Chapter 10 – Drowning is Not a Helpful Diagnosis Written on the Death Certificate

by

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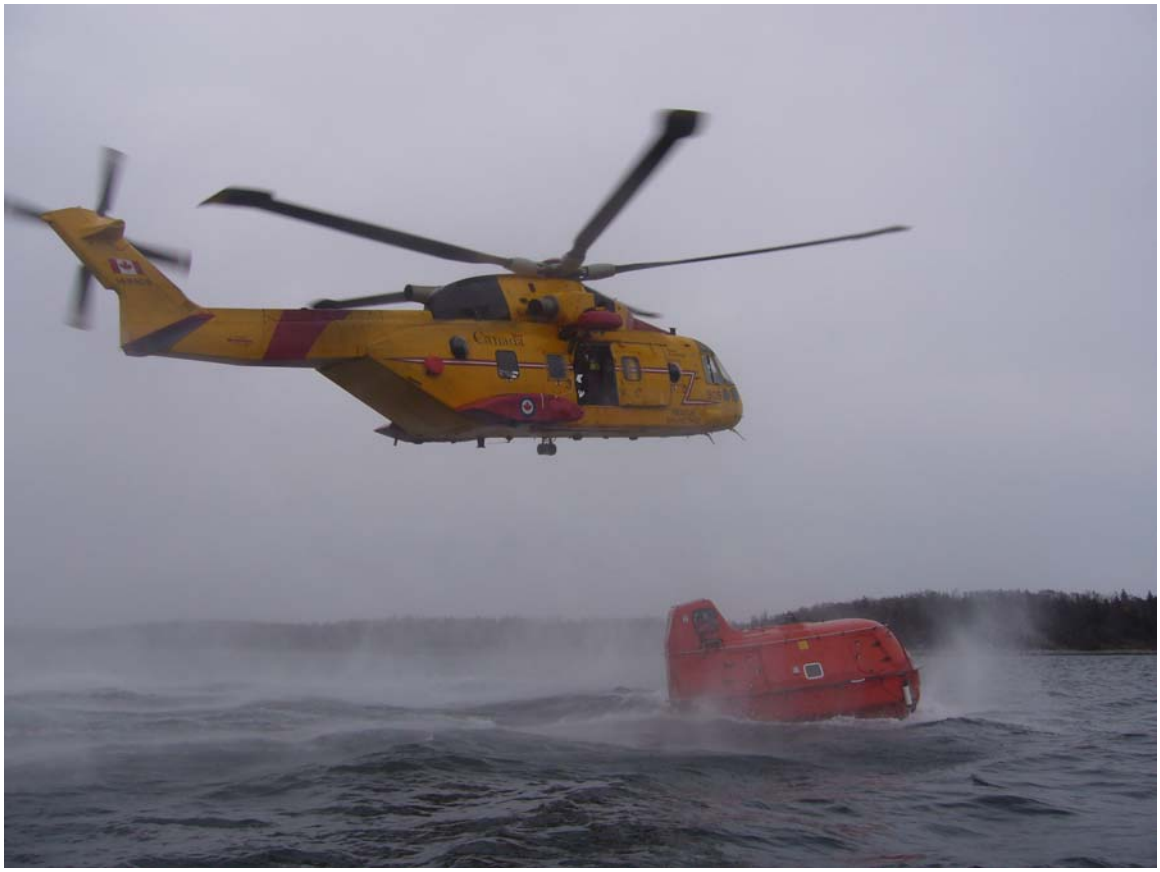

INTRODUCTION

A cursory look at the title of this paper may give the readers the impression that this is of little interest to them. This is a very false assumption. This paper is of great importance for anyone who is involved in accident investigation where a drowning has occurred. It is also of great importance to all marine survival instructors and health and safety managers. Only by understanding the underlying causes of the drowning, is it possible to establish the correct equipment and training preventive measures.

Over the centuries, hundreds and thousands of people who earn their living working on or over the water have drowned, particularly in cold water. It is only in the last 50 years that anyone has taken this death toll seriously.

Records of death from immersion in cold water date back to ancient times. During the Greek-Persian war (circa 450 BC), Herotodus was able to distinguish death from drowning compared to hypothermia [8]. Yet, it was not until the middle of the Second World War, and the analysis of the losses after the cessation of hostilities that the UK and Germany recognized the dangers of sudden cold water immersion [10, 11]. It was not until the Korean war that the United States also realized there was a problem [13].

Consequently, over the last half of the 20th Century, there has been considerable human experimentation performed internationally in cold water physiology. The pioneering work was done in the mid 1940s and 1950s, but by the 1960s, it was forgotten and needed to be relearned. A full summary of this work can be found in the new book written by Golden and Tipton in 2002 [7]. The loss of life in the new Offshore Oil Industry created a demand for more research to produce better immersion suits. This created a flurry of new experimentation in the 1980s and 1990s.

In 1981, Golden and Hervey produced their classic work on the four stages in which death may occur in a cold water accident [6]. These are: stage 1, cold shock, which kills within 3-5 minutes of immersion; stage 2, swimming failure, which kills within the first 30 minutes of immersion; stage 3, hypothermia, which kills after 30 minutes of immersion; and finally, stage 4, post rescue collapse, which kills during or shortly after rescue. Tipton provided a review of the initial response of cold shock in 1989 and conducted further experimentation to explain the phenomena of swimming failure [12].

Until relatively recently, stage 1 (cold shock) and stage 2 (swimming failure) were considered of academic interest only. As a result, regulators, teaching establishments and survival suit manufacturers all concentrated their efforts on protecting the human from hypothermia. In this regard, they have done a very good job. As a result, cold wet bodies removed from the water were assumed in many cases to have died from hypothermia, yet they had not been in the water long enough to become hypothermic.

Even though there are well established teaching programs, good regulations and much improved life saving equipment, there are still 140,000 open water deaths worldwide each year [6]. Barss reported in 2006 that 2,007 people died of cold water immersion in Canada between 1991 and 2000 [1]. What has been overlooked is the significance of the first two stages – cold shock and swimming failure as a cause of death. The severity of the effects of cold shock appears to be most dangerous to the human when suddenly immersed in water below 15°C. Below this temperature, the cold shock response is potentially lethal.

This physiological information has not been disseminated to accident investigators, emergency room physicians, coroners and pathologists. As a consequence, they have not realized the significance of the first two stages. Their line of investigation has not asked the specific questions that might indicate that one or both of these stages contributed to drowning. A typical accident report contains many pages related to the mechanical condition of the vessels and navigation aids, etc., but because the investigators are often under educated in the subject, the human factors aspect is often summarized in less than one paragraph. Here the final published “official” cause of death is listed as “exposure”, “presumed drowned” or “drowned”.

To be able to introduce a good public health program to prevent drowning, it is essential to identify the physiological causes that lead up to the tragic event. Only then can preventive action can be recommended. For instance, the wearing of a personal flotation device will keep the struggling victim afloat during the dangerous first five minutes of immersion during stage 1; this is paramount. Wearing a flotation device is also critical to prevent swimming failure during stage 2. Finally, a combination of flotation device and immersion suit are essential to prevent hypothermia and post rescue collapse in stages 3 and 4. However, if it is not possible to determine which stage caused the drowning, the precise cause of drowning, then it is not possible to introduce a public health policy.

STUDIES CONDUCTED BY SURVIVAL SYSTEMS LTD. FOR THE BRITISH COLUMBIA WORKERS COMPENSATION BOARD

As a result of the True North II accident in Georgian Bay in June 2000, the principal author reviewed the policies on survival in cold water for the Marine Safety Directorate of Transport Canada. Recommendations were made to improve the knowledge of the dangers of cold shock and swimming failure and the part they play in drowning [3]. As a result, this publication was received by the Workers' Compensation Board (WCB) of British Columbia (BC). Their accident investigators inquired as to whether their colleagues were asking the correct questions in their accident investigation process when workers drowned. They suggested a review of their drowning records.

In 2002, the WCB BC requested Survival Systems Limited, Dartmouth, Nova Scotia, to conduct a retrospective analysis of all deaths due to water immersion in British Columbia. The objectives of this investigation were to:

a) Review all the accidents involving drowning;

b) Reclassify deaths into the four stages of immersion (where possible);

c) Draw conclusions on the principal cause(s) of death;

d) Make recommendations on what protective measures to adopt; and

e) Develop a simple check list for WCB investigators, coroners and pathologists to use when investigating a drowning accident.

The first data that was analysed [3] found that between 1976 and 2002, there were 128 deaths: 56 (44.4%) were fishermen; 22 (17.5%) worked in the logging industry; 17 (13.5%) were operating motor vehicles; and 31 (24.6%) were involved in a diverse range of types of accidents from a variety of occupations including a health care worker, a lifeguard and a trail guide. Several years of fishing accident data were missing from this study because the records could not be located at the time. The data was later found and a second study [4] which specifically analyzed all fishermen deaths in water was conducted. In this study, it was found that 130 fishermen died from water immersion in 89 inshore and offshore accidents between 1976 and 2002.

RESULTS OF THE TWO BC WCB STUDIES

Common to both studies was that there was critical missing information such as: water temperature; body core temperature on admission to hospital; previous medical history; swimming ability; and witness testimony. This information would have been extremely helpful in determining whether cold shock, swimming failure, hypothermia, or post-rescue collapse contributed to the drowning or there was some completely different cause such as entrapment or a heart attack from a previous pre-morbid condition, etc. It is important that all those who are involved in the diagnosis of cause of death are educated about human physiology in cold water in order to make the appropriate diagnosis. However, examination of the files revealed that at all levels of the investigation (marine investigator, coroner, and pathologist), there was little understanding of cold water physiology. Moreover, each of the team appeared to be working somewhat in isolation of each other.

Each accident report that was reviewed contained many pages related to marine items such as navigation aids, ship's structure and stability, yet there was only a single paragraph or sentence related to the death and the survival equipment worn or carried on board. Retrospectively, in some cases it was possible to estimate a number of water temperatures. Thus, 95% of the fishing industry drownings occurred in water below 15°C. Even though this was helpful, it was still only possible to re-categorize 22 of the 130 deaths into one of the

four stages of the immersion incident. The water temperature of the drownings in the logging industry ranged from 5 – 14.7 °C and it was possible to re-categorize 4 of the 22 deaths into one of the 4 stages. Finally, for the motor vehicle accidents the water temperature ranged from 8 – 11.5 °C and it was possible to re-categorize only 1 of the 15 deaths into one of the four stages.

As a result, to insure all the critical information on a drowning death is recorded correctly for future analysis, a new common drowning investigation checklist was developed for the BC WCB (see Annex) and a series of lectures were also provided to their accident investigation team and safety policy makers. This educated them about cold water physiology and the dangers of sudden unexpected immersion in cold water.

REVIEW OF THE U.K. MARITIME AND COASTGUARD AGENCY CG-15 INCIDENT REPORTS

As a result of the aforementioned work and the efforts of the U.K. Maritime and Coastguard Agency (MCA) to reduce Maritime and Fishing Vessel fatalities [9, 14, 15] Survival Systems Limited were asked to conduct a similar study for them. The objective once again being to investigate the underlying cause of the drowning deaths.

A similar protocol was developed for this investigation as for the BC WCB as described above. Records were examined back to 1975. It was not possible to review every report for each year, but all records were examined in detail for 1975, 1978, 1982, 1992, 1994 – 1997, and 2004. The findings were very similar to those found at the BC WCB offices. All the CG-15 incident reports were meticulously filled in, and there were volumes of paperwork on the technical aspect of each accident. Yet, when it came to the human data and the cause of death, generally there was one sentence which ended in the word “unfortunately drowned”. Because there was so little human factors data or recorded witness testimony, it was quite impossible to re-categorize any drowning deaths at all. A report was produced to advise them how to proceed in the future [5], particularly in how to harvest the medical and human factors data, and how to use the International Code of Diagnosis to maintain medical confidentiality and be able to record the human data.

CONCLUSION

The marine and accident reports from two large government agencies (BC WCB and UK MCA) have been examined. The objective was to identify the underlying causes of death from drowning. Then, prescribe the way ahead to reduce the number of drownings and save unnecessary loss of life.

In both agencies, there was excellent record keeping, but it was all related to the technical aspects of the accident. At all levels of the accident investigation team, there was little understanding of cold water physiology, and each member of the accident investigation team (investigator, coroner, and pathologist) tended to work in isolation of each other. There was very little human factors or medical information recorded. Except in a few Canadian cases, this made it virtually impossible to understand the true cause of death, and therefore impossible to make recommendations on how to improve safety. From the details in the Canadian fishing accidents, 95% of drownings occurred in water below 15°C. This confirms that sudden unexpected immersion in water below 15°C is very dangerous and should be emphasized on all marine survival training courses. The use of flotation equipment would appear to be the first common sense approach – but support for this idea could neither be supported nor rejected because there was not enough data to draw any conclusions whatsoever.

Advice has been given to both agencies on the best course to proceed in the future, and a specific checklist has been developed for all investigators of drowning accidents (see Annex). It is hoped that these investigations have provided insight into a worldwide problem of water immersion deaths, and will result in improved diagnosis and record keeping of all accidents in order to save more lives.

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ANNEX

INVESTIGATION FORM - WATER RELATED INCIDENTS
(Fill in a separate form for each worker)

PART 1 – Physical Information

- Category of Incident (Fishing, Logging, Diving, MVA, etc) _____
- If Vessel involved Name Of Vessel _____
  Length of Vessel_____
  Vessel Registration Number _____
  Vessel License Number _____
- If Vehicle involved, type of vehicle (type, make and model) _____
- Speed of vehicle or vessel at time of accident _____
- Activity of vehicle or vessel at time of accident_____
- Turnaround time of the vehicle vessel_____
- Estimated distance from shore or edge of river _____ (metres, kilometres)
- Did incident occur in: ☐ice ☐water
- Depth of water _____(metres)
- Time of day _____(24 hour clock)
- Daylight: ☐yes ☐no Twilight: ☐yes ☐no Darkness: ☐yes ☐no
- Weather conditions:

	Observed	Estimated
Air Temp (°C)	_____	_____
Water Temp (°C) _____		_____
Sea State (metres)	_____	_____
Wind Speed (knots)	_____	_____
Direction	_____	_____

- Brief description of the incident:
  _____
  _____
  _____
  _____
  _____
  _____
  _____
  _____
  _____

PART 2 – Human Factors Information

- Number of people involved _____
- Number of persons injured _____
- Number of persons fatally injured _____

Injured Workers Information

- Name _____ Date of Birth _____
- Height _____ Weight_____
- ☐Fatal ☐Injury
- Body Core Temperature at Site ___°C Body Core Temperature at Hospital ___°C
- Could worker swim? ☐well ☐average ☐poor ☐no ☐not known
- Did the worker sustain injuries other than immersion injuries? ☐yes ☐no ☐not known
  - If yes, describe
    _____
    _____
- Had worker taken any survival training? ☐yes ☐no
  - If yes, explain
  - _____
    _____
- Was worker alive when entered the water? ☐yes ☐no ☐unknown
- Does autopsy clarify whether worker was alive or dead upon entry ☐yes ☐no

If the worker was dead before entering the water then this is not a water related incident and there is no need to proceed further. If it remains unclear as to the condition of the worker prior to entering the water then continue as if the worker were alive as s/he entered the water.

- If a motorized vehicle or piece of equipment was involved, was a seat belt available?
  ☐yes ☐no
- Was a seat belt used? ☐yes ☐no
- Was the worker physically trapped within the vessel, vehicle, etc.? ☐yes ☐no
  Describe:
  _____
  _____
- Do post mortem reports aid in answering above questions? ☐yes ☐no ☐undetermined
- How easy or difficult is it to operate the doors/windows underwater? Describe.
  _____
  _____

- If the reports do help, then was worker *physically* drowned (i.e. entrapped) or did they drown by other means?
  ☐yes, physically drowned ☐no, drowned by other means

- Was worker observed to: (tick appropriate box)
  - ☐ make ineffective swimming strokes/struggle violently and appeared to be alive/conscious and even reaching for life rings etc?
    If so, for how many minutes? _____

  - ☐ Commence to swim either to other vessel or shore?
    If yes, how many minutes or hours? _____.
    What distance was covered before worker seen to succumb?_____(metres/kilometres)

- Can you conclude how soon after water entry did worker succumb?
  - ☐ within first 5 minutes
  - ☐ between 5 and 30 minutes
  - ☐ after 30 minutes
  - ☐ at or shortly after rescue
  - ☐ unknown

- Length of time in water before retrieval?
  - ☐ under 5 minutes
  - ☐ between 5 and 30 minutes
  - ☐ over 30 minutes
  - ☐ over 1 hour
  - ☐ unknown

- Were the above estimations determined from:
  - ☐ witness testimony
  - ☐ investigator's estimation (an estimate is encouraged if it is possible and there is no witness testimony)
  - ☐ other (i.e. video) Describe_____

- How well clothed was the victim?
  - ☐ light ☐medium ☐heavy ☐unknown

  Briefly describe how worker was clothed:
  _____
  _____

- Did worker wear a lifejacket, floater coat, pfd, etc.?
  - ☐yes ☐no ☐unknown.

  Describe type, make, age and model:
  _____
  _____

- Did flotation device perform to specifications? ☐yes ☐no ☐unknown

- If 'no', describe what went wrong:
  - ☐ unable to put on while in the water
  - ☐ came off in the water
  - ☐ not secured correctly
  - ☐ poor maintenance

- ☐ inappropriate selection of gear
- ☐ did not inflate
- ☐ punctured
- ☐ damaged
- ☐ did not provide enough buoyancy
- ☐ other, describe:

  _____
  _____

- Were PFD's/Lifejackets carried on vessel or in vehicle? ☐yes ☐no ☐unknown
- Were there enough PFD's/Lifejackets for all on board? ☐yes ☐no ☐unknown
- Did worker wear an immersion suit? ☐yes ☐no ☐unknown
  Briefly describe the type (make and model number):

  _____
  _____

- Were immersion suits carried on the vessel? ☐yes ☐no ☐unknown
- Were there enough immersion suits for all on board? ☐yes ☐no ☐unknown
- Did immersion suit perform to specifications? ☐yes ☐no ☐unknown
- If 'no', describe what went wrong:
  - ☐ sinking occurred too quickly to locate and don.
  - ☐ stowed in a place already underwater
  - ☐ physically stowed in an inaccessible place
  - ☐ no knowledge that suits were on board
  - ☐ suits leaked badly
  - ☐ no training in how to don/doff the suits
  - ☐ poor maintenance
  - ☐ other, describe:

    _____
    _____

- Were lifeboats, liferafts or skiffs carried? ☐yes ☐no ☐unknown
  - What type? _____
- Were lifeboats, liferafts or skiffs deployed? ☐yes ☐no ☐unknown
- If deployed, did they perform to specifications? ☐yes ☐no ☐unknown
- If 'no', describe what went wrong:

With Launch

- ☐ in ability to launch
- ☐ vessel sank too quickly to launch
- ☐ didn't know how to launch
- ☐ too much list to launch
- ☐ already underwater
- ☐ weather made it too difficult to launch
- ☐ got entangled
- ☐ blew up against side of sinking vessel
- ☐ failed to inflate

- ☐ punctured
- ☐ crew too cold and fatigued to launch
- ☐ other, describe:

  _____
  _____

When in Water

- ☐ capsized
- ☐ blew over
- ☐ deflated
- ☐ washed overboard
- ☐ inability to get back in after being washed overboard
- ☐ flooded
- ☐ other, describe:

  _____
  _____

- How many hours/days did the worker work in the last:
  - 24 hours _____ hrs
  - last one week _____ days
  - last one month _____ days

- Was there any medical condition that contributed to the incident (i.e. Epilepsy, Diabetes, Heart Disease, etc.)
  - ☐yes ☐no ☐unknown
  - If 'yes', describe: _____

- Were any other medication, drugs or alcohol involved? ☐yes ☐no ☐unknown
  (Ask specifically about antihistamines and anti-fungals and whether medication was prescribed or over-the-counter)
  Describe: _____

- Include a brief description of the autopsy results:
  _____
  _____
  _____
  _____
  _____

- State the Coroners Cause of Death:
  _____
  _____
  _____

- Final determination
  - ☐ Drowning from entrapment
  - ☐ Drowning from Cold Shock
  - ☐ Drowning from Swimming Failure
  - ☐ Drowning or Death from Hypothermia
  - ☐ Drowning or Death from Post Rescue Collapse
  - ☐ Drowning or Water Related Death from Undetermined Cause
  - ☐ Drowning – Other _____

Checklist for water related fatalities: C.J. Brooks, K.A. Howard, S. Neifer