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Cardiovascular events on board commercial maritime vessels: a two-year review

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ABSTRACT

Background. *Cardiovascular diseases (CVDs) are an important concern in merchant maritime operations. They are responsible for the majority of deaths at sea that are not related to injury or violence. The objective was to better understand the epidemiology of CVD in merchant maritime operations.*

Material and methods. *Retrospective review of medical events on board merchant maritime vessels over a period of two years, from a US-based telemedicine provider's database.*

Results. *A total of 1,394 cases were initially retrieved from the database. CVD was diagnosed in 29 cases and was the eleventh leading cause for accessing the telemedicine provider. Five deaths occurred in the study period, three of which related to CVDs. CVDs resulted in more diversions and the utilization of more urgent means of communication.*

Discussion. *CVDs present a challenge in maritime health. The current pre-employment system is not, in a reasonable cost/benefit balance, able to prevent on board events from occurring. The success of telemedicine depends heavily on the onsite resources, both human and material. Automated External Defibrillators (AEDs), along with other devices such as multi-parameter monitors, are tools generally available to address acute presentations of CVDs, but their applicability on board commercial ships is a matter of controversy.*

Conclusions. *CVDs are an important concern in commercial maritime operations due to the need for subsequent evaluation and potential complications including the risk of sudden cardiac arrest. In this study, CVDs were probably responsible for three on board deaths. Additional research is warranted to provide more evidence about the best resources to have on board to handle CVDs more effectively.*

INTRODUCTION

Cardiovascular disease (CVD) is the leading cause of death and morbidity in the general population according to the World Health Organization's 2007 Fact Sheet [1].

There is no reason that this is not the case for seafarers. Studies on mortality show that seafarers have an overall increased mortality rate ratio (MRR) when compared to a matched sample of the general population. This is mainly because of injury-related deaths but also because of certain diseases such as liver cirrhosis [2].

When on board merchant vessels are fitted with enhanced occupational health and safety practices, the number of injury-related fatalities are decreased. Therefore, CVD tends to become a leading cause of death in less risky operations [3].

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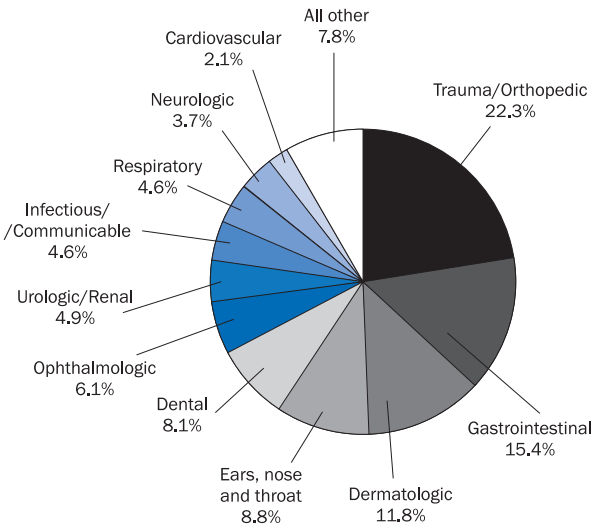

Figures 1. Distribution of diagnostic categories of medical events on board

While CVD risk factors such as arterial hypertension, diabetes, and hypercholesterolemia are screened for during pre-employment/embarkation exams, they are usually not impeditive for most functions on board commercial vessels if under clinical control. Other important risk factors such as a positive family history for CVD, physical inactivity, or smoking are not impeditive at all.

Recent literature addresses the problem of CVD risk factors in the maritime population [4, 5]. One study showed a prevalence of 34.2% of at least three risk factors in the study sample [6].

A conservative approach could estimate the prevalence of CVD among seafarers as at least similar to general population figures. Therefore, it would be reasonable to anticipate medical events related to CVD may occur on board commercial ships.

The objective of this study is to better understand the current epidemiology of cardiovascular events occurring on vessels underway.

METHODS

The proprietary database of a U.S.-based telemedicine provider servicing different types of maritime commercial operators was utilized to retrieve medical case data over a two-year period, from April of 2008 to March of 2010. Only cases where the vessel was offshore and underway were analyzed.

Variables collected from each case were: age, gender, diagnostic category, diagnostic impression, type of operator, and means of communication upon first contact. Cases in which one of those variables was not available were treated as 'missing' in the respective analysis.

The sample was subdivided into CVD and Non-CVD groups to allow for general comparisons. All CVD cases were individually reviewed and eventually reclassified by the first author (cardiologist) as non-CVD as necessary when a second diagnostic impression was subsequently made during the course of the case. non-CVD cases were further subdivided into Injury and non-injury related categories, according to the diagnostic impression. No non-CVD case was reviewed to be converted into a CVD case. Cases were also grouped according to the to the means of communication with the telemedicine provider as 'direct phone contact' (Satcom, Iridium, or cell phone) or 'other' (e-mail, landline phone, fax, etc.).

Epi-Info 3.5.1 was utilized for statistical analysis. Chi-Square, Fisher Exact, and Analysis of Variance (ANOVA) were utilized as required for comparisons. A p value of 0.05 or below was considered as statistically significant.

RESULTS

A total of 1,394 cases were initially available for analysis. Events were categorized as CVD in 29 (2.1%) of the cases. CVD was the eleventh most frequent cause for accessing the telemedicine company (Figure 1). Trauma/orthopaedic cases were the most frequent category observed with 311 cases (22.3%) of which 200 (64.3%) were injury-related. Trauma/orthopaedic cases, as expected, were the most frequent of the 218 injury-related events (91.7%). Burns accounted for the remaining 18 cases (8.3%).

CVD cases could be further divided into diagnostic impressions as shown in Figure 2. Chest pain suspected to be angina pectoris was the most frequent reason to access medical advice, occurring in 20 cases (69%).

Table 1. Demographic characteristics of cardiovascular cases compared to all other cases

	Cardiovascular	All other	p value
Male:famale radio	9:1	9:1	NS
Age:Median (range)	53 (36–66)	40 (18–73)	p = 0.002

Table 2. Death cases summary

Age	Gender	Presumable diagnostic category	AED Used	Collapse Witnessed	Brief description
47	M	Cardiologic	No	No	Captain found unconscious, not breathing, and without a pulse
58	M	Cardiologic	No	No	Found collapsed but still breathing near a staircase
63	M	Cardiologic	No	?	Collapsed shortly after taking a shower
62	M	Gastrointestinal	Yes	No	Captain found unconscious in the restroom. Dark stools compatible with melena were noted at the scene
50	M	Neurologic	No	Yes	Crewmember found unconscious but breathing and with a pulse. No hypoglycaemia. Slow deterioration to cardiac arrest

AED — Automated external defibrillator

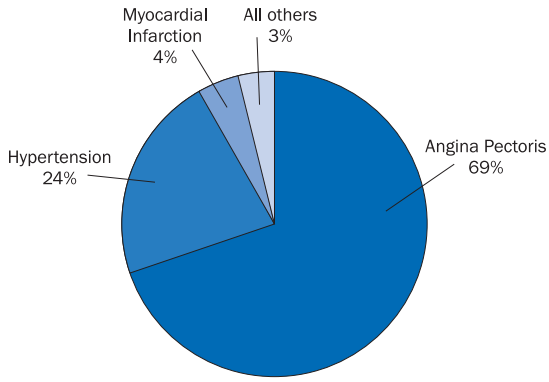

Figure 2. Distribution of diagnostic impressions for cases of cardiovascular disease

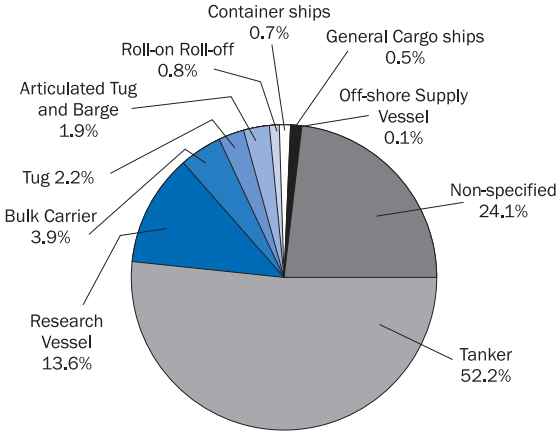

Figure 3. Distribution of operation types in the studied sample

There was no difference regarding gender distribution between CVD and non-CVD cases. Men accounted for 89.7% of all cases. CVD cases were significantly older than non-CVD cases. Table 1 summarizes the demographics of the study population.

Figure 3 shows the distribution of the sample according to the type of operation, reflecting the clientele distribution for the telemedicine provider. No difference was found between CVD versus Non-CVD cases when comparing different kinds of operations.

Five deaths occurred during the study period. The final cause of death was not determined, but CVD-related death was suspected when an otherwise active person underwent cardiac arrest in the absence of trauma or other evident possible mechanism. Three deaths were attributed to CVD, one to possible neurovascular disease, and one to gastrointestinal bleeding. In two cases (one CVD) the victim was the ship's master. Table 2 shows a summary of death cases.

CVD required further shore-side evaluation or hospitalization or resulted in death in 15 (51.7%) of the cases, compared to 397 (29.2%) of non-CVD cases (odds ratio = 2.61; CI 95% = 1.18 < OR < 5.78; p = = 0.008). A diversion was necessary in four (13.8%) CVD cases compared to 48 (3.5%) non-CVD cases (odds ratio = 4.39; CI 95% = 1.47 < OR < 13.11; p = 0.02).

In the injury group there were no hospitalizations or deaths. It was found that 64 cases (29.4%) were recommended for shore-side evaluation. The remaining 154 events (70.6%) were managed on board.

The mode of communication was via 'direct phone' in 79.3% of the CVD cases compared with 50.4% for non-CVD cases (odds ratio = 3.77; CI 95% = 1.45 < < OR < 10.38; p = 0.0015).

DISCUSSION

It is impossible to estimate the actual incidence of CVD on board without knowing the original population of mariners working for the clients being served by the telemedicine provider. It is worrisome that, in this short period of time, three deaths were most probably related to CVD. The very high death to case ratio (3:29) is troubling but not unexpected. Delays in getting proper attention are the rule rather than the exception when dealing within CVD patients, even during an acute episode and were the object of a statement from the American Heart Association [7] reporting the evidence supporting the benefits of early treatment and the magnitude of the problem.

Simply preventing individuals with CVD from boarding would be the best theoretical solution, but it is not a practical one, if at all feasible. Screening for CVD risk factors is very useful in predicting the chances of developing evident coronary heart disease in a given population. However, so-called traditional risk factors often fail to predict acute events when applied to the individual [8] when compared to more recent and more expensive developments such as coronary calcium index evaluation [9] and other techniques [10].

It is unlikely that a cost benefit analysis would favour enhancing pre-employment exams to incorporate screening methods that are more accurate. Declaring potential seafarers unfit based on risk factors alone would dramatically and unnecessarily reduce the availability of candidates. Additionally, the interval between medical evaluations is often long enough for coronary disease that is initially undetected to evolve and to manifest later on since there are instances of rapid progression of the coronary artery lesion [11]. One interesting study has shown that 6% of non-obstructive plaques accidentally discovered during angiographic studies would require intervention within one year [12]. We also know that acute myocardial infarction (AMI) frequently develops from non-severe lesions [13]. Without a highly efficient screening system available, crews need to be prepared to handle effectively CVD on board.

Acute myocardial infarction is certainly the most feared event among CVDs. There is a chance of sudden death and long-term disability. The prognosis of an AMI depends on the ability to manage acute complications such as life-threatening cardiac arrhythmias and, in the long term, reducing the infarct size. Automated external defibrillators (AEDs) were developed that allow minimally trained non-medical personnel to treat fatal arrhythmias. To reduce infarct size, thrombolytic therapy is needed. However, its efficacy is greater if applied within the first few hours of the beginning of symptoms. Ideally, AMI is to be avoided.

To adequately manage CVD on board requires four components: 1) a high level of suspicion to allow early diagnosis; 2) medications and equipment to handle acute complications, particularly lethal arrhythmias, while waiting for advanced resources; 3) a minimum number of trained crew members on board able to provide basic level treatment, such as Basic Life Support (BLS), AED, and intravenous medication and who can relay information to telemedicine providers; and 4) a well-orchestrated coordination to expedite the provision of advanced care.

It is extremely important to get help early in this process to avoid wasting precious time. Working with scarce diagnostic resources, management of on board medical events by a telemedicine provider is based on the probability of the presence of a certain condition; not upon a confirmed condition. The mere suspicion of CVD typically activates a chain of events with a series of consequences, if the system is operting on the safe side.

Based on history alone, ischaemic heart disease can be suspected with a high degree of confidence. In many cases, however, particularly when presenting as atypical chest pain, additional testing is necessary to confirm or rule-out the condition [14].

Our data supports the latter assumption. It is meaningful that a significant difference was noted on the utilization of a direct means of communication. It suggests a sense of urgency on the part of the shipboard caregiver when there is a suspected case of CVD.

Another aspect apparent from the study is the significantly higher number of instances in which a shore-side evaluation was recommended or an adverse outcome ensued when dealing with CVD cases. The same applies regarding diversions, significantly more frequent when a CVD was suspected.

All the above factors have cost implications.

Evaluations to discard the possibility of an acute cardiac event will require at least temporary admission of the patient into an emergency medical unit for observation. Serial electrocardiograms (ECGs) and enzyme testing are necessary as minimum standards. Better telemedicine resources, including the ability to transmit ECGs and testing for cardiac enzymes, could alter this picture.

Enhancing on board equipment to allow for a higher level of telemedicine will certainly improve handling at-sea CVD events and even mitigate the unnecessary costs seen today. At the same time, maritime companies can fulfil their duty-of-care to embarked employees.

AEDs are now widely available in public places such as airports, sports stadiums, amusement parks, etc. AEDs are the only possible way to save the life of a victim of ventricular fibrillation when it occurs away from advanced medical facilities.

Data coming from airport [15] and casino [16] experiences show that long-term survival after AED utilization is high, particularly in those receiving a shock in less than three minutes. This would certainly be a challenge on large vessels where the opportunity to witness a collapse and react quickly is not always attainable. Therefore, their value on commercial ships has been a matter of lively debate [17, 18]. The Maritime and Coastguard Agency (MCA) leaves the decision to incorporate these or not to the operator's discretion [19]. It is true that the excellent results coming from Public Access Defibrillation programs cannot be immediately transposed to this environment with very limited access to advanced medical care.

Nevertheless, AEDs and bystander cardiopulmonary resuscitation (CPR), i.e. BLS-AED, has been demonstrated to be a more important determinant of survival than advanced care for out-of-hospital cardiac arrests [20, 21]. Although advanced care increases the chance for a victim to be admitted to a hospital, quality BLS-AED is the decisive factor in increasing the number of survival-to-hospital discharge cases. There are anecdotal reports of victims surviving without advanced care, including the case of an in-flight cardiac arrest surviving the journey to the hospital after receiving more than 20 shocks and a three-hour interval until the patient reached a medical facility [22]. Recurrent fibrillation complicates 52% of the cases that regain spontaneous circulation after successful defibrillation. However, its occurrence is apparently not related to the rescuer's performance and does not affect, per se, the final prognosis [23].

The small actual number of deaths in this series would not allow any non-speculative inference about the chances of survival of the victims. Without having AEDs on board it is impossible to know precisely the cardiac mechanism of death in those cases. Additionally, the collapse-to-rescue time was not documented. We can be sure, though, that no hope is offered without an AED, since most out-of-hospital sudden cardiac arrests are due to ventricular fibrillation, occurring in 47% to 58% of the cases [24].

AEDs alone will not suffice as a solution. New devices coming out of the medical industry can help in this equation. Multi-parameter monitors capable of transmitting biological data over different means of communication including the internet are today commercially available. Some of them, in addition to ECG recording, incorporate defibrillators that can also be used in so-called AED mode. Most devices can also operate in a standalone mode and generate electronic files which can be sent as e-mail attachments. Such devices can also be utilized in non-CVD cases, monitoring and recording for later transmission multiple parameters such as blood pressure, pulse oximetry, and temperature. This considerably expands the possibilities of utilization.

Limitations and constraints for telemedicine in the maritime environment when compared to onshore are well known [25]. However, advances in telecommunication will certainly allow for greater capabilities in the near future.

With more information at hand, telemedicine providers are certainly better equipped to handle a great number of cases occurring on board, not only in the acute phase, but also during follow-up while waiting to reach care that is more advanced. With a telemedicine system established to support them, the level of training for medical officers on board does not need to change to an advanced care level. BLS-AED training with a specific focus on the type of equipment eventually carried should suffice to resuscitate victims of sudden cardiac arrest on board and to maintain their lives until the first opportunity of evacuation from vessel arises.

This study had some limitations. It was retrospective in nature and required retrospective grouping to allow for a comparative analysis. It must also be noted that the profile of operators in this study is not a mirror of the general distribution found overall in the maritime industry, but simply reflects the unique distribution of the provider's clientele. There are also the limitations intrinsic to the telemedicine model, in which a definitive diagnosis is often not obtained. Nevertheless, it gives useful insight into the magnitude of the problem.

CONCLUSIONS

CVD already plays an important role in medical events on board merchant ships. As occupational safety improves, in turn diminishing the number of injury related fatalities, CVD tends to become the most common cause of death on board.

Preventing and treating CVD in the maritime industry presents a considerable challenge to all those involved and demands careful consideration.

AEDs deserve special attention by the maritime medical community. Available evidence makes us

believe we should not expect the same level of results that are obtained by other public defibrillation programs. However, we cannot dismiss this alternative either. Effective BLS-AED represents the only chance of survival for victims of out-of-hospital sudden cardiac arrest. Solutions specifically designed for the merchant maritime environment should be sought.

Enhancing medical equipment on board, in conjunction with good preventative strategies to promote education, will allow the early suspicion and management of CVD events, potentially contributing to fewer on board deaths, less diversions, fewer costs associated with shore-side evaluation, and better quality of care.

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