

STATISTICS RELATED TO SEVERE DIVING INJURIES AMONG POLISH DIVERS IN THE PERIOD BETWEEN 2003-2014

Jarosław Krzyżak

Polish Medical and Technical Hyperbaric Society in Gdynia, Poland

ABSTRACT

A review of the data collected from the available literature indicates that diving accidents are most commonly related to an improper behaviour of the victims, or other divers involved in the incident, as a result of either their lack of experience, recklessness or ignorance. Apart from the statistical data of DAN USA and the British Sub-Aqua Club it is difficult to obtain data collected by diving organisations. An analysis of diving accidents is instructive and provides a lot to consider for divers. Moreover, it may teach them to anticipate mistakes or even to avoid them.

Polish publications devoted to an analysis of diving accidents are scarce. The analysis presented below was based on a controversial source, a social-networking website of Polish divers – the "Nuras" Forum.

The website www.forum-nuras.com provides a tag marked as "Diving accidents" where the forum participants initiated 225 topics related to diving accidents that took place in the period between 2003-2014. From the above list 99 topics (44%) were selected, which were concerned only with Polish divers and encompassed only severe diving accidents resulting in the occurrence of decompression sickness, pulmonary barotrauma or in the divers' death. The analysis was concerned with estimating the number of recorded accidents in particular years and presenting the end result. Moreover, it provided a classification of places of accident occurrence: diving in lakes and seas, accidents in Poland and outside the country. Also, the work considered the potential causes leading to the unfavourable course of the fateful dives.

The 99 diving accidents reported in the forum affected 113 people. Six of the cases among them (5.3%) involved pulmonary barotrauma, 28 (24.7%) decompression sickness and as many as 79 (70.0%) - the divers' deaths.

Key words: Diving accidents, diving injuries, decompression sickness, pulmonary barotrauma, fatalities among divers.

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INTRODUCTION

At present, recreational diving is almost a mass phenomenon, particularly in the context of the development of tourism in places with interesting bodies of water, diving schools and easy access to diving equipment. What over ten years ago was considered an elite sporting activity today may be taken up by people of all age groups, with a constantly increasing number of women divers.

The growth in the number of divers has led to an increase in the number of diving-related accidents and health conditions.

In the studies implemented by DAN USA and DAN Europe, among numerous different injuries suffered during diving, only 0.9% involved problems related to decompression. In 1993 DAN Europe estimated this risk as occurring in 1/10,000 dives [1].

According to the data from the PDE programme, at the end of 2003 only one case of decompression sickness was reported among amateur divers per 2439 dives, which results in the risk of its occurrence of 4/10,000 dives, i.e. much higher than that estimated by DAN Europe in 1993 [2]. A similar indicator was estimated in 2006 [3]. In 2010 the same risk already concerned 3 such cases per 10,000 dives [4].

Decompression sickness constitutes the main and the most serious risk related to diving; however, it is relatively rare among recreational divers. In concord with the available statistics, the number of cases of this condition in amateur divers in the period of the last 10 years has been maintained at a constant level despite the considerable increase in the number of people taking up this sport discipline.

On the basis of the available data it is possible to assume that the level of safety of recreational dives has significantly increased. This is further influenced by an increase in the quality of diving training as well as good information and analysis regarding diving accidents.

The general number of injuries connected with diving is lower as compared with other sports. Among them as many as 98% are injuries caused by ear and sinus barotrauma or various environmental factors connected with diving. The diving statistics of DAN show that each year 15-18 amateur divers and less than 4 professional divers out of 100,000 lose their lives [1, 2, 3, 4].

This indicates that diving is 50 times more dangerous than driving.

A review of the data collected from available literature shows that diving accidents are most commonly related to an improper behaviour of the victims or other divers as a result of a lack of experience, recklessness or ignorance [1-4, 5, 6]. It is difficult to reach the statistics of CMAS, IDA, PADI or SSI, as they are probably not properly collected at all. Even DAN USA has ceased to publish its annual reports.

The last of them appeared in 2009 and concerned the data for the year 2007. Besides the current reports on diving accidents published on various internet websites the available statistics are those carried out by the British Sub-Aqua Club, which registers nearly 400 accidents on a yearly basis [7].

Mastering the diving technique and obtaining the necessary theoretical knowledge has a significant impact on the number of diving incidents and the occurrence of different health conditions during diving.

An additional factor that could make a contribution towards minimising the number of adverse events under water is an analysis of diving accidents, i.e. an analysis of mistakes made by the victims. The majority of diving accidents are the result of mistakes made by divers themselves and rarely involve failures of the diving equipment.

An analysis of diving accidents is instructive and provides a lot to consider for divers. Moreover, it teaches them to anticipate mistakes or even to avoid them. Polish publications devoted to the analysis of diving accidents are scarce. Of course accidents among Polish divers also take place; however, the information regarding them is not easily accessible.

The first analysis of medical conditions occurring among divers was prepared by Prof. K. Ulewicz and appeared in 1960 [8]. Another, by J. Krzyżak, was published 28 years later and described the cases of 33 divers (on average 8 people/year) treated with hyperbaric oxygenation at the Diver Training Centre of the Polish Army in the years 1983-1986 [9]. Since 1986 the facility treating divers after accidents in Poland is the Clinic of Hyperbaric Medicine and Maritime Rescue of the University Centre of Maritime and Tropical Medicine in Gdynia.

Although the clinic was raised to the rank of the National Centre of Hyperbaric Medicine (KOMH) in 1998, and despite the opening in the year 2000 of a DAN Poland office there, the first report concerned with diving accidents involving 51 divers (on average 10 people/year) from the period 2003-2007 [10] was published as late as in 2008.

Previous reports were concerned with occurrences in diving that did not result in the diver's death. In 2008, S. Poleszak presented an analysis of 60 fatalities (on average 7 people/year) among Polish divers from the period between 1999-2007. The analysis was conducted by a legal expert on the basis of data from accidents provided for this purpose by the court [11].

The presented reviews give a general idea about the number of severe diving accidents and deaths related to diving. It seems that the data are incomplete as not all the people suffering from decompression sickness were referred to a hyperbaric treatment chamber, whether that be at KOMH or anywhere else. Some mild cases of DCS receive initial treatment in the nearby hospitals. We may ask: Why?

On the other hand, presumably not all cases involving divers' deaths in the course of diving were taken into consideration in the course of analysis conducted by the legal expert.

The analysis presented below was based on a controversial source, a social-networking website of Polish divers – the "Nuras" Forum. Certainly the above source does not provide a complete and entirely reliable research material.

The first records were noted in April 2003, and by the end of October 2014 it already had 10,300 registered users. In over 11 years of the forum's existence over 24,000 topics were initiated with over 300,000 posts.

MATERIAL AND METHOD

The website www.forum-nuras.com [12] provides a tag marked as "Diving accidents" where the forum participants initiated 225 topics related to diving accidents that took place in the period between 2003-2014.

From the above list 99 topics (44%) were selected, which were concerned only with Polish divers and encompassed only severe diving accidents resulting in the occurrence of decompression sickness (DCS), pulmonary barotrauma (PB) or in the divers' death.

The analysis was concerned with estimating the number of the recorded accidents in particular years and presenting the end result.

Moreover, it provided a classification of places of accident occurrence: diving in lakes and seas, accidents in Poland and outside the country. Also, the work considered the potential causes that lead to such unfavourable turns of

events during diving. The 99 diving accidents reported in the forum affected 113 people.

RESEARCH RESULTS

In the analysed period as many as 70% of accidents (79 people) resulted in the diver's death.

This amounts to an average of 7 fatalities per year. Decompression sickness was observed in 25% of divers (28 people). Pulmonary barotrauma was recognised only in 6 people – 5%, in whom the diving process resulted in death.

Tab. 1.

List of consequences of the 99 diving accidents, in which 113 people were involved, as reported on the "Nuras" Forum.

Year	Death	DCS	PB	Total
Since 10/04/2003	1	1	1	3
2004	7	6	1	14
2005	4	1	1	6
2006	5	2	0	7
2007	8	0	1	9
2008	10	1	1	12
2009	3	1	0	4
2010	11	5	0	16
2011	11	0	1	12
2012	10	1	0	11
2013	4	7	0	11
Until 31/10/2014	5	3	0	8
Total:	79	28	6	113

Among the 113 people who were involved in diving accidents, 72 – 64% were involved in accidents that took place in Poland, whereas 41 – 36% during diving

trips organised abroad. The majority of them, 67 – 59%, occurred in the course of diving in inland waters (lakes, quarries, caves), and 46 – 41%, during sea dives.

Tab. 2.

List of locations of diving accidents registered on the "Nuras" Forum.

Where?	Number	Where?	Number
Poland	72	Lakes	67
Abroad	41	Seas	46
Total:	113	Total:	113
Lakes in Poland	54	Lakes outside Poland	13
Polish Baltic	18	Seas beyond Poland	28
Total:	72	Total:	41

There are many interesting and popular diving places in Poland. Dives are mainly performed in lakes, old quarries and in the Baltic (mostly dives to shipwrecks). The majority of tragic events took place in Hańcza Lake, which is a real Mecca in relation to inland deep dives. In the analysed period this is where the majority of the fatal accidents and severe DCS incidents were noted. Table 3 contains the list of places in which the discussed diving accidents occurred.

Apart from Poland, the majority of tragic accidents (44%) were reported in Egypt (9 deaths and 9 DCS cases) while diving in clear, warm water. In 6 cases

death occurred following very deep technical dives, whereas the remaining 3 cases involved divers being run over by motorboats.

In as many as 90% of cases, severe DCS appeared following dives performed in Egypt. In 2 cases it occurred following deep dives below 60 m, whereas in 7 remaining cases it was noted in participants of the famous diving safaris, i.e. after 4-5 dives performed in a 24-hour period. The money-thirsty "Diver Killers" caught their "Rookie Divers" and the end result was inevitable.

Tab. 3.

The list of popular bodies of water within Poland in which diving accidents were reported (n = 72).

Location of accident	Number	Death	DCS	PB
Hańcza Lake	19	9	9	1
Łęsk Lake	8	4	2	2
Zakrzówek Quarry	6	4	0	2
Powidzkie Lake	3	3	0	0
Koparki Quarry	2	2	0	0
Piechcin Lake	2	2	0	0
Other lakes with 1 reported accident	14	13	0	1
Total:	54	37	11	6

Location of accident	Number	Death	DCS	PB
The Baltic Sea	18	11	7	0
Total:	72	48	18	6

The other places among the infamous statistics of diving accidents involving Polish divers are: a quarry in the Czech Republic (Svobodne Hermanice) and a deep Alpine lake on the Attersee in Austria.

No reports of pulmonary barotrauma were registered with regard to dives performed outside Poland.

Tab. 4.

List of diving accidents recorded outside Poland (n = 41).

Country	Number	Death	DCS
Australia	1	1	0
Austria – Attersee	3	2	1
The Czech Republic – Svobodne Hermanice	6	6	0
Croatia	3	3	0
Egypt	18	9	9
France – caves	2	2	0
Ireland	2	2	0
Malta	1	1	0
Germany	2	2	0
Norway	2	2	0
Slovenia	1	1	0
Total:	41	31	10

The next table provides information concerning the age of the divers involved in diving accidents. These data were very incomplete in the source material. In as many as 48% of accident descriptions of the age of the divers participating in them was not specified.

However, on the basis of the available data we see that over 40% of deaths concerned divers aged between 31-50 years. Very little is known about the age of 28 divers who suffered from the decompression sickness. In 3 cases these were persons in the age between 21-30 years, whereas 1 person was over 60 years old.

With regard to the few cases of pulmonary barotrauma, the age of 50% of divers is not known; however, what deserves attention is 1 case involving a child aged less than 10 years.

This illustrates the problem of allowing children to participate in equipment-based diving much too soon, making them susceptible to diving injuries.

Ages of divers involved in diving accidents (n= 113).

Diver's age	Death	DCS	PB
Age of the victim unknown	27	24	3
up to 10 years			1
11-20 years	2		1
21-30 years	12	3	
31-40 years	14		1
41-50 years	18		
51-60 years	4		
over 61 years	2	1	
Total:	79	28	6

Tragic diving accidents are noted practically at every depth. The depth of critical diving was unknown only in 25% of cases. It is not known at what depth were the 18 divers (23%) who lost their lives.

The available data indicate that the majority, i.e. 31 people (40%) died while performing shallow dives with P1 (PADI1) or OWD (Open Water Diver) qualifications, i.e. up to the depth of 20 m.

As many as 11 divers lost their lives at the depth greater than 51 m, with 6 of them occurring during dives exceeding 100 m. Half of the divers with reported DCS were diving at a depth below 31 m, with most of them at depths exceeding 41 m.

Tab. 6.

List of diving depths at which the accidents occurred (n = 113).

Depth	Death	DCS	PB
Unknown diving depth	18	10	
up to 10 m	16		3
11-20 m	15		3
21-30 m	6	4	
31-40 m	8	3	
41-50 m	5	5	
above 51 m (including 6>100m)	11	6	
Total:	79	28	6

An analysis of the causes of diving accidents discussed on the "Nuras" Forum provides very interesting results. It is not surprising that among the 6 cases of pulmonary barotrauma 3 were caused by a rapid ascent.

In 1 case the trauma occurred following the diver's vomiting under water. Two divers developed pneumothorax after diving, which was treated in the hospital closest to the place of the incident, and 2 PB cases were referred for treatment at KOMH.

Nearly half of the divers (13 people) suffered from DCS due to rapid ascents related to problems that occurred under water, 8 people carried out insufficient decompression, and 7 were the "victims" of a diving safari in Egypt.

In 5 divers, the "Egyptians", DCS symptoms occurred on a flight back to Poland, with 3 people referred for treatment at KOMH. Among the Polish divers with DCS, 12 people underwent treatment at KOMH, whereas 2 divers were treated in a hospital near the place of diving. It is not known what happened with 11 people after the DCS symptoms were confirmed.

Amidst the analysed fatalities listed in Table 7, according to the descriptions, the majority (16 cases – 20%) were caused due to a loss of consciousness under water for unknown reasons.

What is very disturbing is that in 13 cases (16.5%) the cause of the tragedy was getting lost under water, i.e. the separation of the diving pairs. This illustrates a lack of care of the diving partner in the widely promoted pair-diving (buddy diving) as well as significant training deficiencies. Some of the descriptions are shocking. A pair conducts the first dive in Poland after training conducted in Egypt. In Budziszławskie Lake, a man loses touch with a woman that is later found by others at the depth of 6 m without a mask or a snorkel and with her cylinder turned off. In Zakrzówek, a group of 10 divers lose their colleague under water with others finding his body at 22 m. In Hańcza Lake, an instructor loses his trainee with OWD licence, and his body is later found at 41 m.

In as many as 14 cases (18%) the diver's death is a result of a rapid ascent. In 11 cases, the divers'

symptoms on the surface pointed to severe pulmonary barotrauma, whereas in 3 to severe decompression sickness.

The so-called heart attack was determined as the cause of death in 10 divers, which, in 5 people, occurred

shortly after diving completion. Seven of them were aged between 42 and 66, and the body weight of one of them reached 140 kg.

Tab. 7.

List of the causes of death in divers on the basis of the data available on the "Nuras" Forum.

No.	Cause	Number
1	Loss of consciousness under water	16
2	Getting lost under water	13
3	Rapid ascent → UCP	11
4	Heart attack (including that after the fifth dive)	10
5	Diving in ship wrecks	7
6	Deep technical dive	7
7	Diving with rebreather	4
8	Advanced training	4
9	Diving training	4
10	"Solo" diving	4
11	Cave diving	4
12	Rapid ascent → DCS	3
13	Diving under ice	3
14	Diver overload	3
15	Run over by a motorboat	3
16	Snorkelling	2
17	Diving cylinder explosion	2
18	Deep dive on air - 72 m	2
19	Exhaustion - strong current	1
20	Punctured dry suit	1
21	Night diving	1
22	Underwater explosion (militaria collector)	1

Difficult specialist dives caused death in as many as 26 people (33%). Seven people lost their lives during wreck dives, another 7 during deep technical dives, 4 divers with rebreathers, 4 during cave diving and 4 in the course of further training. A lack of a securing line resulted in 3 fatalities during dives under-ice.

Four deaths were reported to have taken place during diving training. Among them, one person was lost under water by the instructor, in another case the instructor did not prevent the rapid ascent of the trainee, one person was not successfully brought to the surface after the loss of consciousness under water, and one died as a result of a heart attack. Four people died during "solo" dives, with one of them diving alone at night.

A lack of experience and skills constituted the cause of death in 9 divers (11%). Diver overload was the cause of death of 3 people. Deep diving on air ended tragically for 2 people (78 m and 62 m with P1).

Poor snorkelling skills in the conditions of high waves were tragic for 2 people, and exhaustion while diving in the conditions of a strong current resulted in the death of 1 person. One person died as a result of the ingress of water into a punctured diving suit.

DISCUSSION

There is no better method of learning than to reflect on one's own mistakes. The knowledge obtained this way is the most permanent and acquired most knowingly. Unfortunately, this method has no application in relation to diving. The threat caused by a diver's error is so large that the first mistake may well be the last one. Thus, it is necessary to learn on the mistakes of others.

The above research material may seem controversial and unreliable from a scientific perspective. Nonetheless, an analysis of the data obtained from a somewhat "gossipy" communication between the divers of the "Nuras" Forum provides information which is definitely worth pondering upon.

The fact is that more credible information obtained from scientific institutions is practically unavailable. It is small consolation that analyses prepared by the authors from DAN USA, Great Britain, Australia and other countries are also based on incomplete data collected among diver communities.

Eye witnesses to tragic events, other divers, describe what they have seen and what shocked them. This usually opened an instructive discussion on the

causes of particular occurrences, the mistakes made by divers and ways to prevent tragedies. It was always a kind of a lesson for future divers.

The descriptions of those incidents also refer to the shocking atmosphere which is not that rare at the so-called "diving camps". Weekend diving picnics held by Hańcza or Zakrzówko Lakes were not disturbed by tragedies taking place at the neighbouring diving stations.

The passive attitude of divers remaining on the shore towards the tragedy of other divers was described on several occasions, as well as the passive attitude of those that had lost their diving partners. Those in need were not provided support because, quote: "It seemed that they were carrying out rescue drills?!"

Usually a diver's accident and death are not caused by an isolated factor. Most commonly it is a result of the coexistence or overlapping of a number of errors committed in the wrong place and time where there is no safety margin allowing their correction. A diver's death is never caused by a single unfortunate incident. It is always a series of events starting prior to the diver's immersion.

According to a well-known diving instructor, T. Strugalski, a diving accident, i.e. such an aberration of the diving plan which involves a threat to health or life, stems exclusively from errors committed by man [13]. This is in line with an analysis of 1,000 tragic accidents of Australian divers conducted by Acott in 2005 [6]. In as many as 87% of cases the incidents resulted from human mistakes, in 14% from a lack of experience, and in 8% from insufficient training.

In the presented analysis, among the 113 victims of the recorded accidents there was a relatively small number of cases of decompression sickness and pulmonary barotrauma. In foreign reports, DCS cases constitute 80-90% of all severe diving injuries.

Approximately 5-8% are the cases of arterial embolism, while the cases involving divers' deaths are marginal [2, 3, 4].

The reversal in the proportion of registered injuries raises the suspicion that a large number of DCS and PB have not been reported. Many divers consider the fact of DCS occurrence as a dishonour and prefer to treat the light cases themselves immediately after diving by breathing oxygen or choose to suffer secretly at home. Based on my own experience I know that numerous divers with a long-term practice are in fact not familiar with primary symptoms of decompression sickness.

American statistics for the period between 1970-2010 report that annually on average 125 divers (66-147 people) die in America, Europe and Asia, including 50-60 people in the USA only [4]. In the report made by Poleszak, on average 7 Polish divers lose their lives per year, which is similar to the presented analysis [11].

In the analysis of 947 deaths among divers in the period between 1992-2003 carried out by Denoble and others, the authors managed to determine their precise causes in 814 cases. In as many as 70% of victims, the cause of death was drowning, 14% of divers lost their lives as a result of arterial air embolism, 13% due to cardiological conditions, 2% as a result of decompression sickness and 1% due to inflicted injuries [14].

In the analysis of Table 7 of the list of causes of death among Polish divers we may conclude that the end result of the tragic incidents was similar to that obtained by Denoble and others, which is provided in the next table.

Tab. 8.

List of the determined and alleged causes of death in divers acc. to P. Denoble and J. Krzyżak.

No.	Cause of death in %	P. Denoble n = 814 1992- 2003	J. Krzyżak n = 79 2003- 2014
1	Drowning	70	64
2	Arterial gas embolism - UCP	14	14
3	Cardiological conditions	13	13
4	Decompression sickness - DCS	2	4
5	Injuries	1	5
Total:		100	100

In the same report [14] it was possible to determine the factor responsible for accident initiation in 346 out of 947 cases. In 41% of occurrences it rested in running out of gas, in 20% - entrapment, and in 15% - equipment failure.

The situation is similar with regard to determining the main factor occurring during a critical moment while under water, thus causing the diver to be incapable of undertaking rescue activities. In 332 out of 947 cases, 55% involved an uncontrolled rapid ascent, in 27% running out of gas and in 13% of cases problems with buoyancy.

Numerous statistical analyses related to diving accidents draw attention to the fact that a large percentage of tragic dives involve older people. In 2008, Vann R. and others reported that 82% of women and 72% of men who died during diving were aged over 40, with the average age of women being 43 years and of men - 50 years [3]. In the discussed analysis, 30% of fatalities were divers aged over 40.

In conclusion to this sad analysis of accidents among Polish divers it is necessary to state that many of those tragedies could have been avoided if both the divers and the victims properly planned their dives, observed the principles of good diving practice, implemented the



rules of buddy diving and adjusted their plans to their actual capabilities.

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Jarosław Krzyżak MD, PhD

ul. Nizinna 3 A m. 3,

84-230 Rumia,

tel. 501 288 866

e-mail: jaroslaw.krzyzak@wp.pl