# 고압산소치료기의 화재안전 및 비상운용

2021.10.21

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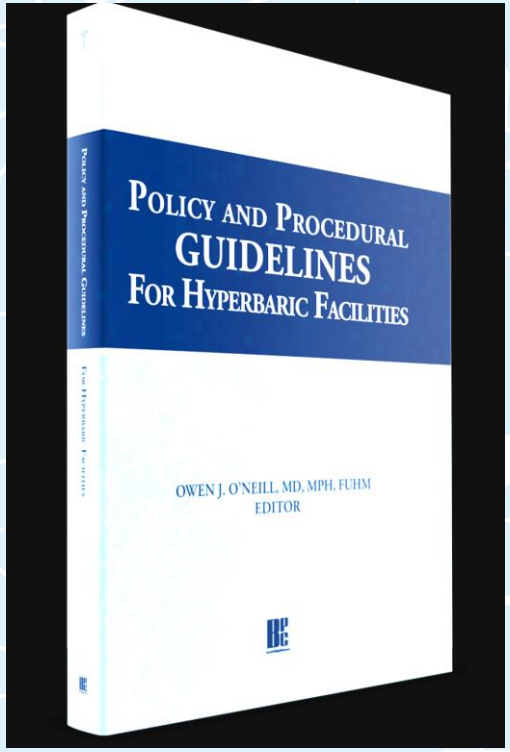



Ⅰ Fire triangle

Ⅱ 챔버 내 복장

Ⅲ 챔버 내 금지물품

Ⅳ Fire Drill

Ⅴ 상황 및 chamber에 따른 지침


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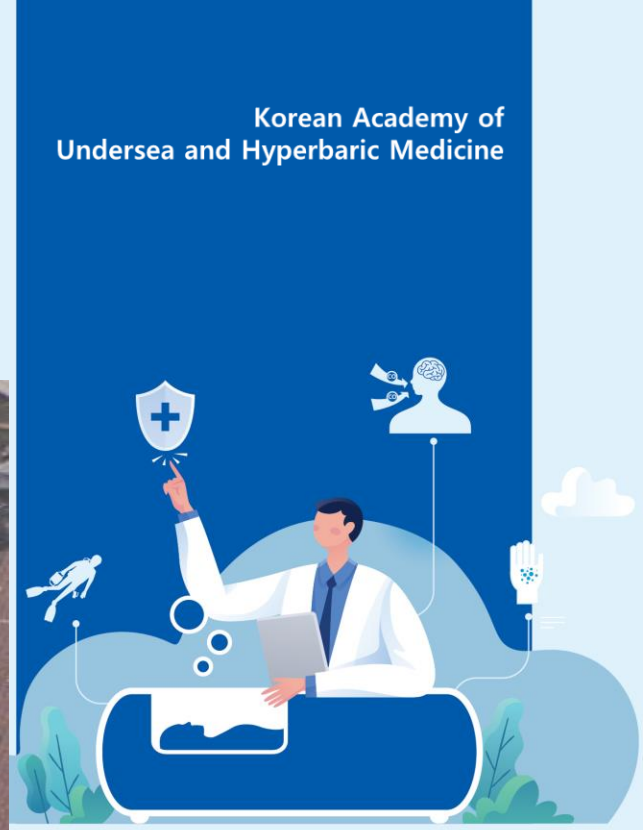
The remains of the high-pressure hyperbaric oxygen chamber, which was destroyed when Liu Hung decided to smoke a cigarette while receiving treatment inside

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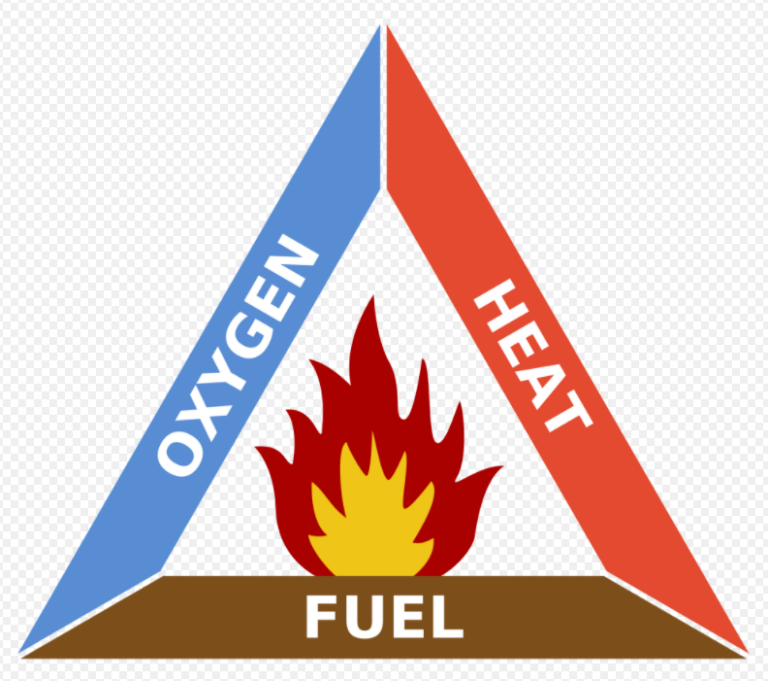
# Ⅰ Fire triangle

➢ **The fire triangle**
- Fuel, Ignition, Oxidizer

➢ **Fuel**
- Any unoxidized material
- Metals, plastic, fabrics, salves, dressings

➢ **Ignition**
- Any energy source
- Electrical arc, friction, thermal ignition

➢ **Oxidizer**
- Air or oxygen



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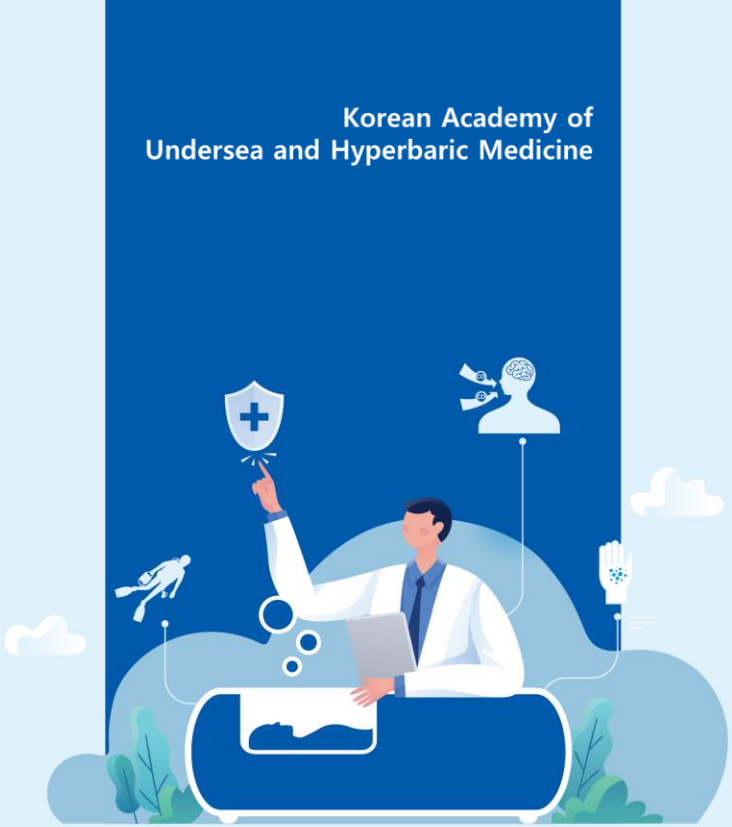
## Ⅱ 챔버 내 복장

➢ 챔버 내에서 일반복 차림은 위험
- 환자에게 정전기 발생 위험이 적은 옷 제공
- 100% 면, 수술복, 가운

➢ 나일론, 폴리에스테르 등 인공소재는 금기
- 정전기 발생 가능

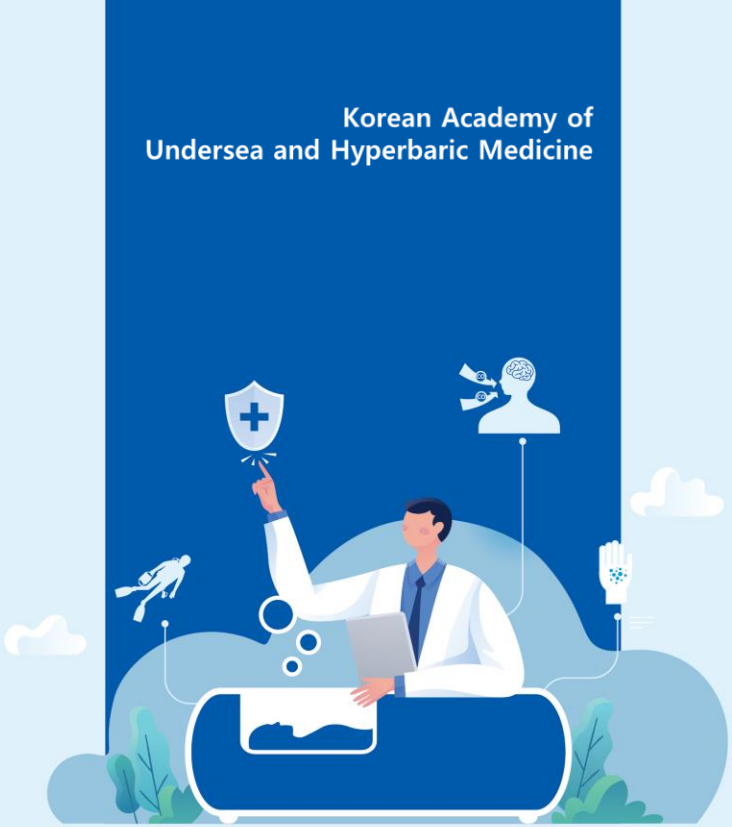


## Ⅲ 챔버 내 금지 물품

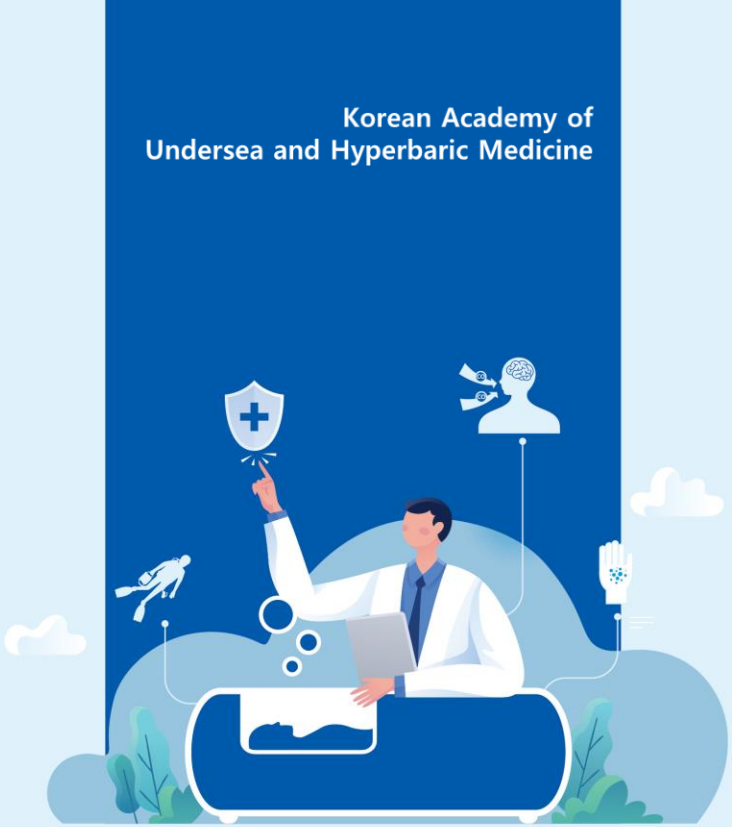
➢ **가연성제품 반입**
- 환자에게 정전기 발생 위험이 적은 옷 제공
- 100% 면, 수술복, 가운

➢ **유기용제 반입**
- 페인트, 섬유 합성 제품

➢ **흡연 및 점화가능 물질 반입**
- 라이터, 전기기구 및 정전기 발생 가능 물질



# Ⅳ Fire drill




## ➢ Chamber operator

- 사용되는 chamber type에 따라 적절한 경우 산소 밸브 차단
- 사람들을 대피시킨다.
- 화재경보를 작동시킨다.
- 필요한 경우 대체 호흡 시스템을 착용 시킨다.

## ➢ Staff member:

- 필요한 경우 소화기를 사용한다.
- 사람들의 대피를 도와준다.

## ➢ Administrative Assistant:

- 119에 연락

## ➢ Department director

- Chamber를 확인하고 각 chamber에 표시를 하여 아무도 chamber 에 남아 있지 않음을 나타낸다.
- 모든 대피자가 모일 수 있는 지역을 지정한다.
- 위의 사항이 완료되는 시간을 기록한다.

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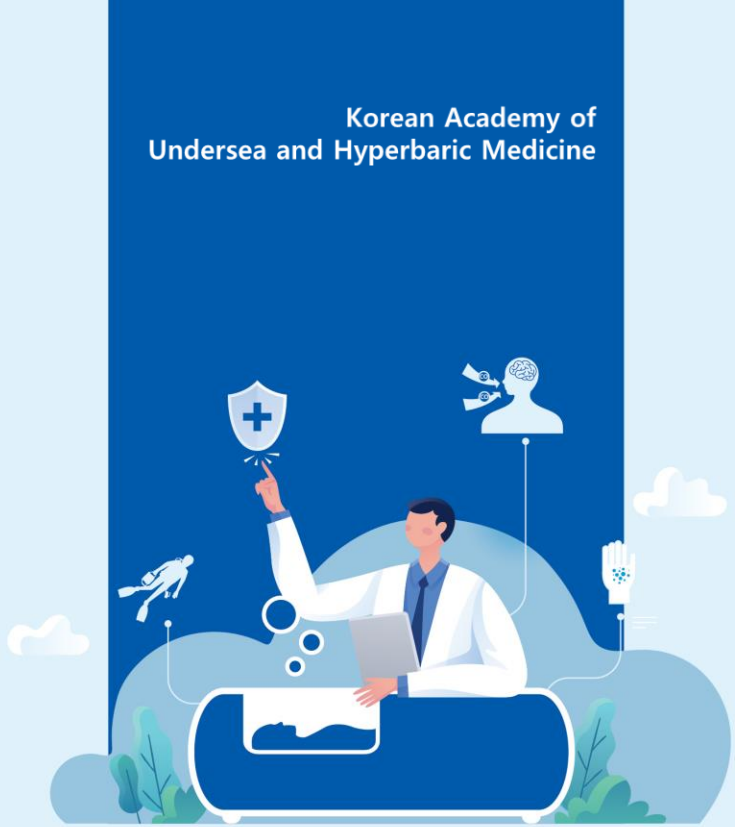
## Ⓥ 상황 및 chamber에 따른 지침
## 1.1 Fire in class B monoplace chamber

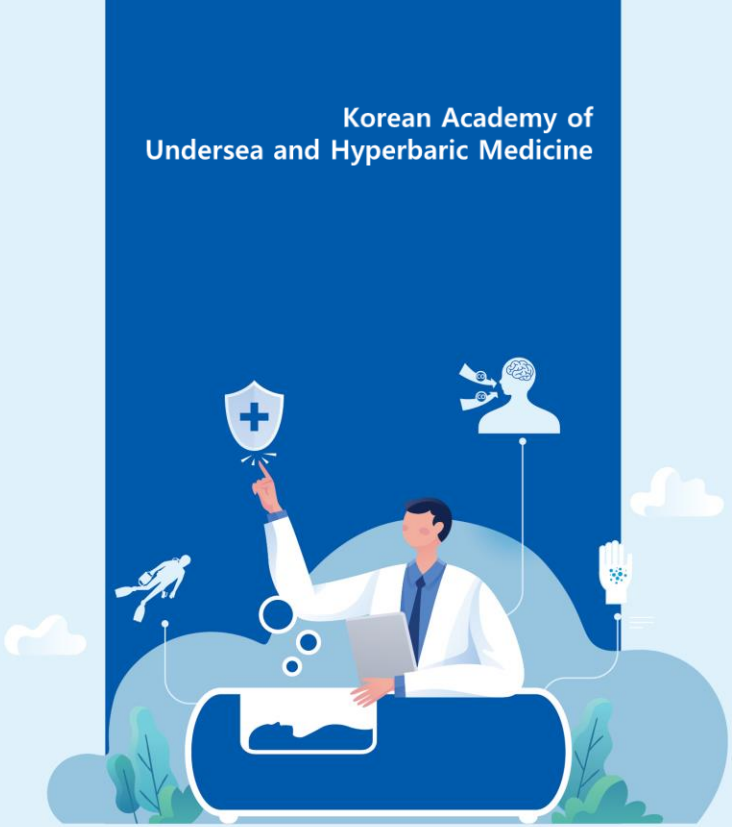
- 챔버의 유형에 따라서 가급적 빨리 산소를 차단하다.
- 즉시 모든 사람들을 대피시킨다.
- 화재경보를 작동시킨다.
- 챔버 끝에서 멀리 떨어진다.



## Ⓥ 상황 및 chamber에 따른 지침
## 1.2 Fire in class A multiplace chamber

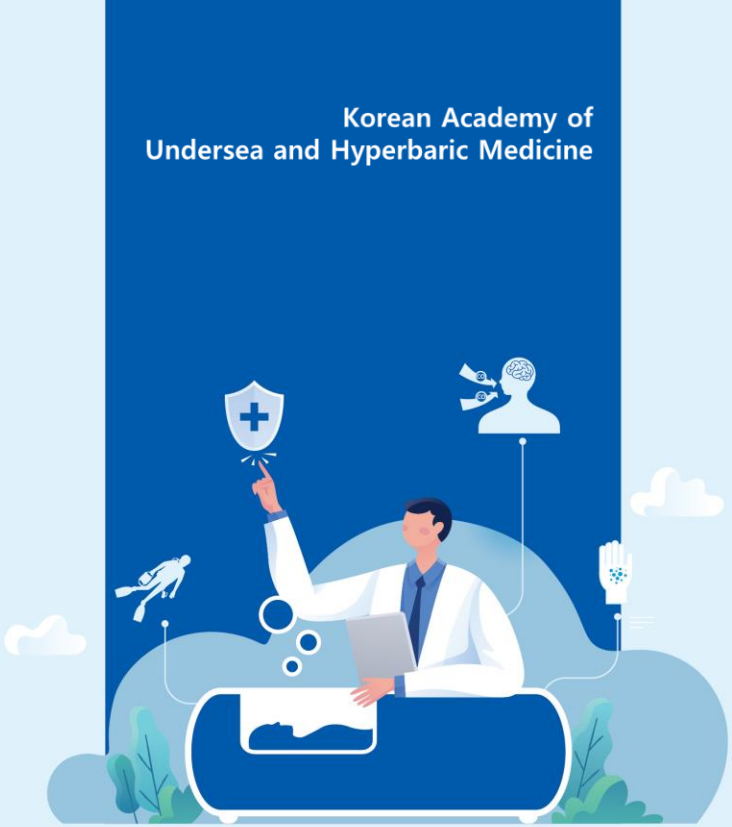
➢ Inside observer
- Chamber operator에게 즉시 알린다.
- built-in breathing system (BIBS) mask를 착용시킨다.
- 모든 환자가 hoods 또는 BIBS masks를 착용했는지 확인한다.
- 휴대용 수도관으로 진압할 수 있는 경우 화재를 진압한다.
- 휴대용 수도관으로 화재 진압이 불가능할 것으로 판단되는 경우 화재 진압 시스템을 작동시킨다.

➢ Chamber operator
- 산소를 중단하고 배관을 공기로 대체한다.
- 근처 팀구성원에게 도움을 요청한다.
- 가능한 팀구성원은 담당 의료진과 고압의학전문의에게 알린다.
- 챔버의 감압을 시작한다.
- 챔버에서 나온 사람들이 모든 구역에서 사람들이 대피하도록 지원한다.



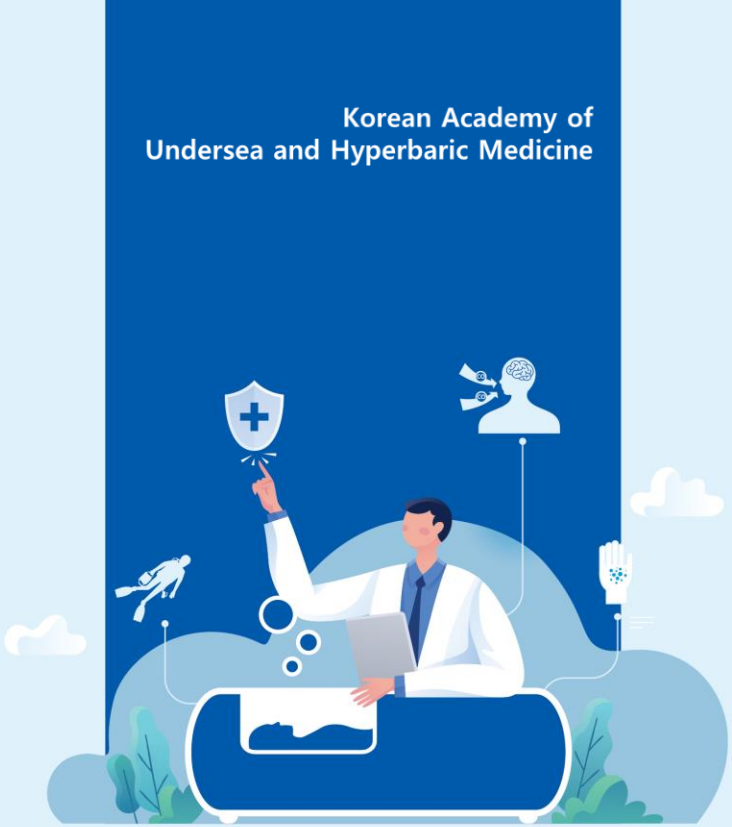
## Ⓥ 상황 및 chamber에 따른 지침
## 1.3 Fire in the Department: class B monoplace chamber

- 챔버 제조사 지침 및 감압 필요성에 따라서 가능한 챔버의 산소밸브를 차단한다.
- 화재경보를 작동한다.
- 가능하다면 화재를 진압한다.
- 환자를 챔버에서 대피시킨다. 챔버 도어를 여는 순간 즉시 산소가 실내로 유출되면서 환자의 의복이 산소 포화 상태가 될 수 있다.



## Ⓥ 상황 및 chamber에 따른 지침
## 1.4 Fire in the Department: class A multiplace chamber

- BIBS gas를 air로 충전한다.
- 화재경보를 작동시킨다.
- 가능하다면 화재를 진압한다.
- 감압 프로토콜을 시작한다.
- 안전할 때 챔버에서 나오도록 한다.



# 고압산소 치료 시 응급상황

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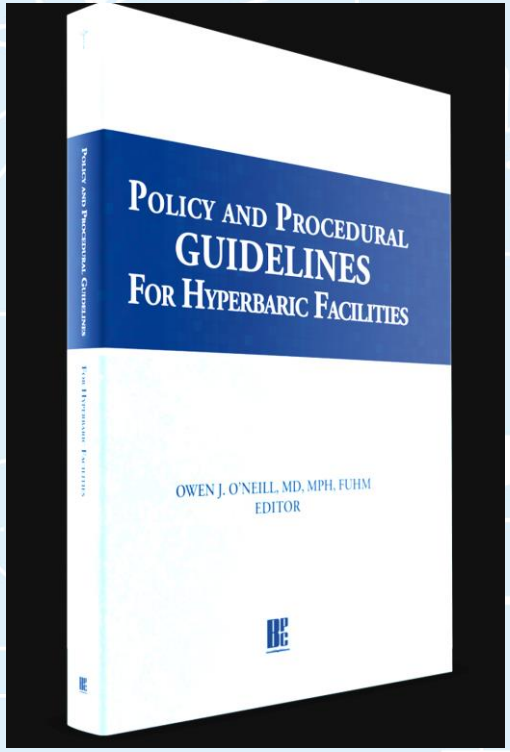



Ⅰ Barotrauma on compression

Ⅱ Claustrophobia/Confinement anxiety

Ⅲ Pneumothorax on ascent

Ⅳ Grand mal seizure

Ⅴ Cardiac/Respiratory arrest in the monoplace chamber


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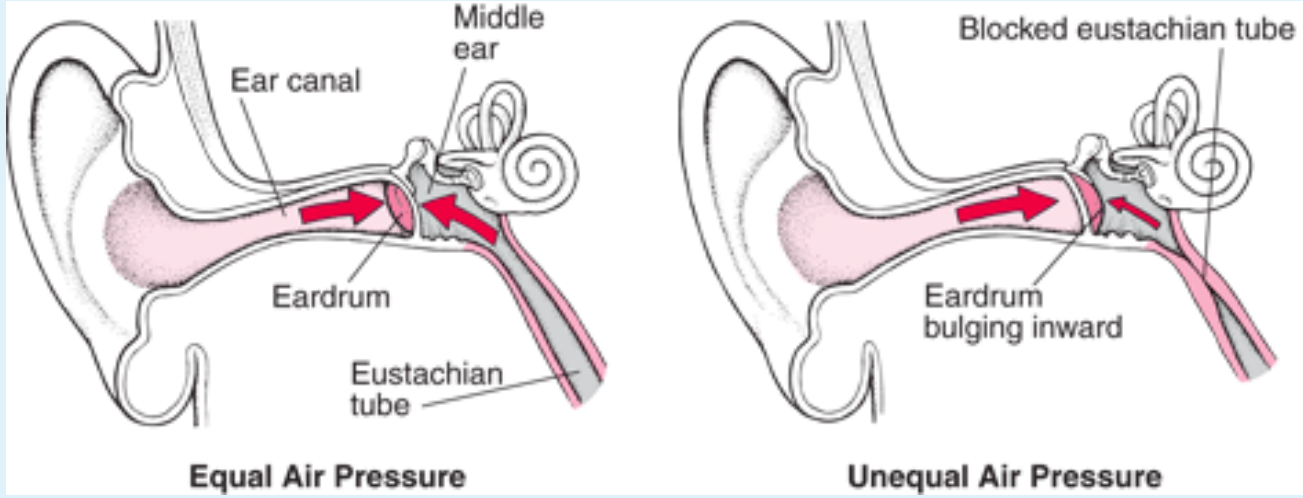
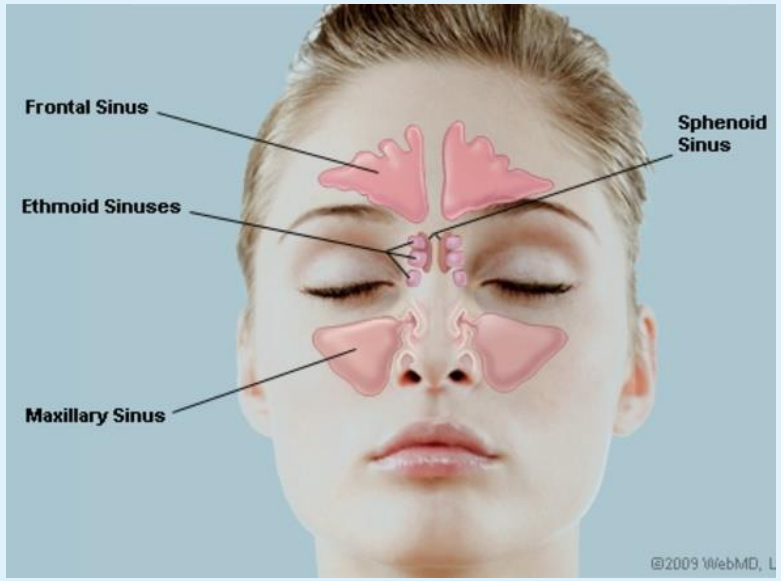
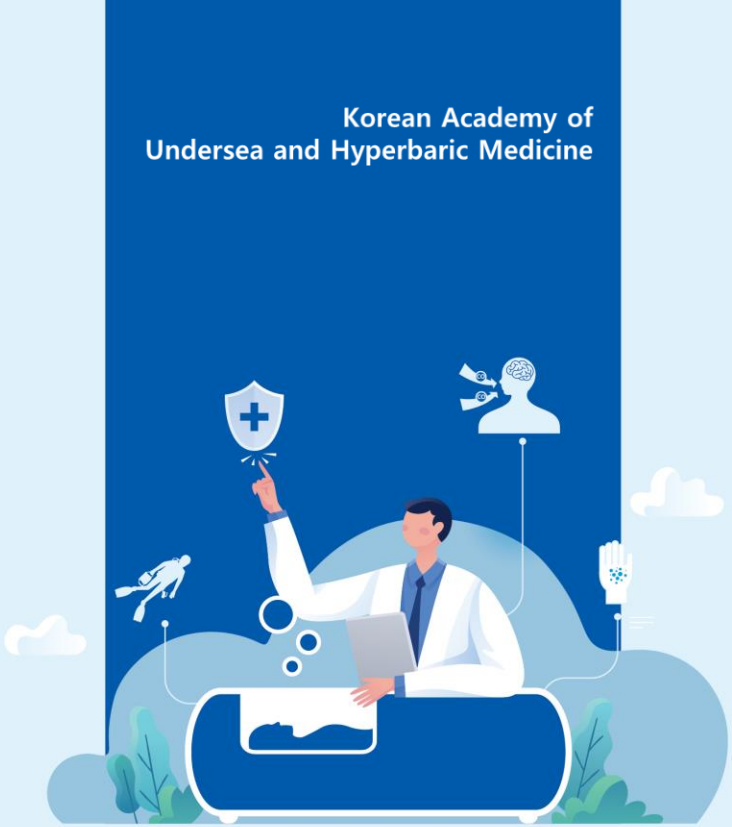
# Ⅰ Barotrauma on compression

## ➢ Ear and Sinus Squeeze

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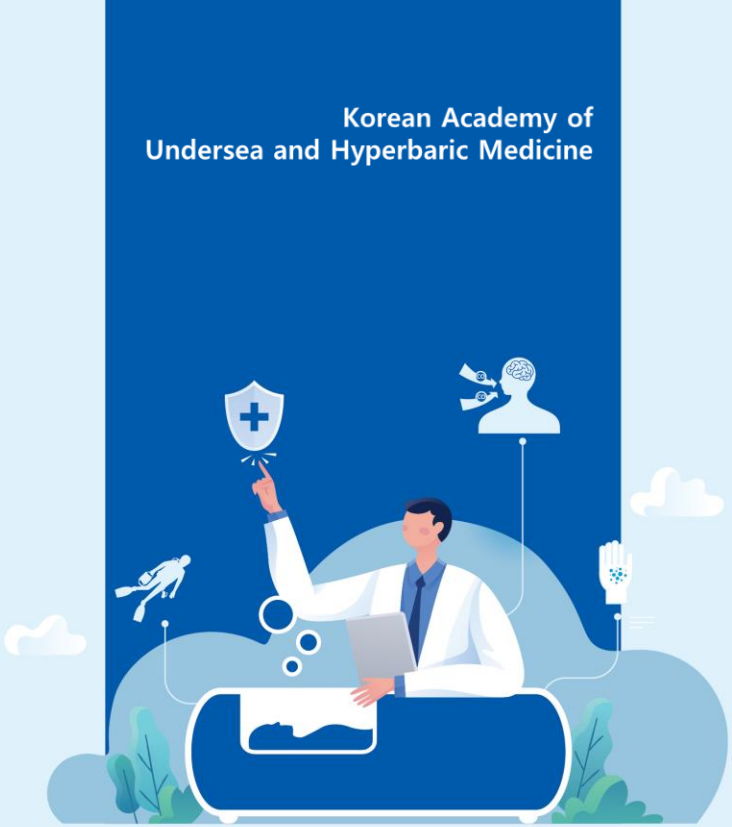
# Ⅰ Barotrauma on compression

## ➢ Ear and Sinus Squeeze

- Risk factors include secondary causes of eustachian tube dysfunction:
  - Current cold or allergy
  - Ear infection
  - Blocked eustachian tube
  - Radiation to head/neck area
  - Trauma to head/neck area
  - Surgery to head/neck area
  - External ear canal packing
  - Endotracheal tube



# Ⅰ Barotrauma on compression

## ➢ Pretreatment Patient Assessment

- Screen patient for history of ear, sinus and tooth problems(dental caries).
- Screen for patient experiences with changes in pressure(flying, diving, mountain roads).
- Assess patient ear with attention to external auditory canal and the tympanic membrane.
- Instruct patient on modified Valsava maneuver and document movement of TM with equalization maneuvers.
- Assess tympanic membrane pre- and post-HBO2 treatment, recording per TEED or O'neil grading systems, noting level, if any, of barotrauma.

# I Barotrauma on compression

## ➢ TEED'S SCORE

**TABLE II [22]**
**MODIFIED TEED'S SCORE GRADING**

| Grade | symptoms and signs |
|---|---|
| 0 | Symptoms with no otological signs |
| 1 | Diffuse redness and retraction of tympanic membrane |
| 2 | Grade 1 plus slight hemorrhage within tympanic membrane |
| 3 | Grade 1 plus gross hemorrhage within tympanic membrane |
| 4 | Dark and slightly bulging tympanic membrane due to free blood in the middle ear; a fluid level might be present |
| 5 | Free hemorrhage into middle ear, with tympanic membrane perforation; blood may be seen outside of or within the external auditory canal |

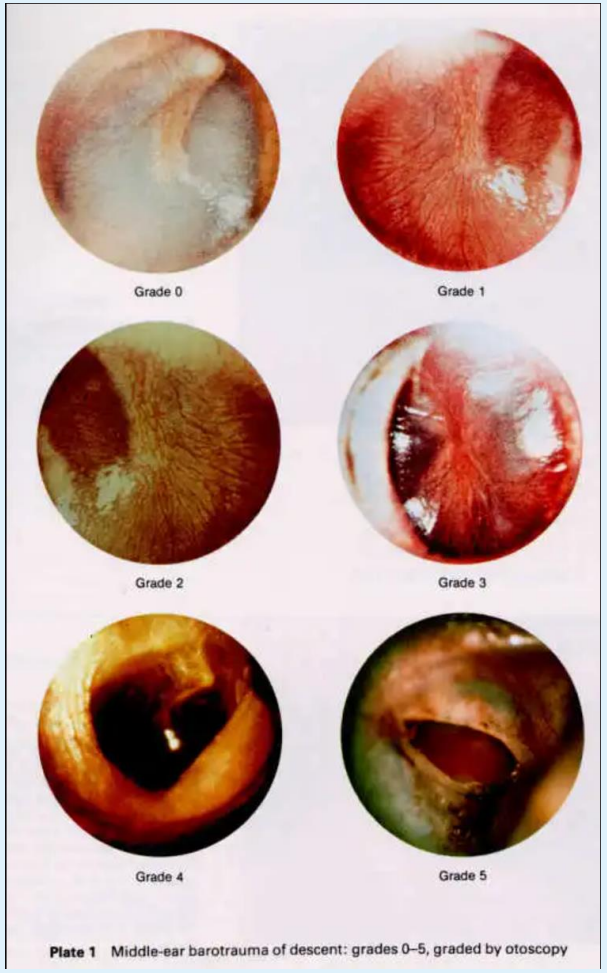
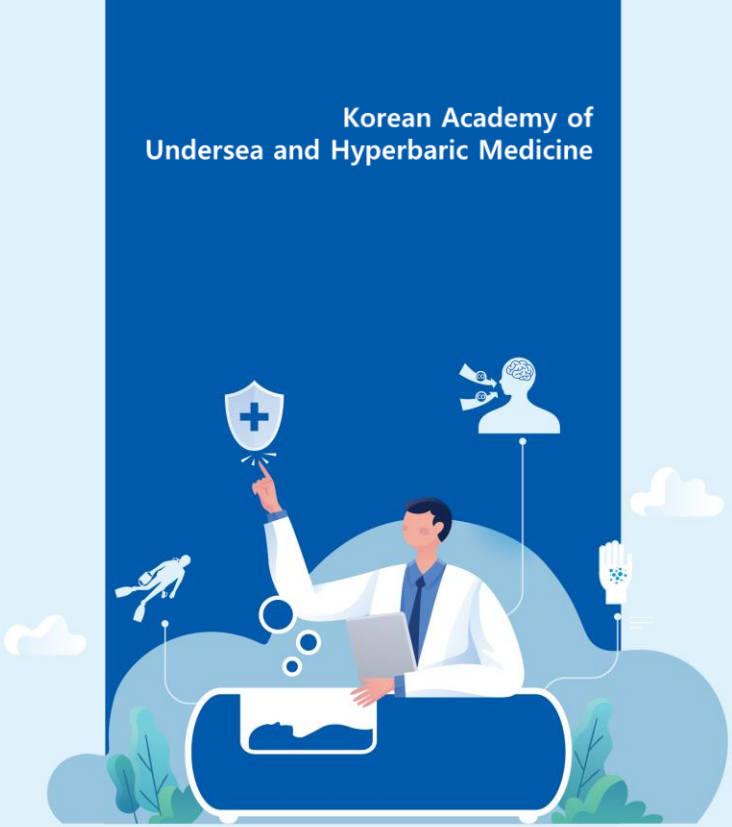


**Plate 1** Middle-ear barotrauma of descent: grades 0–5, graded by otoscopy

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# Ⅰ Barotrauma on compression

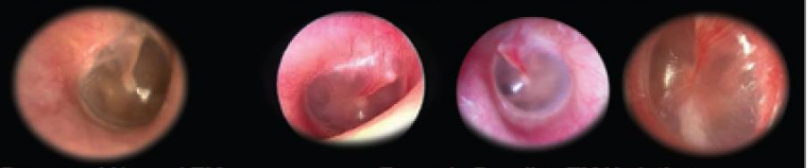
## ➢ O'neil grading systems

### O'Neill Grading System

**Evaluation of the Tympanic Membrane (TM) & Middle Ear Barotrauma (MEB)**

Step 1

Take a baseline photograph of the TM with video documentation of the patient's ability to equalize. Remember, all TM's do not have the same anatomical appearance prior to compression.



Presumed Normal TM — Example Baseline TM Variations

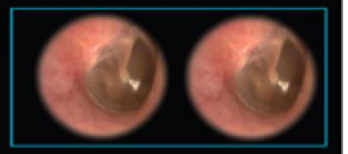
Step 2

Patients requiring stops or experience symptoms related to the middle ear space, require re-evaluation with a comparison TM photograph. Based on that comparison an O'Neill Grade may be properly assigned.

**O'Neill Grades Defined**

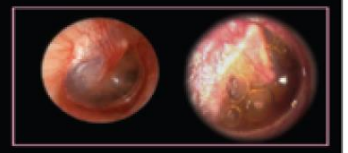
**Grade 0 Eustachian Tube Dysfunction**

- *Baseline* photo depicting anatomical appearance of the TM before pressure
- Symptoms with no anatomical change (no trauma) from *baseline*



**Grade 1 Barotrauma**

- Erythema increased from *baseline*
- Fluid or air trapping (visible bubbles) in the middle ear space



**Grade 2 Barotrauma**

- Any bleeding noted within the tympanic membrane or middle ear space
- Perforation

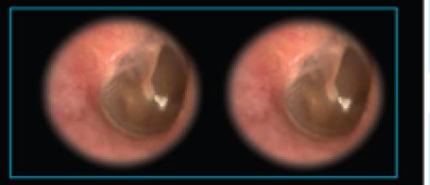
**Table IV.** Evaluation of the tympanic membrane and middle ear barotrauma.

### O'Neill Grading System

**Suggested Intervention/Treatment**

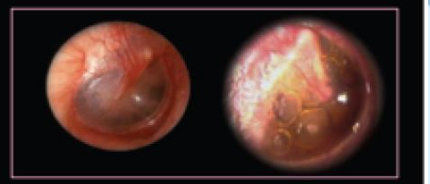
**O'Neill Grade 0**

- Enhanced patient teaching/equalization
- Slow/non-linear compression rate
- Same as above and consider medical therapy



**O'Neill Grade 1**

- Enhanced patient teaching/equalization
- Slow/non-linear compression rate
- Consider medical therapy / myringotomy tubes



**O'Neill Grade 2**

- ENT Referral
- Hold treatments until Tympanic Membrane returns to baseline

**Table V.** Suggested treatment of the different O'Neill grades of injury.

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# Ⅰ Barotrauma on compression

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## ➢ Prior to $HBO_2$ Treatment

- Per physician order, administer decongestant, if needed.
  - Recommend nasal spray or oral decongestant based on primary or secondary ETD
- Elevate the head(semisitting or sitting) during $HBO_2$ therapy to assist in equalization of middle ear
- Ensure chamber operator understands compression should stop when patient is unable to equalize ears due to pressure and should decompress until pain and/or pressure are relieved.
- Patient education of eustachian tube dysfunction and potential barotrauma prior to $HBO_2$ therapy:
  - Methods to equalize pressure in middle ear during compression
  - Patient demonstration of equalization techniques prior to every $HBO_2$ treatment
  - Instruct patient to notify chamber operator immediately when pressure or fullness is felt in ear, sinus or tooth.

## ➢ Changing the rate of compression of the hyperbaric chamber may allow for easier equalization of ear pressure

- Monitor patient closely for any signs of pain or discomfort during compression

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# Ⅰ Barotrauma on compression

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## ➢ Action when patient is experiencing barotrauma during pressurization:

- Stop compression immediately.
- Notify hyperbaric physician (Class B chamber) or the chamber operator(Class A chamber), who will notify the hyperbaric physician.
- Reduce chamber pressure until pain is resolved.
- Have patient perform ear clearing techniques as instructed prior to ascent.
- If unable to clear ears, reduce pressure further.
- If pain had not resolved, abort treatment and notify physician.
- Assess ears when patient treatment is finished, reporting per TEED or O'Neil grading systems, noting level, if any of barotrauma.
- Notify physician of patient ear, sinus or tooth pain during treatment.
- Future patient treatment will be held until evaluated by the hyperbaric physician.
- An ENT consult may be required to examine and/or place PE(pressure equalizer) tube or perform a myringotomy if needed to continue with HBO2 treatments.
- If patient experiences tooth squeeze, refer patient to a dentist for evaluation.
- Patients who suffer barotrauma are not treated in the hyperbaric chamber until cleared by the hyperbaric physician.

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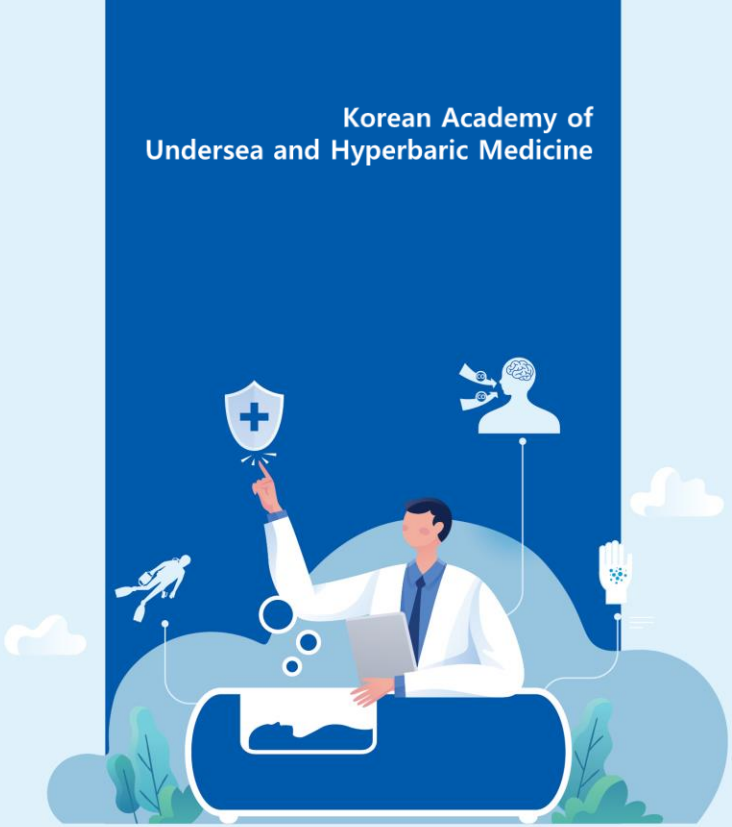
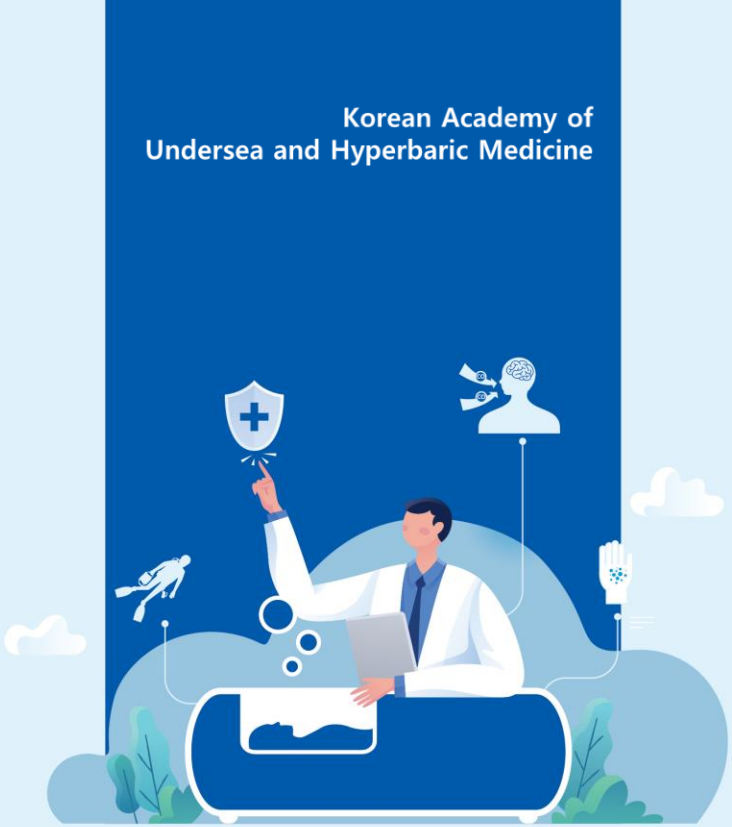
## Ⅱ Claustrophobia/Confinement anxiety

- Talk with and console patient.
- Decompress at a normal rate and remove the patient from the chamber.
- Educate the patient.
- Notify hyperbaric physician as a prescription for antianxiety medication may be of benefit.
- Referral of the patient to a Class A multiplace chamber may be of benefit in those patients refusing treatment in a Class B monoplace chamber.
- Referral to a Class B monoplace chamber may benefit patients refusing to wear a BIBS mask or hood.



# Ⅲ Pneumothorax on ascent




- **Risk factors**
  - Recent invasive procedures(Central lines, etc.)
  - History of spontaneous pneumothorax(can mimic anxiety and cardiac distress)

- **A pneumothorax will get worse upon ascent.**
  - Monitor patient and don't compress or decompress the chamber until ordered to do so by the hyperbaric physician.
  - Preventive measure: Chest auscultation prior to every HBO2 treatment. Chest X-ray indicated for abnormal breath sounds, decreased or absent breath sounds or difficulty breathing.

- **Signs and symptoms of pneumothorax(will see on ascent)**
  - Sudden shortness of breath
  - Sudden chest pain
  - Tracheal shift toward the affected side
  - Asymmetrical chest movement or lack of chest movement on affected side
  - Increase in respiratory distress with decompression and relief upon recompression

## Ⅲ Pneumothorax on ascent

- Action
  - Notify hyperbaric physician immediately
  - HOLD pressure in chamber until physician arrives and a full management team is assembled. The decision to treat a pneumothorax inside the Class A chamber may be considered in extreme circumstances such as with a tension pneumothorax and unstable vital signs. This is a hyperbaric physician decision and will be left to his or her discretion.
  - Hyperbaric physician may choose to lock into the Class A chamber and treat the condition prior to ascent.
  - Have Code/Rapid Response Team available, or
  - Call 911 to have emergent responders available if located off-site of the hospital.
- Per physician order, may elect to recompress slightly to resolve symptoms.
- Prepare for emergent chest tube or needle placement when patient removed form the chamber by having the thoracentesis (chest tube) tray ready. (This will be performed inside Class A chamber prior to decompression.)
- Decompress chamber per hyperbaric physician order, usually taking no more than one minute
- Obtain STAT chest X-ray if time allows.

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# Ⅳ Grand mal seizure

## ➢ Oxygen toxicity - Central Nervous System

- Risk factors include:
  - Prior or current history of seizures
  - Elevated body temperature
  - Current therapeutic use of steroids
  - History of oxygen seizures
  - History of febrile seizures
  - Metabolic acidosis
- Premonitory signs and symptoms during the hyperbaric treatment may include, but are not limited to:
  - V Vision – Visual changes, blurred vision, visual hallucinations
  - E Ears – Auditory hallucinations, ringing in the ears
  - N Nausea – May include emesis
  - T Twitching – Restlessness, numbness, focal twitching (note time, duration and site)
  - I Irritability – Change in personality
  - D Dizziness – Vertigo
  - C Convulsions – Seizure activity
  - C Changes in mentation – Change in affect

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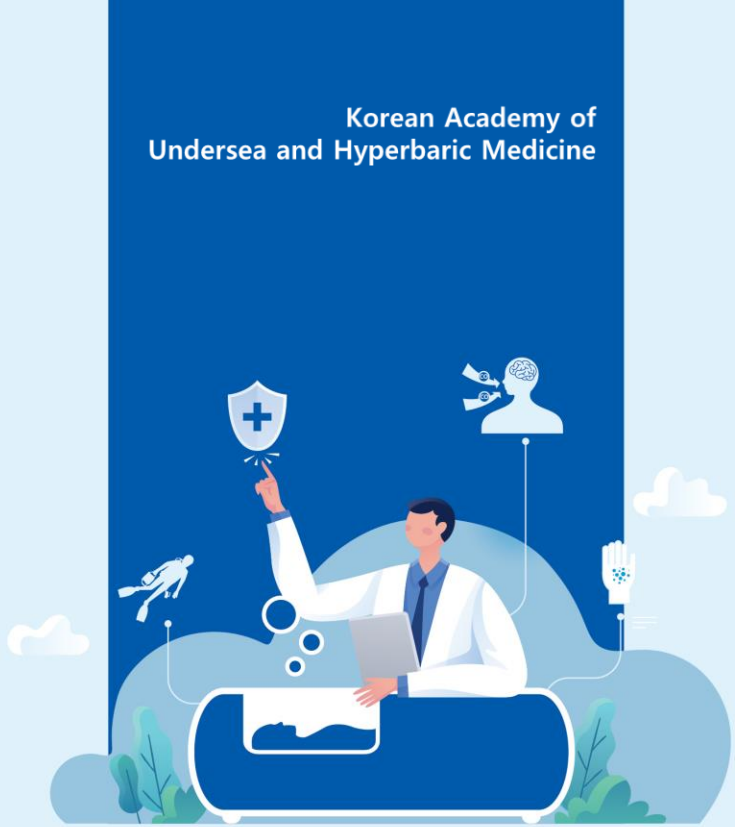
# Ⅳ Grand mal seizure




## ➢ Oxygen toxicity - Central Nervous System

- Actions
  - Change the source of breathing from oxygen to air (Class A and Class B when available).
  - Remove the patient's hood or BIBS mask (Class A).
  - Ask the patient to put on air mask, if possible (Class B).
  - Change chamber oxygen to air, if possible (Class B).
  - Per physician order and if patient is breathing, decrease chamber pressure and abort current hyperbaric treatment (Class B).
  - Remove the patient via the second lock, if available (Class A).
    - Once the seizure had resolved and patient back to baseline, wait 15 minutes and try treating with a lower oxygen dose.
    - If patient seizes a second time during an elective treatment, the hyperbaric physician may choose to abort therapy and search for secondary causes for oxygen toxicity
  - Seizures occurring during prolonged treatment of Type II decompression sickness or air/gas embolism will be treated as directed by the hyperbaric physician (Class A and B)

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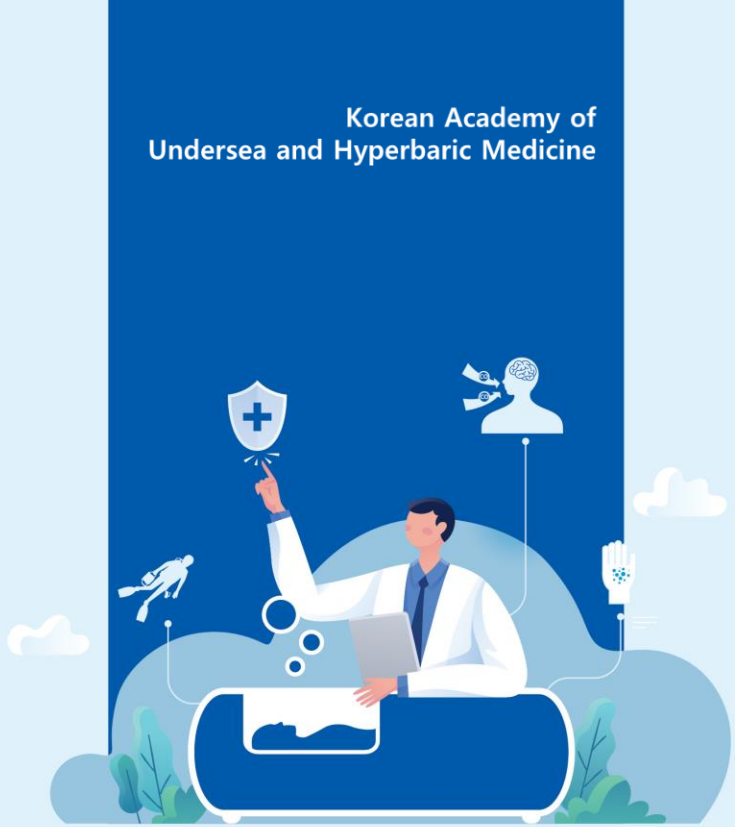
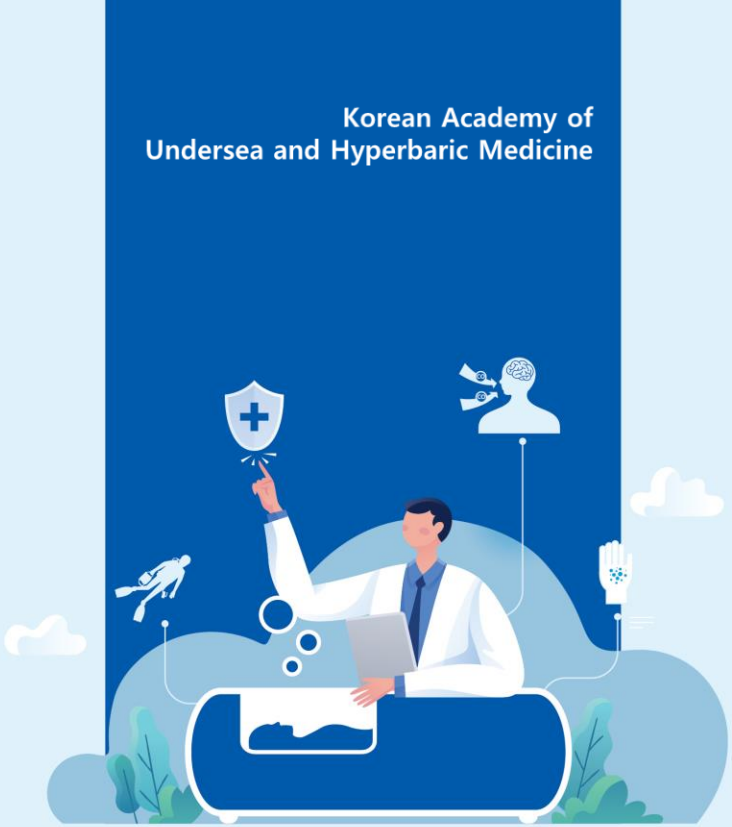
## Ⅳ Grand mal seizure

- ➢ Pulmonary Oxygen Toxicity
- ❖ HBO2 standard treatment tables decrease the potential that patients will experience pulmonary oxygen toxicity
- Risk factors may include, but are not limited to:
  - Intratracheal and bronchial irritation may develop with prolonged hyperbaric exposure.
  - Early changes are generally reversible
  - Prolonged hyperbaric exposure may result in ARDS
  - Symptoms include:
    - Substernal irritation or burning
    - Tightness in the chest
    - Dry cough
    - Dyspnea on exertion
  - Notify the hyperbaric physician if signs and symptoms of pulmonary oxygen toxicity are suspected



## V Cardiac/Respiratory arrest in the monoplace chamber

- Stop compression/decompression.
- Alert physician.
- Remove patient from chamber usually in less than a minute.
- Emergency button may be used.
- Remove patient from chamber – begin CPR.
- Remove patient from chamber side. (NOTE: Oxygen will spill out as chamber door is open.)
- Remove clothing and blankets to decrease chance of spark. (NOTE: It takes the oxygen 30-40 seconds to dissipate from around the patient.)
- Defibrillate after 60 seconds to decrease potential for fire



# 내부의료진의 역할 및 주의사항

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# Contents


Ⅰ Hyperbaric nursing

Ⅱ Inside Attendant


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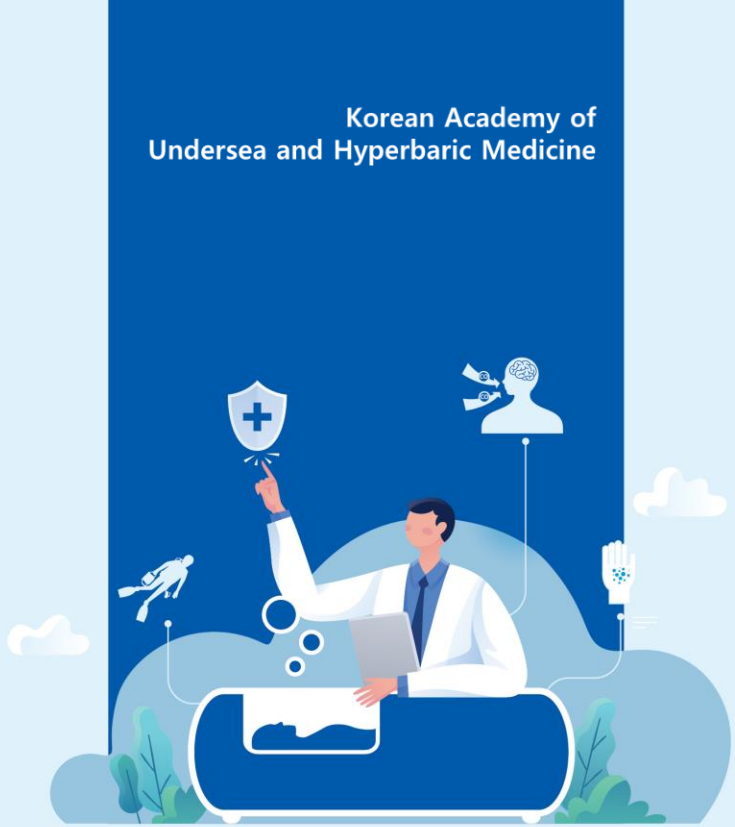
I

# Hyperbaric Nursing
## 1. Definition

➢ **Baromedical Nurses Association**

- Diagnosis and treatment of human responses to actual or potential health problems in the altered environment of the hyperbaric chamber



# Hyperbaric Nursing
## 2. Certification

➢ 미국

- Certified Hyperbaric Registered Nurse(CHRN)
  - 대상: RN
  - 자격:
    - National Board of Diving & Hyperbaric Medical Technology(NBDHMT)에서 인정하는 40시간 교육 수료
    - 2년 이상의 임상 경험 혹은 1년 이상의 중환자 임상 경험
    - 1년 간 480시간의 고압산소치료 관련 경험
    - AHA에서 인정하는 BLS 자격증 수료

# Hyperbaric Nursing
## 3. Baromedical Nurses Association(BNA)

BAROMEDICAL NURSES ASSOCIATION

BNA Home Page | Who We Are | Membership | Corporate Sponsorship | Nursing Guidelines | Education | Job Board | Safety

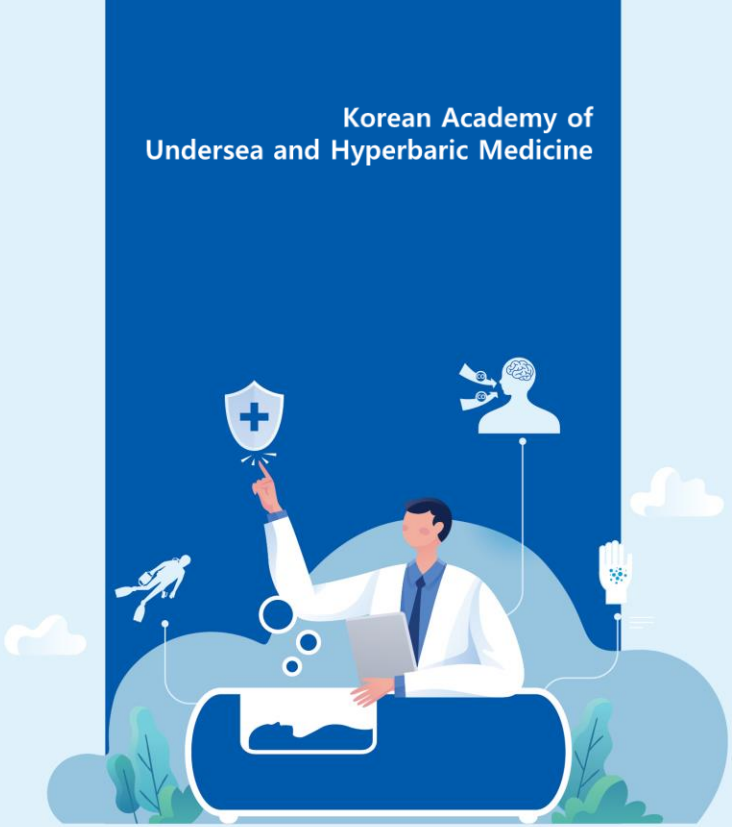
Certified Hyperbaric Nurse (CHRN®) | Chamber Spotlight | Contact Us | Archived Newsletters | Media | Forms | Research | BNA Awards

Members Only Forum | BNA Merchandise | Related Organizations

### BNA Home Page

Supporting Hyperbaric Nurses Worldwide • BAROMEDICAL NURSES BNA Founded in 1985 ASSOCIATION

The BNA was established in June 1985 to provide registered nurses practicing in hyperbaric medicine a formal organization within which nurses can develop a network and provide professional support. This organization has grown and expanded outside the boundaries of the United States. Today, the BNA has members in Europe, Asia, South and Central America and the South Pacific. The BNA remains dedicated to offering educational opportunities, support of nursing research efforts, a presence on Committees and Boards of national organizations, to having a public voice in those issues which impact nursing, and to provide opportunities for networking and information exchange.

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Ⅱ

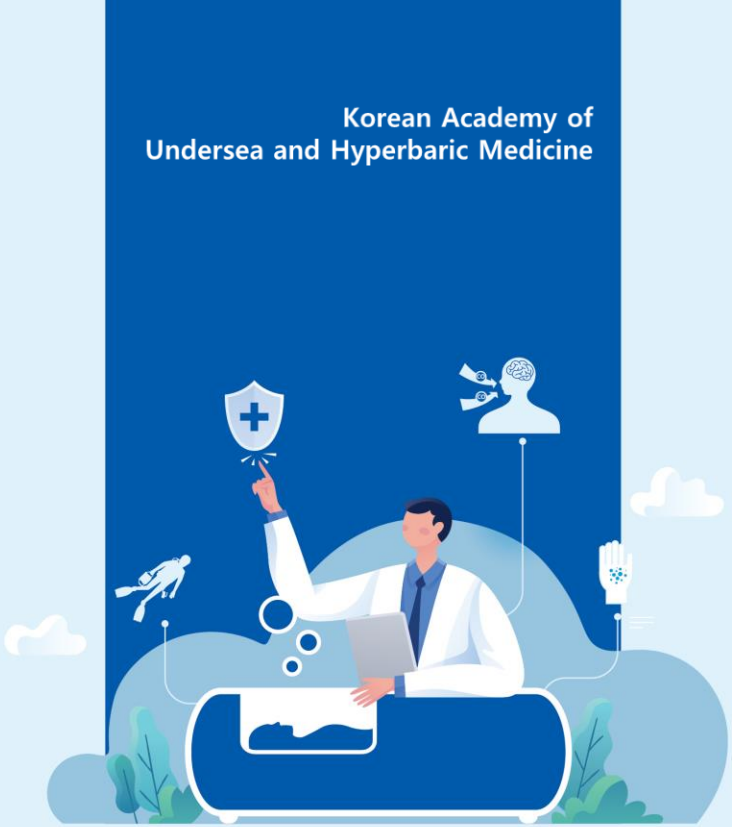
# 1. Inside Attendant

➢ **Elective Inside Attendant**

- 정규 환자
- 고압산소치료에 대한 교육
- 지속적이 환자 모니터링

➢ **Emergency Inside Attendant**

- 응급 환자
- 전문적이 중환자 치료 개입
- 지속적인 환자 모니터링

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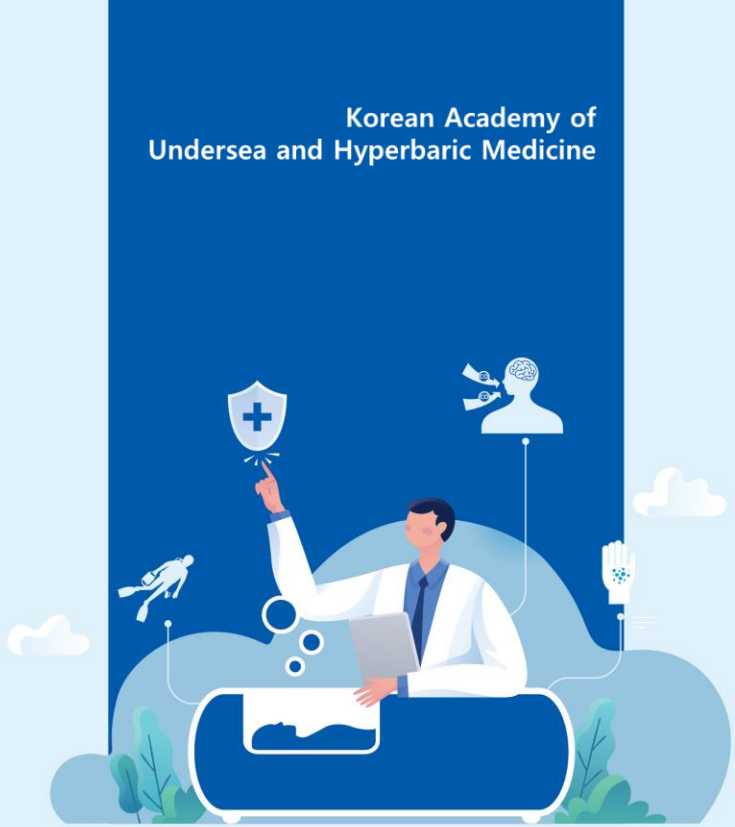
Ⅱ

## 2. Inside Attendant Role




➢ Role

- Patient education
- Communicate with operator
- Prepare HBOT treatment
  - Knowing the patient status
  - Endotracheal intubation tube cuff air to distilled water
  - Full sedation is better than self-ventilation
  - Proper monitoring instrument
  - Over-Prep medications and fluid
  - Anything that you will need during the treatment session
  - Heimlich chest drain valve
    - mechanical one way valve
    - allow air to escape from chest and prevent air from entering chest
- Treatment
  - V/S monitoring
  - Suction
  - Injection

# 3. DCS in Inside attendant

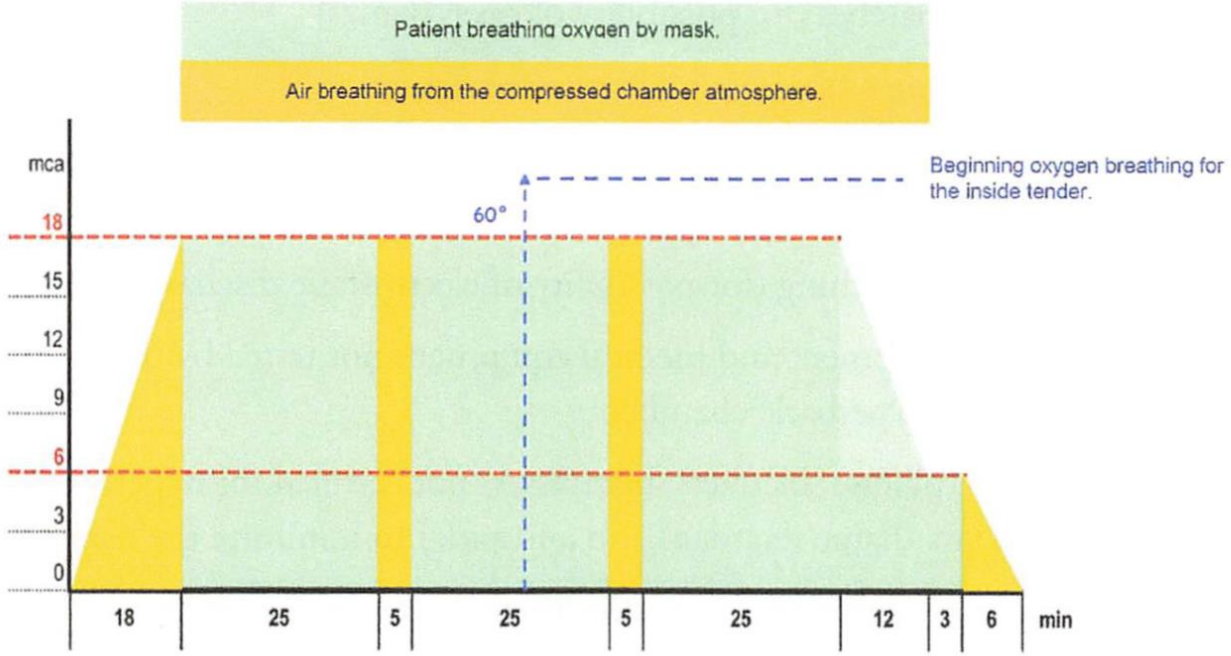
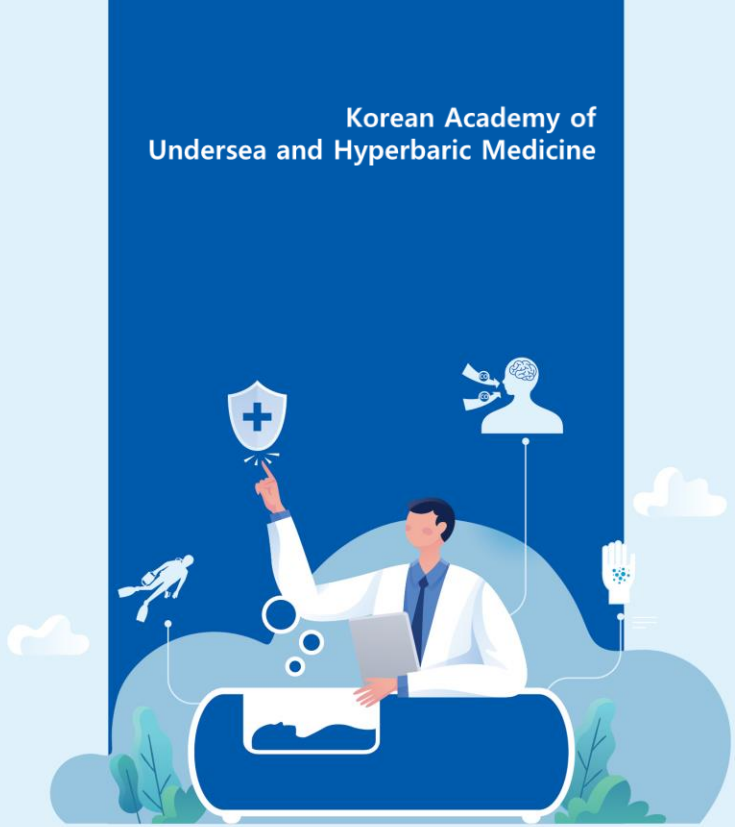



Figure 7. Example of therapy to 2.8 ATA (60 feet). The chamber attendant starts breathing oxygen after 60 minutes. No decompression limits at a given altitude exist according to the U.S. Navy tables.

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# Thank you

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