



# **HYPERBARIC AND UNDERWATER MEDICINE UNIT**

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INTEGRATED ACTIVITY DEPARTMENT of  
PERIOPERATIVE MEDICINE, INTENSIVE CARE AND EMERGENCY

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## **HYPERBARIC AND UNDERWATER MEDICINE UNIT**

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MONDAYS to FRIDAYS**

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Resuscitation ward, 24 hours a day**

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## **A short description and a little history.**

Back in 1973 the Local Health Unit equipped itself with a portable hyperbaric monoplace chamber to be used in case of emergency and which was located in the Resuscitation Unit of Maggiore Hospital.

The real Hyperbaric and Underwater Medicine Unit was set up in 1990 in Cattinara Hospital. The old monoplace chamber had been integrated with a complementary chamber (Galeazzi “duetto” chamber) which allowed the treatment of only one patient at a time but, in case of critical conditions, ensured the presence of an operator inside the chamber.

After a 6-year interruption because of safety reasons, the Unit has been reopened and provided with a new hyperbaric chamber seating 12 people and located in a specially designed 350 sq.m. room. Compressors and air tanks have been placed in a separate room. The facility is also provided with a 50:50 oxygen/nitrogen mixture for the treatment of diver's decompression sickness when an 18-metre compression is not sufficient.

The Unit depends on the Integrated Activity Department of Perioperative Medicine, Intensive Care and Emergency

This Unit can rely on medical staff specialized in Anaesthesia and Resuscitation and/or Hyperbaric and Underwater Medicine, as well as nurses with clinical experience in the Resuscitation ward or the Operating Theatre and possessing the hospital certification required to operate the hyperbaric equipment.

Both planned and emergency treatments are provided to patients affected with all diseases included in the Friuli Venezia Giulia region price list.

The services provided include:

- ◆ Planned and emergency hyperbaric oxygen therapy
- ◆ Medical examinations
- ◆ Medical examinations to grant the certificate of fitness to dive
- ◆ Simple and complex dressing
- ◆ Instrumental controls
- ◆ Follow-up controls

Our Unit aims at achieving the highest therapeutic results, optimizing available resources, ensuring respect for patients and their rights, and in particular:

1. **Equality and fairness** are two fundamental principles applied to all patients
2. **Continuity.** Urgent hyperbaric activity is ensured 24 hours a day, 365 days a year.
3. **Participation.** During the admission visit, the physician shall explain the basic care principles, the safety mechanisms, the objects forbidden in the chamber, and the proper behaviour which is expected. All of which must be understood, agreed upon and undersigned by each patient.
4. **Efficiency and effectiveness** are expected by every patient and required by every referring physician.
5. **Privacy and kindness** – the former is governed by an ad hoc act, the latter by the proper training and the sense of duty that characterizes each member of the staff working in the Unit.



## **THE STRUCTURE AND THE SERVICES PROVIDED**

### **Routine treatment.**

Our Unit ensures the provision of routine and emergency hyperbaric oxygen therapy (HBOT). The treatment of each patient is subject to the successful outcome of the medical examination, which is necessary to exclude absolute contraindications and to solve relative contraindications. Examinations are performed by physicians who have gained a considerable experience in hyperbaric oxygen therapy. During the admission visit, the physician shall explain to the

patient what is hyperbaric oxygen therapy, how it works, what is its purpose and what behaviour is required during treatment. Moreover, patients are recommended to read this brochure with the utmost care and to strictly follow the instructions provided therein. The members of the staff are ready to provide any information to ensure the whole treatment is fully understood and to obtain the patient's full cooperation during therapy.

The whole activity carried out by the Hyperbaric Oxygen Therapy Unit is in keeping with the internal and national “Reference guidelines for treatment”, as well as with the reference guidelines of the Friuli Venezia Giulia region and of ISPESL (Institute for Prevention and Safety at work).



## **Urgent treatment.**

Hyperbaric Oxygen Therapy has an important role in the treatment of some so-called “URGENT” diseases: decompression sickness, carbon monoxide poisoning, mixed soft-tissue infections and acute traumatic ischaemia. For each disease, our Hyperbaric Oxygen Therapy Unit has drawn up the guidelines for treatment, on the basis of national and international literature and reflecting the experience of the hyperbaric centre. According to the physician expert in Hyperbaric Oxygen Therapy, significant variations can be adopted to meet the specific needs of each patient.

Apart from urgent diagnostic-therapeutic interventions, our Unit carries out the first clinical, instrumental and laboratory diagnostic tests, as well as the interventions necessary to stabilize acute patients who require hyperbaric oxygen treatment. Should it be necessary, the patient is admitted to the Resuscitation Centre.

## **Admission**

The referring ward (in the Municipality, in the Region or outside the Region) or the Emergency Department calls the HBOT physician to define the procedure and timing of treatment. The patient is referred to the Hyperbaric Centre for a collective assessment by the hyperbaric physician and the specialists concerned (orthopaedic surgeon, plastic surgeon, urologist, general surgeon, etc). Should treatment be necessary, the patient is admitted to the most suitable ward. If no further consultancy is needed, the referring ward shall get



in touch with one of Cattinara Hospital wards, for the patient to be transferred and admitted. The referring ward of the Region shall send a regular prescription and authorization to treatment.

The ward where the patient is staying is responsible for carrying the patient to the HBOT Unit at the time scheduled for therapy.

The Service guarantees the prompt availability of the hyperbaric chamber, two expert nurses and one expert physician 24 hours a day, 365 days a year.

### **Hyperbaric treatment provided**

The Unit provides treatment to patients affected with all diseases included in the Friuli Venezia Giulia region price list:

1. Decompression sickness
2. Arterial gas embolism
3. Carbon monoxide poisoning
4. Clostridial gas gangrene
5. Mixed soft-tissue infections
6. Osteoradionecrosis (except for other osteonecroses and the radiation-induced soft-tissue lesions)
7. Diabetic lesions in the lower limbs

At present, the new national guidelines issued in the joint document drawn up by SIAARTI (Italian Society of Anaesthesia, Analgesia, Resuscitation and Intensive Care), SIMSI (Italian Society of Underwater and Hyperbaric Medicine) and ANCIP (National

Association of Private Hyperbaric Centres) provide for the following treatments:

1. Decompression sickness
2. (Iatrogenic or barotraumatic) arterial gas embolism
3. Clostridial gas gangrene
4. Acute and chronic soft-tissue infections of various etiology
5. Gangrene and skin ulcers in diabetic patients
6. Carbon monoxide poisoning
7. Crush lesions and compartment syndrome
8. Risk fractures
9. Skin grafts and risk flaps
10. Chronic refractory osteomyelitis
11. Skin ulcers induced by arterial, venous and post-traumatic insufficiency
12. Post-actinic tissue lesions
13. Sudden hearing loss
14. Aseptic osteonecrosis
15. Retinitis pigmentosa
16. Menière's syndrome
17. Algodystrophic syndrome
18. Parodontopathy

The treatment in affiliation regime with the National Health Service requires a prescription drawn up on the regional prescription pad by a specialist working in a hospital, in a polyclinic or in a private NHS-affiliated structure, or even by a general practitioner.

The Unit writes the patient's name in a special booking register and informs him/her about the date of the medical examination for the certificate of fitness. The person concerned may indicate in advance the need to change his/her appointment.

The appointment schedule is planned at the beginning of the cycle in agreement with the ward (in case of inpatients) or directly with the patient if the latter is not hospitalized. The patient or the ward may require to change the appointments only under special circumstances to be assessed individually.



## RESPECT FOR QUALITY STANDARDS

The Hyperbaric Oxygen Therapy Unit takes the utmost care over the quality of the service it provides to patients daily: the staff professionalism, hygiene, efficiency and safety of the working environment and of the equipment, confidential management of personal data, transparent relations with patients and referring physicians, appropriate information to medical colleagues who do not possess the necessary experience in hyperbaric oxygen therapy, respect for the patients' dignity.

At the end of the therapeutic cycle, the end-of-the-cycle visit takes place, and the HBOT physician's report follows.

- ◆ Maximum waiting time to a visit: four days (except for unexpected events).
- ◆ Maximum waiting time to therapy: four days (except for unexpected events or emergencies).
- ◆ Duration of a session: 120 minutes.
- ◆ During the session, according to the patient's conditions, a physician or a nurse may be present inside the Hyperbaric Chamber.
- ◆ Average number of sessions per cycle: 32.
- ◆ Regular maintenance of the machinery and periodical maintenance of electromedical equipment, according to schedule.
- ◆ Cleansing and disinfecting of the HBOT area according to in-house protocols.

- ◆ Compliance with the Regional and National guidelines.



## **ACCESS TO THE HYPERBARIC CHAMBER - REQUIREMENTS**

### **Rules and indications for patients who undergo Hyperbaric Oxygen Therapy**

## **HYPERBARIC OXYGEN THERAPY**

### **What is it**

This therapy administers pure oxygen in a closed circuit through masks, endotracheal tubes or helmets. The therapy takes place in special environments, the Hyperbaric Chambers, where pressure is greater than atmospheric pressure because of compressed air pressurization.

## **How it works**

In air breathing, at atmospheric pressure, 98.5% of oxygen is carried by erythrocytes containing the haemoglobin which is bound to oxygen. For oxygen to reach tissues, intact blood vessels (veins and arteries) are necessary.

The exposure to high-pressure oxygen increases the amount of oxygen dissolved in plasma and thereby transported (which is not bound to haemoglobin), and available for tissue breathing.

The quantity of oxygen transported in this way to tissues can be even 15 times greater than normal when pressure ranges between 2 and 3 ATA (ATA is the unit of measurement for gas pressure. 1 ATA = 1 Absolute atmosphere. The hyperbaric chamber pressure gauges give seawater metre values: 10 metres of water correspond to about 1 ATA pressure. Therefore, a 15 metre depth corresponds to 2.5 ATA, a value resulting from the sum of 1 ATA atmospheric pressure and of the pressure achieved, i.e. 1.5 ATA); all of which fully meets the tissue requirements.

## **What is its purpose**

The increase in the oxygen physically dissolved in plasma implies the opportunity to restore oxygenation in those areas where blood vessels are deficient or damaged. Therefore, in hypoxic or hypoperfused areas, oxygen-dependent tissue functions are restored.

Apart from these effects, hyperbaric oxygen plays a direct and indirect antibacterial role, causes vasoconstriction reducing the post-

traumatic or post-surgical oedema and stimulates the vascular neoformation.

### **What diseases is it used for**

Morbid conditions characterized by a local imbalance between delivery, requirement and use capacity of oxygen: acute and chronic vascular insufficiency, bone diseases, acute and chronic infections of the bone and of the soft tissues.

### **Associated antioxidant therapy**

Given the remarkable quantity of breathed oxygen, patients who undergo Hyperbaric Oxygen Therapy are recommended to take antioxidant drugs such as thioctic acid during the whole therapy cycle. Possible alternatives: vitamin C, vitamin E and acetylcysteine.

## **DESCRIPTION OF THE HYPERBARIC CHAMBER**

The hyperbaric chamber is a metal cylinder divided into two compartments which can accommodate several patients and the physician, or the nurse, at one time.

The larger compartment, called “treatment chamber”, is equipped with individual seats (seats may be uncomfortable, but at present the use of stuffing is not allowed in Italy, for safety reasons) and with oxygen breathing circuits in keeping with the patient’s requirements.

The smaller compartment, known as “transfer chamber”, is also equipped with two individual seats and breathing circuits, and it is used to let the staff or patients go in and out of the chamber, while the other patients carry on with their therapy.

The hyperbaric chamber is regulated through a control panel. The technical-health specialized staff is responsible for the functioning and monitoring of the equipment, by means of special electronic control and audio-visual instruments that make it possible to communicate with the chamber.

In the hyperbaric chamber pressure is increased, in comparison with external pressure, by the inflow of compressed air. The patient perceives this difference in pressure only because he/she must compensate at eardrum level.

The hyperbaric chamber is equipped with the necessary control and safety equipment, which is fully efficient and periodically controlled, in order to ensure the highest safety during hyperbaric treatment. In case of necessity, the staff can quickly go in and out of the chamber during therapy. Patients who require the interruption of the session (because they are feeling ill or because of earache, etc.) can be taken out of the chamber at any time in a just a few minutes.



## GETTING READY FOR THE HYPERBARIC SESSION



### The following objects can be taken inside the chamber:

- ◆ Dental prostheses of any kind
- ◆ Cardiac pacemakers
- ◆ Central venous catheters
- ◆ Zips, belts, buttons, golden items
- ◆ Sight spectacles
- ◆ A pencil, a book or a magazine (dailies are not allowed)

### The following clothes may be used

Patients must wear **cotton clothes** because they do not produce any electrostatic charge.

Before going in, the patient shall wear fireproof overshoes and gown provided by the Unit.





### Forbidden items

For safety reasons, the following items cannot be taken into the hyperbaric chamber:

ELECTRONIC DIARY	BATTERY TOYS	ELECTRONIC EQUIPMENT
HEARING AIDS CONTACT LENSES	SPARK-EMITTING TOYS	AIR TIGHT CONTAINERS
MOBILITY AIDS (CRUTCHES, etc.)	BATTERY EQUIPMENT	FOUNTAIN-PENS
ALCOHOLIC SUBSTANCES	WARMERS	MARKERS
FLAMMABLE LIQUIDS	CALCULATORS	WEAPONS
FLASHLIGHTS	RADIOS	METALLIC OBJECTS
CIGARS	MOBILE PHONES	KEYS
MATCHES	LIGHTERS	CIGARETTES
PIPES	SOURCES OF FLAMES	WATCHES

The hyperbaric physician shall assess whether any implanted medical equipment (neurostimulators, cardiostimulators, pneumatic prostheses) can bear pressure variations.

### **Forbidden clothes**

For safety reasons, the following clothes cannot be taken into the hyperbaric chamber:

JACKETS	GREASY CLOTHES	DIRTY CLOTHES
BULKY CLOTHES	ACRYLIC AND PILE FABRIC CLOTHES	COATS

### **Cosmetics**

No cosmetics can be taken into the hyperbaric chamber:

FOUNDATION	FRAGRANCE	BRILLIANTINE
HAIR SPRAY	CREAM	GEL
AFTERSHAVE	DETERGENT	FATTY SUBSTANCES

Fatty substances next to sources of flame or sparks (electric equipment or lighters) can start a fire, because as pressure increases

(and therefore the amount of oxygen increases) in a confined environment the risk of secondary combustion rises as well.

Other objects which are not intrinsically dangerous can break or suffer damage because of pressure increase.

### **Contact lenses**

Patients wearing semi-rigid or soft contact lenses must replace them with spectacles.

### **Personal hygiene**

With respect for other patients, and considering the confined environment where therapy takes place, a proper and effective personal hygiene is required.

## **HOW IS THE THERAPY CARRIED OUT**

### **Medical examination**

Access to therapy is preceded by a medical examination by the physicians of the Hyperbaric Centre, who assess the patient's clinical conditions and exclude absolute or relative contraindications which make the Hyperbaric Therapy inadvisable. Patients are informed about the way the therapy is carried out.

If the physicians authorize therapy, the secretary schedules the sessions, follow-up visits and dressings.

**N.B: FERTILE FEMALE PATIENTS MUST BE ABSOLUTELY  
SURE NOT TO BE PREGNANT.**

**Arrival at the centre and preparation**

Patients must arrive at least 10 minutes before the beginning of the session in order

- ◆ to leave their personal belongings in the lockers and to take off all clothes and items which cannot be taken into the hyperbaric chamber
- ◆ to wear the clothes provided by the Unit, including the fireproof gown and overshoes.

In case of scheduled clinical assessment or dressing, patients are required to keep to the timetable provided by the secretary.

Patients are also asked to communicate in advance if they cannot keep their appointment. Since HBOT is a group therapy, the maximum punctuality is expected.

**Dressing**

Patients are required to inform the staff of any changes in their dressing, to prevent entering the chamber with unsuitable dressing.

**Diabetic patients**

Diabetic patients must eat before therapy to prevent any hypoglycaemic crisis.

### **In case of changes in the clinical picture**

Patients must inform the physicians of the centre about the appearance of any symptoms during the session. Moreover, the occurrence of any illness between sessions (cold, cough, flu, etc.) must be reported.

### **Entry into the chamber**

The staff of the Unit accompanies patients to their seats into the hyperbaric chamber (patients may also be carried on a gurney according to their clinical conditions and in keeping with the logistics requirement of the Unit). The members of the staff make sure that the patients have complied with the written and oral recommendations provided in advance and every time they enter the chamber.

The technical and health staff are responsible for ensuring the greatest comfort to patients while inside the chamber, in compliance with the therapeutic requirements and the prevention and safety rules set by the bodies concerned. Therefore, any request which runs counter the set parameters cannot be satisfied.

### **Beginning of the session and compression**

During the compression stage, inside the chamber one can perceive an increase in ambient temperature due to the increase in pressure.

During the whole session, in the room there is a background noise generated by the continuous inflow of clean air and the outflow of the same quantity of air as that which has flown in.

## **Ear clearing**

At this stage, which lasts about 15 minutes, the ear clearing manoeuvre must be performed, according to the explanations provided during the medical examination, in order to balance pressure in the inner ear (**pinch nostrils with your fingers, then, keeping your mouth shut, blow air against the mouth, without letting it out, until you feel your ears have cleared, swallow saliva with your mouth shut, and finally contract and move your jaws as for yawning**).

This manoeuvre must be performed several times during the compression stage, until the therapy level is reached, and it is very important to do it properly not to damage eardrums.

Patients must inform the staff about any difficulties in the ear clearing manoeuvre which, if neglected, could bring about eardrum inflammation and perforation (these complications interrupt hyperbaric therapy for some time, according to seriousness). The same holds true if, during the compression stage, the patient feels pain in the zygoma, forehead or teeth area.

## **Rhinitis and nasal vasoconstrictors**

If the patient has caught a cold, he is better give up a session, not to damage his/her eardrums. Should he/she insist on being treated anyway, he/she will have to address the physician in charge who, in case of necessity, shall administer some drops of a nasal vasoconstrictor (Rinazina, Otrivin, etc.). Do not abuse these drugs because there may be some side effects such as nasal mucosa atrophy.

### **Beginning of therapy**

When the therapeutic level is reached, the patient shall wear the mask (please remember to fasten the strap and to make sure the mask fits the face properly). At this stage, oxygen breathing starts.

The Hyperbaric Chamber is pressurized with air (O<sub>2</sub> 21%). The percentage of oxygen in the mask should be as close as possible to 100%.

The mask must be worn properly and duly fastened with straps, in order not to waste the effects of therapy. The oxygen percentage is monitored by means of a special instrument by the technical staff in charge of the equipment.

Both mouth and nose breathing are acceptable (nose breathing is better because it prevents throat dryness) with natural frequency, rhythm and width, without forcing. Oxygen breathing is performed for two cycles lasting 45 minutes each, with a break of air breathing. Then, patients are told to take off their masks.

### **End of therapy and beginning of decompression**

At this stage, decompression begins and normal pressure (atmospheric pressure) is restored.

In the chamber, one can perceive a reduction in the ambient temperature, and some noise in the ears, due to the air outflow from the middle ear. To equalize pressure in the middle ear, just swallow; do not perform the ear clearing manoeuvre.

Should the patient find it difficult to compensate because of the pressure difference (and feel pain in the ears, zygoma, forehead or teeth) he/she should inform the health staff immediately, for they will



adopt suitable measures. Opening the mouth and pronouncing the letter “A” (like in “arm”) continuously can be helpful.

Under normal conditions, decompression lasts about 10/15 minutes; in case of emergency, the hatch can open in less than 4 minutes (2 minutes from 2.5 ATA, with fast outlet).

During the emergency decompression stage in the chamber, please keep breathing normally, **without ever holding breath**.

### **End of the session**

At the end of the decompression, the hatch is opened and people can leave the chamber.

### **Recommended behaviour in the chamber**

Whilst inside the Hyperbaric Chamber, please avoid hitting metal objects one against the other and on the walls. Do not tamper with nozzles providing oxygen to the masks or with the other therapeutic and safety devices located inside the chamber.

### **Smokers**

Smoking patients should **stop smoking** or at least reduce smoking **as much as possible** during the whole therapy cycle, in order not to waste the beneficial effects of Hyperbaric Oxygen.

## **SMOKING IS FORBIDDEN INSIDE THE UNIT.**

After the therapy, wait for at least 10 minutes before smoking.

## HOW TO BEHAVE IN CASE OF EMERGENCY



### **IF YOU ARE IN THE CHAMBER:**

**KEEP YOUR MASK ON YOUR FACE and REMAIN SEATED.**

In case of emergency in the hyperbaric chamber, please **keep calm** and **follow carefully the instructions** of the staff working outside. The chamber is a safe environment, monitored by qualified and trained personnel.

### **IF YOU ARE OUTSIDE THE CHAMBER:**

#### **Evacuation of the Centre**

In case of a disaster, such as structural subsidence, earthquakes etc., the patient, warned by an acoustic signal or personally by the members of the staff who belong to the emergency squad, must move in an orderly fashion and without running towards the closest emergency exit indicated by the signs. Once outside the Centre, the

patient should move towards the area in front of the Centre, where he/she will receive further information.

## **SIDE EFFECTS OF HYPERBARIC OXYGEN THERAPY**

There are several risks associated with hyperbaric therapy, ranging in seriousness. They are due to the higher pressure to be found in the hyperbaric chamber and to high-pressure oxygen breathing.

- **Inflammation or lesion of the eardrum because of faulty ear clearing:**
  - ◆ the likelihood of this side effect may be reduced by means of suitable ear clearing manoeuvres
  - ◆ the health personnel must be informed about any difficulties in ear clearing
  
- **Pain to the forehead or zygoma because of difficulties in equalizing pressure in the paranasal sinuses** (it may appear because of a cold, both during the compression and decompression stages)
  - ◆ during the first medical examination, the physician shall exclude either chronic or acute sinusitis. Should the patient be affected with these diseases, the physician shall prescribe a suitable therapy.

**Spontaneous pneumothorax** (rare event which brings about collection of air in the pleural space)

- ◆ Susceptibility must be assessed during the first medical examination and, if necessary, instrumental tests shall be carried out.

### **Oxygen toxicity induced seizures**

- ◆ Susceptibility must be assessed during the first medical examination.

### **Temporary deterioration of myopia**

- ◆ Vision returns to pre-treatment levels within three weeks following the end of HBOT.

## **ASSESSMENT OF THE RISKS CONNECTED WITH THE EQUIPMENT**

One should reiterate that the modern hyperbaric chambers, regularly controlled and managed by qualified and trained staff, who can reduce sharply any potential risk, are really safe.

### **Risk of fire**

- ◆ The risk may be reduced by carrying out periodical controls and by means of a suitable maintenance of the plant.

### **Fire-fighting plant**

- ◆ The fire-fighting plant guarantees the extinction of fires in the chamber. The working parameters comply with the rules laid

down by I.S.P.E.S.L. (Institute for Prevention and Safety at work).

### **Safety systems**

- ◆ There are three control levels of the percentage of oxygen in the chambers which are activated when such percentage exceeds the set limits. The first and second system inform the operator about the increase in the quantity of oxygen (22.5% and 23.5%) in the atmosphere of the chamber. If the operator, for any reason, cannot interrupt the increase in oxygen, the third control intervenes (becoming active with an oxygen concentration equal to 25%) and turns the oxygen breathed in the mask into air. Therefore, the third parameter - the percentage of oxygen in the atmosphere of the chamber – which is a safety limit, can never be exceeded.



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Drawn up by the Communication Office **in keeping with the accreditation standards of the Joint Commission International**;  
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