Hyperbaric Medicine U.S.A. 1986

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In 1977, the first of a bi-yearly circular was developed and sent to the then known active hyperbaric chambers throughout the country. Over the ensuing 9 years a hyperbaric registry has been developed in which the locations, staffing patterns, diseases treated, affiliations of the chambers and trends of hyperbaric medicine have been followed up since the 1970s. Blue Cross/Blue Shield/Medicare/Medicaid, the major third party insurers, have agreed to payments in 14 conditions labeled the "accepted group", which include gas embolism, radiation necrosis, decompression sickness, carbon monoxide poisoning, gas gangrene, refractory osteomyelitis, necrotizing fasciitis, soft tissue infections, crush injury, ischemic conditions, compromised skin grafts/skin flaps, wound healing enhancement, burns and anemia.

Negotiations may be undertaken in the treatment of 16 conditions in an investigative category. The accepted conditions are those where the body of literature, animal and clinical research, indicate that the use of hyperbaric oxygen is either the primary treatment (decompression sickness, air embolism, carbon monoxide poisoning) or adjunctive treatment. The Diver's Alert Network is a system whereby injured scuba divers or commercial deep sea divers may find the nearest and most appropriate hyperbaric chamber for recompression therapy on a 24-hour/7-days-per-week basis. There is a central telephone network at Duke University, Durham, NC, (919) 684-8111, and a second system through the Hyperbaric Registry located at the MIEMSS, (301) 328-7814.

The statistics of the registry will be presented. Of the 220 existing hyperbaric facilities, there are 85 multiplace, 118 monoplace, and 17 of both types. Over the 16 years (1971-1985) 44,095 patients have been treated for hyperbaric-related conditions. In this group 71.9% are in the accepted category and 28.1% are in the investigative and other categories.

As a result of the registry, one has been able to determine the trend in hyperbaric medicine and also the steady increase in its usage nationwide. From the original 37 chambers in 1977 to the 220 chambers in 1985, one has seen a dramatic increase in usage of hyperbaric oxygen.

Introduction

In the early 1960 s major interest developed in hyperbaric medicine starting from the work in Amsterdam by Boerema, and spreading both to the east and west. The 1960 s marked a period of significant research into the basic sciences on the mechanisms of action of hyperbaric oxygen, and also the concern for oxygen toxicity. The first major publication on hyperbaric medicine was the "Fundamentals of Hyperbaric Medicine," prepared by the Committee on Hyperbaric Oxygen Therapy, a division of the Medical Sciences National Academy of Sciences, National Research Council. This book was published in Washington, D.C. in 1966[1]. The Committee was established in 1963 and took three years to develop its publication. They reviewed the needs and opportunities for research in the field. Critiques of the principle, practice, and administration of oxygen to

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man under elevated pressures and problems relating to selection and operation of equipment and of training personnel were reviewed. This was a landmark preparation and was later followed by the various international and national conferences on hyperbaric medicine.

Associated with this initial interest was the increasing use of hyperbaric oxygen in the clinical arena, using the sound physiological principles that had been initially developed. But in addition to this there was also an over zealous application of hyperbaric medicine that resulted in the ethical medical community discounting hyperbaric oxygen therapy as a dangerous and unproven therapeutic modality. In 1967, the Undersea Medical Society, Inc. (UMS) was established by physicians and scientists particularly interested in support of man in the sea. This body began to develop an interest in clinical hyperbaric medicine and therapy. Because of the mass confusion, and in an endeavor to provide scientific guidelines for hyperbaric therapy, the UMS in 1975 pulled together 50 leaders in hyperbaric research and clinical practice for the first workshop led by Dr. Al Benky and arranged by Dr. Charles Shilling, the executive secretary of the UMS. Drs. Jefferson Davis and T.K. Hunt directed the workshop. As a result of this workshop, the well accepted textbook "Hyperbaric Oxygen Therapy" established the state-of-the-art status in 1978[2]. The many conditions treated with hyperbaric oxygen were divided into groups that included those currently accepted indications and those with promising research areas. While this manuscript was in preparation, the executive committee of UMS established a standing committee on hyperbaric oxygen therapy. Its responsibility was to prepare a report for the physician relating to effectiveness of hyperbaric oxygen treatment in specific disorders. This report was prepared under the chairmanship of Dr. Eric Kindwall and released in 1977. He divided the various conditions treatable by hyperbaric oxygen into four groups: Categories I and II reflected conditions where there was significant clinical and research experience to indicate the effectivity of hyperbaric oxygen. Category III indicated those areas where research was greatly needed; and Category IV encompassed the stranger applications of hyperbaric oxygen therapy. In 1983, this was reviewed under the chairmanship of Dr. Jeff Davis and the categories were refined to represent one accepted category where there was good clinical and animal research to indicate effectivity and a second division, an experimental group, where research was still necessary for proving hyperbaric oxygen effectivity. In 1986, the latest updating of this manual occurred under my chairmanship[3]; the "accepted" category was further refined, and the "experimental" group was changed to an "investigative" group. More references, both clinical and research, were added under each of the groups, and the manual was considerably expanded to reflect the present day needs and understanding of hyperbaric medicine. A deliberate attempt has been made to maintain the two categories. The "accepted" category includes the disorders for which hyperbaric oxygen therapy is either the primary mode of treatment or has proved to be an important adjunctive therapy with other measures. There is sound physiological rationale in both *in vitro* and *in vivo* studies showing effectiveness and, in addition, there are controlled animal studies and extensive clinical experience. The efficacy of hyperbaric oxygen therapy in these disorders is at least as convincing as that for the other currently accepted treatment modalities in these same disorders. Third party payment has been recommended by the Committee for these accepted conditions.

Burn therapy has been retained under a special category because of the great controversy relating to hyperbaric oxygen use in burns. Recent clinical work is strongly in favor of its effectivity and its cost containment.

Finally is the third major category, "investigative" conditions. In this area, there are fruitful areas for research; with further clinical and research endeavors many of these conditions could be elevated into the accepted category. It is felt that peer review and discussion with third party payers in this situation could easily result in payment for treatments.

The major third party insurance carriers including Medicare and Medicaid have agreed to payments for the fourteen conditions under the accepted group. This group includes air and gas embolism; carbon monoxide and cyanide poisoning; compromised skin grafts and flaps; crush injury; decompression sickness; exceptional blood loss anemia; gas gangrene, both clostridial and nonclostridial; necrotizing soft tissue infections; refractory osteomyelitis; radiation necrosis; soft tissue infections; wound healing enhancement, and in a special category, burns.

Conditions in the investigative category are anaerobic and mixed aerobic / anaerobic brain abscess; carbon tetrachloride poisoning and other liver toxins; severe vascular accidents; closed head injury with cerebral edema; fracture healing and burn grafting; hydrogen sulfide poisoning; lepromatous leprosy; meningitis; multiple sclerosis; pyroderma gangrenosum; pseudomembranous colitis; radiation enteritis and proctitis; radiation myelitis; retinal artery insufficiency; selected refractory mycoses; septic chronic intraabdominal abscess; sickle cell anemia crisis; spider bites; and spinal cord injury[3].

Material and Methods

In 1977 the first of a series of biennial questionnaires was developed and sent to the known hyperbaric chambers throughout the country. Over the ensuing 9 years a hyperbaric registry has been developed through which the locations, staffing patterns, diseases treated, affiliations of the chambers, and trends of hyperbaric medicine have been followed since the 1970s[4)5)].

In addition to the clinical application of hyperbaric medicine, a national Diver's Alert Network (DAN) has been established whereby any injured scuba diver or commercial deep sea diver may find the nearest local and most appropriate hyperbaric chamber for recompression therapy on a 24-hour, 7-days-a-week basis. The central telephone network is at Duke University in North Carolina, (919) 684-2948. A second system may be utilized through the hyperbaric registry located at the Maryland Institute for Emergency Medical Services Systems (MIEMSS), (301) 328-7814, and is available for 24-hour information to people involved with diving medicine complications.

Functional Hyperbaric Facilities

From 1980 to 1985, 220 hyperbaric units have been noted to be functional. These have been subdivided into monoplace, multiplace, and combination chambers. A total of 21,015 patients have been treated in 118 monoplace chambers during the 1980-1986 period; 8,941 patients were treated in 85 multiplace chambers; and 5,060 were treated in 70 multiplace / monoplace units. It is apparent that the monoplace chambers are more active; however, by far the majority of multiplace chambers, some 70 odd, are actually related to Navy diving or the commercial diving industry and treat only decompression sickness and air embolisms as they occur in these divers. These facilities are not available for clinical cases and have no experience in the treatment of patients.

Tab. 1. Summary of Patients Treated by Type of Chamber

(1980–1985)

Type of Chamber	Number of Chambers	Number of Patients Treated
Monoplace	118	21,015
Multiplace	85	8,941
Both	17	5,060
	220	35,016

Note: Two hundred and forty (240) questionnaires were sent; One hundred and thirty-three responses were received.

April, 1987

Tab. 2. Functional Hyperbaric Facilities Breakdown: Total Number of Cases Treated by Chambers

(1980–1985)

Number of Cases	Mono		Multi		Both	
0– 100	60	98	65	77	7	9
101– 200	28		7		2	
201– 300	10		5		0	
301– 400	8		3		3	
401– 500	5		1		2	
501– 600	1		1		0	
601– 700	0		0		0	
701– 800	1		0		2	
801– 900	1		0		0	
901–1000	1		1		0	
1001–1100	0		0		1	
1101–1200	0		0		0	
1201–1300	2		2		0	
1301–1400	0		0		0	
1401–1500	1		0		0	
	118		85		17	

(October,1986) Total: 220

When one looks at the numbers of cases treated by various units, it is evident that the majority of hyperbaric facilities have treated fewer than 300 patients. A total of 9 of the 17 combined complexes, 77 of the 85 multiplace chambers, and 98 of the 118 monoplace chambers fall into this category. From this, it is apparent that the majority of treatment centers have had little experience; thus, the potential for problems, mishaps, and disasters is great. At the other end of the scale, 3 of the monoplace and 2 of the multiplace chambers have treated more than 1200 patients. In essence, this group represents the long-time functional chambers, those that have been involved in establishing hyperbaric medicine as a viable clinical specialty.

In looking at the locations of hyperbaric facilities in the U.S.A., California, with 40, is the state providing the greatest number of

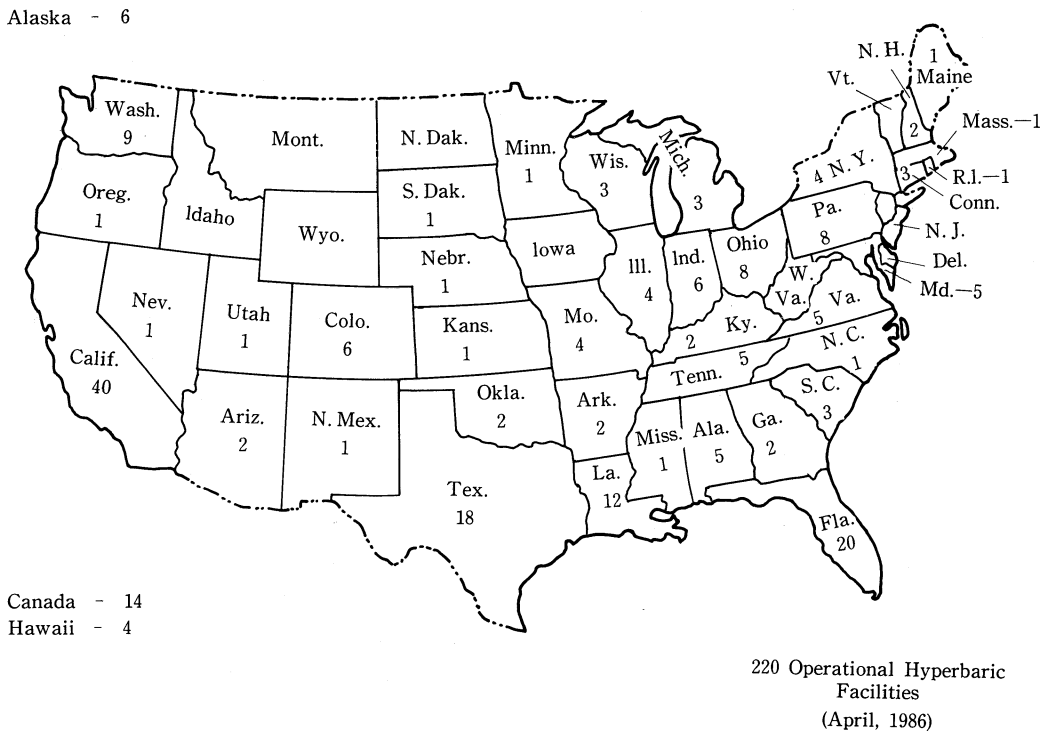

Fig. 1. Functional Hyperbaric Chamber Facilities. (April, 1986)

facilities, followed by Florida with 20, and Texas with 18. Louisiana has 12, and then the rest of the states have from 1 to 8 chambers. This includes both monoplace and multiplace facilities. In at least 5 states, Montana, Wyoming, North Dakota, Idaho, and Iowa, there are no facilities, and 13 states have only 1 facility. Of interest, is the fact that in 1977, when the first survey was undertaken, there were only 37 functional hyperbaric facilities throughout the country. This increase to 220 over the past 8 years has shown that hyperbaric medicine is a growing field. The major increase occurred from 1982–1984, when an average of 40 new chambers per year were installed.

Conditions Treated: Accepted Category

1. Air Embolism / Gas Embolism

A total of 918 patients were treated from 1977 to 1985. A peak in the number of these cases was seen in 1983, with a dropping off in the last two years. It must be pointed out that the diving industry is not reporting its cases of air embolism and decompression sickness of because the concern for litigation. For this reason, the total impact of these two conditions is not known despite the development of the Diver's Alert Network system.

2. Carbon Monoxide, Smoke Inhalation, and Cyanide Poisoning

It should be noted that since 1977, 3,413 cases of carbon monoxide poisoning have been treated. There has been an increase in the number of these cases from 128 in 1977 to 899 in 1985. I believe this reflects an increased awareness of the general physician population, particularly with emergency medi-

Tab. 3. Hyperbaric Chambers-United States and Canada Treatment Census Table

(October, 1986)

Currently Accepted Indications	1977	1978	1979	1980	1981	1982	1983	1984	1985	Totals
Air Embolism	55	96	105	114	65	80	163	140	97	**915**
Carbon Monoxide Poisoning	128	213	243	280	215	391	528	516	899	3413
Cyanide Poisoning				1	1	5	7	26	5	45
Smoke Inhalation		8	18	38	49	110	106	95	98	522
Subtotals:	128	221	261	319	265	506	641	637	1002	**3980**
Crush Injury (Unspecified)	1	8	25	51	84	70	23	82	58	402
Arm						21	49	64	66	200
Leg						34	56	101	70	261
Thigh/Hip						1	10	2	9	22
Trunk							7	4	20	31
Subtotals:	1	8	25	51	84	126	145	253	223	**916**
Decompression Sickness	215	381	398	437	324	497	568	443	414	**3677**
Enhancement of Wound Healing (Unspecified)	9	28	102	136	142	391	53	105	28	994
Head and Neck						12	2	4		18
Lower Extremity						50	57	33	1	141
Trunk						4	7	4		15
Upper Extremity						1	2	1		4
Subtotals:	9	28	102	136	142	458	121	147	29	**1172**
Exceptional Blood Loss Anemia				1	2	6	7	20	14	**50**
Gas Gangrene: Clostridial	136	164	154	195	112	157	186	180	151	**1435**
Necrotizing Fasciitis			4	18	33	44	69	118	133	**419**
Soft Tissue Infection		17	22	77	104	221	288	361	415	1505
Non Clostridial				17	22	29	46	72	89	275
Subtotals:		17	22	94	126	250	334	433	504	**1780**
Osteomyelitis (Unspecified)	167	204	274	390	439	494	188	169	163	2488
Arm						13	15	28	19	75
Foot						68	125	167	180	540
Jaw						84	125	154	95	458
Leg						144	252	302	299	997
Pelvis						11	69	42	37	159
Sinuses							7	8	15	30
Skull						8	8	12	16	44
Subtotals:	167	204	274	390	439	822	789	882	824	**4791**
Radiation Necrosis (Unspecified)	84	126	419	226	189	129	112	89	104	1478
Jaw						123	270	394	374	1161
Soft Tissue			1	163	217	177	138	177	186	1059
Teeth			8	30	53	44	27	64	78	304
Subtotals:	84	126	428	419	459	473	547	724	742	**4002**
Refractory Anaerobic Infection Actinomycosis										**0**
Compromised Skin Grafts and Skin Flaps (Unspecified)	71	95	93	213	277	178	81	83	31	1122
Skin Grafts						112	208	336	411	1067
Skin Flaps						72	240	244	222	778
Subtotals:	71	95	93	213	277	362	529	663	664	**2967**
	866	1340	1866	2387	2328	3781	4099	4640	4797	**26,104**

cine physicians in this country, to the need for treatment with hyperbaric oxygen in carbon monoxide poisonings. Interestingly, there have been 45 cases of cyanide poisoning treated since 1980, with the maximum number in 1984. Smoke inhalation has also increased from 8 in 1978 to roughly 100 in the last 4 years. A total of 522 cases have been treated for smoke inhalation. It is assumed in this situation that one is treating carbon monoxide poisoning rather than anything else.

3. Crush Injury

There has been a steady increase in the number of cases treated, from 1 patient in 1977 to 217 in 1985. The work of Nylander[6] in determining the mechanism of oxygen action has greatly helped in our understanding of the success of treatment with hyperbaric oxygen.

4. Decompression Sickness

In 1977 there were 215 patients with decompression sickness, and in 1985, 414. There was a peak in the reporting of these patients in 1983, with 568 patients. A total of 3,677 patients have been treated with this condition. Much of the increase in reporting of treatments may be due to the Diver's Alert Network system, which started in the late 1970s, early 1980s. This network, centered at Duke University, has been very active in providing information and services for referral of patients with diving problems. The nation is divided into 7 regions, each with a regional coordinator whose responsibility it is to determine the locations and capabilities of the functional hyperbaric facilities. It is important that the patient being referred for treatment be referred to the center most appropriate for the severity of his condition. At the present time, increasing use is being made of monoplace facilities for the treatment of diving problems, particularly those where follow-up treatments are required. Additionally, in an emergency situation where no multiplace chamber is available, the immediate treatment with oxygen can be undertaken in a monoplace chamber while transportation is being prepared to a multiplace system. Emphasis has been made on alerting divers to the locations of hyperbaric facilities in relation to their planned dives, and of making them more aware of the signs and symptomatology of decompression sickness and air embolism. A major problems exists generally in making emergency medicine physicians aware of the vague signs and symptoms of the decompression sickness syndrome, thus enabling the physicians to refer the patients appropriately to recompression centers.

5. Enhancement of Wound Healing

This condition has shown a decline, but mainly as a result of the redefinition of the conditions being treated. Many of these wounds have now fallen into specific ulceration caused either by diabetes or some form of chronic ulceration. The difference at this stage is the localization of the wound to a specific anatomical site.

6. Exceptional Blood Loss Anemia

Only 50 patients have been treated for this condition, the majority in 1984 and 1985. The patients are either those of the Jehovah's Witness religion, in which blood transfusions are not permitted, or patients who have had repeated transfusions and are experiencing major difficulties in obtaining compatible blood.

7. Gas Gangrene

Clostridial gas gangrene continues to remain a problem in the civilian world because of early and inappropriate closure of compound fractures and other potentially infected wounds. In 1977 there were 176 patients, and in 1985 there were 151. There were, however, peaks in the years 1980 with 195, and in 1983 with 186 patients. A total of 1,435 patients were treated in that time frame. It is interesting to note that the number of

patients treated per year in the entire country is significantly higher than all reported cases from the Korean or Vietnam Wars. Part of this is a direct response to the early closure of wounds in the civilian population versus the nonclosure of compound wounds in the military situation because the patient is evacuated to the base hospital from the advance medical unit.

8. Soft Tissue Infections (Necrotizing Fasciitis and Meleney Ulcer)

There has been a steady increase in the treatment of these infections with hyperbaric oxygen over the specified time periods. The number of soft tissue infections has risen from 17 in 1978 to 415 in 1985. The same occurred with the necrotizing fasciitis, going from 4 to 133. This group of conditions has in the past been poorly defined and described. We hope that with a revision of our descriptions of the condition, we will have more accurate reporting of the number of conditions treated. It is most apparent that the increase in the use of HBO in nonclostridial soft tissue infections is a positive step, and our own experience strongly supports hyperbaric oxygen as adjunctive therapy to surgery and antibiotics. It must be stressed that in this situation early surgery is essential and this surgery must be aggressive to remove all necrotic and dead tissue as soon as possible, to enhance the patient's response to the infection and the ability to heal his wounds.

9. Osteomyelitis

A total of 4,791 patients have been treated with this condition; 2,488 were unspecified, and in the earlier years from 1977 to 1981 no attempt was made to try and break down the osteomyelitis cases into regions. Since 1982 descriptions have been made relating to arm, foot, jaw, leg, pelvis, sinus, and skull. The majority of these cases have been in the leg, with 1997 patients, followed by the foot with 540, and the jaw with 458. There still remains a large number of unspecified cases in that same time frame. In viewing the growth of hyperbaric treatments it is evident that osteomyelitis is one of the major growth areas. In 1977, a total of 167 patients were treated for osteomyelitis, whereas in 1985, 824 patients were treated. This increase remained fairly steady over the last four years, averaging between 800 and 880 patients per year.

10. Radiation Necrosis

From 1977 to 1985, 4,002 patients were treated for this condition, but in the early years it was not specified what part of the body was involved. The majority of growth has occurred in this condition, where in contrast to 1977 when 84 patients were treated, 742 patients were treated in 1985. There has been a steady increase in the treatment of this condition and with a further breakdown of the condition into areas involved such as jaw, soft tissue, or teeth, it is apparent that the jaw is the major site of radiation problems with roughly 370 to 390 patients per year being treated. There has also been an increase in the treatment of teeth problems, from 8 in 1979 to 78 in 1985. Soft tissue infections have also dramatically increased (186 treatments were administered in 1985).

11. Ischemic Conditions with Ulcerations

This group is one of the major groups of hyperbaric oxygen treatment. Well over 4,000 patients have been treated within this group during the years 1977 to 1985. The maximum number of patients treated in a single year was in 1983; however, it remained fairly steady with an average of close to 800 patients per year treated for refractory ulcers of multiple etiological backgrounds. These ulcers ranged from chronic nonhealing to arterial, diabetic, and post phlebitic ulcers. The basis remains the same, that is, a compromised wound area with poor oxygenation and a lack of stimulation of fibroblasts and osteo-

blasts.

12. Compromised Skin Grafts and Flaps

This is another area of much hyperbaric therapy activity. From 71 cases in 1977 there has been an increase in skin flaps to more than 220, whereas skin grafts have risen to more than 411. Good animal evidence and clinical experience have resulted in a greater usage of oxygen therapy for these conditions.

Burns

The number of burns treated has remained fairly steady, more than 130 per year, with a peak in 1984. New work being done now, however, is providing excellent evidence of cost containment and a better understanding of the need for earlier treatment of the burn cases. This should result in a greatly increased number of burned patients treated within the next few years. The total number of patients treated during this time period was 1,173.

Investigative Conditions

1. Abscesses / Intraabdominal and Intracranial

A total of 42 of these cases have been treated, with the bulk of them occurring in 1984.

2. Carbon Tetrachloride

Only 11 patients with this condition have been treated. These 11 have occurred during the last 3 years.

3-a. Cerebral Edema

The numbers peaked in 1984 with 122 patients treated, but in 1985 these dropped to 55 a year, with a total of 335 patients.

3-b. Head Injury

This has also shown a decrease from a peak of 154 per year in 1981 to 30 a year in the last 3 years. A total of 612 patients have been treated for head injury. Combining the two (a & b) categories, 947 patients were treated. There has been a problem in the categorization of this condition; initially this was in the accepted category, but insurance carriers pointed out that there was insufficient research and human evidence to support this. Consequently they refused payment for these conditions and the Committee agreed that further research was indicated. There is reasonable evidence to suggest the rationale for hyperbaric oxygen's effectiveness in these conditions, but the animal experimentation is lacking at the present time. It is conceivable that this condition would be elevated to the accepted category with further research.

4. CVA / Stroke

A total of 1,360 patients were treated for this condition, with the peak incidence in 1979 of 276 patients. The numbers have been steadily decreasing, and it is felt that considerable research needs to be undertaken in this condition before hyperbaric oxygen is utilized.

5. Bone Graft and Fracture Healing

From 1982 to 1985, a total of 144 patients were treated for bone grafts and 152 patients were treated for fracture healing. Peak interest in fracture healing was in 1983 with 93 patients treated; this subsequently decreased to 19 per year in 1985. Again, further research is necessary in this condition.

6. Hydrogen Sulfide Poisoning

Only 8 patients have been treated, most within the last 3 years.

7. Lepromatous Leprosy

A single case of lepromatous leprosy has been treated. This is in sharp contrast with the work in Argentina, where large numbers of patients with lepromatous leprosy have been treated effectively. After only 5 treatments the patients have no longer required any anti-leprosy drugs.

8. Meningitis

Only 4 patients have been treated for this in the past 3 years.

9. Multiple Sclerosis

A total of 4,332 patients were treated for multiple sclerosis, with the major peak occurring in 1983 with 1,384 patients treated. In

Tab. 4

Investigative Indications	1977	1978	1979	1980	1981	1982	1983	1984	1985	Totals
Abscesses–Intraabdominal/cranial						1	6	22	13	42
Carbon Tetrachloride Poisoning, Acute							4	5	2	11
Cerebral Edema, Acute						37	121	122	55	335
Head Injury	38	57	52	116	154	73	34	58	30	612
Stroke (CVA)	115	176	276	272	141	79	130	104	67	1360
Bone Grafts						7	41	54	42	144
Fracture Healing						8	93	32	19	152
Hydrogen Sulfide Poisoning							3	3	2	8
Lepromatous Leprosy							1			1
Meningitis							1	2	1	4
Multiple Sclerosis	111	174	288	210	210	213	1384	1159	583	4332
Pseudomembranous Colitis									3	3
Pyoderma Gangrenosum						9	6	11	17	43
Radiation Myelitis/Cystitis/ Enteritis/Proctitis						4	21	22	6	53
Retinal Artery Insufficiency, Acute	4	3	12	18	12	18	51	29	24	171
Retinopathy						2	10	12	14	38
Selected Refractory Mycoses										
Sickle Cell Crisis		1	1	5		4	10	12	14	47
Spider Bites								2	4	6
Spinal Cord Injury (Crush)	53	85	105	91	72	94	79	42	32	653
Reimplantation				51	58	64	55	41	33	302
Senility	57	85	94	168	7	11	1			423
Coronary Artery Disease	52	85	92	152		2		4	13	400
Frostbite	5			2		1	2	7	4	21
General Atherosclerosis	50	83	90	150					53	426
Cancer		8		52	1	3				64
Other	277	373	375	473	182	207	259	155	159	2460
	762	1130	1385	1760	837	837	2312	1898	1190	12,111

the following year 1,159 were treated; 1985 dropped back to 583, corresponding with increasing literature showing relatively little effect on the disease with hyperbaric oxygen. The major peak occurred consequent to the New England Journal of Medicine article by Fisher, et al.[7] on the effectivity of hyperbaric oxygen with multiple sclerosis. There is a possibility that at certain stages of multiple sclerosis hyperbaric oxygen may be helpful in delaying the progression of the condition. It does not, however, change the disease process. Repetitive treatments appear to be necessary to maintain the patient at the stage of disease without rapid progression. A major problem exists in the general documentation of the disease and thus in the general outcome.

10. Pseudomembranous Colitis

Only 3 patients with this condition have been treated, all in 1985.

11. Pyoderma Gangrenosum

A total of 43 patients have been treated, with an increasing number occurring in 1984 and 1985. It is apparent that in this condition, which represents an acute dermal necrosis with hypoxia being registered in the

skin with zero levels of O_2 on transcutaneous O_2 monitoring, hyperbaric oxygen may have a role in the treatment of the condition. These cases require repetitive treatments over many weeks to months and it would appear that the major improvements are only seen after some 35 to 40 treatments.

12. Radiation Effects / Myelitis, Cystitis, Enteritis, and Proctitis

Only 53 patients have been treated for these conditions in the last four years, with major increases in 1982 and 1983. It must be noted that literature is appearing showing the positive effects of intermittent hyperbaric oxygen in the treatment of hemorrhagic radiation cystitis. In this situation, normally the bladder would be removed at cystectomy, but with intermittent hyperbaric oxygen up to 60 treatments have resulted in complete resolution of the problem. This is a very promising field, as are enteritis and proctitis.

13. Retinal Artery Insufficiency and Retinopathy

A total of 171 cases have been treated with this in the last 2 years, between 24 and 29 cases per year. The peak was in 1983 with 51 cases. Thirty-eight patients have been treated for retinopathy.

14. Selected Refractory Mycoses

This initially was listed in the accepted category, but because of the relatively few cases seen and treated generally, it was felt that the evidence to support the use of hyperbaric oxygen therapy was inadequate. It is suggested that where other treatments are failing hyperbaric oxygen therapy may be added to the regimen.

15. Sickle Cell Crisis

Hyperbaric oxygen has been used for the treatment of only 30 patients, on an average of 12 patients per year for the last 3 years. It is believed that the hypoxic state in precipitating sickle cell crisis is resolved with high oxygen concentrations. This is only used in the acute crisis, not in controlling the general condition.

16. Spider Bites

It has recently been reported that the brown recluse spider bite responds positively to hyperbaric oxygen because of the direct action of oxygen on the toxins injected. Several cases have been reported showing major salvage of tissue and a reduced need for plastic reconstructive surgery.

17. Spinal Cord Injuries

A total of 653 cases have been treated with hyperbaric oxygen therapy. There was a peak in interest in 1979 with 105 cases; this slowly declined to 32 patients in 1985. The major problem evidenced in this treatment has been that there is major difficulty in getting a patient from the scene of the accident into a hyperbaric facility within the "golden time frame" of 2 to 4 hours. It is essential that patients with spinal cord injury are stabilized generally and have a relocation of the fracture dislocation with traction. Other conditions that might be life threatening must be treated first. Consequently, the number of patients reaching a hyperbaric facility before the time frame of four hours is greatly reduced. Our own work has shown that those patients with an incomplete lesion do respond well and, according to the spinal cord registry, reach the state of recovery that would normally be reached at 1 year at 3 months, instead.

18. Reimplantation

A total of 302 patients have been treated, with between 30 to 50 cases a year. The earlier work in this line was done by the Chinese; controlled studies are being undertaken at the present time in the U.S.A. An attempt is being made to determine the optimal treatment depth and also the response to therapy. The rationale is good in that high oxygen levels can be transmitted to the reimplanted tissue and at the same time edema of

the area reduced by high oxygenation.

19-a. Senility

Most of these cases were treated in 1980, when 164 patients were treated. Subsequent to that very few patients have been treated. Much confusion exists in this being effective; however, subsequent repeat studies done through the National Institutes of Health showed minimal to no response in the cases of senility.

19-b. Cerebral Palsy

Only 1 patient was treated with this condition, and HBO should not be considered for these patients.

19-c. Coronary Artery Disease

A total of 388 patients were treated with this, with a peak of 152 in 1980. This condition with acute myocardial infarctions was well studied by Thurston, in England, in the early 1970s[8]. He showed some effectiveness in a specific subgroup of patients; however, with the advent of bypass surgery this work may need to be reviewed and retried.

19-d. Frostbite

A total of 21 patients have been treated with this condition at the rate of only a few patients per year. The rationale for early treatment is evident, but most of the patients come beyond the early stages with the disease established and demarcation well evident.

19-e. General Atherosclerosis

A total of 373 patients were treated with this, with the peak in 1980. Some of this reporting may reflect peripheral vascular disease ulceration and response to therapy, which is now in the accepted category. Bad reporting of this condition is a major problem.

19-f. Others

Treatment for other conditions amounted to 2,460 patients in the period from 1977 to 1985. A peak of 473 of these occurred in 1970, but during the last few years this has been averaging about 155 patients per year.

Hospital Affiliations

Ten facilities are related to university hospitals; 31 are related to teaching hospitals with a major university affiliation; and 12 have a minor university affiliation. Twenty-one are related to medical centers and 27 are military related. Twenty-four of the facilities are strictly related to commercial industry and 70 were not specified. From this, it is seen that in general there is lack of academic support for clinical hyperbaric medicine. It is hoped that growth in the coming years will be based in university hospitals or those with major or minor teaching roles. It is only through this approach that clinical hyperbaric medicine can be widely disseminated to the medical schools, where future physicians can be taught its value. The greatest number of facilities appear to be related to community / private hospitals.

Staffing Summary

There is a greater requirement of staff for the multiplace chamber with staff both inside the chamber and outside. This relates to all types of personnel: physicians, nurses, chamber operators, emergency medical technicians, and respiratory therapists. With the multiplace chamber there is generally one person inside the chamber and two outside, whereas with the monoplace chamber there are 1.2 persons available at the time of operation. The cost of running a multiplace chamber is greater; however, as one can dive more people in a single dive it balances out over the time salvaged by diving four to six people together rather than six individual treatments. It appears that when one is treating an average of 14 patients a day, the multiplace chamber becomes economically viable and cheaper to run than the monoplace chamber. The cost of staff to run any chamber is the major cost of the whole project.

Tab. 5. Other Conditions Treated

Disease Name	1984	1985
Pre and Post Operative Surgery		11
Emphysema		4
Black Lung		1
Allergies		3
Poor Circulation		2
Epilepsy Seizure		1
Cirrhosis of Liver		1
Colitis		1
Alzheimer's Disease		4
Arthritis	1	1
Fetal Pulmonary Hypertension		1
Preventive Medicine	3	1
Cerebral Vasospasm		1
Malignant Otitis		4
Bacteroides	1	1
Bone Infarction		1
Lung Lavage		8
EEG, prior to Carotid Bypass		2
Acute Hearing Loss		1
Revascularization		10
Ludwig's Angina		2
Myositis	1	
Pneumatosis Cystoides Intestinalis		2

Tab. 6. Affiliation Summary

Affiliation	Multiplace	Monoplace	Both	Total
University Hospital	2	5	3	10
Teaching Hospital, Major University Affiliation	10	19	2	31
Teaching Hospital, Minor University Affiliation	2	9	1	12
Medical Center	2	18	1	21
Community Hospital	4	25	2	31
Clinic	1	8	1	10
Public Institution	2	5	1	8
Private Institution	2	22	0	24
Military Clinical	1	0	1	2
Military Operational	17	1	3	21
Military Teaching Hospital	3	1	0	4
Researcher	4	1	0	5
Commercial	21	1	2	24
Other (Not Specified)	14	3	0	17
	85	118	17	220

(April, 1986)

Tab. 7. Staffing Summary

Personnel	Multiplace	Monoplace	Both
Physicians	1.0	0.7	1.1
Nurses	1.0	1.0	0.5
Operators	2.3	0.5	2.4
Emergency Medical Techs.	0.5	0.0	0.4
Respiratory Therapists	0.1	0.4	0.1
Diving Medical Techs.	0.9	0.0	0.8
Others	0.6	0.1	0.6
Staff inside the Chamber	1.0	N.A.	1.1
Staff outside the Chamber	2.0	1.2	2.5

Tab. 8. Average Fee Summary

Professional Fees	Multiplace	Monoplace	Both	Average
Initial Evaluation	$ 102.18	$ 114.44	$ 117.67	$ 112.31
Physician Follow-Up	$ 47.92	$ 35.92	$ 60.17	$ 40.24
Routine Wound Care	$ 19.50	$ 36.43	$ 16.50	$ 29.73
Physician In or Around Chamber Area/Care	$ 87.14	$ 41.67	$ 26.33	$ 58.69
Average Standard Treatment Fee Per Hour: (Routine Treatment)			Multiplace =	$ 164.19
			Monoplace =	$ 130.46

(April, 1986)

Average Fee Summary

A great variation is present in the returns relating to the fee charges. These range from $ 102 to $ 117 for an initial evaluation to followup evaluation ranging from $ 36 to $ 60 per visit. Routine wound care also has a wide range from $ 20 to $ 36, with monoplace chambers charging more. Multiplace chambers charge more to have the physician in or around the chamber area to provide care and consultation, the cost being $ 87 compared to $ 41 for the monoplace.

Summarizing the charges, the average fee per hour for a multiplace chamber is $ 164, versus $ 130 for the monoplace chamber. It must be stressed that some of the chambers, such as the military, do not charge anything, because the costs and coverage of their staff and personnel are absorbed.

Insurance carriers are prepared to pay two different costs for hyperbaric facilities: a basic cost to the hospital for the use of the chamber, which is generally worked out on the cost of the chamber including space costs, maintenance, material costs, and staff costs (specifically nurses, chamber operators, and other technical help); and the second cost is fee for service by the individual physician, which includes the initial evaluation and the followup wound care costs, and chamber time.

Conclusion

One of the major problems experienced today is that of a lack of conformity of reporting the various conditions and also the fact that the International Coding of Diseases, 9th Revision (ICD-9) Coding System is not specific enough for all treated conditions. For example, there is no ICD-9 Code to describe a diabetic patient with an ulceration of the left foot on the dorsum. To further compound

the problem no actual description of the diabetic ulceration is offered. As a uniform reporting system is developed the hyperbaric registry should become more specific, with the ultimate goal of adding reports on not only the conditions treated but the outcome of these conditions.

From this it can be seen that 32,035 patients have been treated with hyperbaric oxygen under the accepted indications in the time frame from 1977 to 1985. In the preceeding 7 years, 1970 to 1976, there were only 7,000 patients treated for all conditions both accepted and experimental. There has thus been nearly a fivefold increase in the use of hyperbaric oxygen in the subsequent time period.

It must be stressed that the registry, at present, only reflects the results of people responding to our questionnaire. There are a further 30 to 40 hyperbaric facilities that are treating patients but not responding to the questionnaire. The majority of these chambers are involved in the treatment of more patients in the "investigative" and "other" categories of disease, rather than in the "accepted" categories. The main-line group of hyperbarists are concerned about this, as it seems to reflect poorly on hyperbaric medicine in general and provides much material for harsh criticism of hyperbaric medicine. It must be stressed that a unified and standardized practice of medicine throughout the nation is not possible, as it is considered to be an infringement of the rights of the individual practitioner to earn his living. It is, however, essential for the voice of moderation to be heard at all times, by presentations both locally and at scientific meetings such as this.

The exchange of ideas occurring at meetings like this is essential for the growth of hyperbaric medicine. There are a number of conditions that are being aggressively treated and researched in Japan that have had scant recognition in America. Amongst these conditions are intestinal obstruction, acute retinal blindness, and acute traumatic deafness. You are aggressively pursuing research in head injury and cerebral edema, and we anxiously await your results.

In conclusion, I thank you for this privilege and opportunity to address your 21st Congress, and hope that we continue our exchange of ideas to the advancement of clinical hyperbaric medicine, both on the national and international levels. Thank you.

（本稿は，第21回日本高気圧環境医学会総会における招請講演を基に加筆されたものである。）

〔References〕

1) Committee of Hyperbaric Oxygenation (1966): Fundamentals of Hyperbaric Medicine, Publication No. 1298. National Academy of Sciences, National Research Council, Washington, D.C. Library of Congress Catalog No. 65-61928.
2) Davis, J.C. and Hunt, T.K. (eds) (1977): In Preface: Hyperbaric Oxygen Therapy, pp. XI-XXIII. Bethesda, MD: Undersea Medical Society.
3) Myers, R.A.M. (1986): Hyperbaric Oxygen Therapy: A Committee Report. Bethesda, MD: Undersea Medical Society.
4) Myers, R.A.M., Baker, T.L. and Cowley, RA. (1982): Hyperbaric Medicine, State-of-the-Art, 1979. Am Surg 48 (9): 487-494.
5) Myers, R.A.M. and Schnitzer, B.M. (1984): Hyperbaric oxygen usage: Update 1984. Postgrad Med 76 (5): 83-95.
6) Nylander, G., Nordstrom, H. and Eriksson, E. (1984): Effects of hyperbaric oxygen on edema formation after a scald burn. Burns 10: 193-196.
7) Fisher, B.H., Marks, M. and Reich, T. (1983): Hyperbaric oxygen treatment of multiple sclerosis: A placebo-controlled, double-blind study. N Engl J Med 308: 181-186.