Sodium bicarbonate
- Additional Equipment
  - Biolog heart monitor
  - Laryngoscope & tubes
  - Urinary catheter

# Airline Specific

- Additional Medications:
  - Antivert
  - Solumedrol
  - Haldol
  - Ativan
  - Morphine
- Additional Equipment:
  - Glucometer
  - Tourniquet
  - Burn dressings
  - Steri-strips
  - Disposable scalpel
  - Emergency tracheal catheter

# TO LAND OR NOT TO LAND…

# …THAT IS THE QUESTION

# Diversion

- Based on medical emergency, aircraft may need to go to an alternate destination
- Final choice made by Captain/Pilot
- Usually done in consultation with a ground-based physician

# Diversion

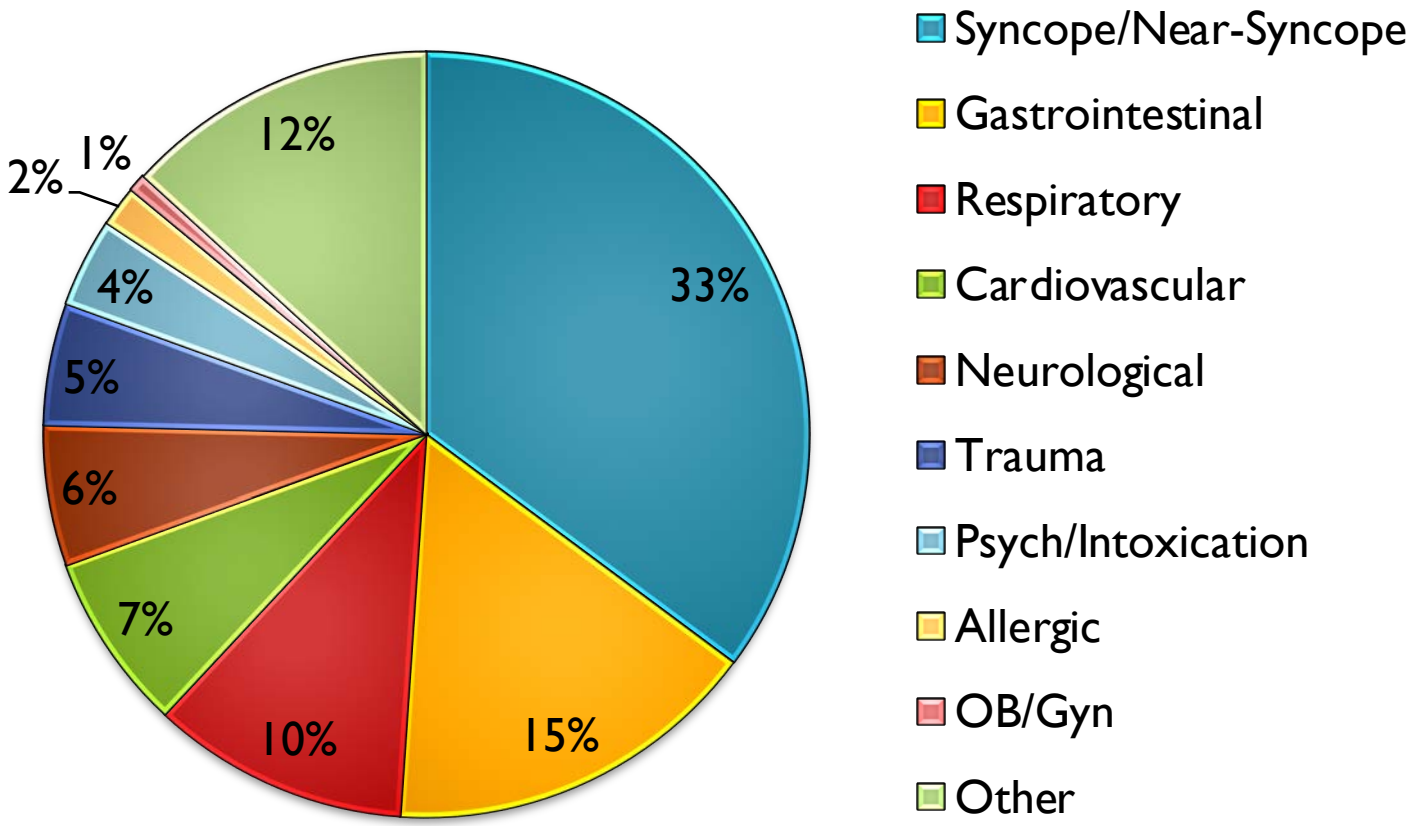
- When do we divert aircraft?

# Considerations for Diversion

- Medical Condition
  - Need for immediate evaluation and treatment?
  - Can the patient receive medical care upon arrival at intended destination?
- Appropriate medical facility?
- Appropriate airport?
- Can the plane land with a full fuel tank?
- High Cost (est. $20,000 to $725,000)
  - Missed connections
  - Airport charges
  - Re-fueling

# MANAGEMENT OF SPECIFIC EMERGENCIES

# Types of In-Flight Emergencies



# Syncope / Near-Syncope

- Most common in-flight medical emergency
- May be associated with dehydration
  - Decreased PO intake in travelers
  - Dry aircraft atmosphere
- Pressure changes → vascular dilation
- Vasovagal syncope

# Syncope / Near-Syncope

- Everyone always looks sick when they pass out
  - Unresponsive
  - Pale, diaphoretic
- Vital signs almost always initially abnormal
  - Hypotension
  - Bradycardia
- Most rapidly improve

# Syncope versus Seizure

- Myoclonic jerking may be mistaken for seizure
- Seizures usually have post-ictal phase
  - If patient wakes up rapidly, unlikely to be a seizure

# Respiratory Emergencies

- Difficult (impossible) to listen to lung sounds
- Identify history
  - Asthma/COPD
  - CHF
- Key medications in basic EMK
  - Albuterol
  - Nitroglycerin

# Nausea, Vomiting & Abdominal Pain

- Limited medications available (depends on airline)
  - Meclizine (Antivert)
  - Promethazine (Phenergan)
  - Dimenhydrinate (Gravol)
  - Ondansetron (Zofran) ODT
- Consider likelihood of surgical emergency
  - Appendicitis
  - Bowel obstruction
- Other common conditions:
  - Post-operative / post-laparotomy pain

# Chest Pain

- History is very important
- For cardiac chest pain:
  - Aspirin
  - Nitroglycerin
- Worrisome chest pain that does not resolve warrants diversion

# Outcomes of In-Flight Emergencies

Literature Review (N=14 articles)

- 4.4% of IMEs result in Diversion

UPMC Data with outcomes (N=875 diversions)

- 26% result in post-flight transport to hospital (by EMS)
- 9% result in hospital admission
- 0.3% result in death

# UNDERSTANDING ALTITUDE MEDICINE

Prevention May be the Best Medicine…

# Case 1

- 60 year old man running late for the plane
- Had to run between terminals to make connection
- Arrives at gate holding his chest, appearing short of breath and with chest pain

*Is it okay for him to fly?*

# Case 2

- 70 year old female with COPD
- Uses oxygen at home at night and as needed during the day
- Plans to make a trip to Chicago

*Is it okay for her to fly?*

# Case 3

- 24 year old male involved in ATV accident
- Suffered chest trauma, including pneumothorax
- Was hospitalized for 5 days with chest tube in place, which was removed yesterday
- Wants to return home

*Is it okay for him to fly?*

# Case 4

- 30 year old female was vacationing in the Bahamas and flies back.
- She was scuba diving 12 hours prior to flight
- Develops chest pain in the flight

*What does she need?*

# FLIGHT PHYSIOLOGY

# Changes with Altitude

- Barometric pressure decreases
- Partial pressure of oxygen decreases
- Gases expand
- Temperature falls
  - 59° @ sea level → -5° @ 10,000 ft.

# Dalton's Law

- As altitude increases, atmospheric pressure (and partial pressure of oxygen) decreases
  - → the availability of oxygen decreases as altitude increases.
  - Even though $FiO_2$ does not change the $PaO_2$ declines

# Dalton's Law

- $PaO_2$ is 20.95% (constant)
- @ Sea Level $PO_2$ = 20.95% x 760 = 159.22mmHg
- @ 5,000 ft. $PO_2$ = 20.95% x 632 = 132.40mmHg
- @ 10,000 ft. $P0_2$ = 20.95% x 523 = 109.52mmHg
- Therefore flight itself can cause or worsen hypoxia!

# Dalton's Law

- Effect on oxygen transfer in the bloodstream:
  - A patient that has an oxygen saturation of **98%** at sea level will have an oxygen saturation of **87%** at 10,000 feet.
  - At 22,000 feet their oxygen saturation will be **60%**.

- How do we increase PaO2?
  - Increase FiO2
  - Increase atmospheric pressure (descend)

# Cabin Pressurization

- Most passenger aircraft maintain a cabin pressure approximately equivalent to 8,000 ft of altitude

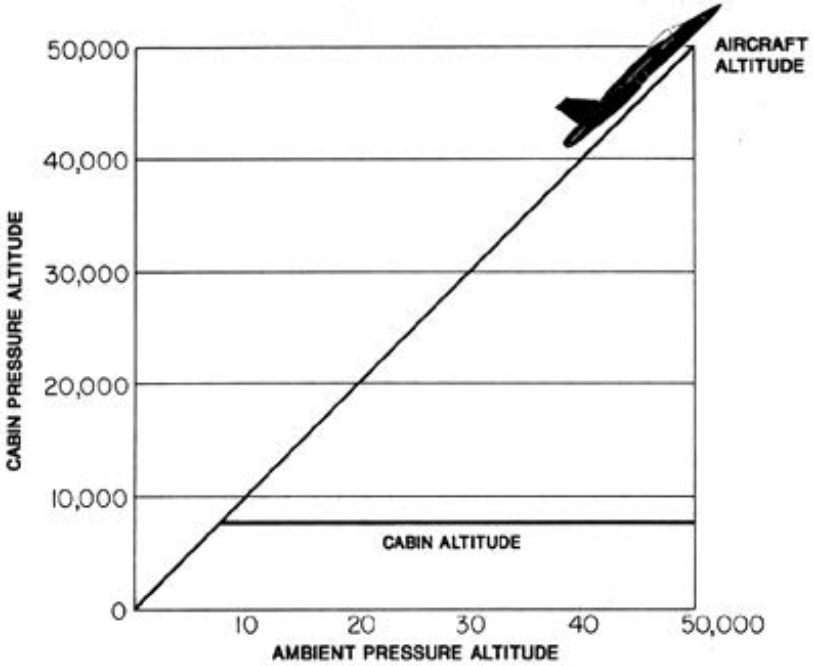



Figure 1-13. Isobaric pressure schedule.

# Dalton's Law in Action

- Patient with COPD
  - Room air O2 Sat at sea level is 95%
  - Flight on commercial aircraft
  - At 8,000 ft, O2 Sat is 86% → patient becomes short of breath

- Solution:
  - On commercial aircraft: Use of portable oxygen
  - On medical aircraft: Routine use of oxygen

# Oxygen Adjustment

- Medical conditions which are exacerbated by hypoxia at altitude:
  - CAD
  - COPD
  - Pneumonia
  - Asthma
  - Pneumothorax
  - Trauma, shock, blood loss

Expansion

# BOYLE'S LAW

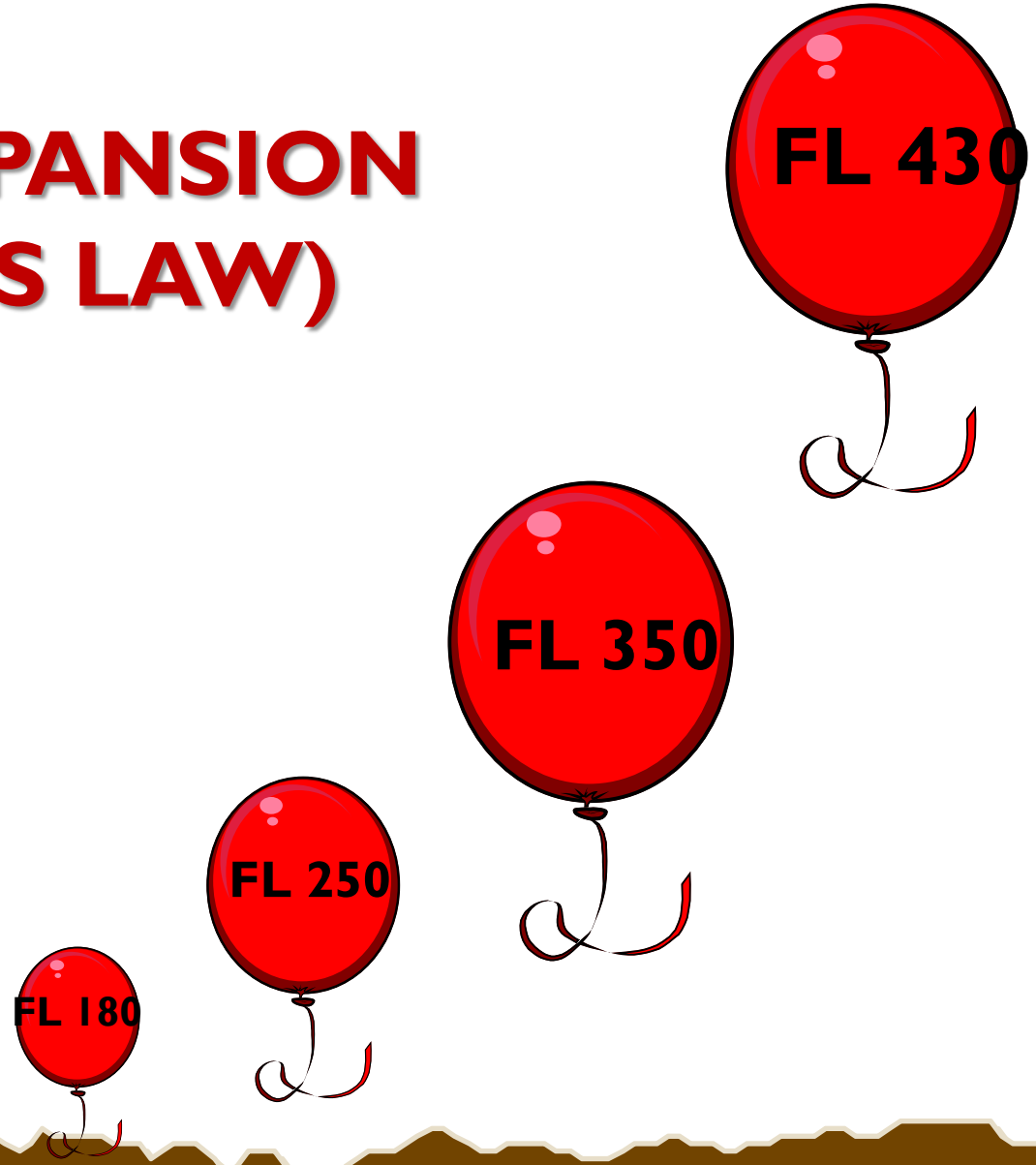
# Boyle's Law (Expansion)

- As the aircraft ascends, the barometric pressure decreases
  - This causes any gas within an enclosed space to expand
  - The reverse occurs on descent
  - In flight gases expand at altitude

- Body is adaptable up to 10,000 feet above sea level

# GAS EXPANSION (BOYLE'S LAW)

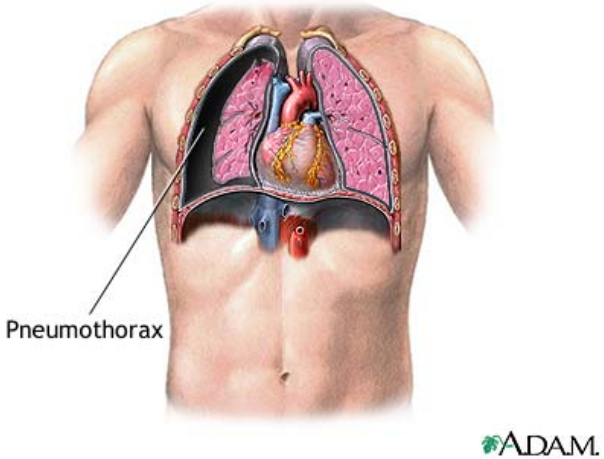
$$\frac{P_2}{P_1} = \frac{V_1}{V_2}$$




Sea Level

# Boyle's Law in Action

- What would happen to a patient with a pneumothorax that travels at higher altitude?




- How much does the volume of the pneumothorax increase?
  - 2,000 feet (helicopter) → 5%
  - 6,000-8,000 feet (airplane) → 25-30%

Solubility

# HENRY'S LAW

# Henry's Law

- The amount of gas that will dissolve in a solution and remain in solution is directly proportional to the pressure of the gas over the solution

- Clinically important in the development of decompression sickness (i.e. dissolved gases in solution vaporize as the ambient pressure decreases)

# Gases in Solution (Henry's Law)

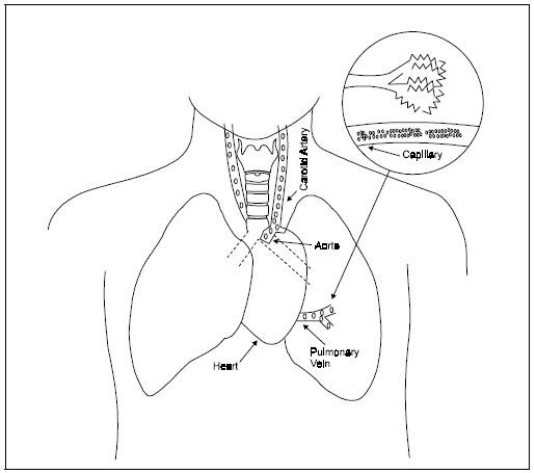

Opening the top results in decrease in pressure over the liquid

# Henry's Law in Action

- Scuba diver enjoying herself diving off an island in the Bahamas
  - Normal ascents, no problems

# Henry's Law in Action

- Patient boards commercial aircraft
  - Plane ascends to altitude
  - Nitrogen bubbles out of patient's bloodstream → **The Bends**
    - Air embolism to brain or lungs
    - Microemboli to body



# FAA Recommendations

- Do not fly within 12 hours of a dive to 30 feet
- Do not fly within 24 hours of a dive which requires any stages of ascent
- Air medical transport may not have the luxury to wait in a medical emergency
  - Increase pressurization of cabin
  - Fly at lower altitude

# Case

- 60 year old man running late for the plane
- Had to run across terminals to make connection
- Arrives at gate holding his chest, appearing short of breath and with chest pain

*Is it okay for him to fly?*

- Depends on history and if symptoms completely resolve

# Case 2

- 70 year old female with COPD
- Uses oxygen at home at night and as needed during the day
- Plans to make a trip to Chicago

*Is it okay for her to fly?*

- Likely needs oxygen at altitude

# Case 3

- 24 year old male involved in ATV accident
- Suffered chest trauma, including pneumothorax
- Was hospitalized for 5 days with chest tube in place, which was removed yesterday
- Wants to return home

*Is it okay for him to fly?*

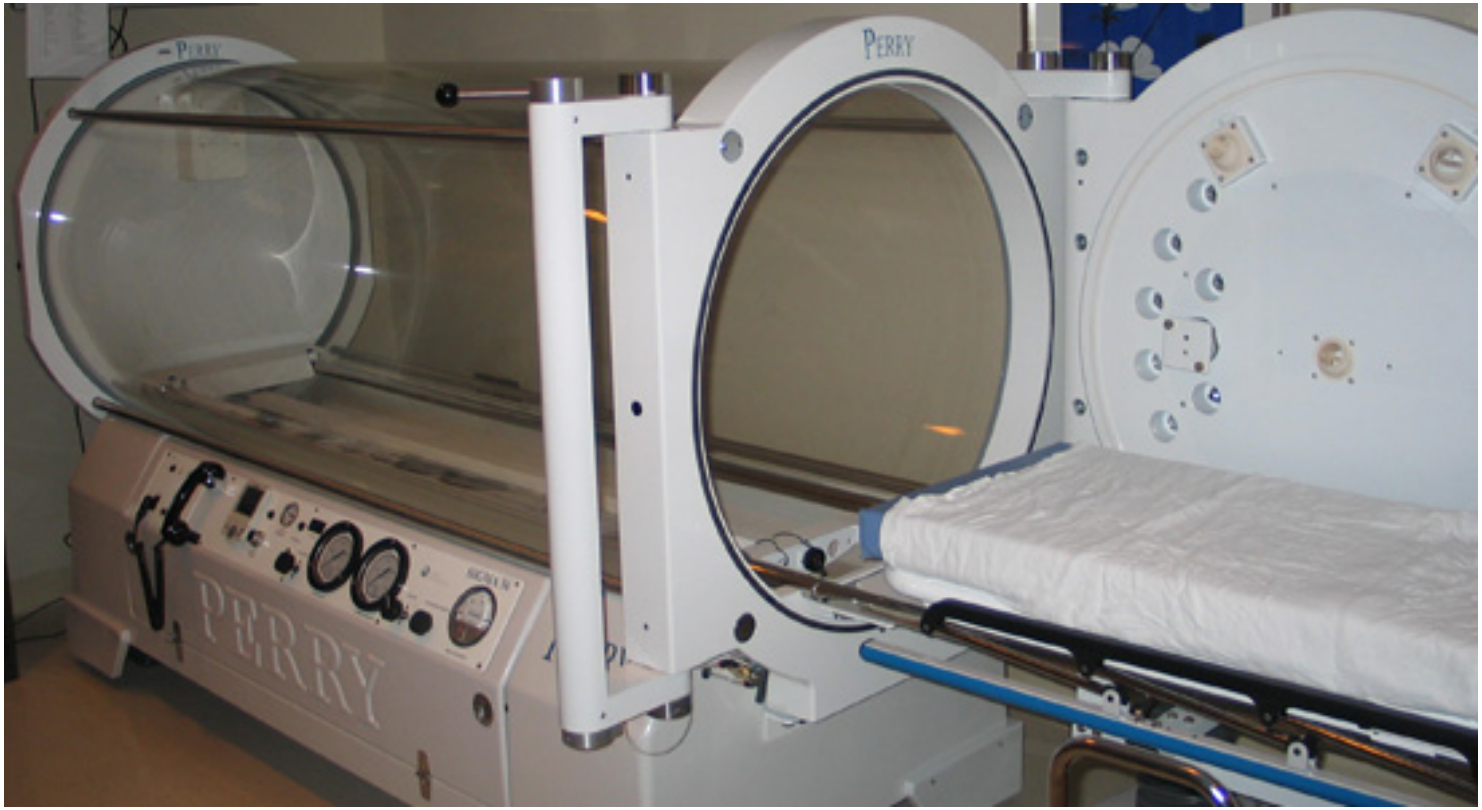
- Probably not safe to fly immediately

# Case 4

- 30 year old female was vacationing in the Bahamas and flies back.
- She was scuba diving 12 hours prior to flight
- Develops chest pain in the flight

*What does she need?*

# Hyperbaric Chamber



# What not to say to a gate agent

- "I have severe peanut allergies. There must not be any peanut products at all on the plane or I could die."
- "I ran out of oxygen, can I use the airplane's during the flight?"
- "I have a really bad case of the flu, I need to be seated in First Class by the bathroom."
- "I have a serious medical condition and I'm travelling to see my specialist."

# Conclusions

- Limited resources available in-flight
- Other medical providers may be available
- Diversion is a challenging issue.
  - Need to weigh risks and benefits
  - How soon does this patient need to be off the plane?
  - Where can the airplane land?
- Better to keep an ill person off the plane in the first place than have to divert

# Questions?