

# Cardiovascular diseases and electrocardiogram teletransmission aboard ships: the French TMAS experience

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## ABSTRACT

**Background.** The aim of this study was to analyse emergency calls for teleconsultation received at French TMAS relating to cardiovascular pathologies, to assess the relevance of electrocardiogram teletransmission.

**Material and methods.** A two-year descriptive and retrospective study from the TMAS medical files database. We selected patients whose telemedical request was related to a possible cardiovascular pathology. The French TMAS receives calls from all kinds of ship (passenger or merchant vessel), and our analysis was conducted by comparing passengers and professional seamen. On board, the caregiver performs the ECG after medical prescription and sends it by satellite to the TMAS.

**Results.** A total of 179 cases of cardiovascular disease were selected, including 79 passengers (PG) (44.1%) and 89 professional seafarers (PS) (49.7%). In 11 cases (6.1%) patient status was not specified. The most frequent diagnoses were chest pain (58 cases) and STEMI (23 cases), followed by NON STEMI (21 cases). An ECG was performed in 70% of cases of chest pain. ECG diagnosed 23 STEMI, and all these patients had been evacuated by a medical team. This diagnosis led to the establishment of antithrombotic therapy. The mortality rate due to cardiovascular diseases was 9.5%. Ten occurred on board and 7 during the evacuation of the patient. Eleven were passengers and 6 were professional seamen.

**Conclusions.** Calls regarding cardiovascular disease are infrequent but require an effective response. Recording and transmitting an ECG to the TMAS is technically feasible and enables treatment to be started with specific drugs, mainly in the management of STEMI.

**Key words:** Cardiovascular disease, ECG teletransmission, Seafarers, TMAS

## INTRODUCTION

Some meta-analysis showed that coronary heart disease risks are increased by 50% when stress at work is present [1]. A recent study identified many stressors in seafaring aboard merchant and passenger vessels [2]. Crewmembers often face high levels

of shipboard stress, and several studies in the literature concluded that working on vessels could increase cardiovascular risk [3].

Cerebrovascular accident and myocardial infarction are medical emergencies. A Polish study has analysed the incidence of myocardial infarction and

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the impact of conditions of work on the mortality rate among Polish seafarers. The authors concluded that work environment and work-related factors significantly reduced the chance of survival at sea in case of myocardial infarction [4].

Different approaches for the management of acute cardiac events are recommended based on the presence or absence of ST-segment elevation in myocardial infarction (STEMI respective Non STEMI) in the initial electrocardiogram [5, 6]. Evidence that early reperfusion is critically important for the outcome in STEMI has led to substantial efforts to develop emergency medical care systems that facilitate timely primary percutaneous coronary intervention (PCI) or transfer to revascularization centres after thrombolytic therapy. Nevertheless, shipping involves a geographical distance that separates the sea worker population from access to care. Telemedicine and particularly telecardiology with electrocardiogram transmission devices have been developed to improve remote medical care. Indeed, a 12-lead tele-ECG recorder proved accurate for the diagnosis of acute coronary syndrome [7, 8]. Many ships are equipped with an electrocardiograph as advocated by international recommendations [9], and teletransmission is very effective with email technology. Regarding medical supplies and the presence of teletransmission devices onboard, French legislation states (since 2004) that merchant or fishing ships practicing navigation without limitation of time or destination (medicine chest A) and any passenger vessel (since 2007) must have material enabling telecardiology practice (ECG, defibrillator). Consequently, most fishing boats (medicine chest B) are not equipped with this type of material, whereas it is well described that cardiovascular risk is increased in the population of fishermen [1–4].

The aim of this study was to analyse all the emergency calls for teleconsultation received at the Centre de Consultations Médicales Maritimes – CCMM (French TeleMedical Assistance Service – TMAS) relating to cardiovascular pathologies, to assess the relevance of electrocardiogram teletransmission.

## MATERIAL AND METHODS

A descriptive and retrospective study was carried out from the CCMM medical files database during a two year period from 1<sup>st</sup> January 2008 to 31<sup>st</sup> December 2009.

### STUDY POPULATION

The CCMM receives calls from all kinds of ships, merchant vessels, fishing ships, passenger ships, and

leisure boats, concerning various patient populations such as crewmembers (seamen, fishermen), passengers aboard ferries or cruising vessels, or yachtsmen. The population of cardiovascular patients was split into two groups according to the function of the patient status aboard the ship: a passenger group and a professional group (including all crew members, whether they were officers, deck or engine workers, fishermen, or scientists).

### THE CCMM, FRENCH TMAS

Since IMO MSC Resolution 70 of 1998, medical assistance at sea has become an integral part of Search And Rescue (SAR), being consistent with the amended SAR Convention: “performance of distress monitoring, communication, co-ordination, and search and rescue functions, including provision of medical advice, initial medical assistance, or medical evacuation...”.

According to the MSC Circ. 960 – June 2000 – [9], the optimal arrangement for medical assistance at sea is based on five elements; one of them is TMAS. The CCMM, created in 1983 and based at the emergency medical service (SAMU) – University Hospital in Toulouse – has been designated as TMAS for France by a state official decision on 10 May 1995. Patient evacuation processes including ship re-routing are managed by Marine Rescue Coordination Centres (MRCC) following medical advice by TMAS. CCMM is accessible 24/7 directly by vessels using standard radio or INMARSAT, or via MRCC. CCMM is staffed by emergency physicians specially trained for telemedical consultation and assistance at sea and aware of the specific conditions of life and work aboard vessels (Lorient Maritime Prevention Institute). Furthermore, CCMM physicians participate in compulsory medical training for ship masters and officers who will be responsible for medical care on board. CCMM is officially in charge of a specific training module regarding patient medical examination and teleconsultation.

For each teleconsultation, a medical record is created by the CCMM physician on duty using specific software, including a medical section with personal records, cardiovascular risk factors, usual treatment, description of the illness history or circumstances of the accident, and all symptoms found during the clinical exam. When an ECG or pictures have been sent by email, it is attached to the electronic file. Depending on the ship’s equipment a video conference with webcam can also be performed if needed using Skype facilities. The detailed treatment as well as the

operational decision (care on board – MEDICO, ship diversion, or patient evacuation – MEDEVAC, with or without a medical team aboard the evacuation craft) are also recorded. The teleconsultation file is concluded with a diagnosis codification (ICD–WHO).

### EXTRACTION OF DATA

The extraction of the data analysed for this study has been carried out from the CCMM database using Business Object software.

For this study we selected patients whose main symptom (call motive) was related to a possible cardiovascular pathology (Table 1). Furthermore, in order to minimize the risk of error or forgotten files, folders have also been filtered according to the diagnosis item codified either at the end of the consultation or when available from the hospital report. Finally, all data were then checked manually to avoid codification errors.

### ECG ANALYSIS

The CCMM receives two types of ECG: a 12-lead standard layout (device type Life12<sup>®</sup>) via internet or satellite, telephone or fax; or an 8-lead ECG from Survcard<sup>®</sup>, transmitted by telephone and specific modem, or by sending an e-mail with attached file by fax via satellite telephone.

The ECG equipment maintenance is performed by the supplier. For commercial vessels, the CCMM receives a “test” ECG done on someone on board as part of an annual procedure. For other types of vessel, the test transmission is only recommended and achieved through security procedures.

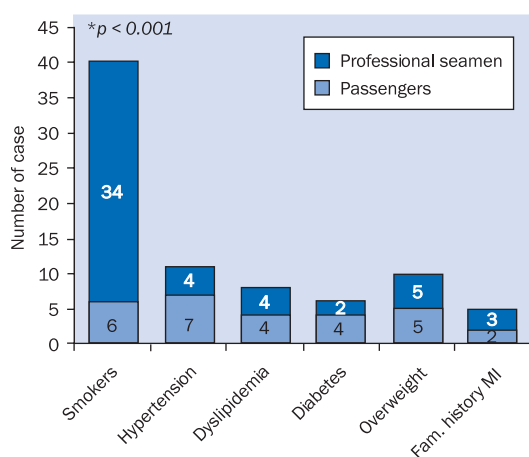
On board, the caregiver performs the ECG: on a ferry it is usually a nurse, and on other vessels it is usually the lieutenant or the second captain. The ECG is performed after medical prescription by the CCMM physician during the consultation. Frequently, the CCMM receives the ECG in advance: it is per-

**Table 1.** Call motive and diagnosis item list from 10-ICD

Call motive	Diagnosis item
Angina pectoris (I209)	Essential hypertension (I10)
Cardiac Arrest (I46)	Angina pectoris (I20)
Aphasia (R470)	Myocardial infarction (I21)
Respiratory Arrest (R092)	Acute pericarditis (I30)
Bradycardia (R001)	Cardiac arrest (I46)
Cardiogenic shock (R570)	Paroxysmal tachycardia (I47)
Shock (R579)	Other cardiac arrhythmia (I49)
Coma (R402)	Pulmonary oedema (I501)
Convulsion (R56)	Cerebrovascular accident (I64)
Death without witness (R98)	Aortic dissection aneurysm (I71)
Chest pain (R074)	Gastroesophageal reflux disease (K21)
Dysarthria (R471)	Peptic ulcer (K269)
Dyspnea (R060)	Gastritis and duodenitis (K29)
Epilepsy (G409)	Tachycardia (R000)
Hemiplegia (G81)	Chest pain (R074)
Essential hypertension (I10)	Pyrosis (R12)
Instant death (R960)	Coma (R402)
Palpitations (R002)	Syncope (R55)
Cutaneous paresthesia (R202)	Cardiogenic shock (R570)
Somnolence (R400)	Transient ischaemic attack SP (G459)
Syncope (R55)	
Tachycardia (R000)	
Headaches (R51)	
Fainting (R53)	

**Table 2.** Distribution of ship type

	Patients				ECG on board	Medical team on board
	Passengers	Professional	Unknown	Total (%)		
Passenger vessel	73	13	0	86 (48)	Yes	Yes
Merchant vessel	0	34	0	34 (19)	Yes	No
Scientific boat	0	9	0	9 (5)	Yes	Yes
Tanker	0	3	0	3 (2)	Yes	No
Fishing vessel	0	34	0	34 (19)	No	No
Leisure boat	1	1	11	13 (7)	No	No
<b>Total</b>	<b>74</b>	<b>94</b>	<b>11</b>	<b>179</b>	<b>132 (74%)</b>	<b>95 (53%)</b>

**Figure 1.** Cardiovascular risk factors of all CVD patients

formed by medical personnel on board (doctor or nurse) just before the telephone consultation, the staff being aware of the contribution of the ECG for certain diseases.

The main indications for carrying out an ECG on board are all chest pains and any discomfort that may be of cardiac origin. The same is true when setting up potentially cardiotoxic medical treatment. For other calls, the ECG is prescribed according to the opinion of the CCMM doctor, the pathology, or the cardiovascular risk factors for the patient.

### STATISTICAL ANALYSIS

Data were entered using Microsoft Excel 2007 (Microsoft, Redmond, WA). Statistical analysis was conducted using Epi-info 3.3.2 (Centers for Disease Control and Prevention, USA). Proportions were compared by using Chi-2 tests or Fisher's exact tests, when appropriate. Differences were considered significant if the p value was less than 0.05.

### RESULTS

Out of a total of 4090 patients supported by CCMM during the 2-year period from 1 January 2008 to 31 December 2009, 2101 files were related to a medical pathology, the others concerned traumatic pathologies. For this study, 179 cases of cardiovascular disease were selected, representing 8.5% of the medical pathology cases and 4.3% of the total CCMM cases.

Passengers accounted for 74 cases (41.3%) and Professional Seafarers (PS) accounted for 94 patients (52.5%). In 11 cases (6.2%) patient status was not specified.

The mean age was significantly higher in the passenger group (PG) ( $59.1 \pm 9.6$  years) than in the PS group ( $45.1 \pm 8.8$ ) ( $p < 0.001$ ). This difference can be explained by the small population of 60-year-old (or more) seamen who still work and the large number of older passengers who are mostly retired cruisers.

Regarding the type of ship, 86 patients (48%) were aboard passenger vessels, 34 (19%) aboard fishing vessels, and 34 (19%) aboard merchant vessels. The ship type distribution is given in Table 2.

The main CVD diagnoses are described in Table 3. The most frequent diagnoses were chest pain (54 cases; 32%), STEMI (23 cases; 14%), and NON STEMI (21 cases; 13%). There was a significant difference between the PG and PS groups for chest pain and pulmonary oedema.

The file analysis enabled cardiovascular risk factors (CVRF) to be found in 134 files of the 179 CVD cases (75%). The differences between the two groups are shown in Figure 1. There was a significant difference between the two groups regarding smoking (6 passengers vs. 34 PS;  $p < 0.001$ ).

Concerning the operational decision, 146 patients were disembarked (82%), 32 patients were treated

**Table 3.** Cardiovascular symptoms and diseases for the passenger and professional seamen

CVD diagnosis/symptoms	Professional seamen	Passengers	Total (%)	p
Cerebrovascular accident	11	10	21 (13)	NS
Chest pain	42	12	54 (32)	*0.005
STEMI	10	13	23 (14)	NS
Non STEMI	7	14	21 (13)	NS
Cardiac arrest	6	7	13 (8)	NS
Arrhythmia	9	6	15 (9)	NS
Essential hypertension	4	2	6 (3)	NS
Pulmonary oedema	3	8	11 (5)	*0.05
Pericarditis	2	1	3 (2)	NS
Pulmonary embolism	0	1	1 (1)	NS
<b>Total</b>	<b>94</b>	<b>74</b>	<b>168</b>	

**Table 4.** Analysis of chest pains

	Final diagnosis			Total
	STEMI	Non STEMI	Chest pain	
ECG performed	23	21	25	69
Doctor on board	7	5	5	17
No treatment	0	6	7	13
Nitroglycerin	10	11	12	33
Anti platelet ± Heparin	16	8	0	24
Analgesics	2	2	17	21
Thrombolysis	2	0	0	2
MEDEVAC	23	16	32	71
<b>Total</b>	<b>23</b>	<b>21</b>	<b>54</b>	<b>98</b>

on board (18%), and in one case the patient refused care.

Among the disembarked patients, 71 presented chest pain, there were 12 cases of cerebrovascular accident, 11 cases of arrhythmia, 9 cases of acute pulmonary oedema, and 1 case of pulmonary embolism, for the most serious diseases. Patients treated on board presented chest pain (non-STEMI, with cessation of pain after Natispray test or parietal pain), an episode of arrhythmia by atrial fibrillation, or pericarditis treated with anti-inflammatories.

Sixty-two were evacuated by helicopter (42%), 6 by ship or with military assistance (4%), and 13 after diversion of the ship to the nearest port (9%); 65 patients were disembarked at the next port of call.

Among the 146 disembarked patients, 72 (49%) patients were hospitalized on French territory, 46

(32%) were hospitalized outside France, 20 (14%) were non-hospitalized, and 8 cases (5%) were without data.

Among all vessels included, 132 vessels (74%) were equipped with an ECG device. An ECG was performed and transmitted for 79 patients (60%). In 4 cases, an ECG was recorded but was not transmitted due to a lack of equipment or transmission problems. In 85 cases (58%), an ECG was not requested even if ships were equipped. Regarding the patients suffering from chest pain, the CCMM physician prescribed an ECG to 70% of them.

Data concerning the completion of the ECG could be effective only for the treatment of chest pain. The overall results are given in Table 4.

An ECG was performed in 70% of cases of chest pain. The rate of medical evacuation is correlated to

the rate of completion of an ECG since we found 72% of medical evacuation for patients who presented with chest pain. ECG could diagnose 23 STEMI, and all these patients had been evacuated by a medical team. This diagnosis led to the establishment of antiplatelet therapy in combination with heparin, when medical supplies allowed it. It is noteworthy that two cases of thrombolysis were performed on the boat by the medical team after arrival on board. Only 13 patients received no treatment (13%), the majority of patients having received at least one analgesic treatment.

Out of the 179 studied patients, there were 17 deaths (9.5%): 10 occurred on board and 7 during the evacuation of the patient. Eleven were passengers and 6 were professional seamen. The causes were cerebrovascular accidents (2 cases, one of them proven to be hemorrhagic), a sudden cardiac arrest without further explanation (14 cases), and in one case a myocardial infarction with secondary ventricular tachycardia.

## DISCUSSION

To our knowledge, this study is the first that suggests the usefulness of performing an ECG on board, mainly in the management of chest pain. Indeed, carrying out an ECG during a call for chest pain led to the diagnosis of coronary syndromes ST+, to the start of antiplatelet therapy with heparin on board once the diagnosis was established, and to the medical evacuation of all of these patients. Treatment is established in 16 out of 23 STEMI or in 70% of cases. The lack of introduction of anticoagulant therapy in 7 other cases can be explained by the absence of these therapies on board, dependent on medical supplies. No patient could have benefited from double platelet anti-aggregation by the combination of aspirin and clopidogrel. This is simply explained by the absence of clopidogrel in the medical supplies. From all of the large number of published studies on the undeniable contribution of clopidogrel in the management of acute coronary syndrome [10-12], the results of our study will perhaps encourage debate about the introduction of clopidogrel to the medical supplies on French ships. In the same way, no thrombolytic therapy is available aboard ships, whatever the medical supplies. Interest in the presence of these thrombolytic therapies should be discussed with the relevant authorities.

A recent study [13] showed that in the general population the myocardial infarction rate has decreased since 2000 with a highly significant decrease

of STEMI and then mortality rates. These changes result from improvement in cardiovascular risk factor management, particularly hypertension and high cholesterol rate (primary and secondary prevention). The widespread use of antiplatelet agents, beta-blockers, and statins may participate in reducing the severity of cardiovascular events.

In our study, an almost identical proportion of the STEMI (14%) and the non STEMI (13%) was found without a significant difference between professionals and passengers, all coronary syndromes representing 25% of cardiovascular diseases treated by the CCMM. In our study, only one case of mortality was observed after myocardial infarction by passage into ventricular fibrillation, the STEMI being previously diagnosed by the TMAS physician from the transmitted ECG. However, we found 14 sudden death cases with no aetiology. Because most cases of sudden death having a coronarian cause we can assume a higher incidence of mortality related with coronary disease in our population of seafarers. However, myocardial infarction is reported in the literature [14-16] as the most frequent non-accidental cause of mortality during periods of navigation. The case fatality of myocardial infarction seems to be higher at sea than onshore, with features such as the absence of typical history and a high incidence of painless forms and commonly late complaints from professional fishermen [17]. Moreover, the risk of death appears to increase above 40 years of age [18]. Novaro et al. [19], who followed, on a contractual basis, cardiovascular problems that occurred aboard ships cruising off Florida, reported during two years of observations 100 identified cases of cardiovascular emergencies for which the most common symptom (50%) was chest pain, with 58% of coronary syndromes (21% STEMI and 37% non STEMI). The mortality on board was 3%, and 73% of them required evacuation. These results are comparable to our population of seafarers. Jaremin et al. [4], in a retrospective study of 11,325 Polish sailors and offshore fishermen between 1985 and 1994, counted 106 acute cases of coronary syndrome (ACS). By comparing this incidence rate to that of the general Polish population of that period, the authors demonstrated that the incidence of ACS among seafarers was not higher, but pre-hospital mortality and mortality rates after one month were higher for the seaman in the case of ACS. The authors explained these results by stating the difficult conditions of care aboard ships: remote situations, delayed diagnoses, inadequate treatment, and delays in the admission of the patient in an adequate specialized service.



This study analysed cardiovascular risk factors among patients suffering from cardiovascular diseases at sea and distinguished professional seamen from passengers. The predominant risk factor among professional seamen was tobacco consumption. It is assumed that seamen have higher tobacco consumption than the general population [20]. A Spanish study revealed that the percentage of smokers can exceed 80% for certain categories of Spanish fishermen [21]. Moreover, a recent study concerning French seafarers showed that fishermen or merchant seamen have a strong tendency to alcohol and tobacco addiction. The authors observed a close relationship between alcohol abuse and nicotine dependency, and they emphasized the prevention of this essential co-dependency [22].

This study demonstrates the feasibility of the teletransmission of ECG between ships and the TMAS. This had already been validated in the general ashore population for the transmission of 12-lead ECG in the pre-hospital field [23] but had not been shown for maritime medicine. Our results show low rates of technical failure during recording and transmission of the ECG (4 cases out of 63 received ECG).

Only recently, ECG teletransmission equipment has been introduced on French ships, and in our opinion it is essential for this to be integrated into official training programs for officers, with a module concerning practical recording and teletransmission of ECGs. Physicians of CCMM actively participate in medical training in maritime schools either for merchant marine officers or fishing captains in France, and, in particular, insist on achieving a clinical examination of the vital functions of the patient before calling the TMAS. During these training sessions, physicians teach the practical use of ECGs, explaining to the officers that the interpretation of the ECG by the doctor of the CCMM will lead to immediate prescription of treatment and to the planning of emergency evacuation of the patient in case of STEMI.

However, this study has limitations, firstly in terms of completeness because all of the data extracted from the CCMM database is done so retrospectively. In addition, the low number of cases concerning cardiovascular pathologies does not give any real conclusions about cardiovascular risk factors for the patients. The practice of maritime teleconsultation, especially in an emergency case, is not often compatible with a comprehensive collection of data. Indeed, this collection is done by questioning the patient, often achieved with an intermediary (officer in charge of care on board), leading to a possible loss of information.

Moreover, we received at CCMM only a few final reports of hospitalization of supported patients. This can be explained by the large number of hospitalizations in countries other than France, as shown in our study. The lack of this final 'feedback' does not therefore allow discussion of the diagnostic agreement between our initial hypothesis and the final diagnosis. A procedure for improving the quality of our data by collecting all of these final reports is being prepared in our TMAS. Thus, performance of an ECG is only of interest regarding STEMI but does not give any conclusions when the ECG is normal or *a fortiori* when it is not performed for chest pain.

In agreement with Schreiner [24], who recommends close cooperation between TMAS to set up procedures and strategies for the management of marine diseases, we support the idea of a common TMAS database. However, this would require coordinated collection of data and codifications. Regarding the European TMAS, an update of the Annex to the CE 92/29 European Directive concerning medical supplies should allow coordinated support in accordance with actualized practices regarding cardiovascular diseases, including the therapeutic as well as telemedical devices (ECG, AED) recommended on-board.

## CONCLUSIONS

Calls to the TMAS regarding cardiovascular diseases are not very frequent but require an effective response. The mortality rate is important for all types of seafarers in case of cardiovascular diseases on board. Recording and transmitting an ECG to the TMAS is technically feasible and enables the start of specific drugs, mainly in the management of STEMI. It would be interesting to continue our work to improve the implementation rate of ECGs during calls regarding chest pain in our TMAS and to continue training on the implementation of ECGs aboard, which is not defined in the STCW training of seafarers.

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## CONFLICT OF INTEREST

All authors declare that they have no conflicts of interest.

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