

Occupational accidents in hyperbaric-chambers inside attendants in France

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KEY WORDS

Occupational medicine; hyperbaric chamber; accidents

PAROLE CHIAVE

Medicina occupazionale; camera iperbarica; infortuni

SUMMARY

Introduction: *The purpose of the study was to assess the number of accidents among staff employed in the operation of hyperbaric chambers in France.* **Materials and Methods:** *A retrospective study using a questionnaire was carried out on occupational accidents in France between 2005 and 2011.* **Results:** *12 (46%) centres participated in the study, representing 73 subjects. The mean age was 43.5 years (SD=9.73). They had worked in hyperbaric chambers for 9.8 years on average (SD=7.7). The average number of hyperbaric sessions was 198.3 per subject (SD=174.25), for a total of 8.072 hyperbaric sessions; 27% of the subjects reported that they had at least one accident during the study period. In all, 30 accidents were reported: 3 blood exposures, 4 accidents related to patient handling, 20 hyperbaric accidents; 3 other accidents. Of the hyperbaric accidents, 2 (10%) involved decompression sicknesses with cutaneous symptoms, 3 (15%) decompression illness (DCI), 14 (70%) ear traumatism, 1 (5%) dental accident. The incidences were 372 per 100,000 sessions in hyperbaric chambers (SHC) for all accidents, 248 per 100,000 SHC for hyperbaric accidents and 173 per 100,000 SHC for ENT barotraumas.* **Conclusion:** *The accidents involving staff operating hyperbaric chambers were mainly ear traumatism.*

RIASSUNTO

«**Infortuni professionali tra gli addetti nelle camere iperbariche in Francia**». **Obiettivo:** *Determinare il numero di incidenti occorsi tra il personale sanitario operativo nelle camere iperbariche in Francia.* **Metodo:** *È stato condotto uno studio retrospettivo utilizzando uno specifico questionario per far emergere gli incidenti sul lavoro occorsi nelle camere iperbariche in Francia tra il 2005 ed il 2011.* **Risultati:** *12 (46%) centri hanno partecipato all'indagine che ha messo in evidenza come siano avvenuti 73 incidenti nel periodo considerato. L'età media è stata di 43.5 anni (SD=9.73) avevano svolto la loro attività nelle camere iperbariche per 9.8 anni in media (SD=7.7 anni). Il*

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numero medio degli accessi per soggetto in camera iperbarica è stato di 198.3 ($SD=174.25$) per un totale di 8.072 sessioni. Il 27 % del personale ha riferito di essere andato incontro ad almeno un incidente sul lavoro nel corso del periodo studiato. In totale si è trattato di 30 incidenti di cui: 3 per esposizione a sangue e liquidi corporei; 4 nel corso dell'assistenza ai pazienti; 20 barotraumi: 3 infine di altro tipo. Tra i barotraumi, 2 (10%) sono stati caratterizzati da malattie da decompressione con manifestazioni cutanee; 3 (15%) da sindrome da decompressione (DCI); 14 (70%) da traumatismi auricolari e 1 (15%) da odontalgia. L'incidenza è stata di 372/100.000 sessioni nella camera iperbarica (SHC) per la totalità degli incidenti, 248/100.000 SHC per i barotraumi ed infine 173/100.000 per quelli auricolari. **Conclusioni:** In conclusione emerge come gli incidenti tra il personale sanitario addetto alle camere iperbariche siano prevalentemente di interesse O.R.L. Vengono infine presentate considerazioni sul modo di limitare questi incidenti sul lavoro adottando procedure attente e misure di controllo adeguate.

INTRODUCTION

Divers are exposed to several types of accidents such as lung or middle ear barotraumas, or decompression illness (DCI) with bubble formation. When accidents type 1 or type 2 occur, treatment is based on hyperbaric oxygen treatment. In addition, some diseases require treatment with hyperbaric oxygen, such as carbon monoxide poisoning (CO) or radiation injuries (4, 5). Hyperbaric oxygen treatment is performed by staff operating hyperbaric chambers.

These employees are exposed both to classical occupational risks and to high pressure exposure risks (like underwater divers). Incidence of hyperbaric risks in operating staff is difficult to estimate. According to some authors, hyperbaric therapeutic procedures are able to prevent barotraumas in staff. For example Witucki et al. and Cooper et al. showed no barotraumas during respectively 24,000 sessions spread over 28 years and 6,062 sessions spread over 14 years (2, 15). Hyperbaric occupational accidents have also been described (6).

In France, there are 23 civilian and 3 military hyperbaric chambers scattered all over the country. Staff operating these hyperbaric chambers are exposed both to hyperbaric risks and to care risks, such as occupational exposure to blood and body fluids (BBFs) or accidents related to patient handling (8). However, little information is currently available about accidents in hyperbaric chambers.

The purpose of this study was to investigate the incidence of accidents in hyperbaric chambers in France.

MATERIALS AND METHODS

A retrospective study based on an anonymous questionnaire was carried out. Questionnaires were sent to hyperbaric chambers in France in December 2011 and in May 2012. The survey covered all accidents, defined as events that led to medical referral or to a modification of hyperbaric session planning, which occurred between 01/01/2005 and 12/31/2011.

Subjects who worked in a hyperbaric chamber between 2005 and 2011 completed a questionnaire on:

- personal data: age, sex, medical history, treatment, smoking and alcohol consumption;
- professional data: profession, professional seniority, seniority in a hyperbaric chamber;
- hyperbaric profiles : number of sessions in a hyperbaric chamber (SHC) per year, number of SHC, depth, times, tables, leisure dives;
- they were also asked to fill in a questionnaire about various occupational accidents: BBFs, handling accidents, hyperbaric accidents and other accidents. For each one, they were asked questions about the consequences of the accident (symptoms and diagnosis, medical referral, treatment, sick leave).

Data were entered and analyzed on Epidata® software. The means and medians of the different parameters were calculated and the extremes were determined. Comparisons of categorical variables were performed using Pearson's χ^2 test or Fisher's exact test (depending on the validity conditions of parametric tests). Comparisons of quantitative variables were performed using variance analysis

test or the Kruskal-Wallis test (depending on the validity conditions of parametric tests) or linear regression. The level of significance chosen was $p < 0.05$.

RESULTS

12 (46%) centres participated in the study, representing a total of 73 operators. There were 36 (51%) nurses, 2 (3%) nursing aides, 13 (19%) hyperbaric technicians and 19 (27%) physicians. There were no differences between men and women as regards age, history or treatment (table 1).

The average number of SHC was 198.3 per subject (SD=174.25), for a total of 8.072 SHC (table 1). There was no difference as regards gender. Depth and duration of SHC increased with age and seniority ($p < 0.01$). Military staff had shorter SHC: 76 minutes on average *vs* 150 ($p = 0.02$). Nurses practiced longer SHC than other professions: 180 minutes on average *vs* 86 ($p = 0.03$). Doctors practiced SHC less often than other professions: 30 SHC per year on average *vs* 56 ($p = 0.03$). Concerning other dive parameters there was no difference between professions.

Twenty (27%) workers reported at least one accident during the study period. There were 30 acci-

dents: 3 BBFs, 4 patient handling accidents, 20 hyperbaric accidents; 3 other accidents. The hyperbaric accidents were mainly middle ear or sinus barotrauma (ENT barotrauma) (figure 1) (table 2).

The incidence of all accidents was 372 per 100,000 SHC; the incidence of hyperbaric accidents was 248 per 100,000 SHC; and the incidence of ENT barotrauma was 173 per 100,000 SHC.

Women and nurses had significantly more accidents: respectively 50% *vs* 20% ($p = 0.03$) and 42% *vs* 14% ($p = 0.01$). Doctors had significantly fewer accidents: 5% *vs* 37% ($p = 0.01$). Subjects who had had a hyperbaric accident practised SHC beyond 2.5 ATA more often per year: 12.2 *vs* 4.4 ($p < 0.01$). There were, however, no differences as regards the number or the duration of SHC.

DISCUSSION

This study showed that in hyperbaric chambers 27% of staff had at least one accident between 01/01/2005 and 12/31/2011. These accidents were mainly hyperbaric accidents, particularly ENT barotraumas. The incidence was 372 per 100,000 SHC for all accidents, 248 per 100,000 SHC for hyperbaric accidents and 173 per 100,000 SHC for ENT barotraumas. Women, nurses and the num-

Table 1- Description of sample

Item	Average (SD)	Median (extreme values)
Sex	Men 29 (59%)	Women 20 (41%)
Military or other	Military 4 (5%)	Civil 69 (95%)
Age	43.5 (9.7)	42 (26-60)
Seniority in the profession	17.2 (9.5)	16 (1-38)
Seniority in hyperbaric centre	9.8 (7.7)	8 (0.5-30)
SHC*/year/person	49.9 (39.5)	30 (3-120)
SHC*/person during study	198.3 (174.3)	141.5 (3-700)
Maximal pressure (ATA)	4.2 (1.5)	4 (1.5-7)
Time(min)	144.4 (132.6)	100 (15-480)
SHC at more 2.5ATA	6.8 (2.1)	3 (0-104)

*Session in hyperbaric chamber

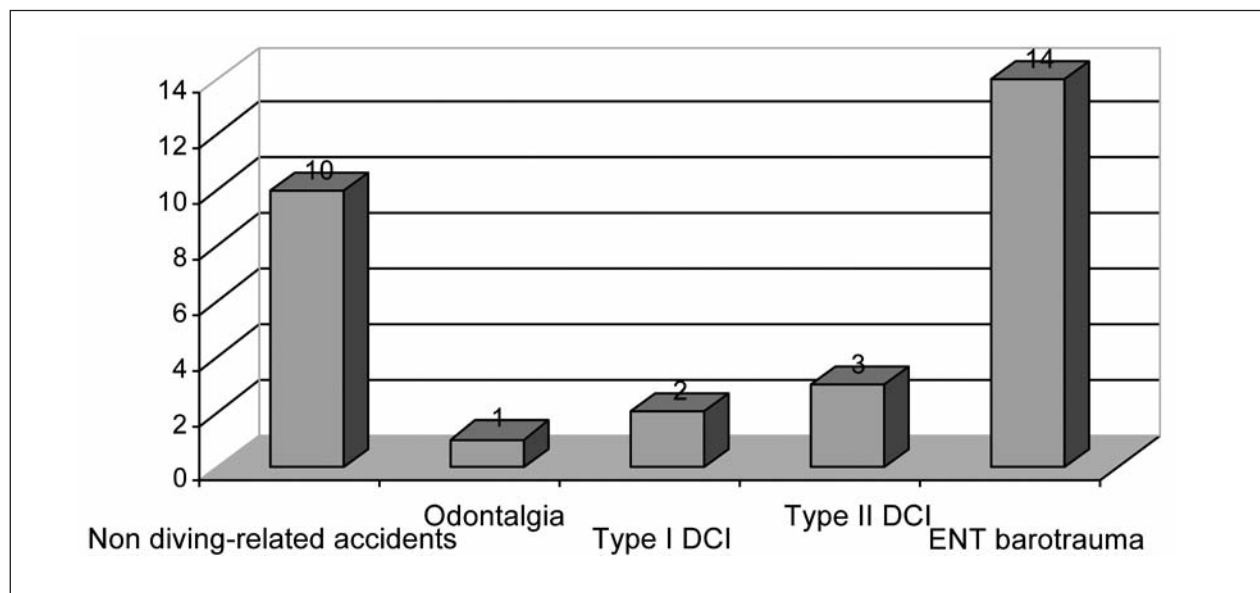


Figure 1 - Distribution of different types of accidents. DCI: decompression illness

Table 2 - Types of accident, diagnosis, modification of SHC, sick leave

Type of accident	N (%)	diagnosis	Sick leave
BBFs**	3 (10%)		Yes 0 (0%) No 3 (100%)
Handling accident	4 (13,3%)	1 Rhizarthrosis 1 Hernia 1 Sciatica	Yes 1 (33%) (22 days) No 2 (67%)
Hyperbaric accident	20 (66,7%)	1 odontalgia 14 ENT barotraumas 2 type 1 DCI 3 type 2 DCI*	Yes 2 (12%) (67 and 180 days) No 15 (88%)
Other accidents	3 (10%)		Yes 2 (67%) No 1 (33%)
Total	30 (100%)		Yes 5 (19%) No 21 (81%)

* 1 central neurologic accident and 2 inner ear accidents

** occupational exposure to blood and body fluids

ber of SHC over 2.5 ATA were significantly associated with hyperbaric accidents.

The scope of this study was limited because it was a retrospective study. However, it provides an

estimate of occupational risk concerning hyperbaric chamber staff. The results showed high incidence rates of occupational accidents in hyperbaric chambers. These were correlated to accidents in profes-

sional divers described in the literature; whose incidence rate is about 1 per 30,000 dives (4, 5). In our study the majority of hyperbaric accidents were ENT barotraumas. Some studies estimated prevalence of ENT barotraumas after diving as between 1 and 2 per 100 dives (10, 12). Staff who participated in the study had fewer ENT barotrauma risks than water divers. The risk of this kind of accident increases when dives are repeated (7).

The results showed several factors associated with accidents: being a woman and diving beyond 2.5 ATA. Several studies have shown a higher DCI incidence in women (13, 14). Several hypotheses have also been put forward to explain this fact: women have more fatty tissues, during menstruations water retention could hinder the elimination of inert gases etc. But this higher incidence was not found in all studies (3). One of the advantages of our study was to highlight that being a nurse and having an accident was statistically related. This should be considered in a preventive approach to better inform and keep a check on this occupational category.

For example, regarding hyperbaric accidents, adequate information should be given to avoid ENT barotrauma. These accidents are often caused by too rapid pressurisation, or by a lack of Eustachian tube function (11). Indeed, during pressurisation, equilibrium pressure level requires an ORL manoeuvre such as Valsalva. As a result, subjects with rhinitis should not do SHC if their Eustachian tube function is reduced. Moreover, some studies showed that Eustachian tube function decreases after 7 dives or SHC (7). Therefore, staff should not do too many SHC in one day. In addition, hyperbaric chamber workers should be aware that an ENT barotrauma requires medical referral. In fact, complications may occur such as vertigo caused by impairment of the inner ear. Finally, an ENT examination will be needed before the resumption of SHC.

Prevention of DCI is based on respect of pressure tables. Workers should also know the signs of type 1 DCI. Indeed, the risk of developing type 2 DCI exists when type 1 DCI occurs. A protocol of care should be implemented in each hyperbaric chamber. Information on the signs of DCI is par-

ticularly important as several cases have been described. The prognosis can be serious. One death was reported by a US team (9).

CONCLUSION

This study using a questionnaire was carried out to assess the incidence of accidents concerning staff operating in hyperbaric chambers: 30 accidents were reported between 01/01/2005 and 12/31/2011. The incidences were 372 per 100,000 sessions in hyperbaric chambers (SHC) for all accidents, 248 per 100,000 SHC for hyperbaric accidents and 173 per 100,000 SHC for ENT barotraumas. Being a nurse was associated with the occurrence of accidents. It is therefore important to remind hyperbaric chamber staff, especially nurses, of these occupational risks.

NO POTENTIAL CONFLICT OF INTEREST RELEVANT TO THIS ARTICLE WAS REPORTED

REFERENCES

1. Beauvais A, Frost L: Saving our backs: safe patient handling and mobility for home care. *Home Healthc Nurse* 201; 32: 430-434
2. Cooper PD, Van den Broek C, Smart DR: Hyperbaric chamber attendant safety II: 14-year health review of multiplace chamber attendants. *Diving and Hyperbaric Medicine* 2009; 39: 71-76
3. Ducassé JL: La femme et la plongée: aspects épidémiologiques, physiologiques et médicaux. In Broussolle B, Méliet JL, Coulange M (eds): *Physiologie et Médecine de la plongée*. Paris: Ellipses, 2006: 592-598
4. Feldmeier JJ: Hyperbaric oxygen therapy and delayed radiation injuries (soft tissue and bony necrosis): 2012 update. *Undersea Hyperb Med* 2012; 39: 1121-1139
5. Hampson NB, Piantadosi CA, Thom SR, et al: Practice recommendations in the diagnosis, management, and prevention of carbon monoxide poisoning. *Am J Respir Crit Care Med* 2012; 186: 1095-1101
6. Johnson-Arbor K: Type II decompression sickness in a hyperbaric inside attendant. *Under Hyper Med* 2012; 39: 915-919
7. Miyazawa T, Ueda H, Yanagita N: Eustachian tube function and middle ear barotrauma associated with extremes in atmospheric pressure. *Ann Otol Rhinol Laryngol* 1996; 105: 887-892

8. Musharrafieh UM, Bizri AR, Nassar NT, et al: Health care workers' exposure to blood-borne pathogens in Lebanon. *Occup Med* 2008; *58*: 94-98
9. No authors listed: Hyperbaric chamber nurse dies of decompression sickness; unit gets OK. *Hosp Secur Saf Manage* 1992; *13*: 3
10. Renon P, Lory D, Belliato R, et al: Les accidents de décompression de l'oreille interne lors de la plongée sous-marine. *Ann Otolaryngol Chir Cervicofac* 1986; *103*: 259-264
11. Renon P, Lory D, Belliato R: Pathologie ORL des plongeurs. *J Fr ORL* 1986; *35*: 223-229
12. Renon P, Jacquin M, Bruzzo M, et al: Accidents barotraumatiques de l'oreille et des sinus. In Brousolle B, Méliet JL, Coulange M (eds): *Physiologie et Médecine de la plongée*. Paris: Ellipses, 2006: 247-256
13. Robertson AG: Decompression sickness risk in women. *Undersea Biomed Res* 1992; *19*: 216-217
14. Robinson TJ: Decompression sickness in women divers. *Undersea Biomed Res* 1988; *15*: 65-66
15. Witucki P, Duchnick J, Neuman T, et al: Incidence of DCS and oxygen toxicity in chamber attendants: a 28-year experience. *Undersea Hyperb Med* 2013; *40*: 345-350