Warning signs prior to in-hospital cardiac arrest. *Need for a rapid response team*

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Patient's safety has become a crucial focus as information has come to light regarding medical errors leading to patient harm. Adverse outcomes related to medical management in the hospital are common, ranging from 4-17% of hospital admissions. The analysis of such events suggests that up to 70% are preventable, and failure to rescue these patients is contributed largely by the failure to recognize a patient's deteriorating clinical condition. Hospitals have monitored and non-monitored areas. There are differences between wards with, and without monitoring facilities such as, the degree of training and expertise of the nurses in advanced and basic cardiac life support, the distance from, and the ability to use emergency equipment, and the location of the ward within the hospital. Previous studies have shown that survival to hospital discharge after in-hospital cardiac arrest is approximately 17-24%. Survival rates after cardiac arrest in the hospital general wards are significantly lower than in those occurring in the monitored areas. Approximately 80% of these patients have signs of significant physiological deterioration preceding the actual cardiac arrest,[1-4] and it was also found that 70% of patients showed evidence of respiratory deterioration within 8 hours of cardiac arrest. Despite documentation of the patient's clinical deterioration and physician notification, interventions are frequently inappropriate or absent.[1,3] Previous studies of antecedents of cardiac arrest and interventions are carried out in Western hospitals, where the hospital culture and practices on wards may differ from many other countries. The current study was undertaken in a Saudi hospital, and the objective was to determine the prevalence of abnormal vital signs prior to cardiac arrest, and to estimate the current practice in patient observation in the wards to identify patients at risk of cardiac arrest.

We reviewed the charts of all adult patients who suffered an in-hospital cardiac arrest during the 2 years (January 2006 to December 2007) at King Abdul-Aziz Hospital, in the Eastern Region of the Kingdom of Saudi Arabia. We used the hospital's cardiopulmonary resuscitation (CPR) registry to identify all in-patient adult cardiopulmonary arrests during the year 2006 and 2007. The CPR registry is a database of all cardiopulmonary arrests, which is collected prospectively by the hospital CPR Committee. This committee reviews all cardiopulmonary arrest events. The Code Blue Team was organized to respond to cardiac arrest calls all over the hospital. When a cardiac arrest occurs, the hospital staff dials a specific number, and the CPR team is immediately alerted.[5]

The research proposal was approved by the Hospital Research Committee. A co-investigator retrospectively reviewed the medical records of all adult patients that had cardiopulmonary arrest, to identify possible abnormal observations within 24 hours prior to the arrest. The following criteria was used: hypotension, as defined by systolic blood pressure below 90 mm Hg, oxygen saturation below 90% with or without oxygen, heart rate below 40 or over 130/min, respiratory rate >24 or <8 breaths per minute, seizures, acute mental status changes (Glasgow coma scale <14). For patients that had arrests more than once during their hospital stay, only the first cardiopulmonary arrest event and resuscitation was considered for analysis.

Cardiopulmonary arrest was defined as an event, if monitoring data showed presence of a non-perfusing rhythm (namely asystole or ventricular fibrillation), or the responding team had documented that the patient was unresponsive, pulseless, and apneic. The patient monitoring is defined by both level of technology used, and the personnel must therefore be present to maintain that level of surveillance. The patient was considered to be "monitored" when continuous pulse oximetry, or continuous electro-cardiogram (ECG) monitoring was being used at the time of arrest event. The unmonitored unit usually had a nurse-patient ratio of 1:5, and a monitored unit had a nurse-patient ratio of 1:2. In all intensive care unit patients are monitored by more than one modality (such as; pulse oximetry, ECG, blood pressure), nurse-patient ratio is 1:1, and an intensivist is in the hospital at all times.[4]

Statistical analysis was performed using Statistical Package for Social Sciences for Windows version 16.0 (SPSS Inc., Chicago, IL, USA). The continuous variables were expressed as mean ± SD, while the categorical variables as a percentage of the group from which they were derived. The association between documentation of vital signs in monitored and non-monitored area were assessed by the Pearson chi-squared test for contingency table. For further evaluation of this association, the risk of an abnormal vital sign being present in the monitored area, compared with the non-monitored group was estimated by the odds ratio (OR), and 95% confidence interval (CI). The monitored area was set as a reference. An OR of more than one,

indicates an increased likelihood of the outcome (return of spontaneous circulation) at a *p*-value of <0.05. All tests of significance were 2-tailed, and reported with the exact *p*-value.

The total number of adult patients that had arrests in the hospital during the study period were 72 (46 males and 26 females). The mean age was 65 years (standard deviation [SD] 19.3, range 16-99), and the median length of stay before the cardiac arrest was 5 days (SD 13.8, range 1-65). Thirty-eight patients (53%, 95% CI 41-64) achieved spontaneous circulation. There were 49 adult in-hospital cardio-respiratory arrests. Thirty-two (65%, 95% CI 52-79) of the arrests occurred in the monitored area (step-down units, intensive and coronary care). All 32 patients had at least one of the abnormal vital sign. The remainder of the cardiac arrests (17 [35%, 95% CI 21-48]) occurred in the wards and of those patients, 14 (82%, 95% CI 64-100) had at least one of the abnormal vital signs.

Documentation of vital signs prior to the arrest. All 49 patients had documentation of vital signs in the hospital charts 24 hours before the arrest. Of those patients, a total of 46 (94%) patients had abnormal observations. The distribution is shown in **Table 1**. Interestingly, no patient showed bradycardia, or reduced respiratory rate. There was a statistically significant difference between hospital location and the documentation of vital signs (p=0.0001). In the monitored areas, all patients had abnormal vital signs. The corresponding figures for the non-monitored wards include 82% with abnormal vital signs, while 18% had the documented normal vital signs. The mean delay from the first documented abnormal vital sign to the cardiac arrest was 4 hours. The frequency of documented observations on the 24 hours before the cardiac arrest varied considerably among the patients on the wards, with a mean of 1.2 observations per patient. Only pulse rate, blood pressure, and pulse oximetry were recorded more than once during these 24 hours. The interventions carried out for the patients with abnormal vital signs on the wards were not adequately documented, however, there was a substantial delay in initiating the treatment. The distribution of patients that achieved spontaneous circulation and was discharged home in the 2 groups are described in **Table 1**.

Our study had shown that the cardiac arrest patients in the wards showed evidence of deterioration hours before the actual cardiac arrest. Eighty-two percent of the ward patients who had suffered cardiac arrest had abnormal vital signs in the preceding 24 hours. We had also shown that interventions during this period are not documented properly, and in some cases, found to be insufficient and are performed late. Our results showed a higher number of ward patients showing abnormal

Table 1 - Comparison of patient characteristics in monitored and non-monitored areas.

Demographics	All participants (n = 49)	Monitored areas (ICU, CCU, SDU) (n = 32)	Non-monitored areas (General wards) (n = 17)	*P*-value	OR (95% CI)
Male, n (%)	32 (65.3)	21 (65.6)	11 (64.7)		
Mean age, years	69.08 ± 15.65	69.10 ± 16.75	69.05 ± 13.85		
Length of stay*	5.0 ± 13.9	4.5 ± 15.3	8.0 ± 11.2		
Warning signs	46	32	14		
↑Respiratory rate	35	27	08	0.006	2.8 (1.3-5.8)
Hypotension	31	26	05	0.001	4.1 (1.7-9.8)
Tachycardia	09	09	00	0.015	0.58 (.44-.75)
Hypothermia	21	16	05	0.166	1.8 (.75-4.3)
GCS ≤14	10	08	02	0.274	1.9 (.52-7.0)
O_2 saturation < 90%	24	20	04	0.009	3.1 (1.2-8.2)
Mean number of warning signs	2.9 ± 1.2	3.3 ± 1.1	2.1 ± 0.9		
Specialty, n (%)					
Medicine	46 (94.0)	30 (94.0)	16 (94.0)		
Surgery	03 (6.0)	2 (6.0)	1 (6.0)		
Return of spontaneous circulation	38	27	11	.01	
Hospital discharge	15	12	3	.004	

*values are median, ICU - intensive care unit, CCU - coronary care unit, SDU - special duty unit, OR - odds ratio, GCS - Glasgow coma scale

vital signs before the actual arrest, in contrast with those reported by researchers from other countries.[2-4]

In addition, the most common warning signs before a cardiac arrest in the wards were, increased respiratory rate, hypotension, and tachycardia. Tachypnea is one of the most important predictors of the cardiopulmonary arrest, however, it was recorded only in the minority of patients. In the patients whose cardiac arrests occurred in a monitored setting, all had documented abnormal vital signs prior to their cardiac arrest, probably as they were monitored more intensively. However, all the patients with abnormal vital signs in those areas received interventions without unnecessary delays. Thus, the major benefit of measuring the vital signs could be observed within patients deteriorating in the unmonitored wards. From the patients who suffered cardiac arrest on the wards, 18% do not have any documented abnormal vital sign. The prevalence of abnormal vital signs prior to cardiac arrests in our study, is higher comparable to the previous studies.[1,2,4]

We believe that it is for 2 reasons: first, in all previous studies, the patients' charts were reviewed to identify possible abnormal observations within 8 hours prior to the arrest, while we increased that period to 24 hours. Secondly, the previous studies did not include respiratory rate and level of consciousness in the analysis, and it is found recently that these 2 signs are the most specific predictors of poor outcome.[1] However, it would be interesting to look prospectively at all the patients with abnormal vital signs to find out how many would actually develop cardiac arrest.

Our data suggest as in the literature, that the problem lies in responding to the information, rather than the absence of pertinent information. Thus, the recording of a high respiratory rate did not lead to therapy that prevented arrests. This might have occurred due to inadequate or delayed communication of the information to physicians, perceptions by the physician staff that such information was not important or reliable, insufficient therapy by physician staff, or the failure of maximal, appropriate therapy to prevent arrests. These possibilities are worthy of future investigations.

Based on high proportion of abnormal vital signs in patients that underwent cardiac arrests, we recommend the introduction of a "Rapid Response Team" (RRT) in our hospital. We expect that it should enable patients at risk of cardiac arrests to be treated promptly and appropriately, and may reduce the incidence of cardiac arrests in the hospital wards. It may provide an opportunity to identify and proactively treat "pre-arrests" in adult in-patients effectively, and thus, may reduce in-patient mortality rates. Our aim was not to assess the potential benefit of RRT, and we do not know whether some of the cardiac arrests could have been avoided. Previous studies[2-4] had demonstrated a decreased rate of cardiac arrests and mortality after the implementation of RRT.

Our study has several limitations. The typical problems related to the retrospective nature of the study, where the data may be incomplete or absent, and we relied on whatever documentation was available regarding the vital signs and the related intervention. The sample size was small and only from one facility. Although our hospital is a typical secondary care hospital, it may not be representative of all Saudi hospitals.

In conclusion, 82% of the ward patients who suffered cardiac arrests had abnormal vital signs documented in the preceding 24 hours. During this period, the interventions were found to be sub-optimal on occasion. The introduction of RRT could lead to prompt and appropriate treatment of these patients.

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