

DIVERS' DEATHS IN SPLIT-DALMATIAN COUNTY, CROATIA (CASES STUDY, 1994-2004)

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SUMMARY

The circumstances which lead to divers' death in Split-Dalmatian County in eleven-year period (1994-2004) were analyzed. The data were extracted from the files of autopsy reports of the Department of Forensic Medicine, Split University Hospital and School of Medicine, and the police reports of the Ministry of Internal Affairs, Split-Dalmatian County. A total of 31 cases were found during the study period. The number of diving deaths didn't vary significantly through the years 1994-1999 but it increased after year 2000, mostly as a result of domestic and foreign tourists who practiced diving during their summer vacation. The average age of victims was 37.65 years. Of the 31 cases, 13 (41.9%) were apnoea (skin) divers and rest of them (18; 58.1%) were scuba divers. The leading activity of the apnoea divers was underwater fishing, while the majority of scuba divers were in recreational diving. The major cause of death was drowning. The circumstances which had led to the death remained unknown in most cases, mainly due to inexistence of proper criminal investigation.

Key words: diving, drowning, epidemiology

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INTRODUCTION

According to the unofficial data, some 100.000 scuba divers dive annually in the Republic of Croatia, mainly during summer period. The number of apnoea divers still remains unknown. Despite their relatively infrequency, fatal diving accidents are tragic events, and, as popularity increases, the incidence of related fatalities is also likely to increase. In the most lethal cases drowning is a direct cause of death (1). However, it is always indispensable to determine all preceding occurrences and to examine all circumstances that could lead to death.

The aim of this paper is to analyse divers' death in Split-Dalmatian County in eleven-year period (from year 1994 till 2004) and to clear the ways and reasons which led to occurrence of this events, as well as, if possible, to identify certain preventive activities whose intention would be to reduce their number.

MATERIAL AND METHODS

The data about causes and circumstances of divers' deaths in period from year 1994 till 2004 were extracted from the files of autopsies' reports of the Department of Pathology and Forensic Medicine, Split University Hospital and School of Medicine and the police reports of the Ministry of Internal Affairs, Split-Dalmatian County.

The following parameters were observed: sex, age, nationality, location of the event, time of the event, weather conditions, depth and type of the dive, purpose of diving, use of signal buoy, cause of death and health condition of the victim.

All data were statistically analyzed and presented in tables and charts.

RESULTS

In the observed period there were 31 deaths related to diving. The largest number of diving related deaths was in year 2002 (Figure 1).

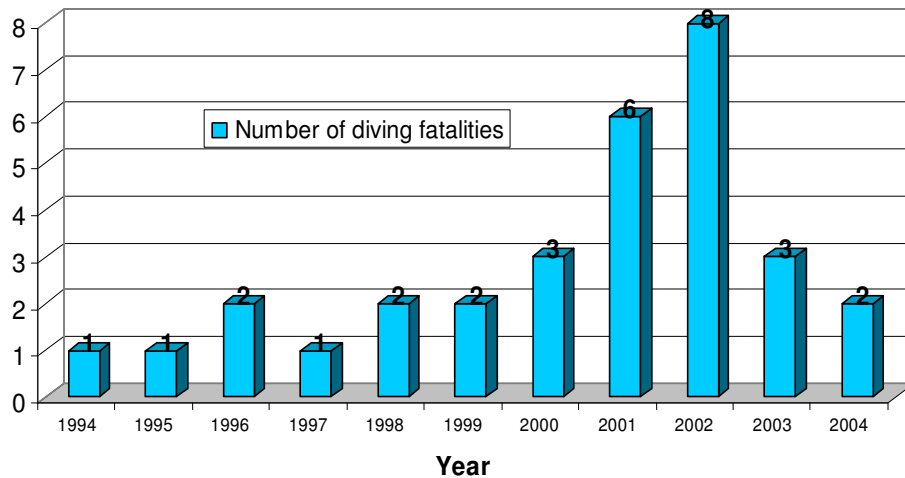


Figure 1. Number of diving fatalities through years (1994-2004) in Split-Dalmatian County.

The average age of all victims was 37.7 years (SD \pm 14.1 years). The most of the victims were from the age group of 20 to 29 years (35.5% of all victims) (Figure 2).

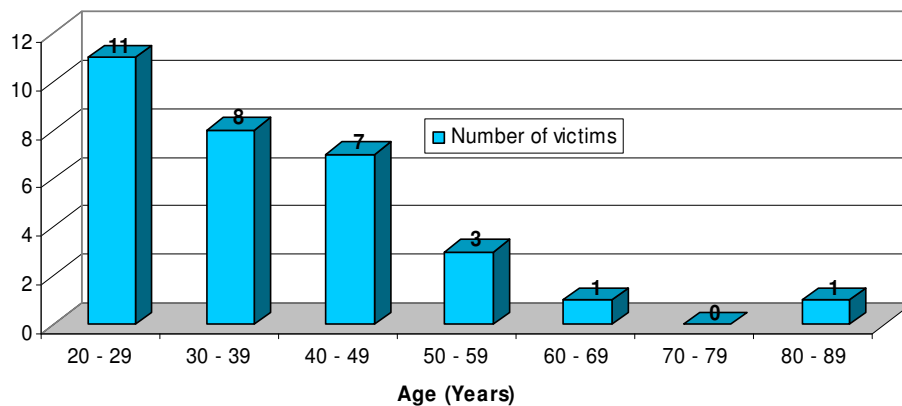


Figure 2. Age distribution of the victims (1994-2004) in Split-Dalmatian County.

Out of 31 victims, 30 victims were men whose average age was 37.4 years (SD ± 14.3 years; the youngest was 20 years old, and the oldest was 82 years old). There was one woman 46 years old.

Eleven victims were foreign citizens (35.5%), and 20 victims were citizens of Republic Croatia (64.5 %) (Table 1).

Table 1. Nationality of the victims (1994-2004) in Split-Dalmatian County

Nationality	Number	Portion (%)
Austrian	1	9.1%
Czech	6	54.6%
Hungarian	3	27.3%
Slovenian	1	9.1%
Total	11	100.0%

The most diving accidents occurred during the summer period from June to September (25; 80.7% respectively) (Figure 3).

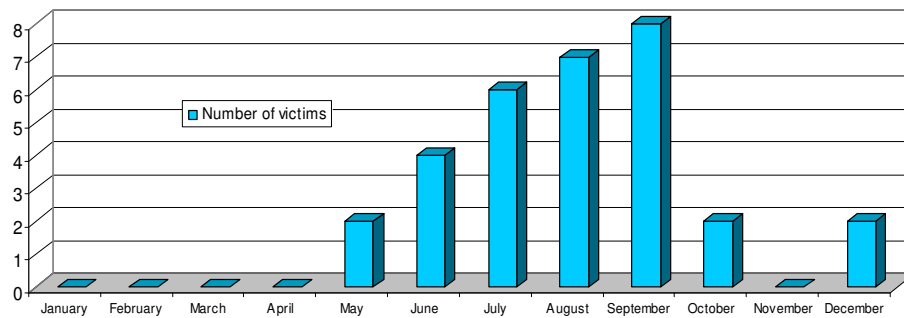


Figure 3. Number of diving fatalities considering time of year (1994-2004) in Split-Dalmatian County.

Out of 31 victims, 13 (41.9%) were apnoea divers, and 18 (58.1%) were scuba divers (Figure 4). All apnoea divers were citizens of Republic Croatia. Out of 18 scuba divers, 11 (61.1%) were foreign citizens, and 7 (38.9%) were domestic citizens.

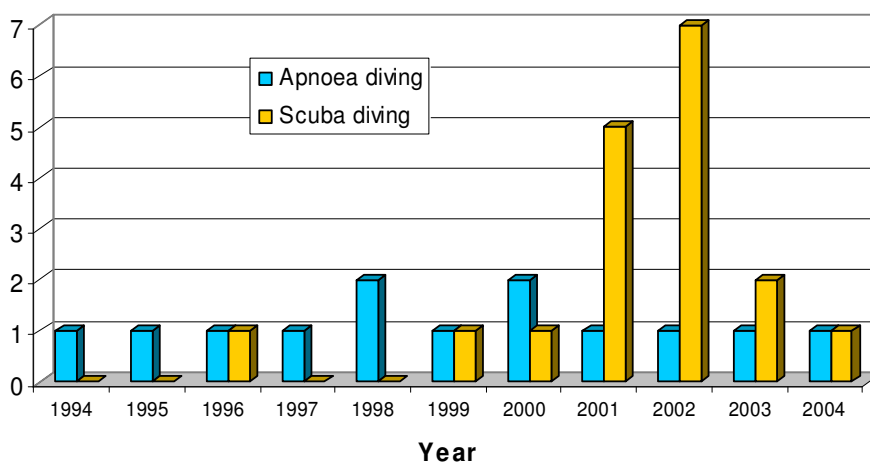


Figure 4. Types of diving through years (1994-2004) in Split-Dalmatian County.

Twenty divers were diving in the purpose of recreational diving, eight divers were doing underwater fishing and remaining three divers died during their job as professional divers. All divers who were practicing underwater fishing were apnoea divers.

Of all apnoea divers (13) one (7.7%) was diving accompanied with a diving buddy, and three (23.1%) were using signal buoy. Eight (44.4%) out of 18 scuba divers were diving in group, 5 (27.8%) were diving in a pair, 4 (22.2%) were diving alone and for one remaining diver we had no data (Table 2).

Table 2. Comparison of diving manner between apnoea divers and scuba divers (1994- 2004) in Split-Dalmatian County

	Apnoea divers	Portion (%)	Scuba divers	Portion (%)
Diving in group	0	0.0%	8	44.4%
Diving in pair	1	7.7%	5	27.8%
Diving alone	12	92.3%	4	22.2%

All 8 scuba divers who were diving in group were foreign citizens.

All scuba divers had passed the diving exam and all of them had diving licences. Data about their readiness and experience were unknown.

Thirteen out of eighteen deceased scuba divers and one apnoea divers were not diving alone. In that 14 cases the circumstances during the incidents were known for eight of them. Four deaths occurred during the ascent, two during descent and two divers lost their conscience at the depths from 30 to 35 meters.

In 3 cases the diving buddy who accompanied the deceased diver was also injured. In one case both divers who constitute a pair died. In the remaining two cases the diving buddy of the deceased diver developed the symptoms of decompression sickness after the ascent.

Three scuba divers intentionally violated the rules of safe diving despite the warnings of the diving instructor or the group leader. First deceased diver dived without permission of the diving instructor. Another one was in a small group of divers which separated from the larger group without permission. And the last deceased diver was diving alone despite the warnings.

Autopsy was performed over twenty nine bodies (in two remaining cases autopsy wasn't performed by the decision of investigative judge). The most common cause of death (25 out of 29 autopsied bodies, 86.2% respectively) was drowning (Table 3).

Table 3. Causes of death in autopsied divers (1994-2004) in Split-Dalmatian County

Cause of death	Number of victims	Portion (%)
Drowning	25	86.2%
Drowning due epileptic attack	1	3.5%
Stab wound and drowning	1	3.5%
Decompression sickness	1	3.5%
Lung barotraumas	1	3.5%
Total*	29	100.0%

* In two cases the autopsy was not performed

Two divers were epileptic and one diver was drug addict for many years. One diver suffered from diabetes and arterial hypertension. For two deceased divers autopsy revealed mild and severe atherosclerosis of the blood vessels. One diver had liver cirrhosis and one of his kidneys had been operatively removed. In one case the deceased diver was an invalid of war without both fists and forearms and he was using prostheses. Toxicological results were positive on alcohol in two cases (one was apnoea diver and another one was scuba diver). In one diver the toxicological analysis was positive on methadone.

The diving gear expertise in two cases prove gear malfunction. In one case the diving gear which was used during the incident was obsolete.

Weather conditions during time of accident were known in four cases. In two cases the strong wind was blowing from south-east in addition with rain and wavy sea. In other two cases the weather was calm and sunny. Two divers died after they were lost in underwater cave during the conditions of darkness and extremely low visibility caused by turbidity of water with mud from the bottom. Two professional divers lost their lives after they enmeshed in rope during work on the sea floor.

DISCUSSION

There were 31 diving related fatalities during the period from year 1994 till 2004 in Split-Dalmatian County. Number of diving fatalities didn't change significantly during the observed period, but it increased after year 2000, and reached the maximum in year 2002 when there were 8 diving fatalities. Increased number of them can be explained by the increased number of domestic and foreign tourists that dive in this area during their summer vacation.

In behalf to the statement mentioned above goes the data that from total number of diving fatalities which included foreign citizens during the observed time period, 90.9 % of them died during the period from year 2000 till 2004. The majority of deceased divers were Czech nationality.

Among deceased divers was only one woman. This data confirms that the diving is still "masculine" sport and respectively that male divers are more common in this sport (2). That specially refers to apnoea diving. Besides that, women in general are more obedient to rules of safe diving, while men are liable to risky behaviour during the dive which is another reason of reduced mortality of women divers (3, 4).

When we classified the deceased divers in age groups it can be seen that 83.9 % of deceased divers were younger then 50 years. The third of all deceased divers belonged

to the age group from 20 to 29 years. That result can be explained by the statement that the younger people more often practice diving than the older ones.

Adriatic Sea is a warm sea and one can dive in it during whole year. Our results confirm that the most dives occurred during the warmer time of year, when the diving is more pleasant (5). Analyzing occurrence of diving fatalities during the time of year it can be seen that the most accidents occurred during the warmer time of year, hence the summer. Accidents occurred starting from May and their number increased during the summer reaching the maximum in September.

Out of 31 deceased diver in total, 13 (41.9 %) of them were apnoea divers, and the rest (18, 58.1 % respectively) were scuba divers. Considering activity performed by the deceased diver during the fatal dive it can be seen that the most common reason for diving among deceased divers was recreational diving (64.5 % of all cases). On the second place was underwater fishing (25.8 % of all cases). Diving fatalities which occurred during work by professional divers were the rarest (9.7 % of all cases). It is important to point that all deceased divers who were practising underwater fishing were apnoea divers and local residents. Opposite to them, majority of deceased scuba divers were foreign citizens (61.1 %). The most common reason for diving among deceased scuba divers was recreational diving (83.3%). All scuba diver had passed the diving exam and all had valid diving licence, however the data about their qualification and experience were unknown.

Considering obedience of safety criteria, differences between these two types of divers can be seen. Apnoea divers less obey the rules of safe diving. Results show that 92.3 % of all deceased apnoea divers violated basic rule of safe diving and that is to never dive alone. Only one deceased apnoea diver had diving buddy which wasn't in vicinity of him during the time of accident. The reason why majority of divers who practice underwater fishing are diving alone is the fact that the underwater fishing is considered an individual sport and it would be impossible for two divers to be close to each other without scaring each other's pray.

Deceased scuba divers in 72.2 % of cases didn't dive alone. Eight (44.4 %) deceased scuba divers were diving in group. All diving groups were organized by diving schools or diving clubs. All deceased scuba divers who were diving in group were foreign citizens.

Considering the number of diving fatalities during observed time period, it can be seen that the number of apnoea diving fatalities didn't change. It was a one to two deceased apnoea diver per year. Situation with scuba divers is different. During the period from year 1994 till 1998 only one scuba diver died. The number of that fatalities increased reaching its maximum during year 2002 when 7 scuba divers died.

The most common cause of death, in 25 autopsied bodies, was drowning (in 86.2 % of all autopsied bodies). That results prove already known fact that drowning is the most common cause of death in majority of divers, after they, for any other reason, lost their conscience or their ascent was prevented by any other way (5,6).

The toxicological analysis was positive on methadone in one diver who was a treated drug addict. Presence of alcohol in blood was proven in two deceased divers. One was an apnoea diver and another one was a scuba diver. Presence of these substances in diver's blood influences significantly on the level of judgement and rationality of decisions, and it is considered as an important predisposition factor of diving accidents. That effect is specially emphasised during diving on compressed air. In those situations the effect of these substances is enhanced by the narcotic effect of inert gasses which are inhaled under increased pressure (7).

The expertise was performed over a diving gear which was used by the deceased diver during the fatal dive. The expertise showed irregularities in two cases. Both divers who were using that equipment were diving alone.

Circumstances which led to diving fatalities in most cases remained unknown. The apnoea divers were usually diving alone so there were no witnesses who could help to enlighten the circumstances with their testimonies. However, it can be presumed that the most of deceased apnoea divers were victims of abused hyperventilation before dive. Majority of divers who practice this type of diving are not aware of jeopardize after using that technique of diving, which leads to loss of conscience only few meters below the surface.

The circumstances which anticipated the diving fatality of scuba divers were known in 8 cases thanks to the testimonies of other scuba divers who were participating in fatal dive. Half of incidents occurred during the ascent, which is expected since the uncontrolled or irregular ascent most often results with development of life threatening conditions like different forms of lung barotrauma or with severe form of decompression sickness. Every single condition mentioned before can be cause of diver's death or can lead to drowning of a diver. In four remaining cases two divers lost their conscience during the descent, and the other two lost their conscience while abided on depths between 30 and 35 meters.

CONCLUSIONS

The truth is that most diving accidents end with drowning, and this paper also indicates it. However, the circumstances which anticipate and eventually lead to

drowning are the most important. In majority of cases these circumstances remained unknown. Better familiarization with predisposition factors of diving accidents can help to avoid them and to reduce their number in future. Therefore all the needed data must be collected during every diving accident according to predefined protocol. Investigation of these accidents must be entrusted to team made of specialists originating from the police, judiciary, diving medicine and forensic medicine.

LITERATURE

1. Edmonds C. Why divers die: the facts and figure. In: Edmonds C, Lowry C, Pennefather J, Walker R, editors. Diving and subaquatic medicine. 4th ed. London: Arnold Publishing; 2002. p. 477.
2. Barković D, Miletić-Barković M, Kovačević D. Ozljede ronilaca u sportsko-rekreacijskom ronjenju na Kvarneru: rezultati četverogodišnjeg praćenja [Injuries of divers in sport-recreational diving, in Croatian]. In: Petri NM, Andrić D, editors. Selected chapters in diving medicine. Split: RePrint. 1999. str. 50-4.
3. St Leger Dowse M, Bryson P, Gunba A, Fife W. Comparative data from 2250 male and female sports divers: diving patterns and decompression sickness. Aviat Space Environ Med. 2002; 73:743-9.
4. Hagberg M, Ornhagen H. Incidence and risk factors for symptoms of decompression sickness among male and female dive masters and instructors – a retrospective cohort study. Undersea Hyperb Med. 2003; 30:93-102.
5. Spira A. Diving and marine medicine review; part II: diving disease. J Travel Med. 1999; 6:180-98.
6. Haydon JR, Williamson JA, Ansford AJ, Sherif S, Shapter MJ. A scuba-diving fatality. Med J Aust. 1985; 143:458-62.
7. Michalodimitrakis E, Patsalis A. Nitrogen narcosis and alcohol consumption – a scuba diving fatality. J Forensic Sci. 1987; 32:1095-7.