Association between clinically abnormal observations and subsequent in-hospital mortality: a prospective study

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Abstract

Background: Patients with unexpected in-hospital cardiac arrest often have an abnormal clinical observation prior to the arrest. Previous studies have suggested that a medical emergency team responding to such patients may decrease in-hospital mortality from cardiac arrest, but the association between any abnormal clinical observation and subsequent increased mortality has not been studied prospectively. The aim of this study was to determine the predictive value of selected abnormal clinical observations in a ward population for subsequent in-hospital mortality.

Design and setting: Prospective data collection in five general hospital ward areas at Dandenong Hospital, Victoria, Australia.

Interventions: None.

Results: During the study period, 6303 patients were admitted to the study areas. Of those, 564 (8.9%) experienced 1598 pre-determined clinically abnormal events and 146 of these patients (26%) died. The two commonest abnormal clinical events were arterial oxygen desaturation (51% of all events), and hypotension (<90 mmHg). Using a multiple linear logistic regression model, there were six clinical observations which were significant predictors of mortality. These were: a decrease in Glasgow Coma Score by two points, onset of coma, hypotension (<90 mmHg), respiratory rate <6 min−1, oxygen saturation <90%, and bradycardia >30 min−1. The presence of any one of the six events was associated with a 6.8-fold (95% CI: 2.7–17.1) increase in the risk of mortality.

Conclusions: Six abnormal clinical observations are associated with a high risk of mortality for in-hospital patients. These observations should be included as criteria for the early identification of patients at higher risk of unexpected in-hospital cardiac arrest.

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Keywords: Medical emergency team; Cardiac arrest

Resumo

Contexto: Os doentes vítimas de paragem cardíaca intra-hospitalar inesperada têm frequentemente uma observação clínica anormal antes da paragem. Estudos prévios sugerem que se esses doentes forem socorridos por uma equipa médica de emergência pode-se diminuir a mortalidade intra-hospitalar por paragem cardíaca, mas a associação entre alterações clínicas e aumento da mortalidade subsequente não foi estudada de forma prospectiva. O objectivo deste estudo foi determinar o valor preditivo, para mortalidade intra-hospitalar de alterações clínicas, selecionadas, numa população de enfermaria. Desenho: Recolha prospectiva de dados em cinco áreas de enfermaria geral hospitalar no Hospital Dandenong, Victoria, Austrália. Intervenções: Nenhuma. Resultados: Durante o período de estudo, foram admitidos 6303 doentes nas áreas de estudo. Em 564 (8.9%) ocorreram 1598 alterações clínicas de um grupo pré-determinado e 146 (26%) morreram. As duas alterações clínicas mais frequentes foram a desaturação de oxigénio arterial (51% de todos os eventos), e a hipotensão (17.3% de todos os eventos). Utilizando um modelo de regressão logística linear múltipla, houve seis observações clínicas que significativamente prediziam a mortalidade: Deterioração do Score da Escala de Coma de Glasgow em 2 pontos, início de coma, hipotensão (<90 mmHg), frequência respiratória <6 min, saturação de oxigénio <90%, e bradicardia >30min. A presença de qualquer um destes seis acontecimentos associou-se ao aumento de 6,8 vezes (95% CI: 2,7–17,1) no risco de morte. Conclusões: Identificaram-se seis alterações clínicas associadas a aumento de risco de morte.

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em doentes hospitalizados. Estas observações devem ser incluídas como critérios para a identificação precoce dos doentes com risco mais elevado de paragem cardíaca intra-hospitalar inesperada.

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Palavras chave: Equipe de emergência médica; Paragem cardíaca

Resumen

Antecedentes: Los pacientes con paro cardíaco no esperado intrahospitalario tienen frecuentemente hallazgos clínicos anormales previos al paro. Estudios previos sugieren que el equipo de emergencias médicas que responde a tales pacientes podría disminuir la mortalidad intrahospitalaria, pero la asociación entre los hallazgos clínicos anormales y mortalidad aumentada subsecuente no ha sido estudiada prospectivamente. El objetivo de este estudio fue determinar el valor de determinados hallazgos clínicos anormales para predecir mortalidad intrahospitalaria.

Diseño y Ambiente: Recolección prospectiva de datos en cinco áreas de salas generales en el Hospital Dandenong, en Victoria, Australia. Intervenciones: Ninguna. Resultados: Durante el período de estudio, 6.303 pacientes fueron admitidos en las áreas del estudio. De aquellos, 564 (8.9%) experimentaron 1.598 eventos clínicamente anormales y 164 de estos pacientes (26%) murieron. Los dos eventos clínicos anormales más comunes fueron la desaturación (51% de las alertas), y la hipotensión (17.3% de los eventos). Se analizó usando un modelo de regresión logística lineal múltiple, y se encontraron seis hallazgos clínicos que eran predictores significativos de mortalidad. Estos fueron: una disminución en dos puntos en la escala de coma de Glasgow, instalación de coma, hipotensión (<90 mmHg), frecuencia respiratoria < 8/min⁻¹, saturación de oxígeno <90%, y bradicardia >50/min⁻¹. La presencia de cualquiera de estos 6 eventos se asoció con un aumento en 6.8 veces del riesgo de mortalidad (95% CI, 2.7–17.1).

Conclusiones: Seis hallazgos clínicos anormales están asociadas con mayor riesgo de mortalidad intrahospitalaria de pacientes. Estos hallazgos clínicos deberían incluirse como criterios para la identificación temprana de pacientes en mayor riesgo de paro cardíaco intrahospitalario inesperado.

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Palabras clave: Equipo de emergencias médicas; Paro cardíaco

1. Introduction

Unexpected in-hospital cardiac arrest is common and associated with a high mortality rate [1–4]. When cardiac arrest occurs in a general ward area, many hospitals use a “cardiac arrest team” to respond and provide immediate resuscitation. However, this approach has not been associated with an improvement in the mortality rate.

Previous studies have suggested that 66–84% of in-hospital cardiac arrests are preceded by at least one abnormal clinical observation [5–8]. Traditionally, these observations are reported by nursing staff to junior medical staff, leading to delays in evaluation and definitive care.

In order to decrease the incidence of unexpected cardiac arrest, the concept of the medical emergency team (MET) has been described [9–11]. The MET consists of experienced clinicians who are called to respond immediately to patients with any abnormal clinical observations and/or laboratory findings. The rationale of a MET system is that early intervention might prevent subsequent cardiac arrest and/or unplanned intensive care admission. We reported in a previous study that the introduction of a MET significantly decreased the mortality rate of unexpected cardiac arrest in our hospital [11].

However, the clinical criteria for the paging of the MET have been based on retrospective studies of the clinically abnormal observations which have been found to precede cardiac arrest. This methodology may significantly underestimate the true incidence of these observations among hospital in-patients. Therefore, we undertook this study to determine prospectively the incidence of selected abnormal clinical observations and their association with discharge mortality status for in-hospital patients.

2. Study design and methods

This study was a prospective, observational investigation at Dandenong Hospital, Melbourne, Victoria, Australia. Dandenong Hospital is a 320-bed, university affiliated teaching hospital and provides most clinical services (except elective cardiac surgery and neurosurgery) to a population of approximately 500,000 in the outer south-eastern suburbs of Melbourne, Australia. During 1999, the hospital admitted 28,000 patients and there were 520 ICU admissions.

The study was conducted as part of an evaluation of the Dandenong Hospital MET, the details of which have been described elsewhere [11]. Introduced in 1997, the MET was activated when the nursing staff found one or more clinical or laboratory abnormalities, as shown in Table 1.

Data collection was undertaken over a 33-week-period, between May and December 1999, in five ward areas with a total of 164 beds. These wards comprised two general medical wards, two general surgical wards and one orthopaedic ward. Each day during the study period, an investigator would visit each ward and review the medical records of every patient. The investigator checked all observation charts and any documented adverse event reports. The investigator also checked directly with nursing and medical staff any unreported or undocumented adverse events. In particular, the development of any one of 10 defined abnormal clinical observations were sought (Table 1). All patients in the
Table 1
Definition of abnormal observations considered in this study

<table>
<thead>
<tr>
<th>Event</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>SaO₂ &lt;90%</td>
<td>Saturation less than 90% using oximetry machine attached to finger with or without supplemental oxygen</td>
</tr>
<tr>
<td>Hypotension</td>
<td>Systolic blood pressure less than 90 mmHg</td>
</tr>
<tr>
<td>Hypertension</td>
<td>Systolic blood pressure greater than 200 mmHg</td>
</tr>
<tr>
<td>Tachycardia</td>
<td>Pulse rate greater than 130 beats min⁻¹</td>
</tr>
<tr>
<td>Bradycardia</td>
<td>Pulse rate less than 50 beats min⁻¹</td>
</tr>
<tr>
<td>Tachypnoea &gt;30</td>
<td>Respiration rate greater than 30 min⁻¹</td>
</tr>
<tr>
<td>Bradypnoea &lt;6</td>
<td>Respiration rate less than 6 min⁻¹</td>
</tr>
<tr>
<td>Loss of consciousness</td>
<td>Loss of consciousness (Glasgow Coma Score of 3)</td>
</tr>
<tr>
<td>Decrease level of consciousness</td>
<td>Decreased level of consciousness by &gt;2 Glasgow Coma Score points</td>
</tr>
<tr>
<td>Fitting</td>
<td>Any seizures</td>
</tr>
</tbody>
</table>

ward during the study period were included regardless of resuscitation status.

Ethical approval for the study was granted by the Dande-nong Hospital Ethics Committee.

2.1. Statistical analysis

The association between an event and the mortality was assessed by the univariate linear logistic regression analysis using the maximum likelihood method [12]. As the events could be correlated, and to construct a “final” predictive model, both stepwise and backward elimination algorithms were used to search for independent risk factors of mortality. Before constructing the model, a relatively high P-value (0.15) was used for the immediate steps to include the effects of any potentially important variables that might be statistically non-significant because of the size (and resulting power) of the study. Odds ratio of mortality associated with each of the independent predictors was then estimated by a multiple linear logistic regression model, by the statistical analysis system [12].

3. Results

During the 7-month study period, 6303 patients were admitted to the study wards, with a total of 38,115 bed-days and a mean length of stay of 6 days. During this period, 1598 abnormal bedside observations were observed in 564 patients, making the incidence of abnormal bed observations 4.2 per 100 bed-days in 8.9% patients.

The prevalence of adverse events is shown in Fig. 1. The two commonest events were the bedside observation of oxygen desaturation to less than 90% (on or off oxygen therapy), comprising 51% of all events; and hypotension (17.3%). The occurrence of tachycardia, tachypnoea, and hypertension accounted for 23% of all abnormal observations (Fig. 1).

In the 564 patients with abnormal observations, there were 146 (26%) who subsequently died. In univariate analysis, decrease in respiratory rate (<6 min⁻¹) was associated with a 13.7-fold (95% CI: 2.9–64.0) increase in the risk of mortality at hospital discharge, making it the strongest predictor of mortality (Table 2). Decrease of consciousness or loss of consciousness were present collectively in 4.7% of all events, and were associated with a 5.5-fold (95% CI: 2.6–11.9) and 6.1-fold (95% CI: 3.1–11.8) increase in the risk of mortality, respectively. Other events which were associated with increased mortality at hospital discharge were: tachypnoea >30 min⁻¹ (OR: 6.1, 95% CI: 3.6–10.6), tachycardia >130 min⁻¹ (OR: 2.3, 95% CI: 1.3–2.9), and hypotension (OR: 2.3, 95% CI: 1.3–2.9). When these events were considered simultaneously in a multiple linear logistic regression model, decrease of consciousness, coma, hypotension, respiratory rate <6 min⁻¹, oxygen saturation <90%, and tachycardia >30 min⁻¹ were found to be significant predictors of mortality (Table 3).

The higher the number of events experienced by a patient, the higher the risk of mortality (Fig. 2). For instance, among those patients who had only one adverse event, the probability of death was 16.2%; this probability increased progressively to 88.2% among patients with four or more abnormal observations. Using logistic regression, it was found that each additional event was associated with a three-fold (95%
Table 2  
Risk of mortality associated with adverse event

<table>
<thead>
<tr>
<th>Events</th>
<th>Probability of death among those (%)</th>
<th>Odds ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Without the event</td>
<td>With the event</td>
</tr>
<tr>
<td>Decrease of consciousness</td>
<td>23.8</td>
<td>63.3**</td>
</tr>
<tr>
<td>Loss of consciousness</td>
<td>22.8</td>
<td>64.3**</td>
</tr>
<tr>
<td>Fitting</td>
<td>26.3</td>
<td>11.8**</td>
</tr>
<tr>
<td>Respiratory rate &lt;6</td>
<td>24.7</td>
<td>81.8**</td>
</tr>
<tr>
<td>Bradycardia</td>
<td>19.4</td>
<td>24.3*</td>
</tr>
<tr>
<td>Tachycardia &gt;130</td>
<td>23.9</td>
<td>41.5**</td>
</tr>
<tr>
<td>Hypertension</td>
<td>27.8</td>
<td>17.3*</td>
</tr>
<tr>
<td>SaO2 &lt;90%</td>
<td>22.3</td>
<td>33.7**</td>
</tr>
</tbody>
</table>

*0.001< P<0.05; **0.0001< P<0.001.

Table 3  
Risk of mortality-independent predictors

<table>
<thead>
<tr>
<th>Event</th>
<th>Odds ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decrease of consciousness</td>
<td>6.4 (2.6-15.7)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>2.5 (1.6-4.1)</td>
</tr>
<tr>
<td>Loss of consciousness</td>
<td>6.4 (2.9-13.6)</td>
</tr>
<tr>
<td>Respiratory rate &lt;6 min⁻¹</td>
<td>14.4 (2.6-80.0)</td>
</tr>
<tr>
<td>SaO2 &lt;90%</td>
<td>2.4 (1.6-4.1)</td>
</tr>
<tr>
<td>Tachycardia &gt;30min⁻¹</td>
<td>7.2 (3.9-13.2)</td>
</tr>
</tbody>
</table>

CI: 2.3–3.8) increase in the risk of mortality. The presence of any one of the six events was associated with a 6.8-fold (95% CI: 2.7–17.1) increase in the risk of mortality.

The majority of the abnormal observations spontaneously resolved (66.7%), or were brought back to normal with treatment on the ward (21.6%). Unplanned operation (4%) or unplanned admission to the intensive care unit (2.4%) were relatively uncommon outcomes at the time of the abnormal observation.

4. Discussion

Recent studies have proposed that the introduction of a MET may prevent subsequent unexpected cardiac arrest and therefore decrease in-hospital mortality [10,11]. However, the clinical criteria which have been used in previous reports for the calling of a MET have been based on clinical experience and/or retrospective data [5–9,13]. Since the introduction of a MET requires additional resources, the development of accurate clinical criteria is required to avoid unnecessary calling of the MET.

In this prospective study, we have shown that during a 33-week follow-up, approximately 9% of admitted patients experienced at least one of the 10 specific clinical abnormal observations. Further analysis confirmed that six specific events were independently associated with a high risk of subsequent mortality. In particular, we found that changes in neurological and respiratory status were associated with the highest risk of mortality, although these accounted for only 5% of the total adverse events. In addition, hypotension emerged as a significant risk factor for subsequent mortality. Also, the number of abnormal observations correlated with a higher risk of mortality.

These abnormal clinical observations can be easily identified by junior medical and nursing staff using simple visual observation. We propose that these observations may be useful as criteria for the identification of “high risk” patients for early intervention, and should be included in criteria for activation of a MET.

There are a number of limitations of this study. Firstly, since a MET responded to many of these patients, the outcomes may be different in hospitals without a MET system. Second, all patients regardless of their resuscitation status were included. Patients who are not for resuscitation may have an increased incidence of abnormal observations, particularly if they are in a terminal phase of their illness. However, these abnormal observations may not be recorded because they are expected to die. In our hospital setting we find that the institution of “do not resuscitation” orders and their actual implementation to be ad hoc at best. As such we felt that important epidemiological information on the natural history of abnormal observations would be lost if these patients observation data were not included in the study.

Third, the overall incidence of abnormal observations may be underestimated because observations in the general ward setting are collected intermittently, and not continuously as in the hospital critical care areas. Also, the incidence of abnormal saturation and blood pressure observations may be greater as these observations were often collected by mechanical devices as opposed to observations that required the nurse to actually measure the observation, such as respiratory rate. Finally, the study was based on data from one tertiary teaching hospital, and the patient case mix and organisational structures may be different from other hospitals in other regions and countries.

In summary, the present study has shown that during a 33-week observational period, 9% of in-hospital patients were associated with at least one clinically abnormal observation or adverse event, and that several neurological and
respiratory clinical events combined were associated with higher risk of mortality. These clinical observations should be included as criteria for the identification of high risk patients in whom earlier intervention by a MET may prevent subsequent mortality.

References