Clinical paper

Role of cardiac troponin in the diagnosis of acute myocardial infarction in comatose patients resuscitated from out-of-hospital cardiac arrest

Sebastian Voicu a, b, c, d, *, Georgios Sideris a, b, c, j, Nicolas Deye b, c, d, Jean-Guillaume Dillinger a, b, c, Damien Logeart a, b, c, Claire Broche e, f, Benoit Vivien e, g, Pierre-Yves Brun c, d, Dragos Daniel Capan h, Stéphane Manzo-Silberman a, c, Bruno Megarbane c, d, i, Frédéric J. Baud c, d, i, Patrick Henry a, b, c

a Cardiology Department, Lariboisière Hospital, Assistance Publique Hôpitaux de Paris, Paris, France
b INSERM U942, Paris, France
c Université Denis Diderot, Paris, France
d Medical and Toxicological Intensive Care Unit, Lariboisière Hospital, Assistance Publique Hôpitaux de Paris, Paris, France
e SAMU de Paris, Assistance Publique Hôpitaux de Paris, Paris, France
f SMUR, Lariboisière Hospital, Assistance Publique Hôpitaux de Paris, Paris, France
g Canadian Institute for Health Information, Department of Statistics, Toronto, Canada
h INSERM U705, Paris, France

A R T I C L E   I N F O

Article history:
Received 31 July 2011
Received in revised form 10 October 2011
Accepted 18 October 2011

Keywords:
Heart arrest
Myocardial infarction
Troponin I
Coronary angiography
Acute myocardial infarction diagnosis

A B S T R A C T

Background: Troponin is a major diagnostic criterion of acute myocardial infarction (AMI) but in out-of-hospital cardiac arrest (OHCA) patients, its diagnostic value may be altered by cardiopulmonary resuscitation.

Methods: Single-centre study assessing the diagnostic characteristics of troponin for AMI diagnosis in consecutive patients resuscitated from OHCA between 2002 and 2008 with coronary angiogram (CA) performed on admission. Patients with obvious non-cardiac cause of OHCA, unsustained or absent return of spontaneous circulation were excluded. AMI was defined on CA by the presence of acute occlusion or critical stenosis with intracoronary fresh thrombus easily crossed by an angioplasty wire. Troponin concentration was recorded once on admission and once 6–12 h after the OHCA.

Results: A total of 163 patients aged 56 (median) years (interquartile range (IQR) 48–65) was included, all comatose. Most prevalent initial OHCA rhythms were ventricular fibrillation (49%) and asystole (41%). AMI was diagnosed on coronary angiogram in 37% of the patients.

Median troponin concentration on admission was 1.7 (0.3–10) ng ml−1 and sensitivity for AMI diagnosis was 72% and specificity 75% for a 2.5 ng ml−1 cut-off. A combined criterion comprising ST elevation and troponin >2.5 ng ml−1 had a sensitivity of 93% and specificity of 64%.

Six to twelve hours after the OHCA, median troponin concentration was 7.6 ng ml−1 (1.4–47.5), sensitivity was 84% and specificity 84% for a 14.5 ng ml−1 cut-off.

Conclusion: Troponin I has a good diagnostic value for AMI diagnosis in OHCA patients. In combination with ST elevation, troponin I on admission achieves a very high sensitivity.

© 2011 Elsevier Ireland Ltd. All rights reserved.

Out-of-hospital cardiac arrest (OHCA) is a condition with a dismal prognosis despite continuous efforts to improve outcome. The most frequent cause of OHCA without an obvious non-cardiac cause is acute myocardial infarction (AMI)1 and one of the procedures improving survival in this setting is coronary angioplasty.2,3 Therefore, the diagnosis of AMI appears to be an important step in the management of these patients.

Electrocardiographic (ECG) data are the mainstay of the diagnosis of AMI in patients not suffering cardiac arrest, but in OHCA the diagnostic value of ECG data is still open to discussion.2–5 A reliable method of AMI diagnosis is immediate coronary angiogram (CA) after OHCA,2–4 but this is not available in all centres in the emergency setting and it may delay the diagnosis and management of other causes of the OHCA.

Cardiac troponins are widely available and highly sensitive biochemical markers of acute ischaemia6 and might be of great help...
in AMI diagnosis. However, their diagnostic characteristics are less well defined in this setting and may be difficult to interpret.\textsuperscript{7,8} Studies assessing the diagnostic value of troponin in OHCA patients without obvious non-cardiac cause showed that at hospital admission troponin was not useful for AMI diagnosis\textsuperscript{6} but 12 h after admission and at peak value during the hospital stay, it had good diagnostic value.\textsuperscript{7,8} A major limitation in these studies was that the method used for the diagnosis of AMI was not the same in all patients,\textsuperscript{7,8} the diagnosis was occasionally uncertain\textsuperscript{7} and coronary angiographic data were not available.

Therefore, we performed a study aiming to evaluate the diagnostic characteristics of cardiac troponin measured at hospital admission and in the interval 6–12 h after the OHCA, using a unique, angiographic definition of AMI, based on the CA performed immediately after resuscitation.

1. Methods

This study was conducted according to the principles of the Declaration of Helsinki (2008 version) of the World Medical Association. The ethics committee of our institution approved the study and no informed consent was required from the patients or the next of kin.

It is a retrospective single-centre study for which we screened all patients >18 years old admitted after successful resuscitation from an OHCA between January 2002 and June 2008. Sustained return of spontaneous circulation (ROSC), CA and troponin assessment on admission were required for inclusion. Sustained ROSC was defined as the presence of circulatory function with palpable pulse for at least 20 consecutive minutes.\textsuperscript{9} We excluded patients with an obvious non-cardiac cause of OHCA.

1.1. Management and angiographic analysis

Pre-hospital management of the patients in France has been previously described.\textsuperscript{10,11} Patients are transferred in our centre directly to the catheterisation laboratory for routine CA performed through femoral or radial access using standard techniques.

CA was retrospectively analysed by two independent observers. Coronary artery stenoses ≥50% of the lumen diameter were considered significant. Coronary artery flow was assessed according to thrombolysis in myocardial infarction (TIMI) classification.\textsuperscript{12}

AMI was defined angiographically by the presence of lesions suggestive of ruptured plaques (Ambrose type II)\textsuperscript{13} with evidence of fresh thrombus in a main coronary artery\textsuperscript{14} with TIMI 0 or 1 flow, or TIMI 2 or 3 flow with critical stenosis and presence of thrombus (spontaneous reperfusion), easily crossed by an angioplasty wire.\textsuperscript{1} This definition is in accordance with the universal definition of myocardial infarction\textsuperscript{14} and previous studies.\textsuperscript{3,5,15}

Therapeutic hypothermia was usually initiated in the catheterisation laboratory by cold saline infusion. After the CA with angioplasty, if indicated, patients were transferred to the intensive care unit (ICU).

1.2. Troponin concentration assessment

Blood samples were drawn in the catheterisation laboratory after establishing arterial access for the CA. Blood was collected in sterile 3 ml BD Vacutainer® PST™ II tubes containing lithium heparinate.

All assessments were of troponin I and were performed by the hospital laboratory using immunoenzyme techniques by Abbott Laboratories, AxsYM® Troponin-I ADV from 2002 to 2004 (99th percentile normal concentration <0.4 ng ml\(^{-1}\)) and ARCHITECT STAT Troponin-I\textsuperscript{®} from 2005 to 2008 (99th percentile normal concentration <0.04 ng ml\(^{-1}\)). The analytical sensitivity of the tests is 0.3 ng ml\(^{-1}\) and 0.01 ng ml\(^{-1}\), respectively, and the cut-offs for AMI diagnosis are 1.9 ng ml\(^{-1}\) and 0.3 ng ml\(^{-1}\), respectively (manufacturer stated). The reference limit at which the coefficient of variation (CV) is <10% is 0.03 ng ml\(^{-1}\) for ARCHITECT STAT\textsuperscript{®} (manufacturer stated). For AxsYM® the CV was <9.6% for concentrations ≥1.29 ng ml\(^{-1}\).\textsuperscript{16} The upper limit of assessment of undiluted samples for both techniques is 50 ng ml\(^{-1}\). These techniques may suffer interference from heterophile antibodies and rheumatoid factor, responsible for false positive/negative cases.\textsuperscript{17}

Troponin concentrations measured by the two techniques were analysed separately and together as they are very well correlated (correlation coefficient of the two techniques = 0.98).\textsuperscript{17}

We recorded troponin concentrations twice after the OHCA:

- on admission to the hospital for all patients (T\textsubscript{a}), as in the study by Mullner et al.\textsuperscript{8}
- 6–12 h after the OHCA (T\textsubscript{6–12}) because in AMI patients the best sensitivity for troponin is achieved after 6 h\textsuperscript{6} and the artery reopening can be beneficial in the first 12 h after the AMI.\textsuperscript{18}

The interval between the OHCA and the assessment of troponin was calculated using the time of the OHCA in the patients’ medical record and the time of assessment recorded by the laboratory.

1.3. Other parameters

We recorded baseline clinical characteristics, the initial rhythm of the OHCA\textsuperscript{8} and the durations of no-flow and low-flow intervals. No-flow was defined as the time interval between the patient’s collapse and the beginning of chest compressions, and low-flow as the time between the beginning of chest compressions and the ROSC. Shock on admission was defined as hypotension requiring treatment with catecholamines. The presence of ST elevation was interpreted according to recommendations\textsuperscript{14} on the first ECG trace obtained after sustained ROSC.

Neurological outcome was evaluated using cerebral performance category (CPC) score.\textsuperscript{19} Data were recorded according to the Utstein-style recommendations for reporting resuscitation outcomes.\textsuperscript{9}

1.4. Statistical analysis

Continuous variables were expressed as medians (IQR) and compared using the two-tailed Mann–Whitney test. Categorical variables were reported as frequencies and percentages and were compared using the chi-square test and, if not applicable, Fisher’s exact test. For AMI diagnosis, sensitivity, specificity, positive (PPV) and negative (NPV) predictive values and accuracy were calculated according to standard definitions and expressed as percentages (95% confidence interval (CI)). Diagnostic characteristics of troponin were evaluated using the manufacturer’s cut-off and also the cut-offs of maximum accuracy obtained after the receiver operator characteristic (ROC) curve analysis. Univariate analysis was performed to determine correlates of troponin at T\textsubscript{a} above the ROC curve-suggested cut-off. Significant variables were introduced into a stepwise multivariable logistic regression to determine the independent correlates of this parameter.

Significant correlates of troponin were also searched for in univariate regression.

Statistical analysis was performed using MedCalc\textsuperscript{®}, version 11.0.1.0 (MedCalc Software, Mariakerke, Belgium).
2. Results

During the study period, 1451 OHCA patients were admitted to a hospital in Paris city. Among the 235 patients admitted to our centre, 163 were included, all comatose on admission (Fig. 1). Characteristics of the patients and the OHCA are shown in Tables 1 and 2. None of the patients had a history of positive rheumatoid factor or treatment with heterophile antibodies.

CA showed angiographically defined AMI in 37% of the patients, of whom 62% had TIMI 0 and 38% had TIMI 1 flow. Angioplasty was successful in 94%. Only 82% of the patients with AMI had ST elevation on the first ECG after sustained ROSC, diagnostic sensitivity of 82% (70–90), specificity 84% (75–90), PPV 74% (62–84), NPV 89% (82–94) and accuracy 83% (75–89).

Other OHCA causes were ischaemic heart disease without AMI – 17%, hypoxemia – 9%, non-ischaemic cardiomyopathy – 6% and primary rhythm disturbance (Brugada or long QT syndrome, idiopathic ventricular fibrillation (VF)) – 4% of the patients. Miscellaneous causes were found in 19%; pulmonary embolism, electrolyte disturbances, neurologic disorders and aortic dissection. The OHCA cause remained undetermined in 8% of the patients.

2.1. Management and outcome

In the pre-hospital phase, 66% of the patients required three (1–5) external electric shocks. Adrenaline (epinephrine) boluses were administered in 86%, median total dose 3 mg (2–5), 99% required mechanical ventilation and 52% presented with shock on admission. None of the patients received pre-hospital therapeutic hypothermia, and 65% received hypothermia in the ICU.

Of all patients, 18% died during the first day of hospitalisation and 30% survived to hospital discharge after an ICU and hospital

Table 1

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>All n = 163</th>
<th>With AMI n = 60</th>
<th>Without AMI n = 103</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, years median (IQR)</td>
<td>56 (48–65)</td>
<td>50 (45–61)</td>
<td>60 (51–70)</td>
<td>0.0003</td>
</tr>
<tr>
<td>Men, n (%)</td>
<td>130 (80%)</td>
<td>55 (92%)</td>
<td>75 (73%)</td>
<td>0.007</td>
</tr>
<tr>
<td>Risk factors, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypertension</td>
<td>54 (34%)</td>
<td>15 (25%)</td>
<td>39 (38%)</td>
<td>0.09</td>
</tr>
<tr>
<td>Hypercholesterolemia</td>
<td>36 (22%)</td>
<td>15 (25%)</td>
<td>21 (20%)</td>
<td>0.73</td>
</tr>
<tr>
<td>Diabetes</td>
<td>28 (17%)</td>
<td>3 (5%)</td>
<td>25 (24%)</td>
<td>0.002</td>
</tr>
<tr>
<td>Active smoking</td>
<td>65 (40%)</td>
<td>30 (50%)</td>
<td>35 (34%)</td>
<td>0.09</td>
</tr>
<tr>
<td>Unknown risk factors</td>
<td>7 (4%)</td>
<td>1 (2%)</td>
<td>6 (6%)</td>
<td>NC</td>
</tr>
<tr>
<td>History of coronary artery disease n (%)</td>
<td>30 (18%)</td>
<td>11 (18%)</td>
<td>19 (18.5)</td>
<td>0.9</td>
</tr>
<tr>
<td>Unknown, n (%)</td>
<td>4 (2%)</td>
<td>0 (0%)</td>
<td>4 (4%)</td>
<td>NC</td>
</tr>
<tr>
<td>Adrenaline or noradrenaline rate of infusion on admission(a) (mg/h)</td>
<td>2 (1–4)</td>
<td>1(0.6–3.5)</td>
<td>2 (1–4)</td>
<td>0.17</td>
</tr>
<tr>
<td>Dobutamine on admission(b) ((\mu)g/kg min)</td>
<td>10 (7–11)</td>
<td>10 (6–10)</td>
<td>10 (5–20)</td>
<td>0.5</td>
</tr>
<tr>
<td>Lactate concentration on admission (mmol/l)</td>
<td>4.6 (2.5–9)</td>
<td>4.3 (2.5–6)</td>
<td>5.8 (2–9)</td>
<td>0.049</td>
</tr>
</tbody>
</table>

NC: not calculated.
\(a\) 72 patients were treated with adrenaline or noradrenaline.
\(b\) 13 patients were treated with dobutamine.
stay of eight (6–13) and 20 (15–40) days, respectively. Their CPC is shown in Fig. 1.

2.2. Troponin concentration and diagnostic characteristics

Troponin concentrations and diagnostic characteristics are shown in Tables 2 and 3.

Troponin concentration at Ta was available for all patients. The interval from the OHCA to Ta was 209 (158–267) min, similar between patients with and without AMI (p = 0.5).

Troponin at Ta was above the manufacturer's cut-off in 112 patients. When the manufacturer's AMI cut-off was used for diagnosis, sensitivity was 95%, specificity 47% and accuracy 64%.

After ROC curve analysis at Ta we found a cut-off of 2.5 ng ml⁻¹, with 72% sensitivity and 75% specificity for AMI diagnosis, for maximum accuracy of 74%.

When troponin concentrations obtained by each assessment method were analysed separately, the cut-offs were very similar, 2.4 ng ml⁻¹ for AxSYM® and 3 ng ml⁻¹ for ARCHITECT STAT® on admission (Fig. 2).

When the diagnostic criterion at Ta was a combination of troponin >2.5 ng ml⁻¹ or ST elevation, sensitivity was 93% (83–98), specificity 64% (54–73), PPV 60% (50–70), NPV 94% (86–98) and accuracy 75% (66–82).

Troponin concentration at T6–12 was available in 127 patients. The interval from the OHCA to T6–12 was 9.5 h (7–11.5) similar between patients with and without AMI (p = 0.4). The maximum accuracy cut-off was 14.5 ng ml⁻¹ (Table 3).

2.3. Troponin concentration on admission in patients with normal CA

In the 43 patients with normal CA, troponin at Ta was 0.6 ng ml⁻¹ (0.07–5.5) and 15 had concentrations >2.5 ng ml⁻¹. Troponin concentration was as high as 23 ng ml⁻¹ 30 min after the OHCA and 48 ng ml⁻¹ 220 min after the OHCA. The causes of OHCA in these 15 patients were rhythm disturbances (idiopathic or due to dilated cardiomyopathy), pulmonary embolism, hypoxia, poisoning, cerebral haemorrhage and unknown in two patients.

2.4. Correlates of troponin

None of the variables – age, lactate concentration on admission, rate of catecholamines infusion on admission, no-flow and low-flow – were correlated with troponin on admission in univariate linear/non-linear regression (R² < 0.5).

In univariate logistic regression, significant correlates of troponin at Ta > 2.5 ng ml⁻¹ are shown in Table 4.

In stepwise multivariable logistic regression, independent correlates of troponin at Ta > 2.5 ng ml⁻¹ were ST elevation OR = 9.8 (95%CI 3.6–27), p < 0.0001 and low-flow OR = 1.05 (1.01–1.08), area under the curve (AUC) = 0.83 (95%CI 0.74–0.9), p < 0.0001.

Table 3

<table>
<thead>
<tr>
<th>Timing of assessment</th>
<th>Troponin cut-off (ng ml⁻¹)</th>
<th>Se (CI)</th>
<th>Sp (CI)</th>
<th>PPV (CI)</th>
<th>NPV (CI)</th>
<th>Ac (CI)</th>
<th>AUC (CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ta</td>
<td>Manufacturer recommended</td>
<td>95%</td>
<td>47%</td>
<td>51%</td>
<td>94%</td>
<td>64%</td>
<td>NC</td>
</tr>
<tr>
<td></td>
<td>2.5 ng ml⁻¹</td>
<td>(86–99)</td>
<td>(47–58)</td>
<td>(41–60)</td>
<td>(84–99)</td>
<td>(54–71)</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td>5.0 mg ml⁻¹</td>
<td>(79–83)</td>
<td>(66–84)</td>
<td>(51–75)</td>
<td>(73–89)</td>
<td>(68–81)</td>
<td>(0.73–0.86)</td>
</tr>
<tr>
<td>T6–12</td>
<td>Manufacturer recommended</td>
<td>100%</td>
<td>31%</td>
<td>46%</td>
<td>100%</td>
<td>57%</td>
<td>NC</td>
</tr>
<tr>
<td></td>
<td>14.5 ng ml⁻¹</td>
<td>(92–100)</td>
<td>(21–43)</td>
<td>(36–56)</td>
<td>(86–100)</td>
<td>(49–65)</td>
<td>0.9</td>
</tr>
</tbody>
</table>

* The 2.5 and 14.5 are the cut-offs of maximum accuracy suggested by the ROC curves at Ta and T6–12. Ta-troponin concentration on admission. T6–12-troponin concentration 6–12 h after the out-of-hospital cardiac arrest. Se – sensitivity, Sp – specificity, PPV – positive predictive value, NPV – negative predictive value, Ac – accuracy, CI – 95% confidence interval, AUC – area under the ROC curve. NC – not calculated, since ROC curves were only constructed in the case of cut-offs of maximum accuracy.
Fig. 2. ROC curves for acute myocardial infarction diagnosis and diagnostic characteristics. Troponin concentration measured by Troponin AsYS® technique and ARCHITECT STAT were analysed together (overall population), and separately (Troponin AsYS® and Troponin ARCHITECT STAT). The cut-offs and detailed diagnostic characteristics and confidence intervals are also represented. The markers on the ROC curves represent the point of maximum accuracy corresponding to the cut-off of maximum accuracy for AMI diagnosis.

Table 4
Correlates of troponin > 2.5 ng ml⁻¹ on admission in univariate logistic regression.

<table>
<thead>
<tr>
<th>Variables</th>
<th>OR (95% CI)</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMI</td>
<td>8 (3.9–16)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>ST-elevation</td>
<td>5.1 (2.6–10.1)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Ventricular fibrillation</td>
<td>3 (1.6–6)</td>
<td>0.01</td>
</tr>
<tr>
<td>Smoking</td>
<td>2.3 (1.2–4.4)</td>
<td>0.01</td>
</tr>
<tr>
<td>Single vessel disease</td>
<td>2.1 (1.03–4.3)</td>
<td>0.04</td>
</tr>
<tr>
<td>Number of electric shocks</td>
<td>1.7 (1.03–1.3)</td>
<td>0.003</td>
</tr>
<tr>
<td>Low-flow</td>
<td>1.05 (1.02–1.08)</td>
<td>0.002</td>
</tr>
<tr>
<td>Age</td>
<td>0.96 (0.94–0.99)</td>
<td>0.004</td>
</tr>
<tr>
<td>Asystole</td>
<td>0.3 (0.16–0.6)</td>
<td>0.0008</td>
</tr>
<tr>
<td>Diabetes</td>
<td>0.3 (0.1–0.8)</td>
<td>0.01</td>
</tr>
</tbody>
</table>

AMI – acute myocardial infarction.

In a model not adjusting for ST elevation, significant variables were AMI, OR = 9.4 (3.5–25), p < 0.0001, tobacco smoking, OR = 3.3 (1.2–9.1), p = 0.02 and low-flow OR = 1.04 (1.003–1.08), p = 0.03, AUC = 0.83 (0.75–0.9), p < 0.0001.

3. Discussion

In this study in which the method of reference for AMI diagnosis was the CA on admission, the most important finding is that in OHCA patients without obvious non-cardiac cause, troponin can be useful for the AMI diagnosis alone or in combination with ST elevation. We evaluated the diagnostic characteristics of troponin on admission and 6–12 h after the OHCA because early diagnosis and treatment in patients with AMI may improve survival,2,3 while coronary reperfusion after a diagnosis of AMI made more than 12 h after the onset of artery occlusion does not improve outcome.8 Thus, by diagnosing AMI while artery reopening is still beneficial, our results can influence the management of the patients.

Our data show that AMI diagnosis can be made using the manufacturer’s cut-offs with very high sensitivity and NPV, but low specificity and accuracy due to numerous false positive cases.

To improve these last parameters we used the ROC curve analysis to find cut-off concentrations of maximum accuracy, and we obtained a diagnostic performance at T6 comparable to another study8 which found a Youden index of 0.36 versus 0.47 in our patients. The cut-offs we obtained are higher than those suggested by the manufacturer, especially at T6–12. This is consistent with previous studies,2,8 which found very different cut-offs for AMI diagnosis: 4 ng ml⁻¹ for troponin at peak concentration during hospitalisation and 0.6 ng ml⁻¹ 12 h after admission, probably due to differences in the severity of the patients, and possibly between the time from the OHCA to the troponin assessment. Unlike the afore-mentioned studies, we provided information on the time intervals between the OHCA and the troponin assessments. Even though these may be in some cases overestimated by up to 30 min (the delay of transportation of the blood samples was not always accounted for), they make our results interpretable in everyday practice.

Interestingly, the strongest correlate of troponin at T6 above the AMI cut-off in multivariable analysis was not the presence of AMI, but the presence of ST elevation which is a marker of myocardial injury. The injury may be not only due to an acute coronary occlusion20 but also due to ischaemia due to diffuse hypoperfusion possibly aggravated by chronic stenoses, or to myocardial injury during chest compressions21 explaining another important finding in our study, the correlation in multivariable analysis between low-flow and troponin concentration above cut-off.

The non-ischaemic myocardial injury during chest compressions and the ischaemia and reperfusion syndrome22 may explain the high troponin concentrations very early after the OHCA even in patients with normal CA, which is another important finding in our study. Other causes (myocarditis and transient coronary spasm)
could be suspected only in four patients with normal CA and troponin above cut-off: two patients with unknown causes of OHCA and two who suffered VF considered ‘idiopathic’.

At T6–12, diagnostic characteristics of troponin were better than at Ta, but lower than in a study assessing troponin at peak during hospitalisation: sensitivity 84% versus 95% and specificity 84% versus 88%. However, in 21% of the patients in this report, the diagnosis of AMI was equivocal by ECG criteria, and they were excluded from the analysis, probably accounting for the high diagnostic value. AMI diagnosis using ECG criteria after OHCA may be difficult, and the advantage in our study is that all patients underwent CA immediately on admission, allowing for angiographic diagnosis of AMI. However, troponin concentration at T6–12 in patients with angiographic AMI was most certainly influenced in our study by the angioplasty and, in their case, the concentration at T6–12 does not reflect the natural ‘rise and/or fall’ of troponin. Angioplasty may precipitate a rapid increase or diminish the release of troponin and, therefore, in AMI patients not undergoing angioplasty, the concentration and the cut-off of troponin at T6–12 may be different. Also, all our AMI patients had culprit arteries with TIMI 0-1 flow and our results may be different in patients presenting with spontaneous reperfusion of the culprit artery (TIMI 2–3).

Interestingly, on admission, the use of a composite diagnostic criterion ST elevation or troponin >2.5 ng ml−1 may improve diagnostic sensitivity compared with ST elevation or troponin concentration alone, allowing for a better detection of AMI patients. This combination could be used as a diagnostic tool if future studies confirm its value.

It has been suggested that hypothermia may decrease myocardial injury after AMI, but in our study, no differences occurred in troponin concentrations between hypothermia and non-hypothermia patients at Ta, T6–12 or at peak concentration during hospitalisation (p > 0.2, data not shown). However, since hypothermia was not randomised for, no certain conclusion can be drawn about its effect.

The causes of OHCA in our population are similar to other studies: AMI in 37.5–51%,14 of the patients, ischaemic heart disease without AMI in up to 34%4 and non-ischaemic cardiomyopathy in up to 11%.4 Our population had high prevalence of shock and high lactate concentration on admission, and even though may be considered heterogeneous, it represents a ‘real-life’ cohort of OHCA patients, making our results applicable in everyday practice. The survival in our patients is similar to studies including patients without selected initial rhythm3,24 and, as expected, lower than in studies including only patients with initial shockable rhythm.25

3.1. Limitations

Since this is a retrospective study, troponin concentration at T6–12 was not available in all patients mainly because 18% expired during the first day. Nevertheless, troponin at Ta was recorded in all patients and our study provides data on a number of patients larger than in similar studies.7,8,20

Troponin assessment was performed using two different methods by the same manufacturer. However, our results remain valid because the cut-offs obtained are above the thresholds of recommended CV < 10% for both methods, the two methods are very well correlated17 and also the cut-offs are very similar when assessments by the two methods are analysed separately (Fig. 2).

Also, our study did not include a multimarker approach using creatine kinase (CK)/CKMB or myoglobin, but these were shown to be less sensitive and specific and influenced by the external electric shocks26 or circulatory shock.27 Therefore, an improvement of the diagnostic characteristics by their use seems less likely.

Troponin assessment by the hospital laboratory may be too long in the setting of OHCA, and a bedside test may be more valuable due to its rapid results. Such tests were not available in our population but could be the object of future evaluations.

Certain parameters remained undetermined in up to 27% of our patients (low-flow), but this occurred in a similar range in other retrospective studies,6,8 and is difficult to avoid.

Finally, the diagnostic sensitivity of troponin may be improved by highly sensitive troponin assays;29,30 which could be evaluated in future studies. However, the Abbott ARCHITECT Troponin test used in our study was one of the four sensitive troponin tests that showed very good diagnostic value (AUC = 0.96) in one of these studies30 and thus our results remain valid.

4. Conclusion

Using an angiographic definition of AMI, our study showed that cardiac troponin assessment may be useful for the AMI diagnosis after OHCA. When combined with ST elevation, troponin on admission achieves very good sensitivity. Troponin on admission may reach high concentrations even in patients with normal CA and is correlated with the duration of chest compressions during the resuscitation. Troponin 6–12 h after the OHCA is a good diagnostic criterion with an excellent NPV when using the manufacturer’s cut-off, but these findings should be interpreted cautiously due to the influence of the primary angioplasty on the troponin release in our population.

Conflicts of interest statement

None.

References