



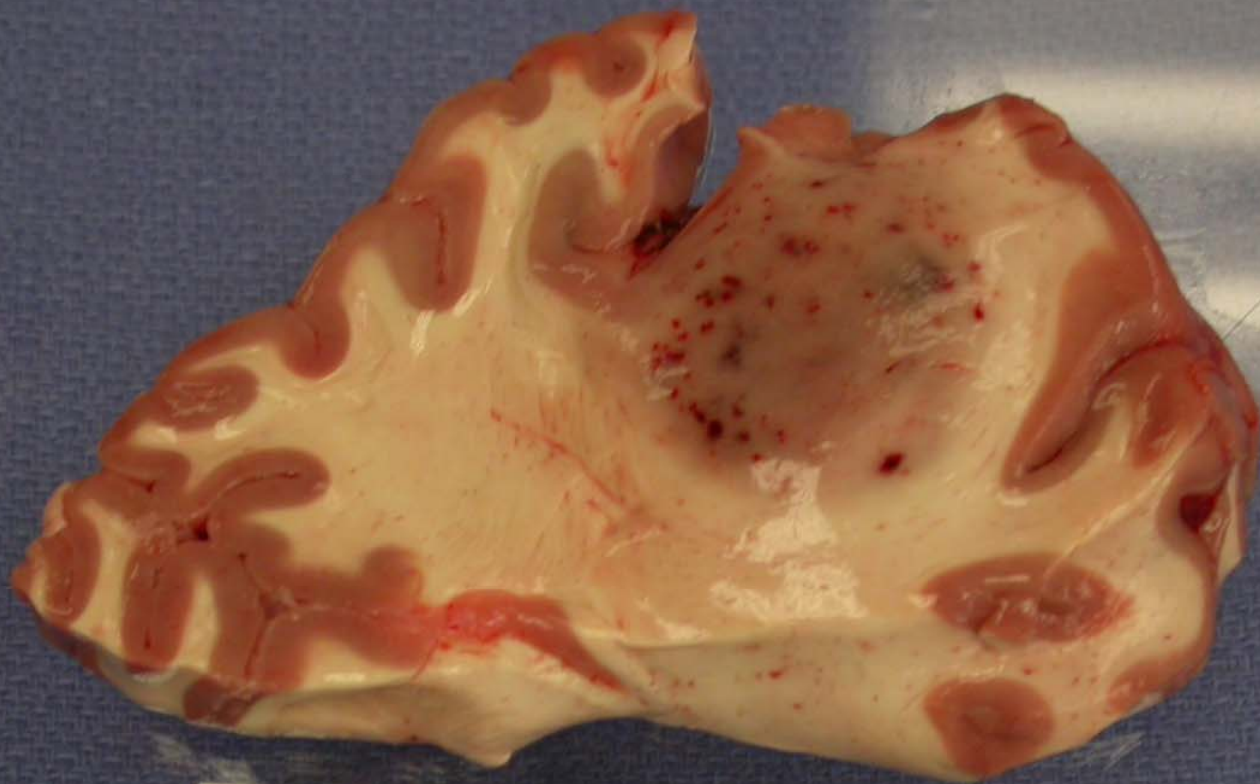
Diving Fatalities The Medical Examiner Perspective

April 2010

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DMO/FS
Bureau of Naval Personnel**

Key West Case

- 26 YO Navy SEAL using 100% oxygen rebreather rig for shallow excursions
- Short buddy separation at end of dive and LOC
- Presumed seizure
- Autopsy disclosed typical drowning findings – fluid in sinuses, edematous/hyper-expanded lungs, pleural effusions



10-0030

Dist 16 ME, FL



Recreational Diving Fatalities

- Often litigated; frequently involve young victims
- Majority are non-natural, all are unexpected deaths so medical examiner has jurisdiction
- An autopsy is nearly always performed (should be always)
- History (medical, dive, scene) is critical



What is a Forensic Pathologist?



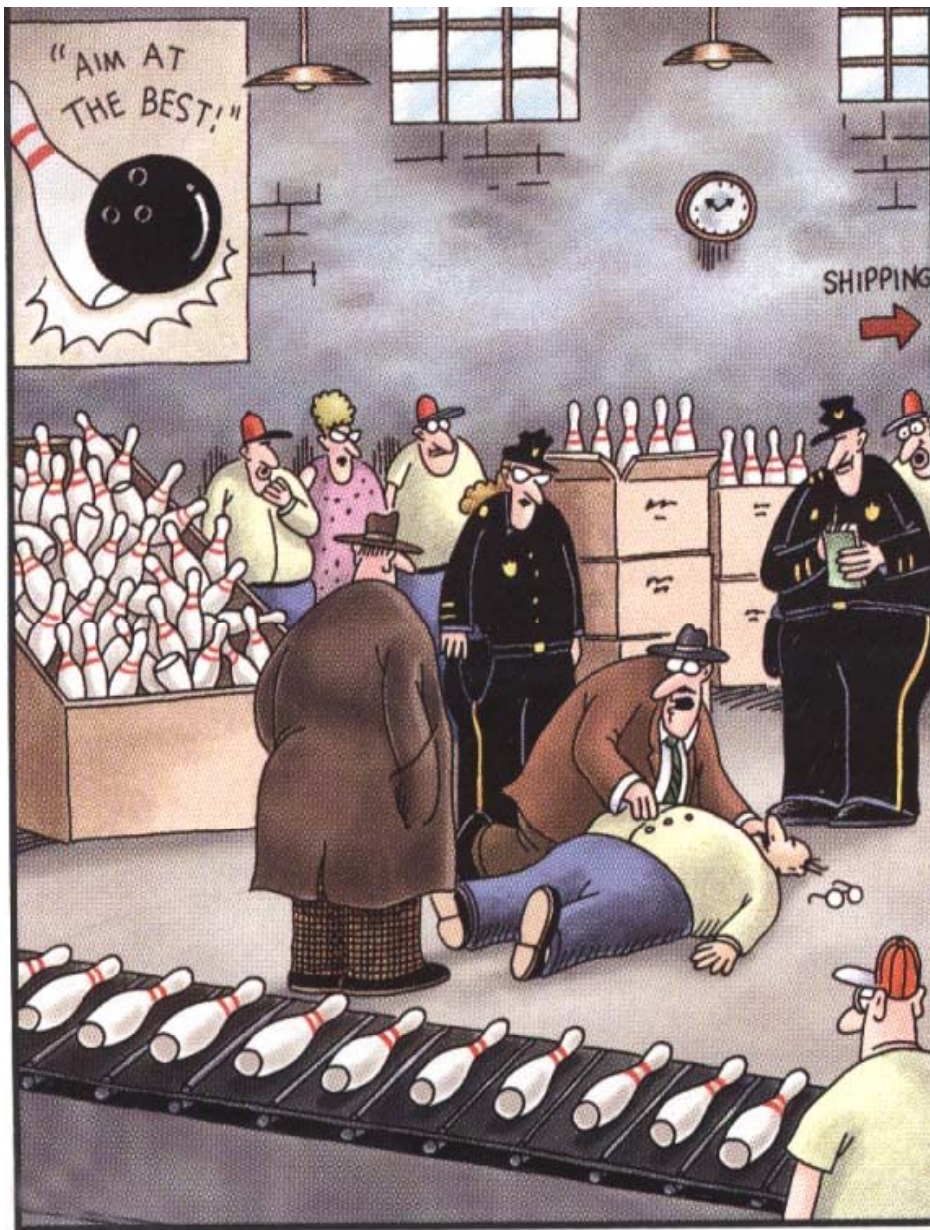
A physician that specializes in the investigation of deaths that are sudden, unexpected, or appear unnatural in any way



Personnel

- Coroner
- Sheriff-Coroner
- Justice of the Peace
- Medical Examiner
- Forensic Pathologist

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"Struck from behind, all right ... and from my first examination of the wound, I'd say this was done by some kind of heavy, blunt object."

Death Investigation

- × Collaborative effort
- × Multiple disciplines
- × Ultimate goal: Reconstructing event

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Cause of Death

- The disease or injury that initiated the lethal chain of events that brought about a person's death
- Etiologically specific derangement which lead to demise.
- Different from mechanism of death

Cause of Death: Examples

- × Arteriosclerotic heart disease
- × Metastatic breast cancer
- × Multiple blunt force injuries due to car crash
- × Gunshot wound of the head
- × Hanging
- × Drowning
- × Air Embolism

Variety limited only by permutations of cruelty, stupidity, and bad luck.

Manner of Death

**How the cause of death came
about**

-or-

**The circumstances under
which the person died**

Manner of Death

- × NATURAL
- × ACCIDENT
- × HOMICIDE
- × SUICIDE
- × UNDETERMINED



Diving Related Deaths

- The cause of death is most often drowning but that is simply a final common pathway
- More important is the “trigger”, or critical event that directly resulted in the death
- Most diving related deaths are due to “diver error”.... a critical error in judgment, diving beyond one’s level of experience/training, or violating generally accepted safe diving practices

Why Investigate?

- Generate “Lessons Learned”
- Families demand an explanation – automatic blame placed on training, dive shop, Divemaster, charter operator
- Drowning as a diagnosis is unrewarding for those purposes
- Causative and contributing factors important to elucidate

DAN Objectives

- Decrease diving deaths through public education
- Assist Medical Examiners and investigating authorities
- Provide meaningful data for epidemiological studies

Case Collection

- DAN collects all available information on each diving related fatality
- Investigative reports, media clippings, medical examiner reports, DAN accident report forms, witness accounts
- All cases reviewed by DAN staff, including a forensic pathologist/DMO

Diving Physiology

- Most diving fatalities are related to the effects of pressure, inert gas, or insufficient breathing gas
- Proper investigation requires a thorough understanding of diving physiology and the effects of the underwater environment on the body

Natural Disease

- As divers age many want to continue active diving; older individuals may finally have the time and resources to take part
- Often have a poor fitness level and pre-existing health problems
- Additional risks of exertion and being in the water environment if a problem occurs

Natural Disease

- Cardiovascular disease the most common natural cause of death/contributing factor
- Air trapping diseases could prove catastrophic: COPD, asthma, previous pneumothorax
- Inherent risks with seizure disorder, diabetes – may also put dive buddy at risk

Drugs, ETOH, CO

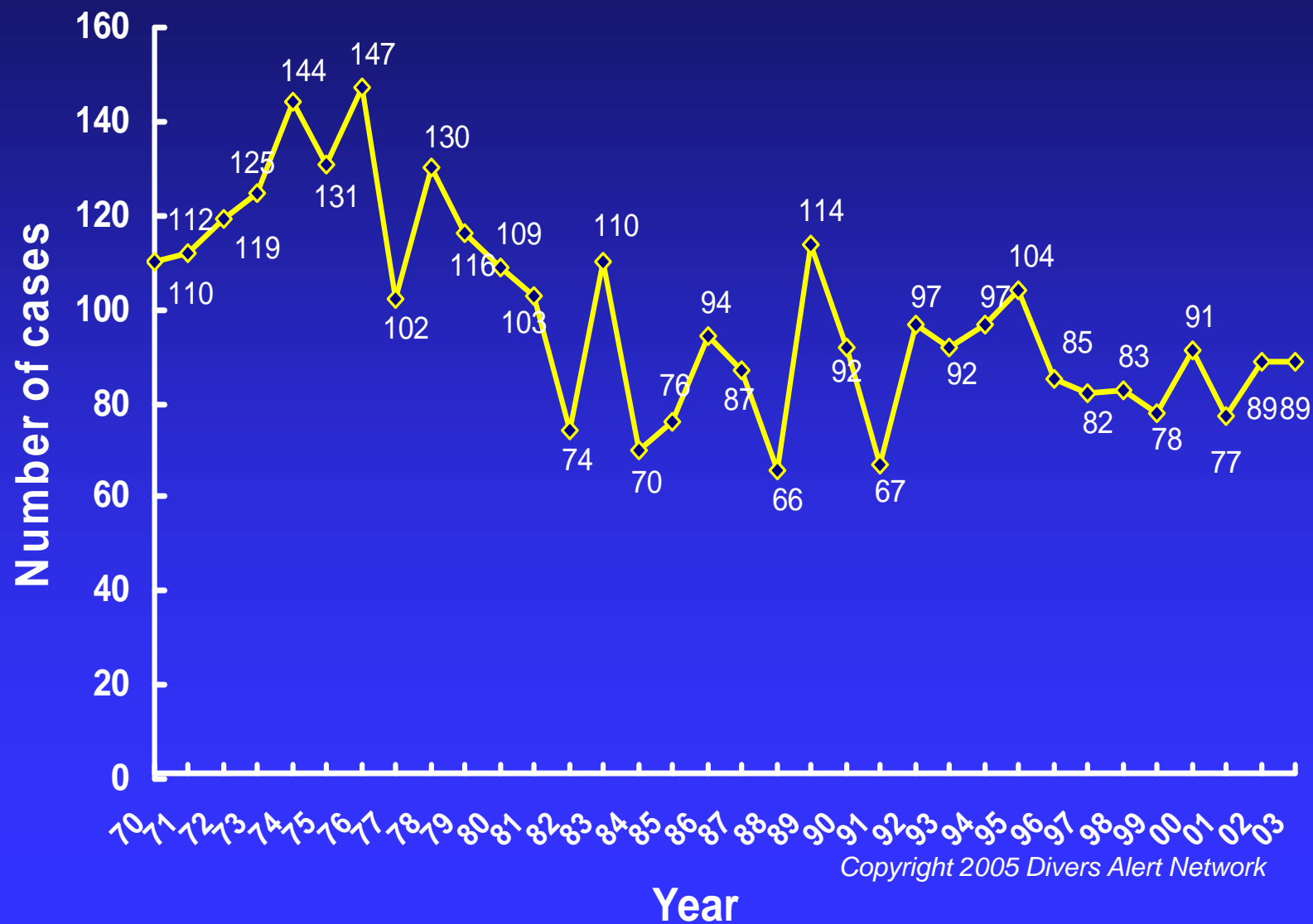
- Each year a few fatalities involve intoxicated divers, divers on sedating prescription meds, and even a few diving under the influence of drugs of abuse
- Contaminated gas sources do occur and should be excluded

Other Hazards/Risks

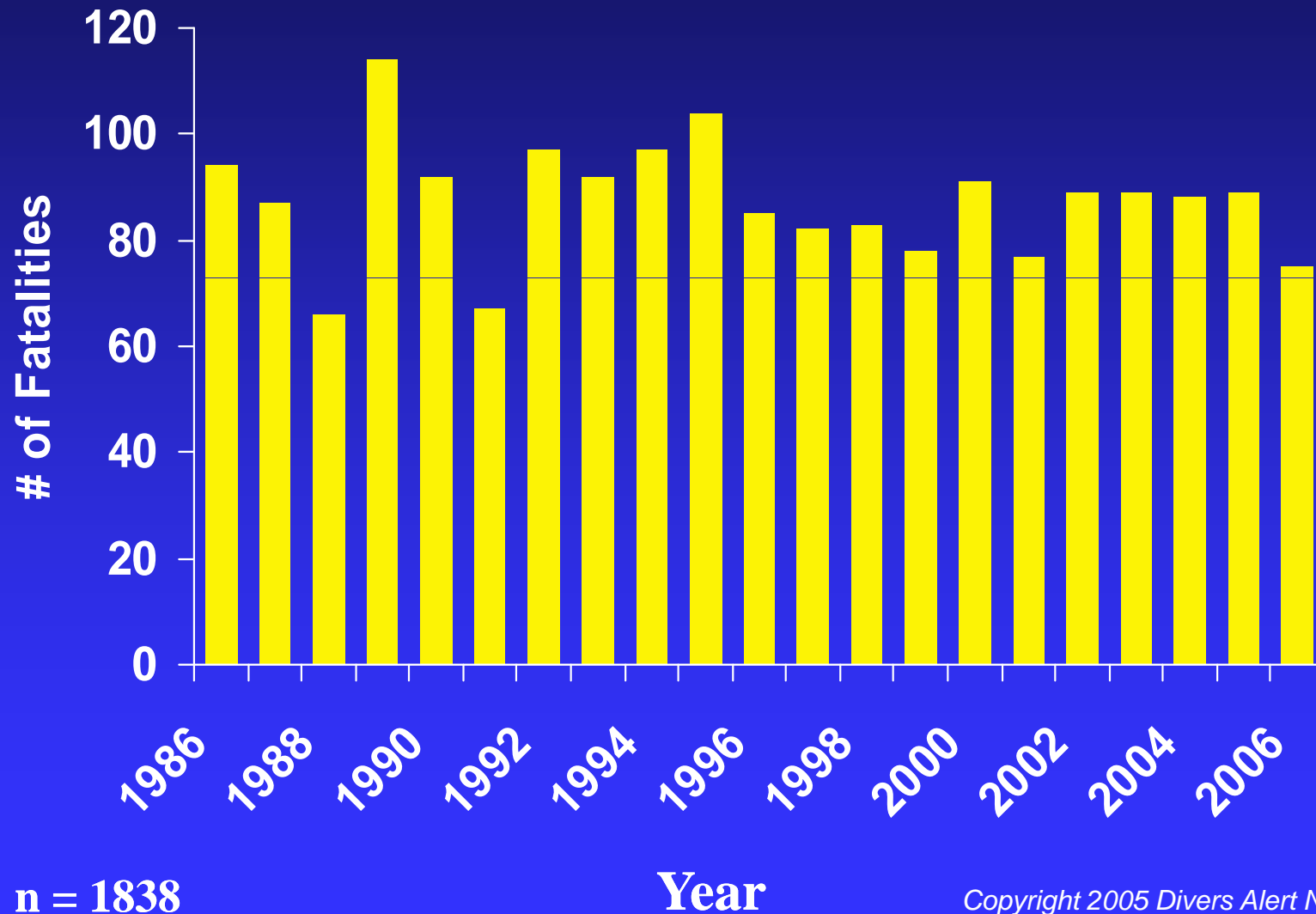
- **Mechanical Trauma** – every year a few divers are struck by watercraft or suffer other mechanical trauma in the water
- **Marine Life** – rarely contribute to a fatal outcome: bites, envenomations, and stings all pose potential hazards

DIVING FATALITIES

1970 - 2003



Annual Record of U.S. & Canadian Diving Fatalities



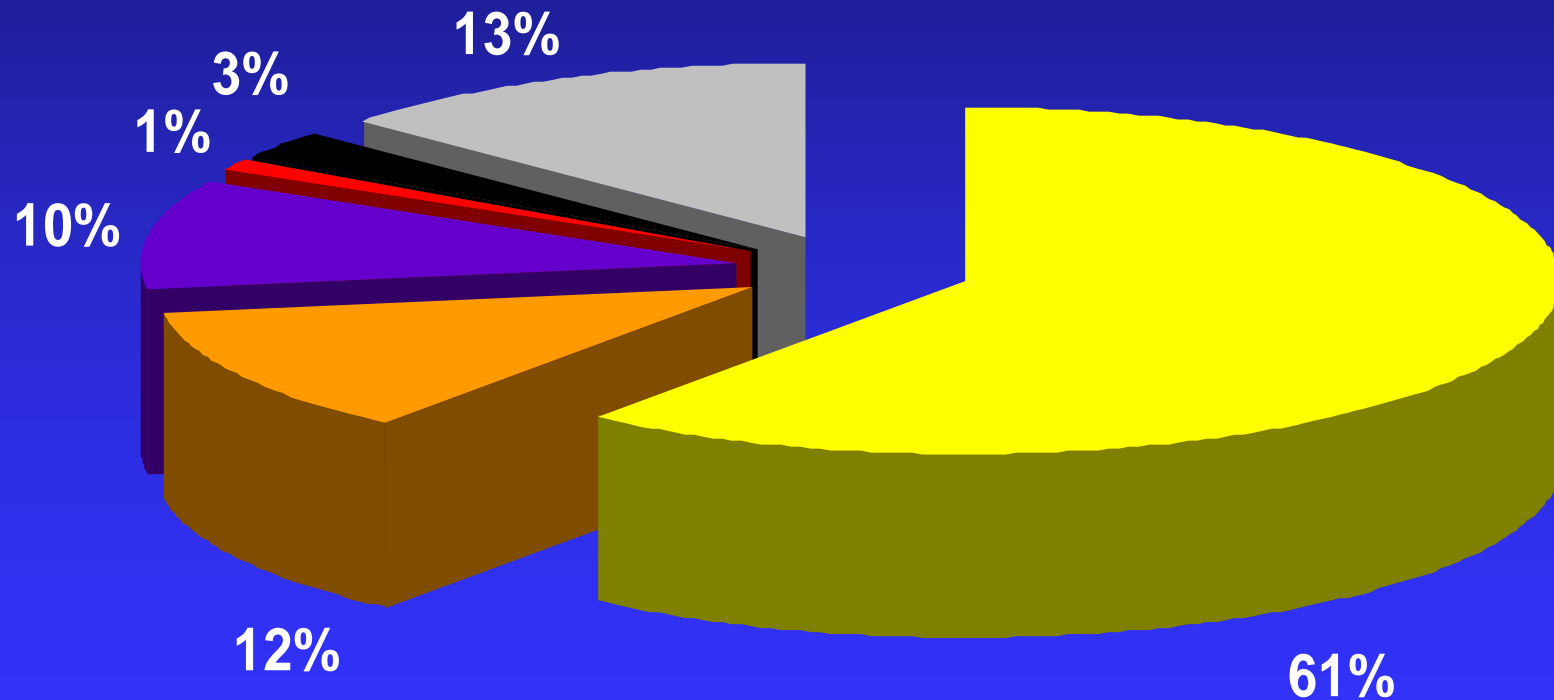
n = 1838

Year

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Primary Cause of Death 1997 - 2006

■ Drowning ■ AGE ■ Cardiac ■ DCS ■ Other ■ Unknown



n = 841

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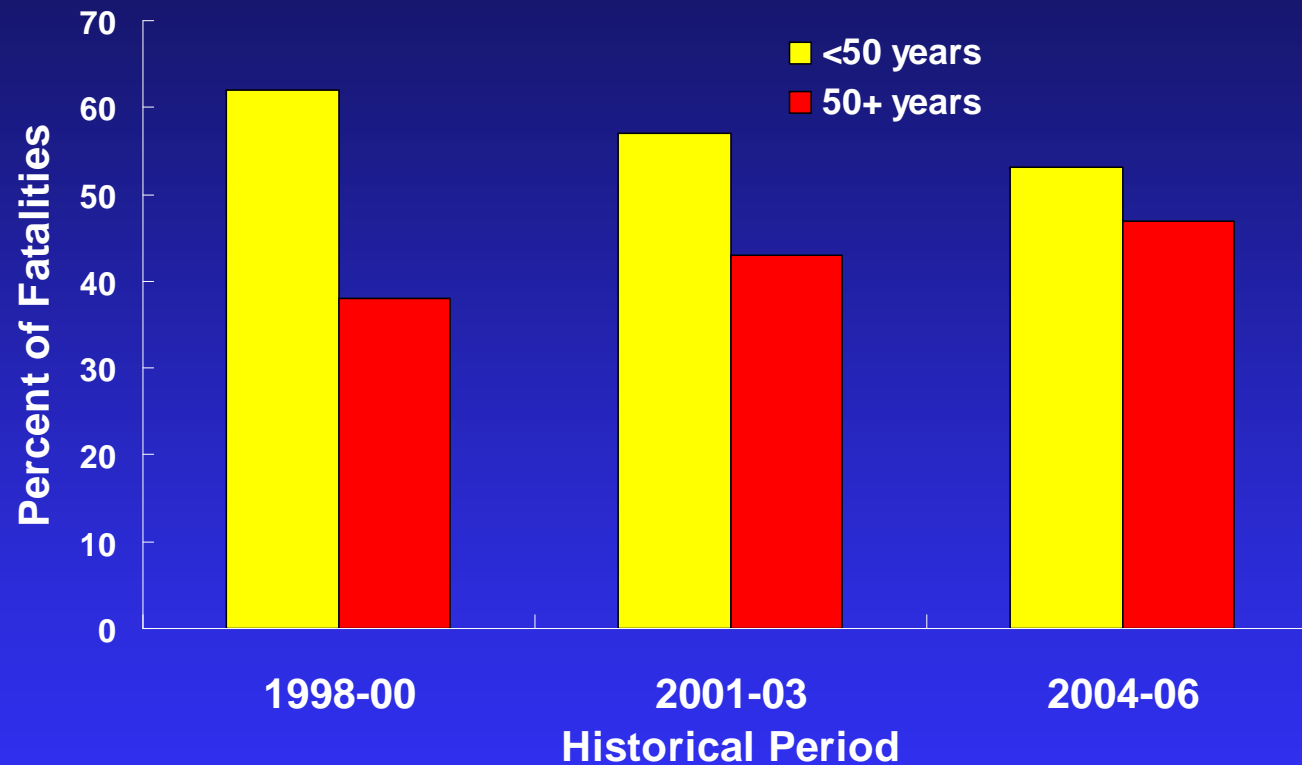
Major Contributing Factor Leading to the Primary Cause of Death

Cause	Number	Percent
Insufficient Air	159	19.9
Cardiac	120	15.0
AGE	79	9.9
Rapid Ascent	50	6.2
Entrapment	32	4.0
Struck by Boat	14	1.7
Other Causes	348	43.4

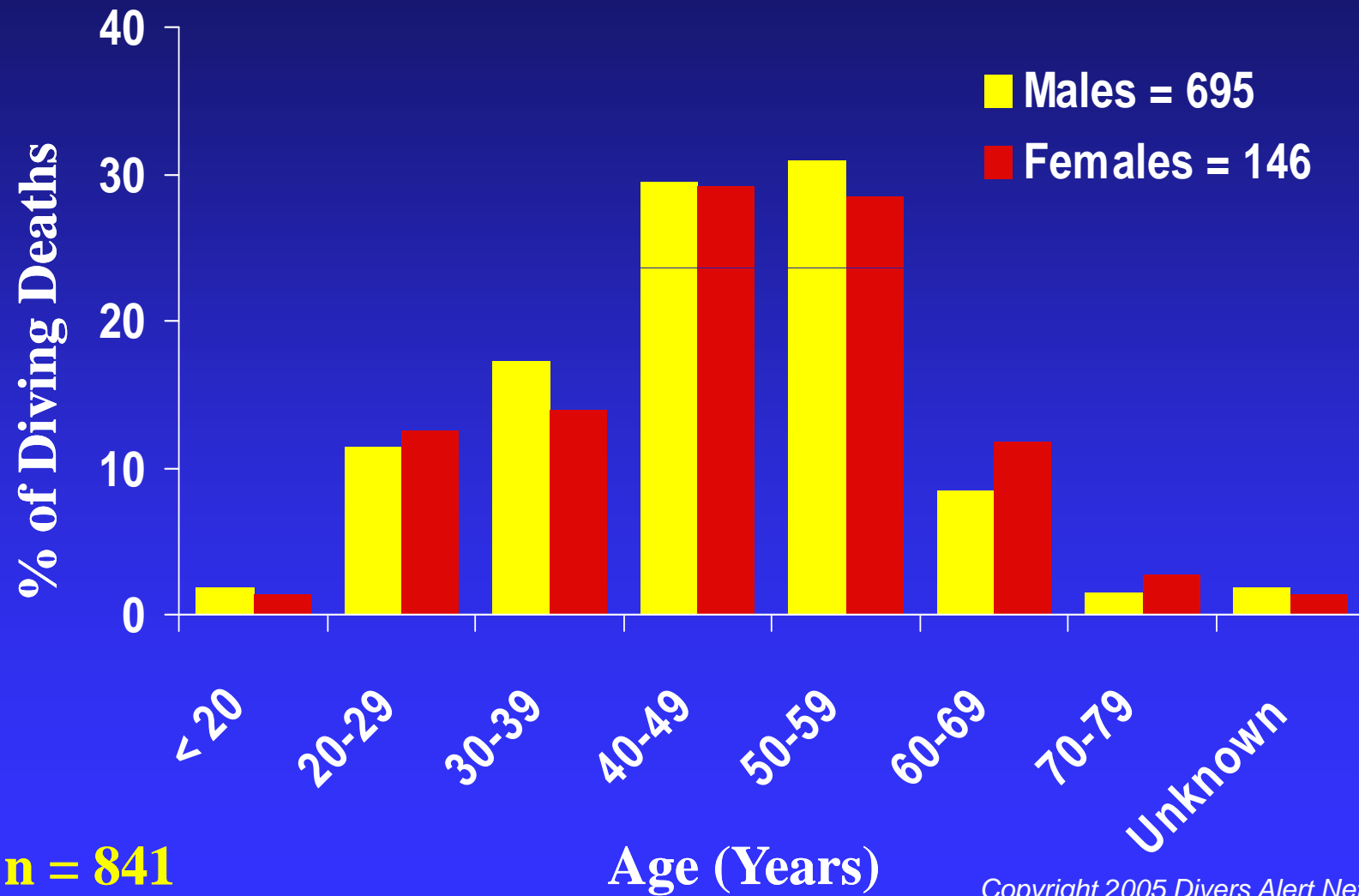
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DAN Fatalities over Age 50

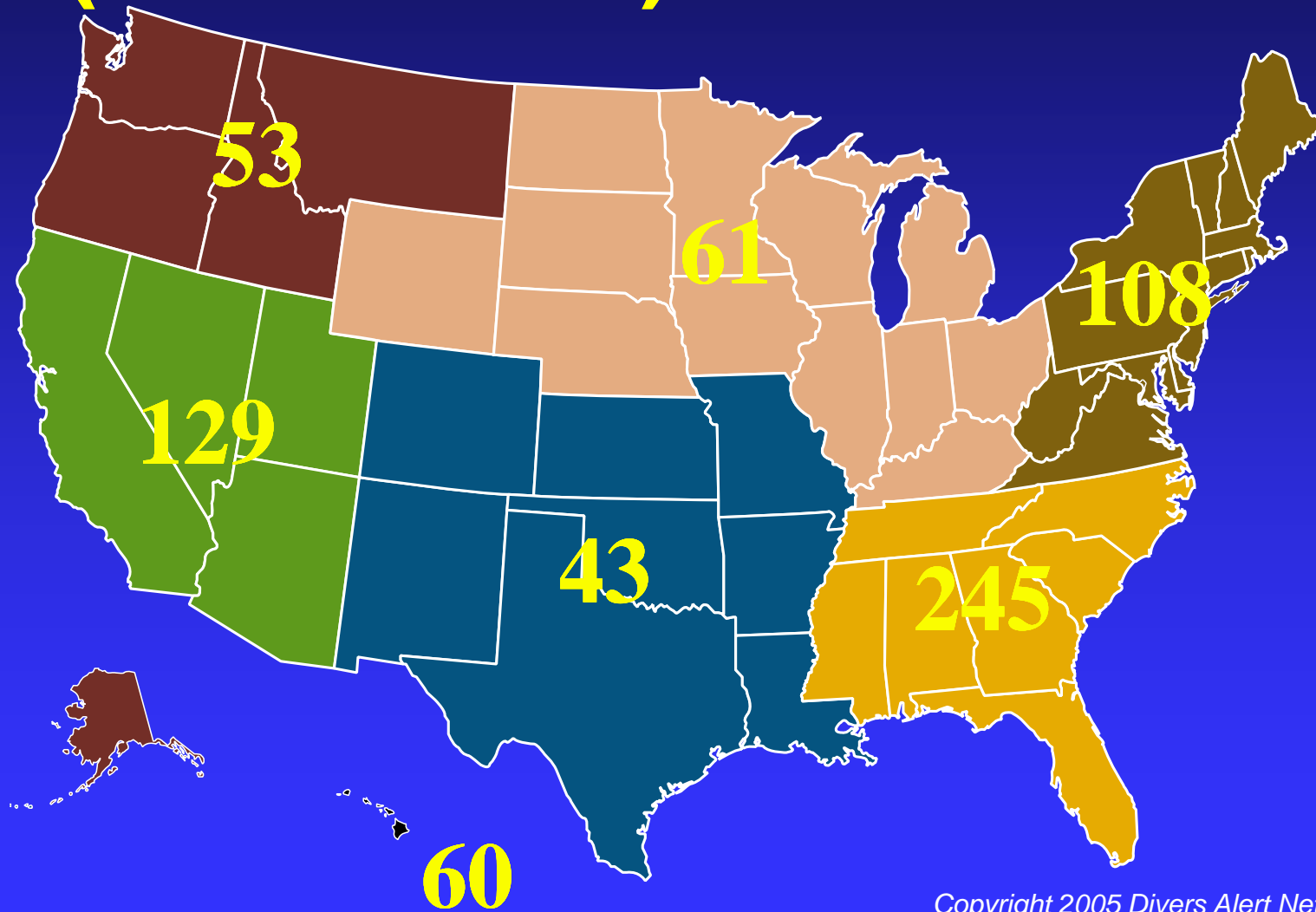


Age and Gender of Diving Fatalities (1997 - 2006)



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U.S. Fatalities by Region (1997 - 2006)



DAN Insights

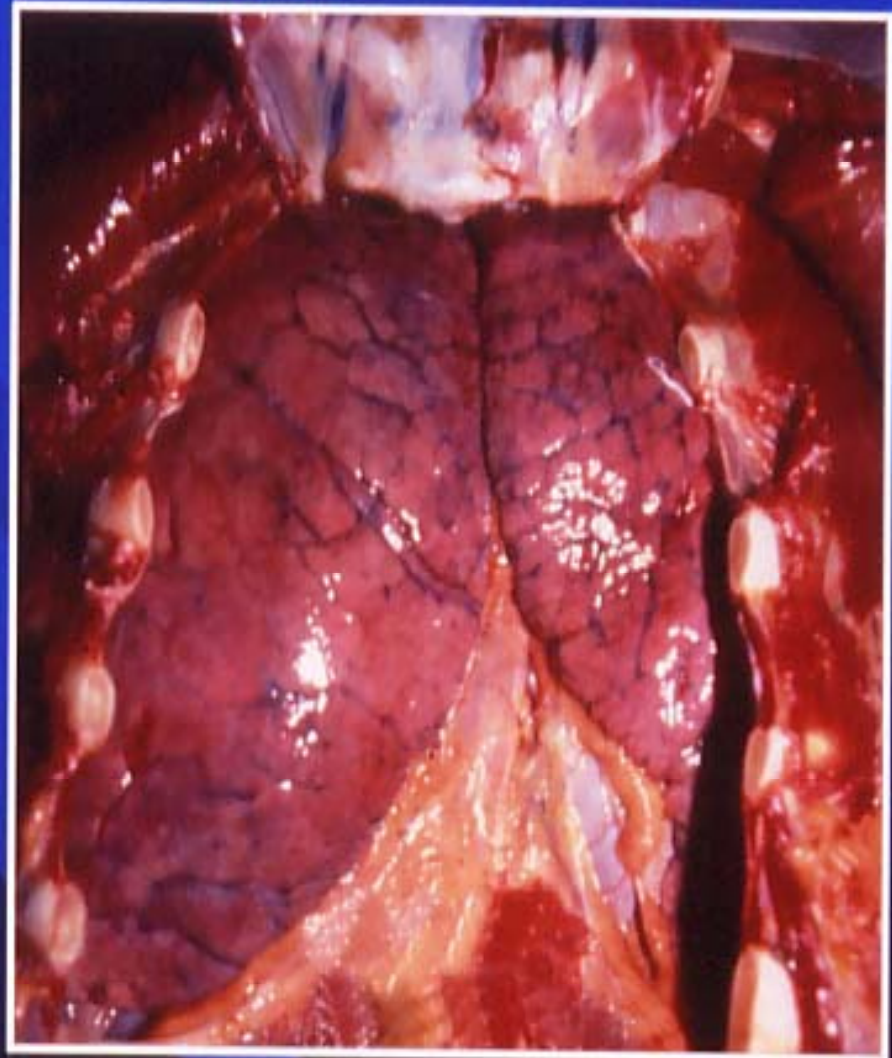
- Nearly half of all diving deaths involve divers who have made 20 or fewer lifetime dives; 7-8% are students
- Buddy separation occurs in 40% of all diving related deaths solo divers account for another 14% of the deaths
- Barely a third of divers who died during a specialty dive (cave, wreck, deep, etc.) had documented formal training in that type of diving

The Autopsy

- Short postmortem interval ideal
- Thorough external examination
- Use special techniques to evaluate for evidence of pulmonary barotrauma and air embolism
- Be aware of artifacts of breathing compressed gas at depth and postmortem effect

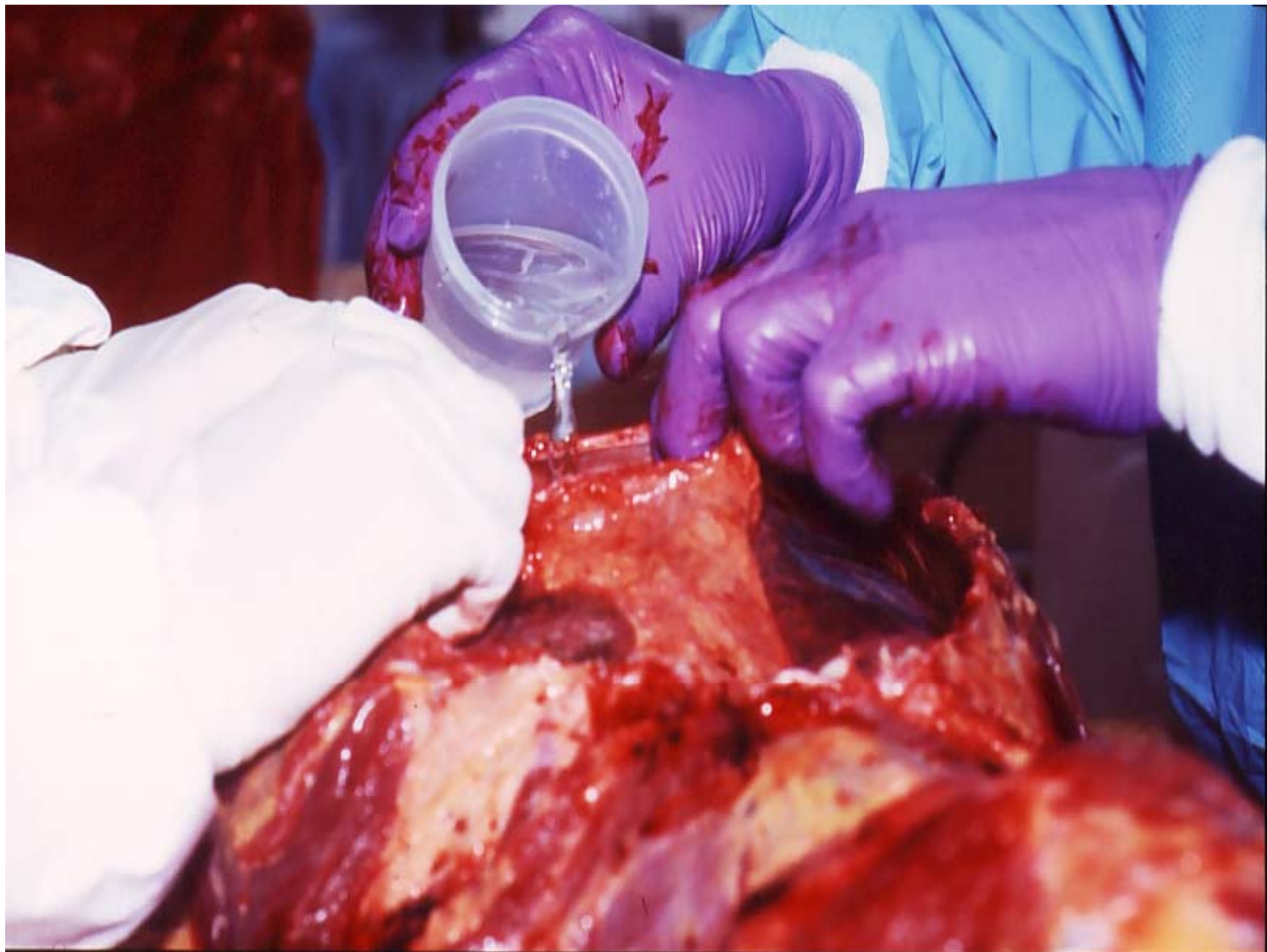
Autopsy-Key Organs

- Lungs
- Heart
- Brain
- Middle ear and sinuses
- Spinal cord

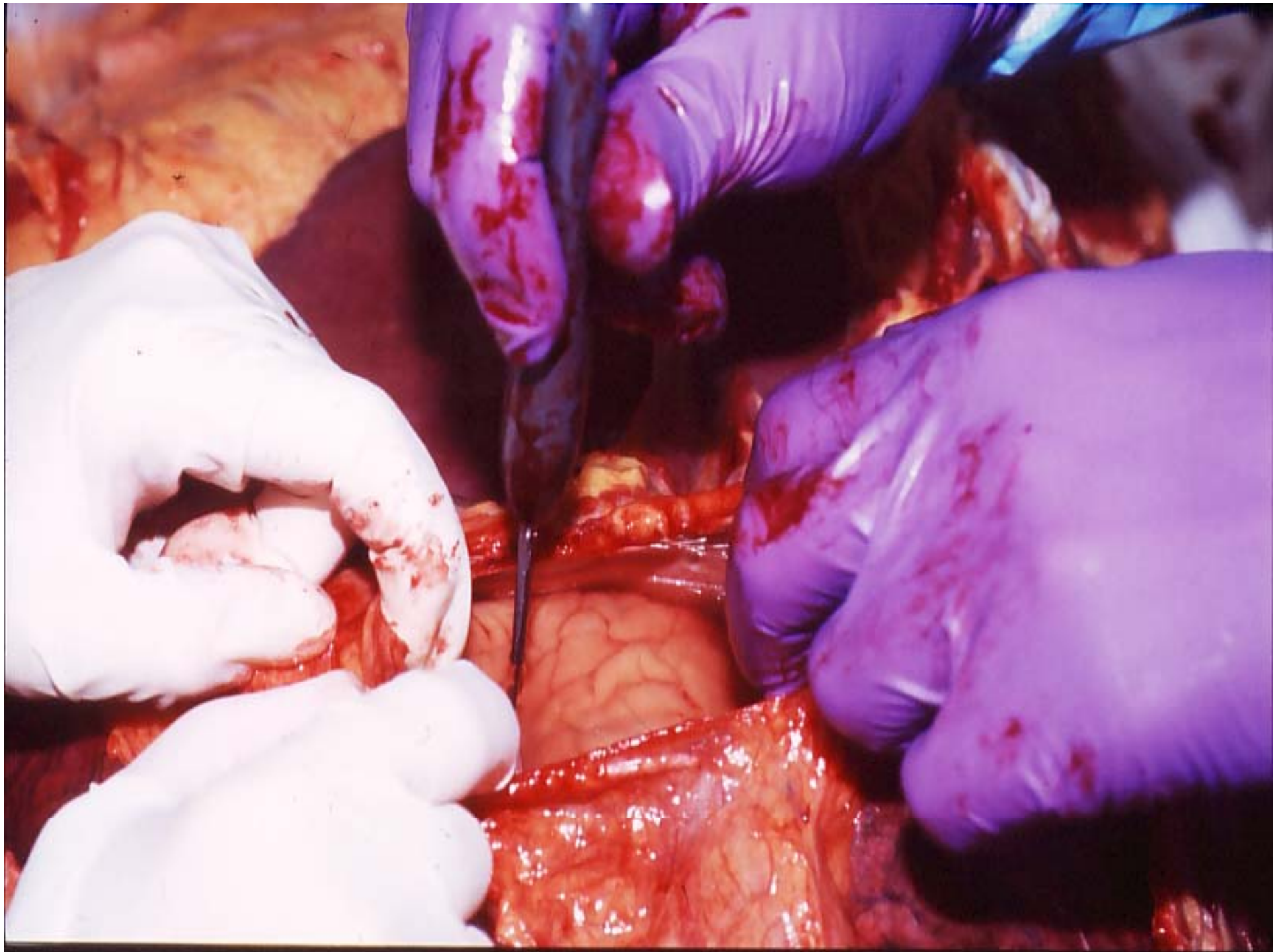


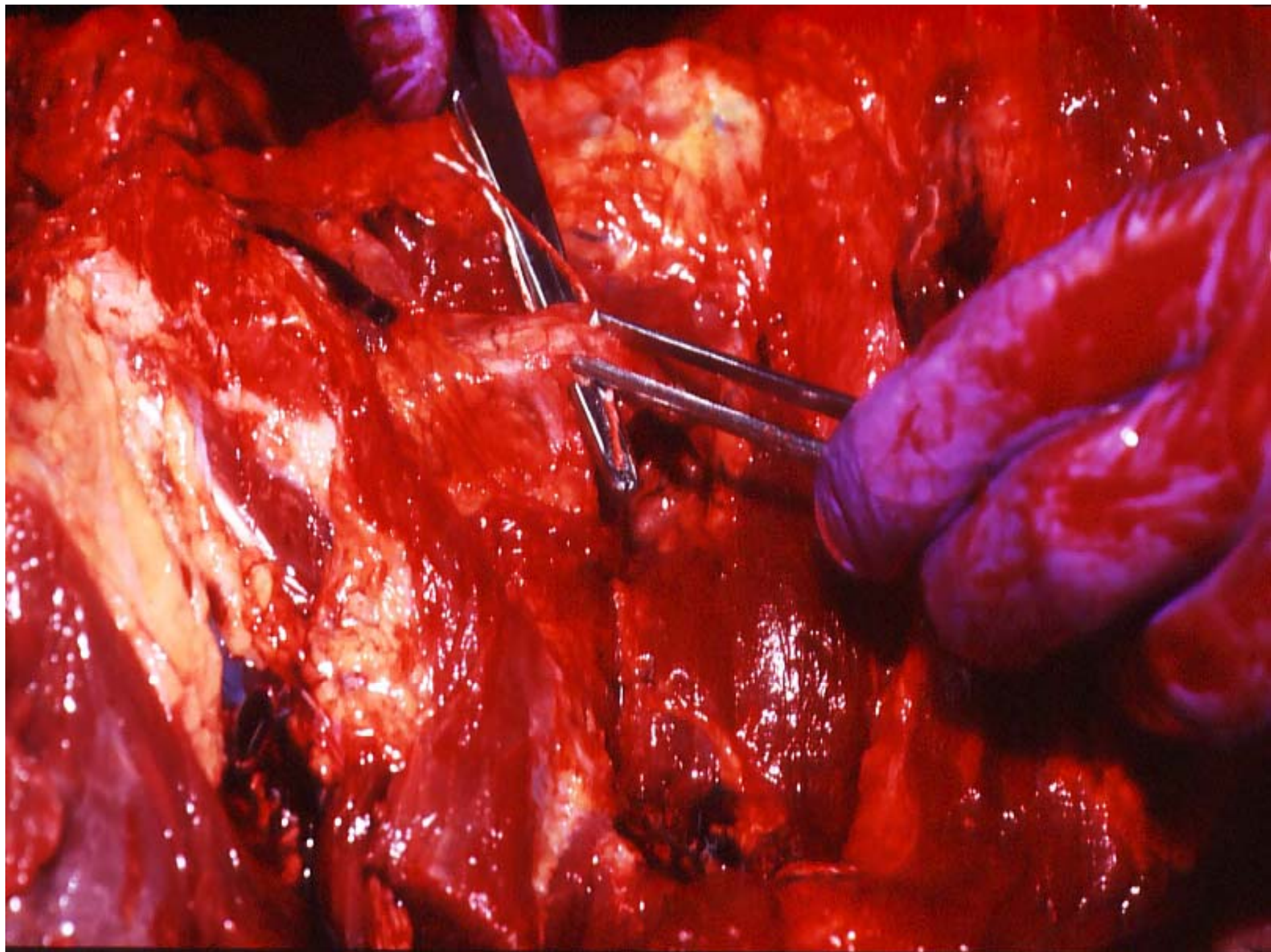


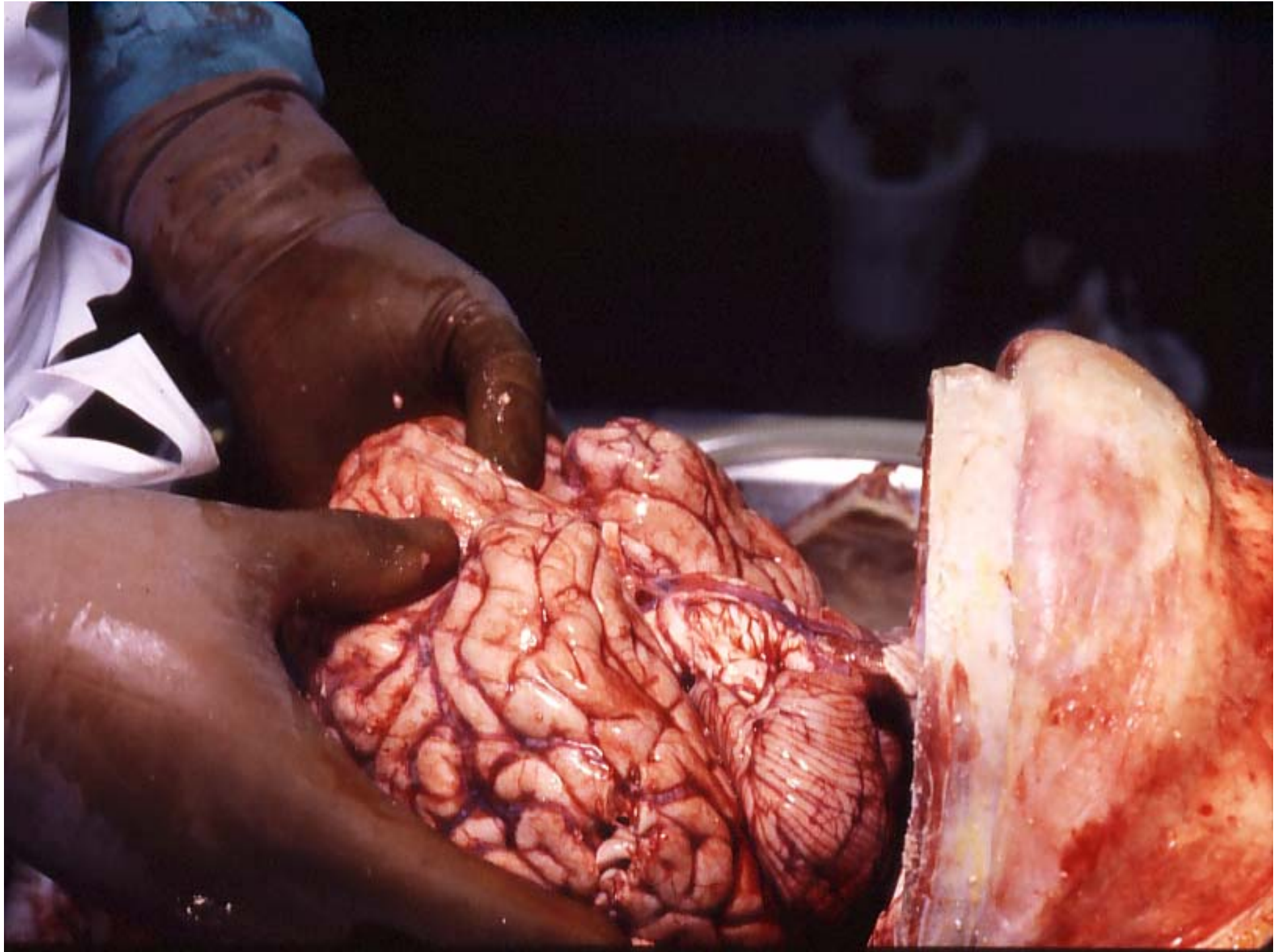










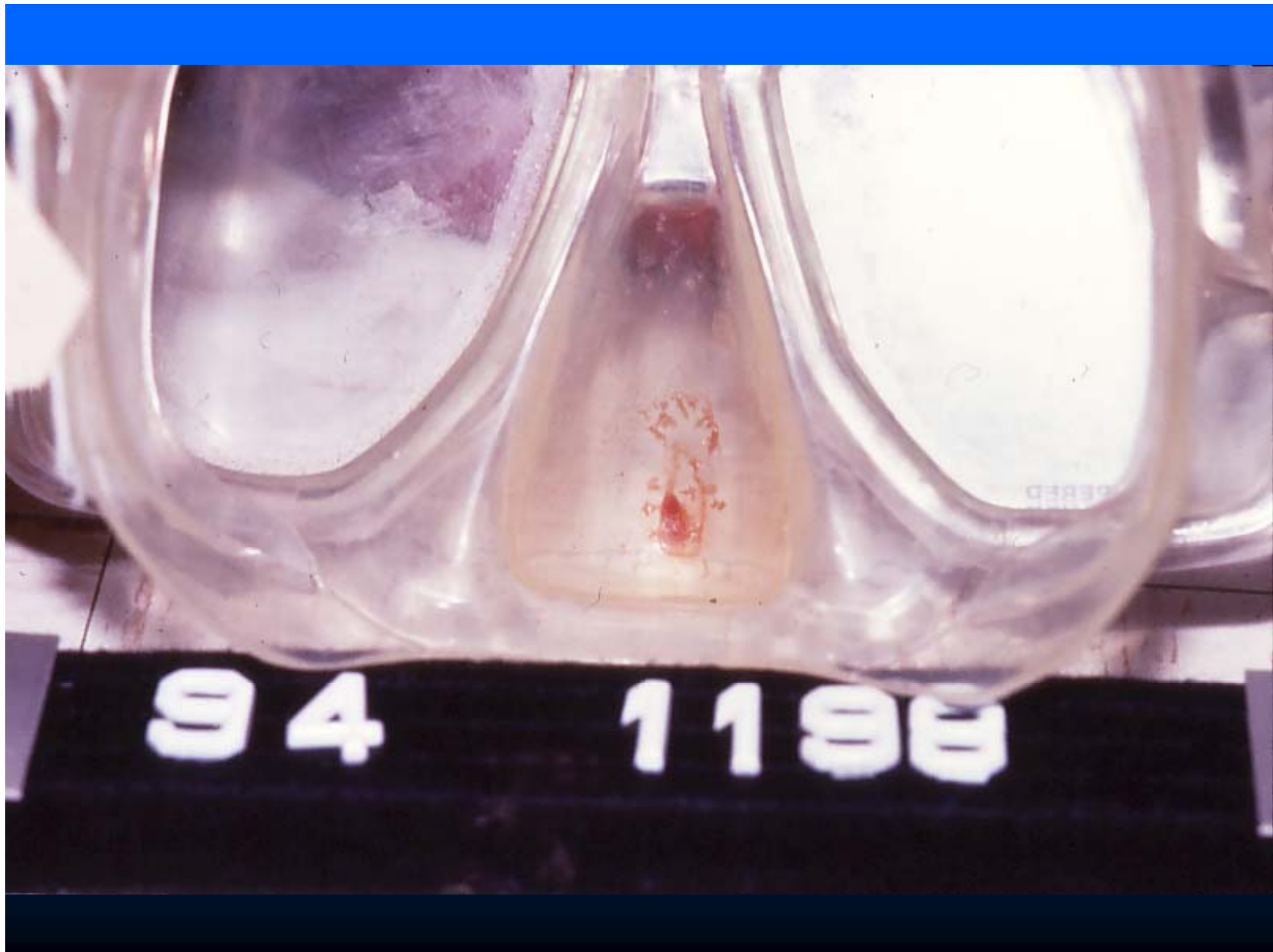


Bubbles

- Anyone breathing compressed gas at depth may have intracardiac or intravascular gas at autopsy, especially with deep/long dives
- Postmortem off-gassing does occur
- Keep the dive profile in mind (e.g., there is no AGE without an ascent)

History D94-1198

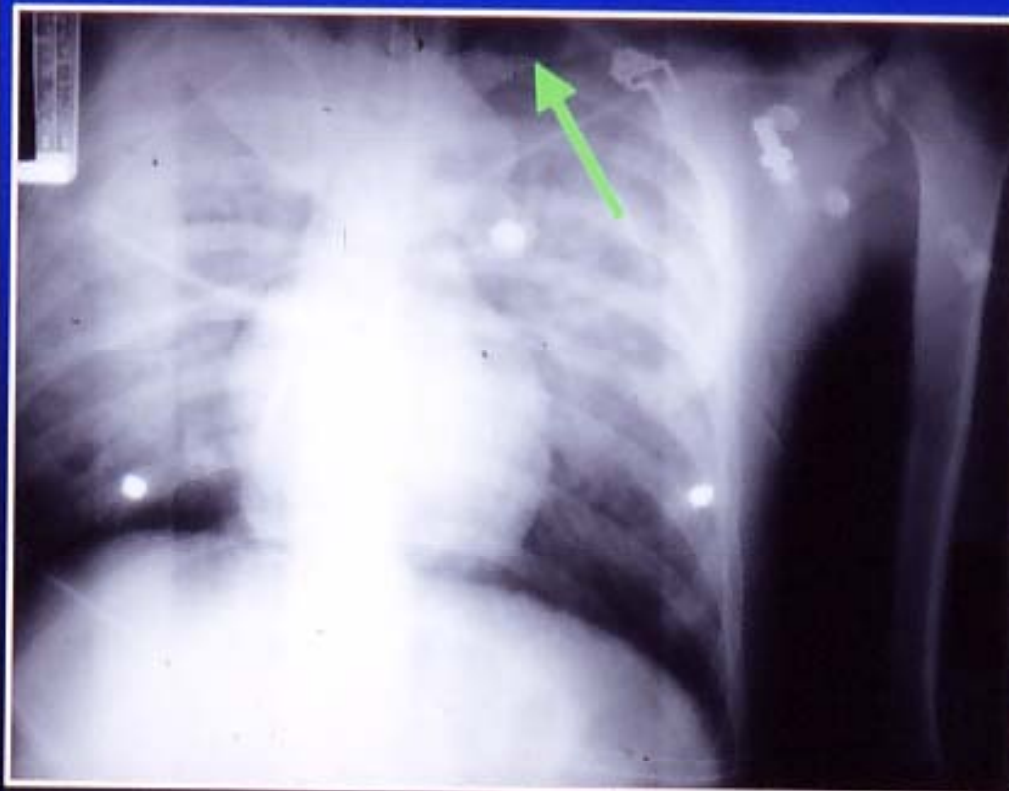
- 20-year old man with no scuba diving training or experience
- On boat while his 3 friends were diving
- When they returned, the victim was gone
- Air bubbles seen next to boat
- Victim found on ocean floor with mouthpiece out, unconscious, fists clenched



D94-1198 (cont.)

- **Resuscitated but arrived at the hospital comatose**
- **Imaging shows subarachnoid air on cranial CT**
- **Bilateral pneumothoraces**
- **No response to recompression with HBO**
- **Dive equipment provided answer**

Radiography/CT scan



94-1198



94-1198



DataMax
SPORT

OCEANIC

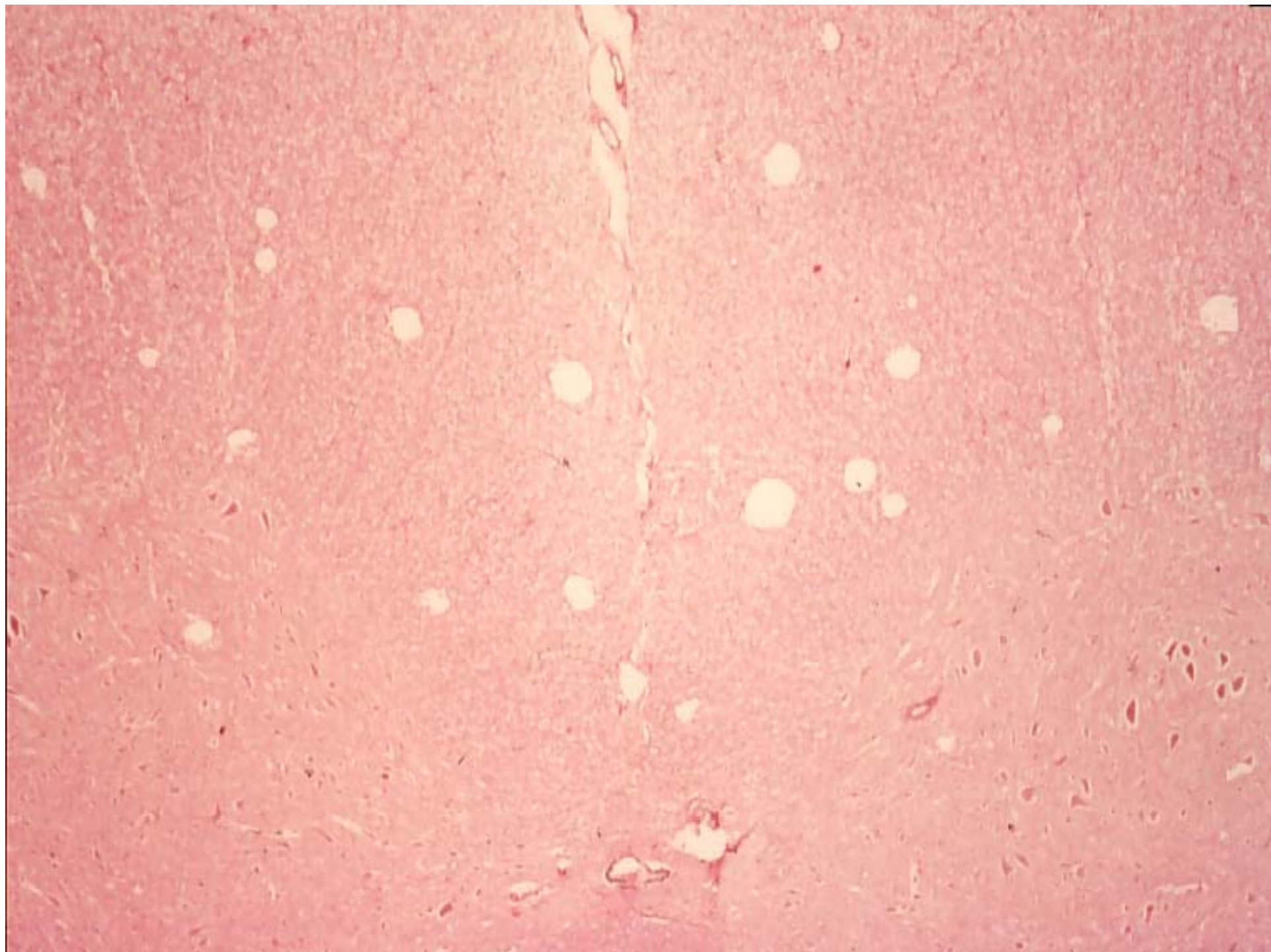
FATALITY CASE-RD

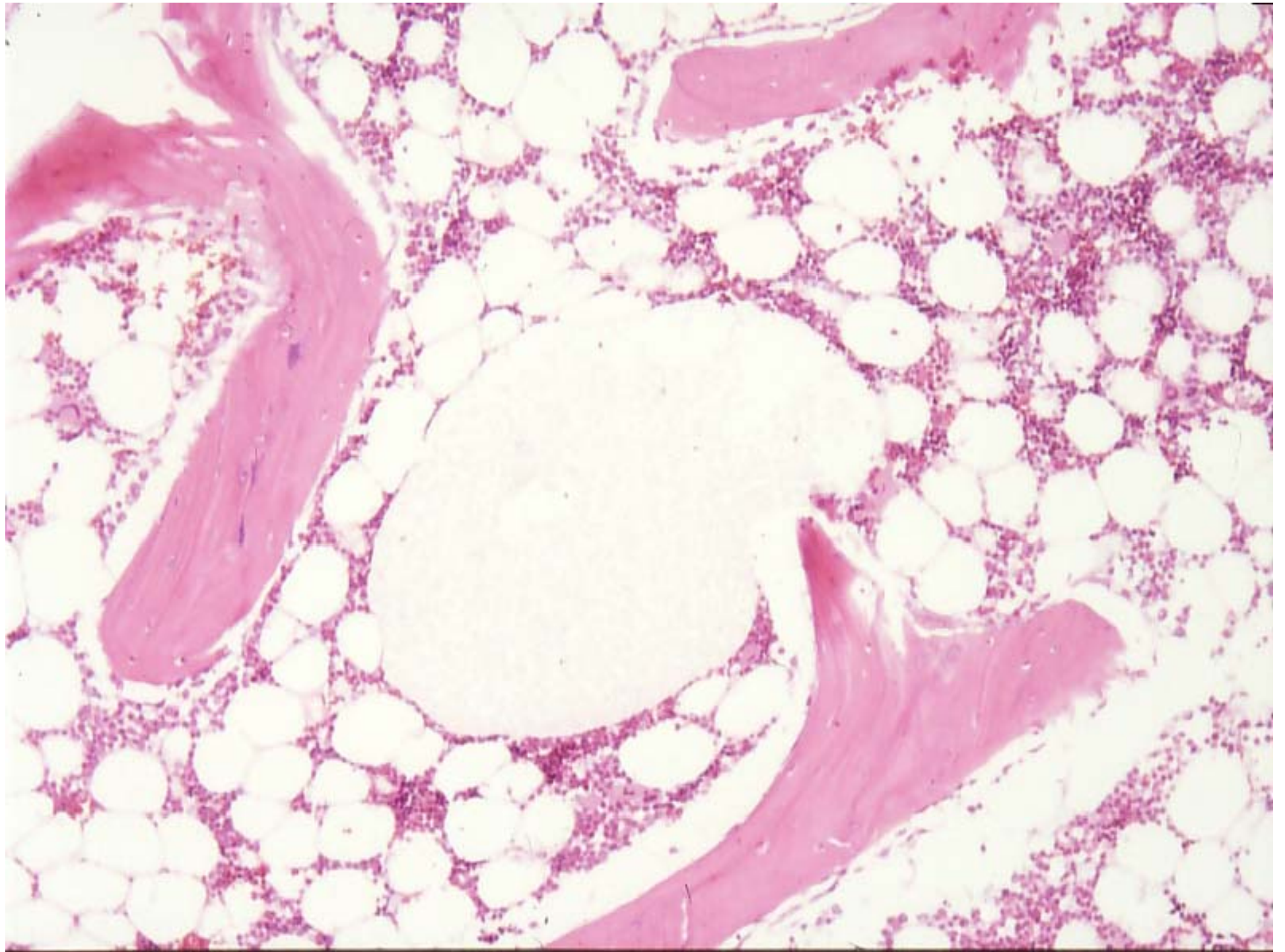
- **35 year old somewhat experienced diver with nitrox certification makes a dive with a buddy to 276 FSW max (BT~:15) to explore a wreck**
- **Regulator free-flow causes diver to run low on air and his buddy saw the diver head to the surface without a stop**
- **Diver radios USCG before becoming incapacitated**

FATALITY CASE-RD (cont)

- **Diver is resuscitated and transported to hospital with multiplace chamber where he was treated with HBO repetitively-pulmonary status declined**
- **Autopsy performed and erroneously signed out as “Complications of Nitrogen Narcosis” as the cause of death**
- **Omitted 50-80 minutes of decompression time**
- **AGE also a possibility**







DIVE CASE-AG1

- **38 year old experienced diver was spearfishing with 2 buddies when he signaled that he wanted to ascend from 91 FSW**
- **He was witnessed to ascend but stopped and headed back down**
- **His dive buddies found him on the bottom unconscious and brought the diver to the surface**
- **Resuscitation was unsuccessful**

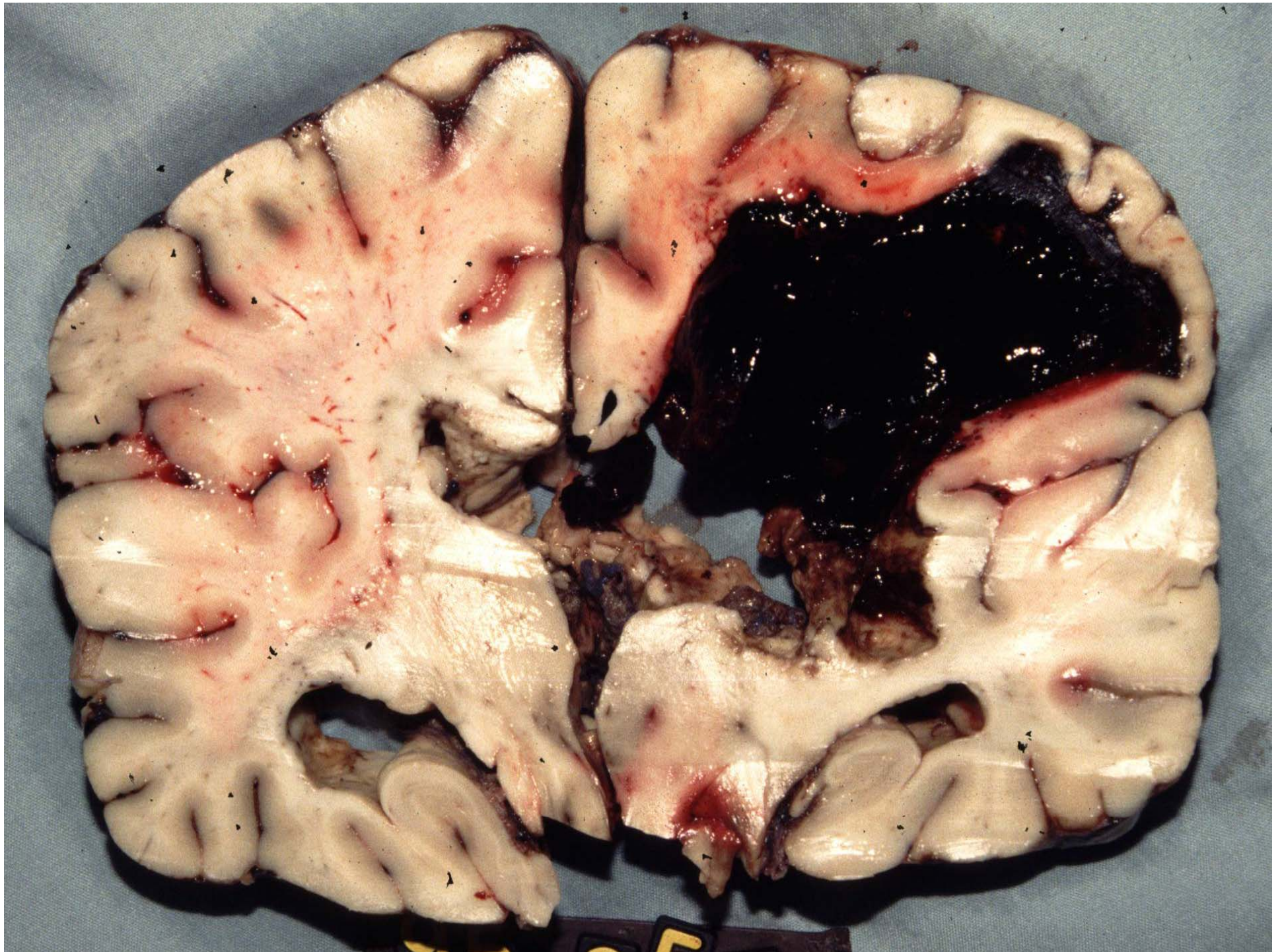
DIVE CASE-AG2

- **The autopsy disclosed extensive subcutaneous and intracardiac air**
- **Other significant diagnoses included obesity and a blood alcohol level of 178 mg/dl (nearly twice legal limit for driving in most states)**



History

- 37-year old man spear fishing alone while scuba diving
- Divemaster certified; hx of hypertension
- Found floating on surface with mask off. He was incoherent. His left side was kicking and right side was limp. Vomited.
- Died in hospital 2 days later.



CASE HISTORY-CVD

- **A 43 year old male in an initial open-water certification course told a friend that he felt light-headed with “pressure” in his chest prior to the dive. He had a history of fatiguing easily and was also a smoker.**
- **He was found unconscious on the surface and the autopsy revealed severe coronary atherosclerosis, left ventricular hypertrophy, and a fatty liver.**





CASE HISTORY-CVD

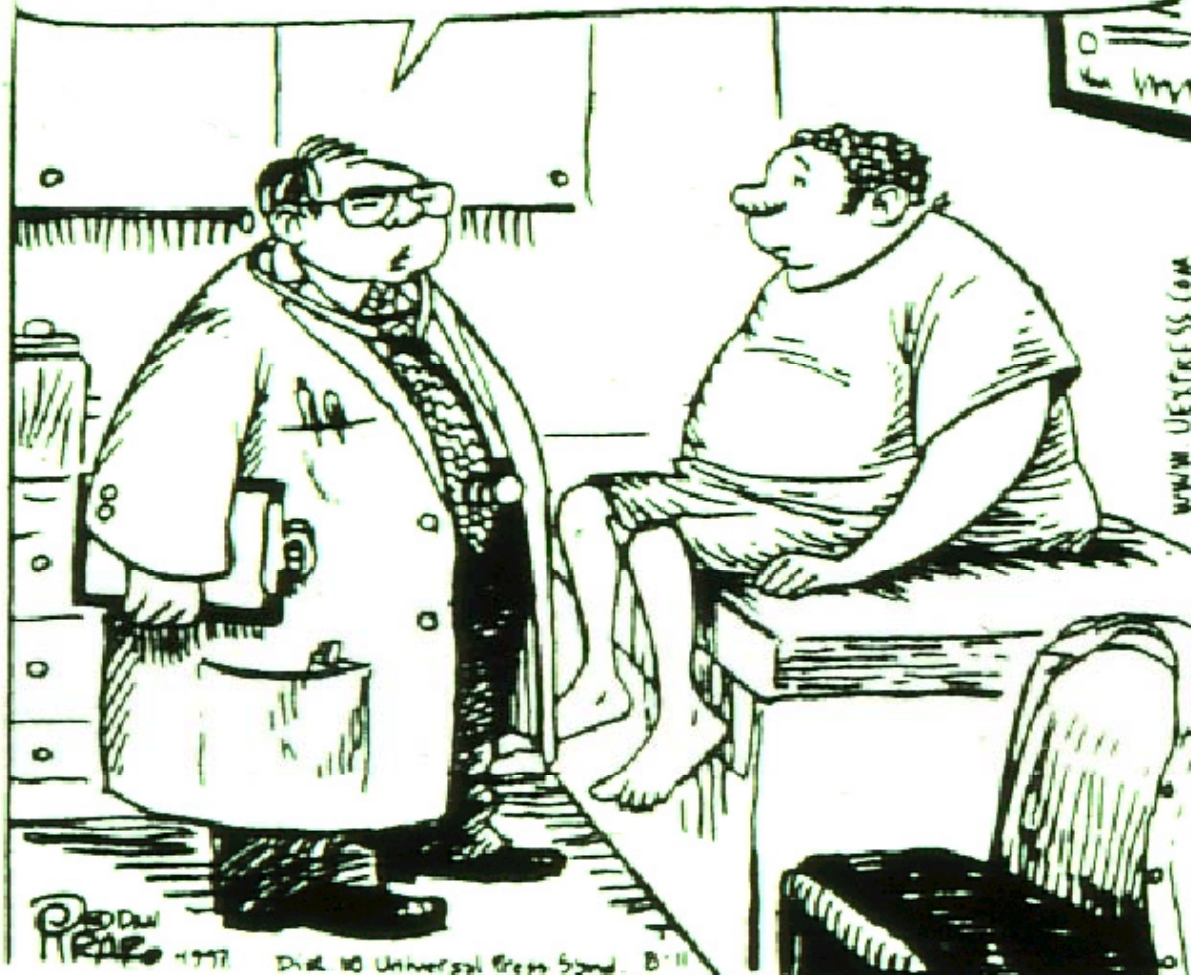
- **A 44 year old, obese, insulin-dependent diabetic male with minimal diving experience made a shore entry alone-the body was found on the surface later that day. He also had a history of depression**
- **The autopsy disclosed dilated cardiomyopathy, LVH, cirrhosis, and sarcoidosis with mild pulmonary involvement**

CASE HISTORY-CVD

- **A 42 year old experienced diver was lobster hunting without a buddy, but in a large group**
- **When he did not return, a search found his dive buoy tied off to a weight-the body was recovered 2 hours later**
- **The decedent had a history of a remote MI, a pacemaker for syncopal episodes, and LVH**
- **Toxicology was positive for propoxyphene and hydrocodone**

BIZARRO / Dan Piraro

I want you to quit smoking & lose forty pounds. Then I want you to come back & tell me how the heck you did it.



WWW.UXPRESS.COM



FATALITY CASE-ST

- **33 year old male certified cave diver making complex mixed gas dive with experienced buddy**
- **Cave dive with max depth 160 feet; after :60 BT, dive aborted due to poor visability**
- **Seizure witnessed by buddy during ascent at 130'**
- **Body recovered several hours later-Medical Examiner signed out case as air embolism**





FATALITY CASE-ST

- **Investigation showed that the decedent inadvertently used 50/50 nitrox at 130 feet likely causing an O2 seizure**
- **ME based his conclusion on minimal findings of gas in the heart and great vessels without corroborating evidence of pulmonary barotrauma or a dive profile that would likely cause an AGE**

History D79-1505

- 17-year old college student
- Rented a boat for scuba diving
- Rough weather, boat anchored at buoy
- Entered water with scuba gear and asked for an orange dive bag
- Failed to re-surface after 30 minutes
- Found 3 days later close to buoy

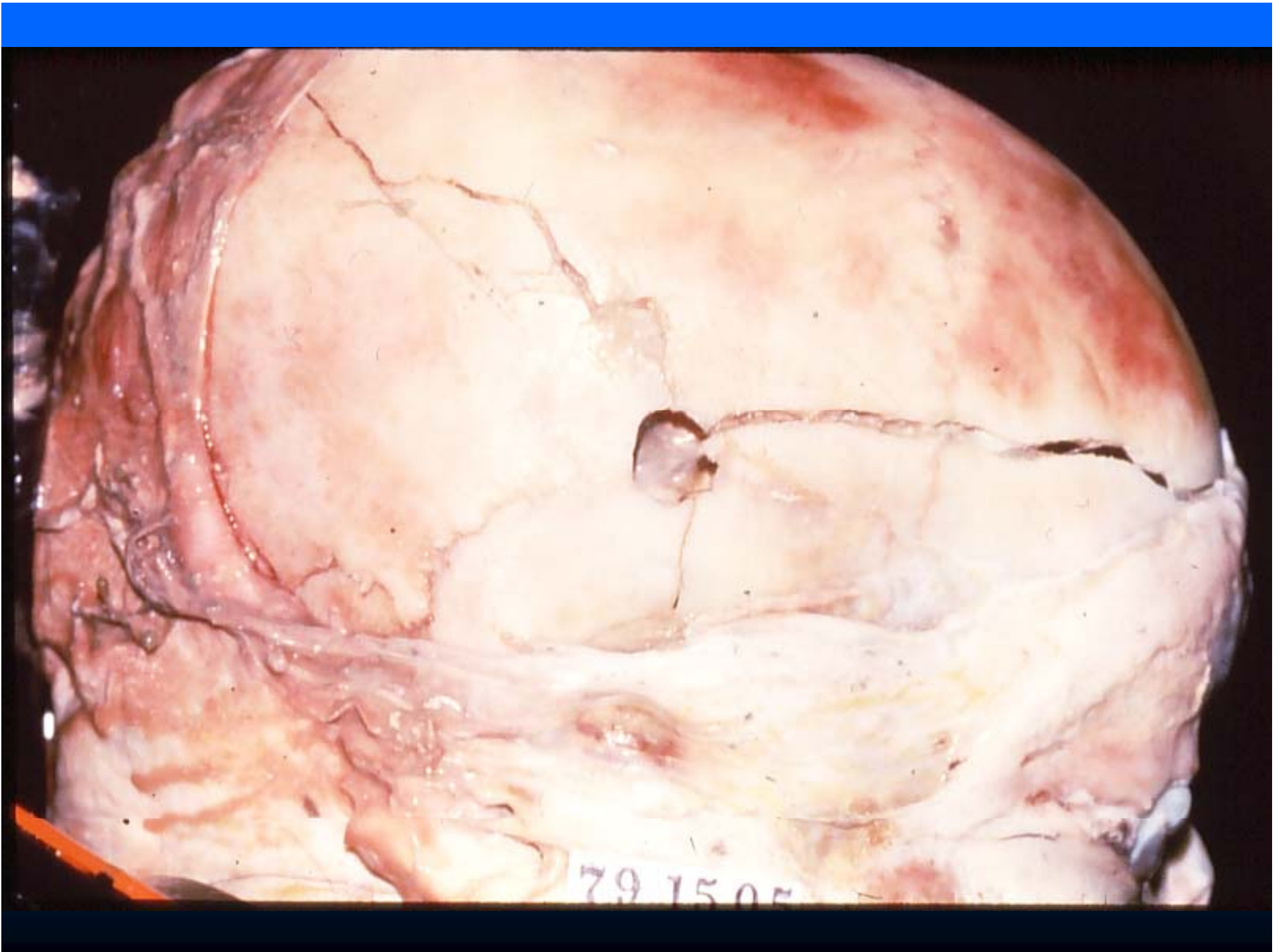




Autopsy-Putrefied Bodies

GOOD LUCK!





DIVE CASE-79-1505

- **During intervening period, the lost diver's family was contacted and it was revealed that he had recently dropped out of college and was depressed**
- **Investigation revealed that the decedent had purchased a handgun several days before making the dive**

Rebreather HK 1

- **72 Y.O. male, Rx for elevated cholesterol**
- **Used MK 5 Rebreather (similar to military MK 15/16)**
- **Planned cave dive in freshwater spring for photography**
- **Entered with group but forgot fins and went back to lodge to retrieve them**

Rebreather HK 2

Dive buddy went to get gear also; HK returned and entered the water before buddy joined him

Witness saw flashing red light on MK 5 but HK disregarded the inquiry

HK was discovered unconscious on the bottom (after a 7 minute bottom time)



A “typical” primary display might look like this, indicating “A” for alarm, “L” for low ppO_2 , “H” for high ppO_2 , and “0” for the correct set-point.

Rebreather HK 3

- **Resuscitation at scene and transferred to hospital, but declared brain dead**
- **Autopsy:**
 - 1000 cc blood in stomach with angiodysplasia and esophagitis
 - Other changes consistent with drowning
- **ME considered signing the case out as a natural death; consultation obtained**

Rebreather HK 4

- **Equipment evaluation revealed that switch had been placed in “external source” position, which would be used in a surface supplied position**
- **HK had a history of skipping some of the tedious pre-dive checks that are mandatory with these types of rigs (software checks, pre-breathing, etc.)**



Case Report-CO

- 42 year old male with 400+ lifetime dives made a dive to 45 FSW with a group of friends (repet)**
- Diver became separated from his buddies; found on the bottom with the regulator out of his mouth; cardiac event presumed, resuscitation attempted**
- Other diver in group with tingling in fingers and mouth, nausea-had to stop and change tanks because of failed O ring**



Autopsy

- **Findings consistent with drowning**
- **LAD with moderate stenosis; LVH**
- **COPD**
- **Toxicology**
 - COHb 32% (IVC blood)**
 - positive for caffeine, nicotine, THC**



Investigation

- **Multiple tanks rented from same location contained elevated CO levels**
- **Decedent's tank for second dive contained 563.5 ppm of CO**
- **First theory was that a truck running near the compressor air intake was the culprit; more thorough investigation pointed to possible faulty compressor**

Recommendations

- If you have any involvement with a diving related death, use your influence to strongly suggest an autopsy be performed
- Offer expertise to the M.E./Coroner
- Assist DAN in collecting information on the case
- Feel free to suggest that the ME/Coroner/ Investigator contact DAN for assistance



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