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Original Article

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ABSTRACT

Objective: The aim was to evaluate the translation of an ST-segment elevation myocardial infarction (STEMI) bypass protocol to the outcomes of patients with acute coronary syndrome in the Emirate of Ras al-Khaimah in the United Arab Emirates (UAE).
Methods: A prospective cohort study was conducted, which included all patients who had a prehospital 12-lead electrocardiogram (ECG) performed by ambulance crews. Analysis of those who were identified as having STEMI and who subsequently underwent percutaneous coronary intervention (PCI) was performed.
Results: A total of 152 patients had a 12-lead ECG performed during the pilot study period (February 24, 2016–August 31, 2016) with 118 included for analysis. Mean patient age was 52 years. There were 87 male (74%) and 31 female (26%) patients. Twenty-nine patients suffered a STEMI, and data were available for 11 who underwent PCI. There was no mortality, and no major adverse cardiac events were reported. The median door-to-balloon (D2B) time was 73 min (range 48–124), and 81% of patients had a D2B time < 90 min. Discharge data were available for six patients: All were discharged home with no impediments to rehabilitation.
Conclusion: This pilot study has demonstrated agreement with the existing literature surrounding prehospital ECG and PCI activation in an unstudied STEMI population and in a novel clinical setting. It has demonstrated a D2B time of < 90 min in over 80% of STEMI patients, and a faster mean D2B time than self-presentations (mean 77 min vs. 113 min), with no associated mortality or major adverse cardiac events.

Key words: 12-lead electrocardiogram, Middle East, myocardial infarct, percutaneous coronary intervention, prehospital, ST-segment elevation myocardial infarction

INTRODUCTION

Acute coronary syndrome (ACS) is one of the leading causes of morbidity and mortality worldwide[1] and almost half of the mortality associated with ACS in the Middle East occurs in the prehospital setting.[2] Only an estimated 15%–20% of the total population of the United Arab Emirates (UAE) are UAE nationals, with the remainder comprised expatriate workers.

The Gulf Registry of Acute Coronary Events and its second iteration (Gulf RACE and Gulf RACE-2) demonstrated that patients suffering from ACS in the Arab Middle East are younger (mean age

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56 years) and have higher rates of diabetes and smoking (diabetes 40%, smoking 38%) than in developed countries (mean age ~66 years; diabetes ~20%–30%, smoking ~18%–30%).[3-6]

Previous studies have shown significant underuse of emergency medical services (EMS) among ACS patients in the Arabian Gulf. Gulf RACE and Gulf RACE-2 revealed that EMS was only utilized by ST-segment elevation myocardial infarction (STEMI) patients in 17% and 25% of cases, respectively.[2,7] A recent study by Callachan *et al*. demonstrated that of 587 patients with STEMI in the Emirate of Abu Dhabi, only 15% presented through EMS, and the remainder came through private transport. This compares to an EMS utilization rate in the ACTION Registry in the USA of 60%.[8]

Historical practice

The National Ambulance (NA) Northern Emirates service is a single-tier Basic Life Support (BLS) ambulance service which is staffed with over 450 Emergency Medical Technicians (EMTs), manning 24 ambulances at 14 stations and 25 standby points across the Northern Emirates. The geographic area covers approximately 12,100 km^2 and contains a population of approximately 4.7 million persons. The service responds to approximately 35,000 emergency medical calls per annum.

EMTs are authorized to perform BLS procedures including medication administration, such as the administration of aspirin and nitroglycerin for ACS. They are also authorized to perform cardiac monitoring through 3-lead electrocardiogram (ECG). This BLS scope of practice is broadly similar across several jurisdictions, including the UAE, the Republic of Ireland, the United States of America, the United Kingdom, and Canada.

The acquisition of a 12-lead ECG, the subsequent interpretation and transmission of the ECG, and the activation of a percutaneous coronary intervention (PCI) center were not possible in the Northern Emirates region before the commencement of this pilot project in the Emirate of Ras al-Khaimah (RAK). The Emirate of RAK was initially chosen as the pilot as a new purpose-built PCI facility had become operational.

Prehospital electrocardiogram

A prehospital 12-lead ECG allows for earlier identification of acute STEMI.[9] Prehospital identification and care of STEMI patients were developed in the United Kingdom in the 1990s. The majority of studies on prehospital ECGs have focused on early identification of STEMI, but several studies have provided evidence that the prehospital ECG may also detect signs of transient ischemia and arrhythmias, which may no longer be present on arrival at the emergency department (ED).[10,11] Although the use of prehospital 12-lead ECG has expanded significantly in the past 10 years, not all services have this capability worldwide, and there is a paucity of BLS level services performing this.

A number of studies have identified that Advanced Life Support (ALS) paramedics can accurately identify patients who would have the greatest likelihood of benefiting from early thrombolytic[12,13] as well as influencing a reduction in mortality during 30 days following hospitalization.[14]

In general, prehospital emergency care, including 12-lead ECG acquisition, appropriate pharmacological therapy, and transport to a PCI capable center, appears to provide several benefits including decreased mortality, reduced symptom-onset-to-arrival time and door-to-reperfusion time, increased likelihood of receiving therapy (thrombolysis or angioplasty), and most importantly a decrease in the time to treatment.[8,12,15]

Prehospital triage to percutaneous coronary intervention

The mortality of STEMI patients can be reduced by emergent PCI, which is the recommended first choice therapy. The American College of Cardiology, American Heart Association, and European Society of Cardiology all recommend a door to PCI (door-to-balloon or [D2B]) time of under 90 min where possible.[16,17] When this timeframe is achieved, PCI has been shown to significantly reduce mortality and morbidity.[18]

Prealert or activation of PCI by prehospital personnel can reduce the D2B time. The acquisition of a prehospital 12-lead ECG is a necessary step before the decision to activate a PCI center. Several studies have shown improved reperfusion timeframes in patients with STEMI when a prehospital ECG is acquired.[19-24] It has not been possible until the implementation of this study to activate a PCI facility in the Northern Emirates region based on a prehospital ECG.

By utilizing EMS in ACS, treatment decisions can be made more effectively and within a shorter period. EMS can perform prehospital ECGs, identify STEMI, provide appropriate pharmacological therapy, prealert the hospital that the patient is en route, activate PCI, and thus minimize reperfusion timeframes.

Challenges

The act of translating the evidence from the literature review to a practical system implementation in the UAE had the potential to raise some serious challenges. The majority of existing evidence for the inclusion of prehospital ECGs and prehospital PCI activation has been produced in Western countries, with established, high-performing EMS systems, using clearly defined address systems and ALS level clinicians such as paramedics.

In this study, we sought to apply this evidence to an Arab Gulf country, where the concept of EMS, with the capability to provide both clinical treatment and not just transport, is a relative novelty. The service in which this system of care was implemented is only 2.5 years in existence. There is no clearly defined address system in the UAE, with many callers providing landmarks and directions instead of a physical address, potentially introducing delay to first medical contact. Finally, as previously outlined, care is delivered in the Northern Emirates through BLS level clinicians.

Aim

The aim of this pilot study was to document the impact a STEMI bypass system has on patient outcomes in the Emirate of RAK, UAE, through observation of a service improvement scheme.

METHODS

An observational design of the service improvement scheme allowed for inclusion of all patients who had a 12-lead ECG performed by EMT crews over a 6-month study period (February 24, 2016–August 31, 2016). Subsequent analysis of patient data for patients who were identified as suffering a STEMI and were brought for PCI at Sheikh Khalifa Specialty Hospital (SKSH) in RAK, UAE was performed.

This study received ethical approval from the office of the Chief Medical Advisor, National Ambulance, UAE (Approval 12122015).

Inclusion criteria for this pilot study population included all adult patients (over the age of 18) treated by EMTs in RAK, UAE, during the 6-month pilot project period who had a 12-lead ECG performed.

Any patient who met the criteria for obvious death (rigor mortis, lividity, decapitation, hemisection, or decomposition) was excluded, as were patients under the age of 18 years old, and those for whom significant amounts of data were missing (entire patient care report, entire STEMI form, only the 12-lead ECG available, etc.). Patients who were treated by EMT crews but whose call originated outside of the Emirate of RAK were also excluded, as were those who declined or withdrew consent to participate.

The primary outcome measured was inhospital mortality rate among the STEMI group. Mortality is a useful primary outcome measure as it is binary (dead/alive), clearly definable, reliable, reproducible, and clinically relevant.

Additional outcome measures analyzed included inhospital major adverse cardiac events (MACE), reperfusion timeframes (including D2B time), and condition on discharge.

Data collection and analysis

EMTs who provided care for patients presenting with suspected ACS completed a prehospital data collection form specifically designed for this study. EMTs were provided with training on both the clinical protocol and study protocol including data collection form. Patients who subsequently underwent PCI in SKSH had a hospital data collection form completed. Data were input in a database application (Access 2013, Microsoft, WA, USA) by a trained researcher, and statistical analysis was performed by a trained statistician using a spreadsheet application (Excel 2013, Microsoft, WA, USA) and using SAS procedures (SAS Institute, 2013). Timeframes were measured in minutes; pain was measured using the 11-point Numeric Rating Scale from 0 (no pain) to 10 (worst pain imaginable), which is a valid and reliable scale to measure pain intensity.[25]

Categorical data were presented as percentages. Continuous variables such as response time or pain scores were presented as means, median, standard deviations (SD), minimum, or maximum. Frequency is presented for continuous variables if the sample size is too small to compute descriptive statistics. Pearson's Chi-square test or Fisher's exact test was used to compare categorical variables as appropriate. Independent Samples *t*-test was used to compare the means of continuous variables (e.g., pain scores) to determine statistically significant differences between two groups (e.g., STEMI vs. non-STEMI). All analyses were two-tailed and $P < 0.05$ was considered significant.

RESULTS

One hundred and fifty-two patients were treated for suspected ACS in RAK during the pilot study period. Nine patients refused transport and were considered to have withdrawn their consent for inclusion in the study as a result. A total of 34 patients were excluded due to incomplete study data received from crews ($n = 21$), withdrawal of consent ($n = 9$), the STEMI originated outside of the Emirate of RAK ($n = 1$), or the patient was a pediatric patient defined as under 18 years old ($n = 3$). After applying all exclusion criteria, 118 patients were included in the final dataset for analysis. Figure 1 shows the study population details.

A total of 29 patients were confirmed as STEMI cases. One of these patients was incorrectly transported to another facility in a breach of study protocol. Inhospital data were available for 13 of these patients, with the remainder outstanding at the time of analysis. Only one patient from these 13 consented to follow up on discharge from SKSH. Mean patient age was 51.10 years (SD ± 15.86, range 20–88). Table 1 outlines demographic details of the STEMI group.

Patients with suspected STEMI who had prehospital ECG and subsequent PCI performed at SKSH had no mortality (0%) in the study period. Self-presentations also had no mortality (0%) in the outlined study period.

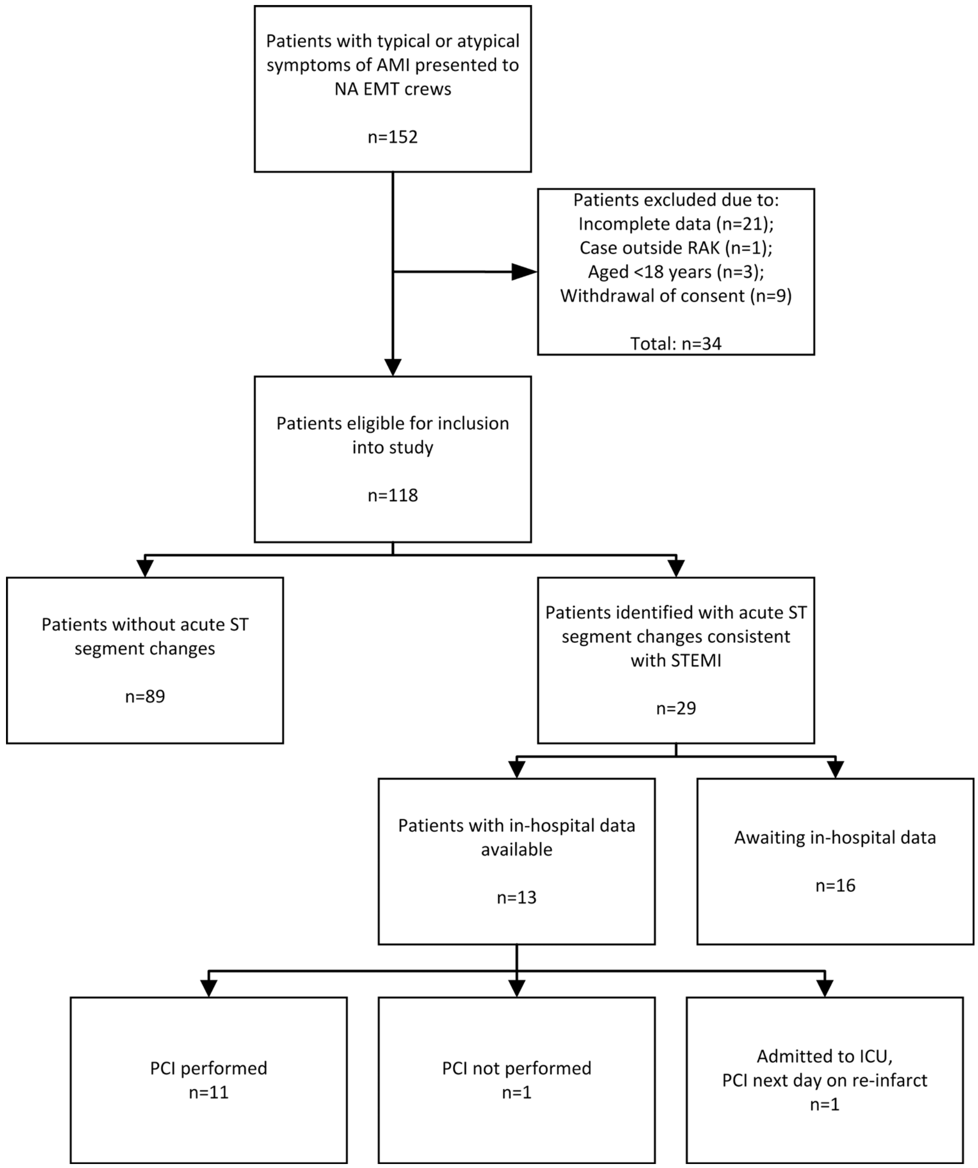

Figure 1: Study population

No patient (0%) suffered any major adverse cardiac event in the period post-PCI.

Median ambulance response time to patients with STEMI was 7 min (interquartile range [IQR] 7). The median symptom onset-to-dispatch time was 32 min (IQR 145). Symptom onset data were missing for 19 cases (66%). The median dispatch-to-door time was 57 min (IQR 18.7). The failure rates of prehospital ECG transmission were also tracked; two-failed transmissions were recorded. Both of these patients had a prehospital ECG performed in the field, a printed copy of which was given to the ED staff on arrival at the ED. These cases would have been assessed at the ED and not had prehospital PCI activation and thus were not included for analysis.

A total of 14 of the 29 STEMI cases (48%) had a pain score of four or less on assessment, with five cases having a pain score of zero on assessment. There was a nonsignificant difference in the pain scores for non-STEMI (mean 3.584, SD 3.45) and STEMI (mean

Table 1: Patient demographics (STEMI group)

	n (%)
Gender	
Female	5 (17.24)
Male	24 (82.76)
Age, mean (SD)	51.10 (15.86)
Nationality	
Asian	3 (10.34)
UAE national	6 (20.69)
European	1 (3.45)
Indian subcontinent	15 (51.72)
Other Arab nation	2 (6.9)
Other	2 (6.9)

UAE: United Arab Emirates, SD: Standard deviation

4.5926, SD 3.15) presentations (t [100] = −1.33, $P = 0.1859$).

Of the 29 STEMI patients, cath lab times were available for 12 patients. The mean D2B time for prehospital triage cases was 77 min (range 48–124, median 73). Numerical trends presented in Table 2. This compares with a mean D2B time of 113 min for self-presentations. One patient was brought to the cath lab and had no evidence of occlusion and did not undergo angioplasty. This patient was excluded from analysis.

Discharge data were available for six patients (21%), with the remainder outstanding. All six patients were discharged home after hospital stays ranging from one to seven days. All were discharged with independence in activities of daily living; none required assistance, and all were expected to have probable improvement in functioning.

DISCUSSION

This is one of few studies conducted within the UAE to evaluate the incidence of ACS, STEMI and the impact of systems of cardiac care on outcomes. It is the first study of its kind in the Northern Emirates region and provides the foundations of an evidence base for the management of ACS and STEMI in the wider region. Due to the absence of mortality and MACE in our study population, we are unable to make meaningful assertions regarding this pilot study and its effects on mortality or morbidity.

Previous studies, however, have illustrated the impact of prehospital 12-lead ECG on mortality and morbidity of those suffering from STEMI by reducing reperfusion timeframes. The findings in our study agree with the findings of several previous studies about the benefit of prehospital ECG acquisition. Rokos *et al*. described a higher rate (86%) of D2B time ≤90 min for regions that had implemented prehospital ECG compared with the national standard of <50%.[24] A study by Canto *et al*. found that patients with prehospital ECG had significantly shorter D2B time (92 min) than those without prehospital ECG (115 min).[26]

Table 2: Door-to-balloon times

D2B (min)	Cumulative frequency (%)
48:00	1 (9.09)
59:00	2 (18.18)
63:00	3 (27.27)
68:00	4 (36.36)
70:00	5 (45.45)
73:00	6 (54.54)
75:00	7 (63.63)
78:00	8 (72.72)
86:00	9 (81.81)
111:00	10 (90.9)
124:00	11 (100)

D2B: Door-to-balloon

The findings of our study are in agreement with previous findings that patients suffering from ACS in the Middle East are younger (mean age 53.5 years), have higher rates of comorbidities, and utilize EMS less than Western populations. Our population was more comorbid and on average 10 years younger than the study population in other published studies from Western countries. In the Gulf RACE-2 study, the UAE demonstrated one of the lowest rates of EMS use in ACS, far behind its neighbors Bahrain, Qatar, and Oman. Callachan *et al*. studied the utilization and perceptions of EMS use in STEMI in Abu Dhabi and concluded that patient knowledge and perceptions may contribute to underutilization.[27] Considering that on average, fewer than one in five patients with ACS in the Gulf nations was demonstrated to have used EMS, there exists a significant opportunity to improve the recognition and management of ACS in the region.[2,27,28] Delays in seeking help need to be minimized to ensure patients have the best chance of a successful outcome. A national awareness initiative highlighting when and how to call an ambulance is underway in mainstream and social media platforms in the UAE (for example see http://bit.ly/2u2oJrw and https//bit.ly/1W6pKdc).

This study also highlighted the importance of acquiring an ECG in atypical presentation. A previous study by Cannon *et al*. demonstrated that over one-quarter of STEMI patients presented without chest pain and did not receive a prehospital ECG.[29] Atypical presentations were common in our study, with classic STEMI recognition characteristics (pain, nausea, dyspnea) not present in many cases. Almost 50% of the patients in our study had a pain scale under 5, and many had no pain on assessment. This supports our assertion that EMTs need to be provided with education stressing the importance of assessing for atypical presentations such as patients with little to no pain, those with vague symptoms, and those from at-risk groups such as those from the Indian subcontinent.

Before the implementation of this pilot, there was no system of STEMI bypass care for patients in the Northern Emirates. Therefore, it can be postulated that before the implementation of this system, first medical contact for many of these patients would have occurred on arrival at an ED. There would still be a time delay from this ED presentation until the acquisition of an ECG. Overall, the mean D2B time for the patients in our study was 77 min (range 48–124). This was an improvement of 36 min over the D2B time for self-presentations at the same facility (mean 113 min).

This is also one of the very few studies conducted internationally which observed EMT performed acquisition and interpretation of 12-lead ECGs. A previous study in Canada by Cantor *et al*.

demonstrated that non-ALS clinician performed 12-lead ECG acquisition, was feasible, and was associated with an acceptable false-positive rate.[21] Results from our study support the assertion that non-ALS level clinicians can be trained in the acquisition and interpretation of 12-lead ECGs and can successfully implement this as part of a larger cardiac care protocol with telemetry oversight.

Limitations

Due to study design, we were unable to exclude that trends such as workforce staffing, offload delays, and hospital capacity did not affect D2B times. Although we eventually enrolled a significant number of patients, our study did not recruit enough patients to measure mortality statistically as an endpoint nor the other secondary outcomes. EMS dispatch-to-balloon time was measured as a surrogate for first-medical-contact-to-balloon time.

We did not collect information on patients whose prehospital ECG was negative for STEMI but subsequently whose ED ECG revealed STEMI. While a prehospital ECG may highlight information that subsequent ECGs may not, as demonstrated by Davis *et al*. (2014), our crews performed serial ECGs before arrival at the ED, and we would estimate the number of patients in this category to be quite small.

All patients who had a prehospital ECG performed were included in the data collection. However, the majority of patients with ACS in the UAE still arrive through private transport to the hospital, rather than call for an ambulance.[2,28] This contributed to the relatively small sample size in the study.

A significant proportion of the inhospital data on the STEMI population is outstanding. Further analysis of this data, once available may influence results significantly and may result in changes to some of the conclusions made. Despite our efforts, data collection was incomplete for several records as described due to several factors including human error, communications issues, data chain fragility, and patient refusal to transport.

CONCLUSION

In summary, this pilot study has demonstrated agreement with the existing evidence base for inclusion of prehospital ECG and prehospital PCI activation in the management of patients with ACS. It also supports the assertion that the implementation of an inclusive cardiac care system which includes prehospital ECG and triage to PCI is feasible, safe, and can be implemented in a novel non-ALS clinician setting. It demonstrated a reduction in D2B timeframes for those patients who present through EMS compared to those who self-present to the ED. The adoption of this model across the remainder of the Northern Emirates is recommended by this study, and further research into the effects of this wider implementation is warranted.

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Conflicts of interest

There are no conflicts of interest.

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