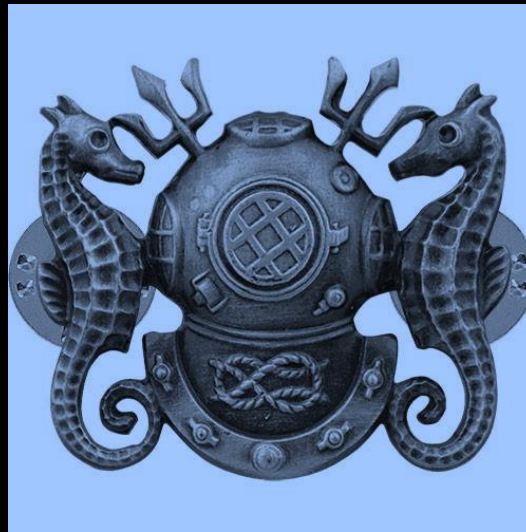


Pulmonary Consideration in Divers



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AGENDA

➤ Pulmonary Barotrauma





BAROTRAUMA

Boyle's Law:

At constant Temperature, Volume varies
inversely proportional to
Pressure



BAROTRAUMA

- Elements needed to produce barotrauma
 - ✓ Membrane (vascular) lined space
 - ✓ Ambient pressure change
 - ✓ Rigid walls
 - ✓ Gas filled space
 - ✓ Enclosed space

If rigid gas filled spaces are properly vented,
barotrauma will not occur



PULMONARY BAROTRAUMA

- **Pulmonary Over-inflation Syndrome (POIS)**
- **Expansion of gas trapped in lung during ascent (decreasing ambient pressure) with rupture of lung tissue**
- **Causes: -**
 - ✓ **Breath-holding during ascent**
 - ✓ **Inhaling while pushing purge button**
 - ✓ **Rapid uncontrolled ascent (blow-up)**
 - ✓ **Air trapped in lung**



PULMONARY BAROTRAUMA

- **Air trapped in lung due to:**
 - ✓ **Airway obstruction as in asthma**
 - ✓ **Thick secretions**
 - ✓ **Lung granulomas (sarcoidosis)**
 - ✓ **Cysts and blebs**
 - ✓ **spontaneous pneumothorax**



PULMONARY BAROTRAUMA

- **Clinical presentation**
 - ✓ **Initial rupture of lung tissue with release of gas**
 - ✓ **Gas may remain in lung tissue**
 - ✓ **migrate to pulmonary circulation**
 - ✓ **move to the pleural space**
 - ✓ **dissect along the bronchial tree into the mediastinum and subcutaneous tissues**



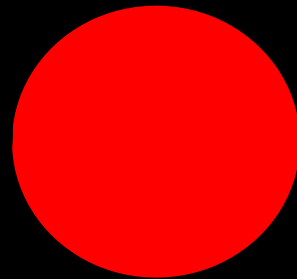
PULMONARY BAROTRAUMA

- **Conditions resulting from POIS**
 - ✓ **Arterial gas embolism**
 - ✓ **Pneumothorax**
 - ✓ **Mediastinal emphysema**
 - ✓ **Subcutaneous emphysema**
 - ✓ **Pneumopericardium**

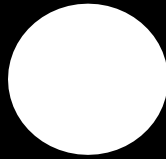




PULMONARY BAROTRAUMA

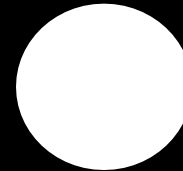


Surface

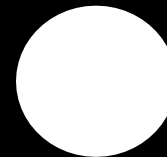


3 FSW

96 FSW



99 FSW





PULMONARY BAROTRAUMA

I'll take this balloon to 16mt
(50ft) to see what the pressure
does to it!





PULMONARY BAROTRAUMA





PULMONARY BAROTRAUMA

- **Arterial Gas Embolism**
 - ✓ **Alveolar rupture with concomitant venous or capillary rupture**
 - ✓ **Air traverses pulmonary vein to left heart**
 - ✓ **Emboli are pumped out to the systemic circulation and distributed to all organs**



ARTERIAL GAS EMBOLISM (AGE)

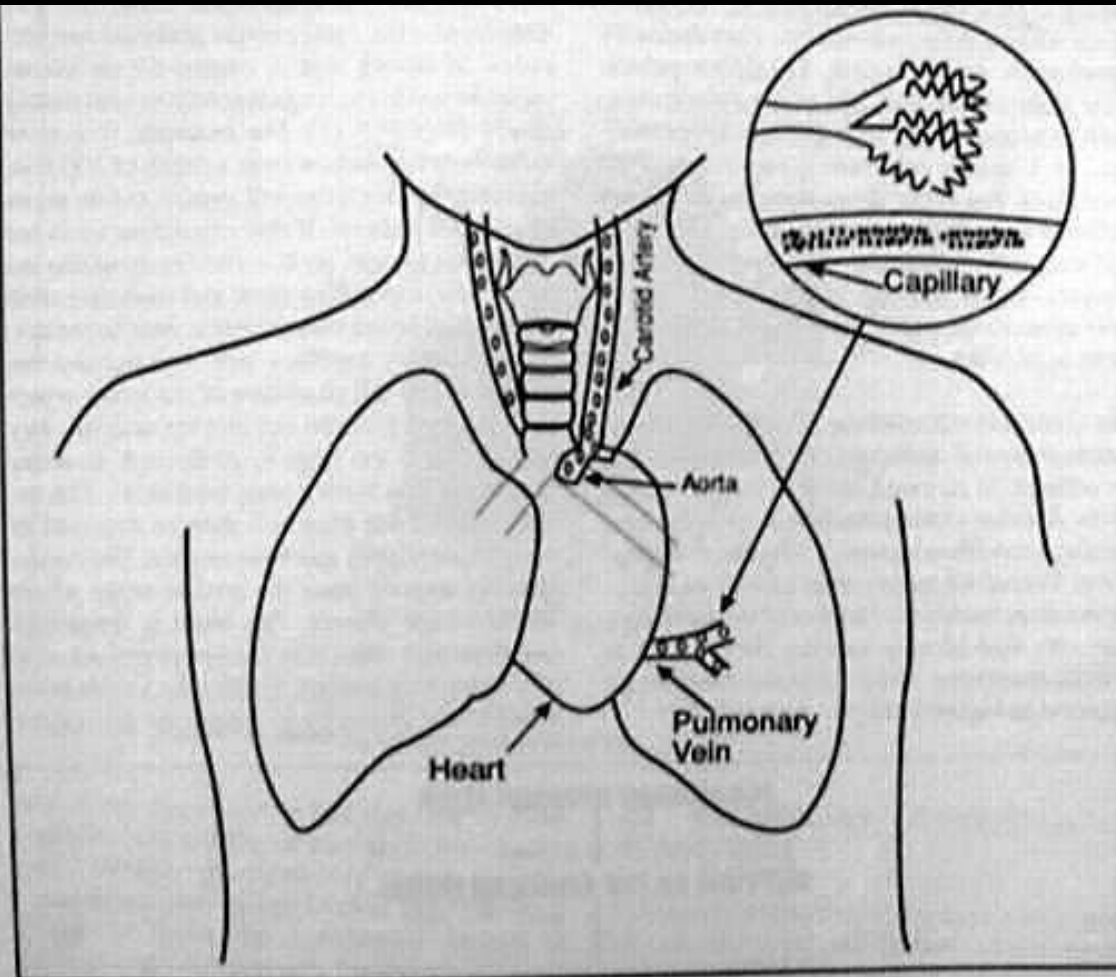


Figure 3-11. Arterial Gas Embolism

Under these circumstances, the gas embolus can travel through the aorta, pulmonary vein, and capillary.



PULMONARY BAROTRAUMA

- **Arterial Gas Embolism**
 - ✓ **CNS and Heart most susceptible to injury**
 - ✓ **CVA sxs commonly caused by emboli to brain**
 - ✓ **Emboli to coronary arteries may cause myocardial ischemia or infarction**
- **Usually present within the first ten minutes of a surface interval**



PULMONARY BAROTRAUMA

- **AGE – Presenting Signs and Symptoms**
 - ✓ **Stupor or confusion**
 - ✓ **Coma with or without seizures**
 - ✓ **Unilateral motor deficits**
 - ✓ **Visual disturbances**
 - ✓ **Vertigo**
 - ✓ **Sensory abnormalities**



PULMONARY BAROTRAUMA

- **AGE – Treatment**
 - ✓ **A, B, C's; check vital signs**
 - ✓ **Keep patient warm**
 - ✓ **Neutral position, not Trendelenberg**
 - ✓ **100% O2 by facemask or ET tube**
 - ✓ **IV Fluids**
 - ✓ **Serial Neurological exams**
 - ✓ **Immediate recompression upon diagnosis**
 - ✓ **Cabin pressure below 1000 feet**

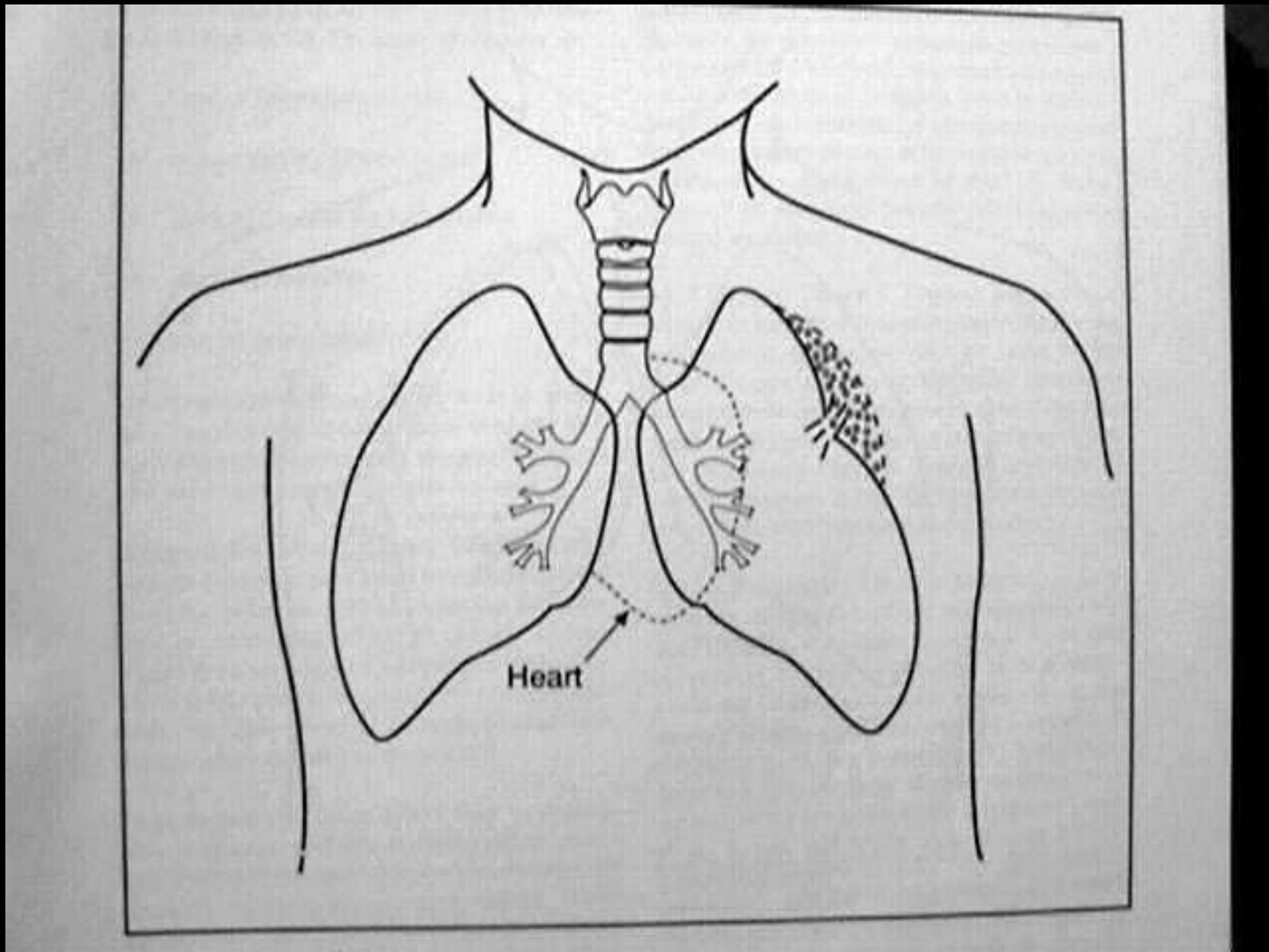


PULMONARY BAROTRAUMA

- **Pneumothorax – Simple Symptoms**
 - ✓ **Chest pain (lateral or apical)**
 - ✓ **Cough**
 - ✓ **Shortness of breath Signs**
 - ✓ **Decreased breath sounds**
 - ✓ **Typical CXR findings**



SIMPLE PNEUMOTHORAX





PULMONARY BAROTRAUMA

- **Pneumothorax – Simple Treatment**
 - ✓ **Needle thoracostomy, Chest tube**
 - ✓ **Observe if pneumo is small**
Resumption of diving
 - ✓ **Spontaneous - unsafe for diving**
 - ✓ **Traumatic - may return to diving after
resolution with proper evaluation**



PULMONARY BAROTRAUMA

➤ Pneumothorax – Tension Symptoms

- ✓ Chest pain and cough**
- ✓ Increasing SOB and tachypnea**

Signs

- ✓ Asymmetric chest wall movement**
- ✓ Tracheal deviation**
- ✓ Rapid pulse with decreasing pulse pressure**
- ✓ Mediastinal shift on CXR**



TENSION PNEUMOTHORAX

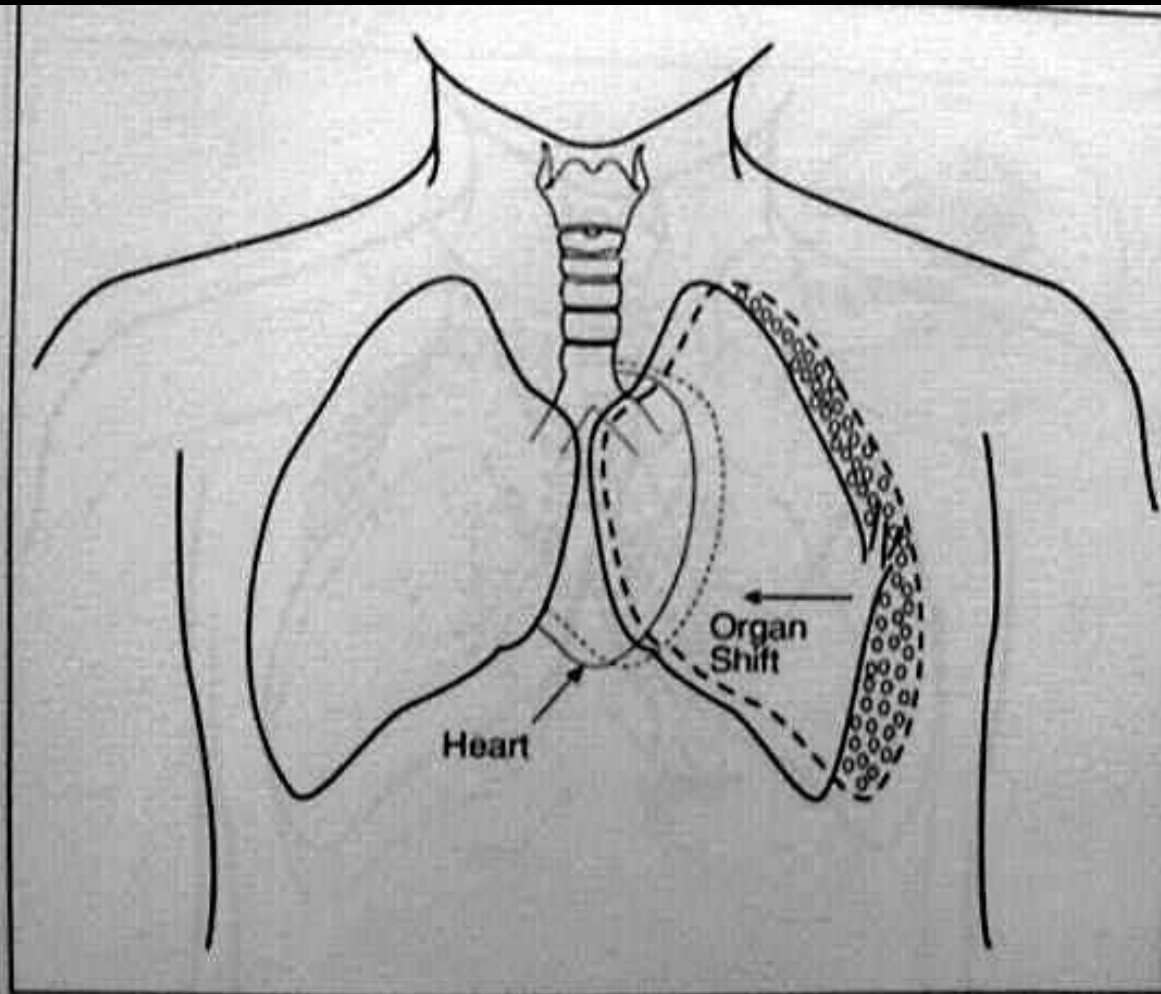


Figure 3-15. Tension Pneumothorax.



PULMONARY BAROTRAUMA

- **Pneumothorax – Tension Treatment**
 - ✓ **Immediate needle decompression**
 - ✓ **Chest tube**

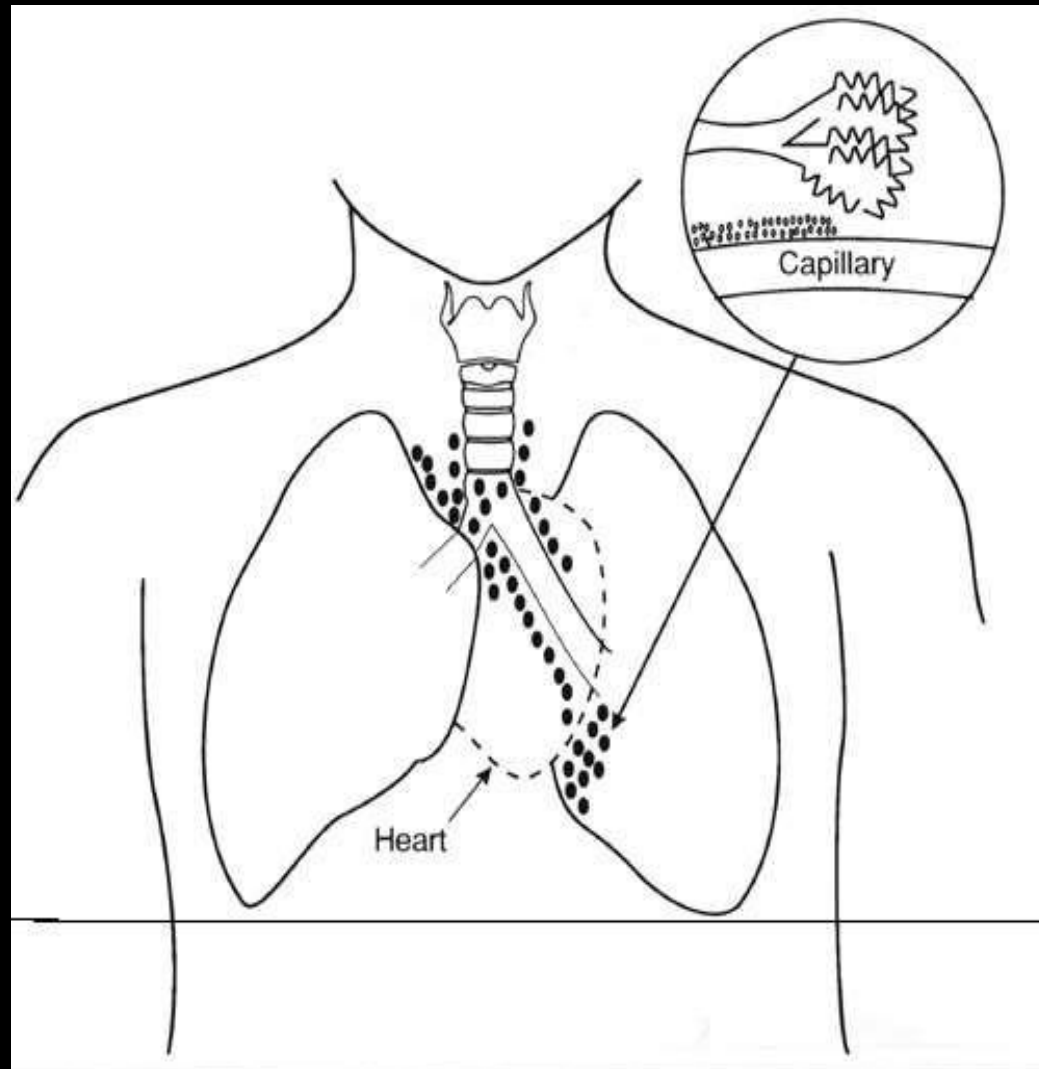


PULMONARY BAROTRAUMA

- **Mediastinal Emphysema Symptoms**
 - ✓ **Substernal chest pain or burning**
 - ✓ **May be worsened by inspiration**
 - ✓ **Intensity of pain may vary greatly**
- Signs**
 - ✓ **Mediastinal air on CXR**
 - ✓ **May hear crepitus - Hamman's sign**



MEDIASTINAL EMPHYSEMA





PULMONARY BAROTRAUMA

- **Subcutaneous Emphysema Symptoms**
 - ✓ **Substernal chest pain or burning**
 - ✓ **May be worsened by inspiration**
 - ✓ **Feeling of “Rice Krispies” under skin**
 - ✓ **Subjective voice changes**
 - ✓ **Signs**
 - ✓ **Crepitus in neck and supraclavicular area**
 - ✓ **Audible voice changes**



SUBCUTANEOUS EMPHYSEMA

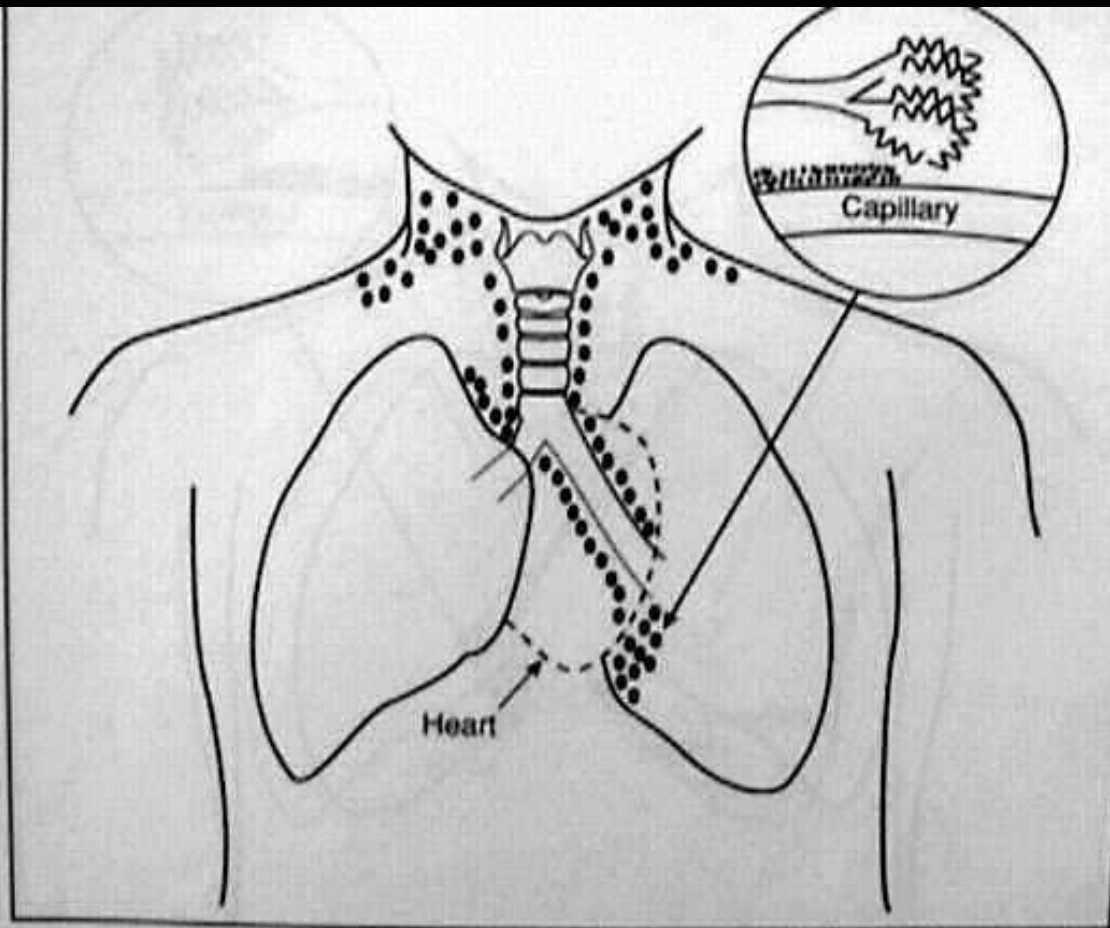


Figure 3-13. Subcutaneous Emphysema.



PULMONARY BAROTRAUMA

➤ Mediastinal or Subcutaneous Emphysema

Treatment

- ✓ Surface O₂
- ✓ For cardiac or respiratory compromise
consider recompression
- ✓ 5 - 10 FSW may be sufficient



PULMONARY BAROTRAUMA CASE

- ✓ Mr Sarath was a relatively inexperienced diver, 19 years old, and in good health.
- ✓ He was performing a **free ascent** from **10 meters**.
- ✓ On reaching the surface, he **gave a gasp, his eyes rolled upward and then he floated motionlessly.**
- ✓ **While he was being rescued from the water it was noted that blood and mucus were coming from his mouth and that he was unconscious.**
- ✓



BAROTRAUMA

- ✓ Resuscitation was commenced immediately, using oxygen. He was noted to be groaning at this time but soon after appeared dead.
- ✓ Resuscitation was continued while he was rushed to the nearest recompression chamber.
- ✓ Thirty minutes after the dive he was compressed to 50 meters but with no response.
- ✓ Autopsy verified the presence of pulmonary barotrauma (PBT).

Diagnosis: Air embolism resulting from PBT of ascent.



PULMONARY BAROTRAUMA PREVENTION

DIVE TRAINING

- ✓ **The most important rule in scuba diving is to breathe normally at all times and never hold your breath.**
- ✓ **Avoided include skip breathing, buddy breathing at depth and during ascent, ditch and recovery training, and emergency free ascent training when there are no experienced medical staff and full recompression facilities on site.**



PULMONARY BAROTRAUMA PREVENTION

MEDICAL SELECTION

- ✓ Exclusion of candidates with significant pulmonary disorders as below
- ✓ **previous spontaneous pneumothorax, asthma, sarcoidosis, cysts, tumors, pleural adhesions, intrapulmonary Fibrosis, infection, previous penetrating chest wounds and inflammation**
- ✓ **Asthma -Magnitude of risk that is very context-sensitive**



PULMONARY BAROTRAUMA PREVENTION

DIVER EVALUATION

- ✓ **Respiratory function tests and a pre- diving chest x-ray study**
- ✓ **Inspiratory and expiratory x-ray studies**
- ✓ **High-resolution or spiral CT scans of the lungs**

Pulmonary Barotrauma in Divers: What to Remember

- *Pulmonary barotrauma is preventable**
- *Never hold breath during ascent**
- *Greatest risk is near the surface**
- *Any neurological symptom post-dive = AGE until proven otherwise**
- *Early 100% O₂ and recompression saves lives**
- *Careful pulmonary screening determines diving fitness**

Thank You