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Abstract

Hyperbaric medicine is practiced throughout the world, but the indications vary from one country to another. As examples, HBO developments in various countries are described here as well as the worldwide distribution of hyperbaric facilities. Since the USA is covered in Chap. 50 and Latin America in Chap. 51, the rest of the countries are included in this chapter with examples limited to Germany, China, Japan, and Russia.

Keywords

Hyperbaric oxygen (HBO) • Hyperbaric medicine • Indications for HBO • Hyperbaric chambers • Hyperbaric medicine in China • Hyperbaric medicine in Russia • Hyperbaric medicine in Japan • Hyperbaric medicine in Germany

Introduction

The practice of medicine varies around the world and so does hyperbaric medicine. It was considered appropriate to include a brief description of trends in the practice of hyperbaric medicine around the world. It was not possible to include all the countries. Only those countries outside of the USA where hyperbaric medicine is practiced on a significant scale are included. A brief description of hyperbaric medicine in the USA is given in Chap. 50 and Latin America in Chap. 51. This chapter will briefly describe the current state of hyperbaric medicine in China, Japan, Russia, and Germany. The European hyperbaric centers are listed on the Oxynet website: <http://www.oxynet.org/03HBOCenters/Index03.php>. Within Europe, Italy, and Germany, each has the largest number of hyperbaric centers, i.e., ~30 in each. Turkey is next with ~28 hyperbaric centers, and France is in the third place with 20 hyperbaric centers. There are 13 hyperbaric centers in the UK. Hyperbaric medicine is not covered in the National Health Service of the UK. Most of

the monoplace chambers are privately owned and used by multiple sclerosis patients.

Hyperbaric Medicine in China

The first Chinese hyperbaric chamber was built in 1964 by Dr. Wen-ren Li at Fujian Medical University Union Hospital; hyperbaric medicine developed rapidly in China after the cultural revolution, and there are now >5000 hyperbaric chambers in the country (Yan et al. 2015). The total staff including physicians, nurses, technicians, and research scientists is over 35,000. The number of patients treated yearly with HBO exceeds 2.5 million. Apart from the routine practice, research is being carried out on the mechanisms of action of HBO and its role in the management of the following conditions:

- Stroke
- Persistent vegetative state
- Autoimmune diseases
- Cancer
- Rejection in transplants

The Chinese Professional Committee of Hyperbaric Oxygen drafted the indication and contraindication stan-

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dards of practice in 1982 in an effort to reduce the number of patients experiencing toxic side effects of HBO therapy. The Chinese Medical Association revised the indication and contraindication standards in 2004 and 2013; the 2004 version is widely used in clinical practice, followed by the indications and contraindications of 2004. Indications and contraindications for hyperbaric oxygen in China are shown in Table 49.1.

There is considerable research activity in hyperbaric medicine in China. By mid-2016, there are ~15,000 articles that can be retrieved from various databases using “hyperbaric oxygen” and “China” as keywords, of which 395 articles appeared in PubMed. This amount of hyperbaric oxygen research suggests that HBO therapy in China is still in the development stage. The amount of published HBO research has been increasing every year during the past decade.

Hyperbaric Medicine in Japan

This account is partially based on the chapter on this topic in the 5th edition of this textbook written by late Prof. Hideo Takahashi from University of Nagoya and has been updated by the current author. Before World War I, research on hyperbaric medicine in Japan was focused mainly on the environmental physiology of Ama diving or the industrial hygiene of caisson workers. Hyperbaric air was used for stroke rehabilitation in the late 1950s. Clinical work in hyperbaric medicine started in 1960s with the construction of a hyperbaric surgical theater and a hyperbaric recovery room at Tokyo University. Around the same time, a series of clinical investigations of hyperbaric oxygen therapy were initiated at Nagoya University, which led to the installation

Table 49.1 Indications for HBO approved by the Chinese Medical Association 2013

<i>Emergency indications, first line</i>
1. Acute carbon monoxide poisoning and other harmful gas poisoning
2. Gas gangrene, tetanus, and other anaerobic bacteria infections
3. Decompression sickness
4. Air embolism syndrome
5. A variety of risks for acute brain dysfunction after cardiopulmonary resuscitation (CPR)
6. Aid in the treatment of shock
7. Brain edema
8. Pulmonary edema (except cardiac pulmonary edema)
9. Crush syndrome
10. Compromised blood supply after skin transplantation of limbs (finger, toe)
11. Drug and chemical poisoning
12. Acute ischemia anoxic encephalopathy
<i>Second-line indications, nonemergency, adjunctive</i>
1. Carbon monoxide poisoning or other toxic encephalopathy
2. Sudden deafness
3. Ischemic cerebrovascular disease (cerebral arteriosclerosis, transient ischemic attack, cerebral thrombosis, cerebral infarction)
4. Craniocerebral injury (concussion, cerebral contusion of intracranial hematoma removal surgery, brain stem injury)
5. Cerebral hemorrhage recovery
6. Poor healing fractures
7. Central serous retinal inflammation
8. Vegetative state
9. Plateau adaptation insufficiency syndrome
10. Peripheral nerve injury
11. Intracranial benign tumor surgery
12. Periodontal disease
13. Viral encephalitis
14. Facial paralysis
15. Osteomyelitis
16. Aseptic osteonecrosis
17. Cerebral palsy
18. Fetal developmental delays
19. Diabetes and diabetic foot
20. Coronary atherosclerotic heart disease (angina and myocardial infarction)
21. Rapidly arrhythmia (atrial fibrillation, premature beat, tachycardia)
22. Myocarditis

(continued)

Table 49.1 (continued)

23. Peripheral vascular disease; vasculitis, e.g., Raynaud's disease; deep vein thrombosis; etc.
24. Vertigo
25. Chronic skin ulcer (arterial blood supply obstacles, venous congestion, bedsore)
26. Spinal cord injury
27. Peptic ulcer
28. Ulcerative colitis
29. Infectious hepatitis (use the special chamber of infectious disease)
30. Burns
31. Frostbite
32. Plastic surgery
33. Skin grafting
34. Sports injuries
35. Radioactive damage (bone and soft tissue, cystitis, etc.)
36. Malignant tumors (with radiotherapy or chemotherapy)
37. Otic nerve injury
38. Fatigue syndrome
39. Angioneurotic headache
40. Pustular
41. Psoriasis
42. Pityriasis rosea
43. Multiple sclerosis
44. Acute Guillain-Barre syndrome
45. Recurrent oral ulcer
46. Paralytic ileus
47. Bronchial asthma
48. Acute respiratory distress syndrome
<i>Absolute contraindication</i>
Untreated tension pneumothorax
<i>Relative contraindications</i>
1. Intraventricular external drainage
2. Fracture of the skull base with cerebrospinal fluid leakage
3. Birth weight < 2000 g in premature and low birth weight infants
4. Serious infection of the upper respiratory tract
5. High blood pressure (syst BP > 180 mmHg, diast BP > 110 mmHg)
6. Patients with chronic obstructive pulmonary disease with CO ₂ retention

of the world's largest hyperbaric chamber there (see Chap. 7). Many new indications for HBO were developed there. This was followed by installation of multiplace chambers at Osaka and Kyoto Universities. The Japanese Society for Hyperbaric Medicine (JSHM) was formed in 1969. In 1982, JSHM launched the Educational Course in Hyperbaric Medicine for hyperbaric nurses and engineers. In 1981, the *Japanese Journal of Hyperbaric Medicine*, the official journal of JSHM started to publish quarterly. Currently accepted indications for HBO by JSHM are listed in Table 49.2.

At the end of year 2015, the total number of hyperbaric chambers in Japan was ~820, of which 760 were monoplace (93%) and 60 multiplace (7%). These chambers are located at 620 medical facilities. The total number of clinical chambers is still growing and at least one university hospital introduces a new multiplace chamber every year.

Historically, Japanese hyperbaric medicine has emphasized clinical applications, and fundamental research to provide a

scientific background for clinical indications has tended to be delayed. By conducting more basic investigations, many new indications will be established in the future. One of the most important goals of HBO therapy is to participate in cancer therapy; the combination of hyperbaric medicine and oncology is considered to be an attractive new horizon.

Hyperbaric Medicine in Russia

Russia has extensive hyperbaric facilities. There are >60 centers with hyperbaric facilities and ~1400 hyperbaric chambers are currently in use. HBO therapy indications in Russia do not resemble those recommended by the Undersea and Hyperbaric Medical Society in the USA. HBO is used in the following areas of medicine in Russia: cardiology, pulmonology, gastroenterology, hepatology, nephrology, hematology, oncology, endocrinology, rheumatology, allergology

Table 49.2 Currently accepted indications for hyperbaric oxygen therapy in Japan as recommended by the Japanese Society for Hyperbaric Medicine

<i>Emergency (acute) indications</i>	
1.	Acute carbon monoxide and other gas-induced intoxications, including delayed intoxications
2.	Gas gangrene
3.	Air embolism and decompression sickness
4.	Acute peripheral vascular disorders:
	(a) Severe burn injury and frostbite
	(b) Combined with large crush injury or massive vascular damage
5.	Shock
6.	Myocardial infarction and other coronary insufficiencies
7.	Consciousness disorders and brain edema after brain embolism or severe cranial injury
8.	Acute and severe hypoxic disorder of the brain
9.	Paralytic ileus
10.	Acute obstructive disorders of the retinal artery
11.	Sudden deafness
12.	Severe spinal cord disorders
<i>Nonemergency (chronic) indications</i>	
1.	Malignant neoplasms, combined with radiation or chemotherapy
2.	Peripheral circulatory disorders with refractory ulcers
3.	Skin grafts
4.	Subacute myelo-optic neuropathy (SMON)
5.	Motor paresis, as the later sequelae of cerebrovascular attack, severe cranial injury, or craniotomy
6.	Delayed syndromes in carbon monoxide intoxication
7.	Spinal cord neuropathy
8.	Osteomyelitis and radiation necrosis

and immunology, infectious disease, emergency medicine, diving medicine, general surgery, orthopedic surgery, thermal injuries, neurology, neurosurgery, obstetrics and gynecology, neonatology and pediatrics, otolaryngology, clinical toxicology, ophthalmology, urology, and psychiatry. There are >60 approved indications for HBO therapy in Russia, and some of these are shown in Table 49.3.

Hyperbaric Medicine in Germany

Germany is chosen as an example in Europe as it has played an important part in the development of modern hyperbaric medicine, particularly in the applications for neurological disorders. Important work in this area was done in the late 1960s and early 1970s at the University Neurosurgical Clinic, Bonn, by Professor K.H. Holbach and colleagues, of whom Prof. Wassmann continued this work. The author (K.K.J.) had an opportunity to work with this team. HBO was applied to patients with head injuries and stroke, and the important contribution was the response to HBO for selecting patients for extra-intracranial bypass operation. This application of HBO did not spread in clinical practice for the next decade when the group in Bonn moved to other centers and followed other interests in neurosurgery. In 1980s, research was done into the applications of HBO for inner ear disorders, particularly

sudden deafness. In 1986, the author returned to Germany and during the following 3 years had a chance to work on the clinical applications of HBO in a rehabilitation clinic. This is where the work on treatment of chronic stroke patients was carried out.

In Germany, the professional scientific association for hyperbaric oxygen therapy is the “Gesellschaft für Tauch- und Überdruckmedizin e.V.” This professional association evaluates possible applications of HBO therapy from a medical perspective. On its websites (<https://www.gtuem.org/>), there is a directory with contact details of pressure chambers in Germany, Austria, and Switzerland.

In 1989, there were only four active hyperbaric chambers for clinical HBO therapy in Germany. In recent years, there has been a rapid expansion of hyperbaric facilities in Germany, and as of mid-2016, there are 30 hyperbaric centers in Germany. The breakdown according to availability and scope of service is as follows:

Centers for emergency use of HBO and for diving accidents	6
Centers with 24 h service for HBO therapy and availability of intensive care beds	5
Centers with 24 h availability of outpatient HBO therapy but no hospital beds	4
Centers with limited hours of service for HBO therapy	15

Table 49.3 Indications for hyperbaric oxygen in Russia

Vascular diseases
Arterial obstructions in the limbs before and after surgery (embolism, trauma, thrombosis)
Arteriosclerosis
Gas embolism in the blood vessels
Ulcers caused by defective blood circulation
Cardiac disorders
Heart strain
Heart rhythm disturbances
Irregular heartbeat
Paroxysmal extrasystole
Cardiac insufficiency
Cardiosclerosis decompensation
Cardiac insufficiency after heart surgery
Heart contraction disturbances
Cardiopulmonary insufficiency
Pulmonary disorders
Lung abscess before and after surgery
Nonspecific chronic lung affections with cardiopulmonary insufficiency signs
Gastrointestinal disorders
Stomach and duodenal ulcers
Intestinal obstruction
Liver diseases
Acute viral hepatitis
Hepatic encephalitis
Liver cirrhosis
Obstructive jaundice
Hepatic insufficiency after resuscitation
Toxic hepatitis

Germany has only multiplace chambers (monoplace chambers are not approved in Germany currently), and >60,000 patients were treated in the year 2015. Most of these patients (about 85%) are treated on an ambulatory basis. Some of these chambers are in university centers where research is done, and others are private business enterprises with little research activity.

Germany has the usual indications accepted in most Western countries. Most HBO therapies are conducted for the following indications:

- Tinnitus
- Acute hearing loss with or without tinnitus
- Noise-induced hearing loss, acoustic trauma
- Chronic wound(s)
- Diabetic foot: nonhealing wound(s)
- Bone marrow necrosis
- Radiation cystitis
- Radiation proctitis
- Borreliosis/lyme arthritis

Use for tinnitus and hearing loss is more common in Germany than in other countries.

World Distribution of Hyperbaric Facilities

Some idea of the quantity of hyperbaric medical facilities in the world can be obtained by a review of the statistics regarding the distribution of hyperbaric chambers in various countries. Accurate information on this subject is difficult to obtain, but the available figures are shown in Fig. 49.1. The largest number of chambers is located in China (>5000) and the USA with 2400 chambers is next. Russia has ~1800, Japan has ~820, and Europe has ~480 hyperbaric chambers.

The total number of hyperbaric chambers in the world is not known. The number of chambers does not necessarily correlate with the number of patients or the number of treatments given. There is no separation of multiplace and monoplace chambers in the statistics for most countries.

Worldwide Distribution of Hyperbaric Chambers **Conclusion**

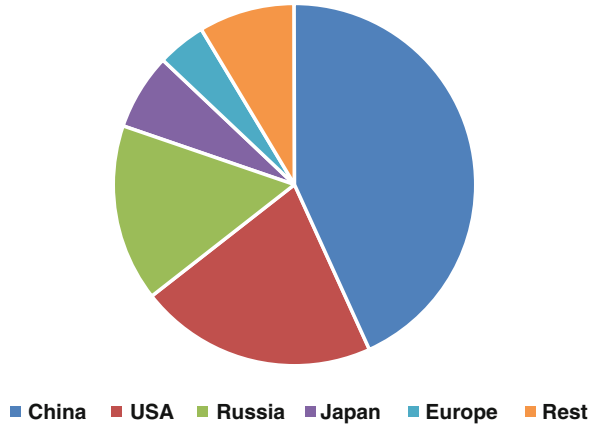


Fig. 49.1 World distribution of hyperbaric chambers

Hyperbaric medicine is practiced worldwide with the greatest activity in China, Russia, and the USA. The USA has the most regulated applications of HBO with the most restrictive list of applications. Japan is also active in hyperbaric medicine in clinical applications as well as in research. China has the largest number of hyperbaric chambers and is most active in basic as well as clinical research in HBO therapy. Within Europe, Germany and Italy are most active in hyperbaric medicine and have the largest number of hyperbaric centers.

Reference

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