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Multicenter evaluation of analytical performance of the Liaison® troponin I assay☆

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Abstract

Objectives: This study evaluated the analytical characteristics of the Liaison® immunoassay for cardiac troponin I (cTnI).

Design and methods: The protocol consisted of eight sections: evaluation of antibody specificity, linearity, detection limit and imprecision, method comparison, evaluation of endogenous interferents, anticoagulant interference, sample stability, and reference values.

Results: The assay equally measured free and complexed cTnI. The minimum detectable cTnI concentration was 0.021 μg/l. The cTnI concentration corresponding to a total CV of 10% was 0.056 μg/l. Linearity of response was demonstrated along the entire dynamic range of the assay. Assay interferences were minimal. cTnI concentrations in serum and heparinized plasma were significantly different. Values in EDTA plasma were on average approximately 5% higher than in matched serum, but this difference was not significant. The 99th percentile cTnI value in healthy subjects was 0.036 μg/l.

Conclusions: Being sensitive, specific, and precise, the Liaison® cTnI assay meets current requirements to aid in the diagnosis of myocardial necrosis.

Keywords: Troponin I; Immunoassay; Myocardial infarction; Reference values

Introduction

Cardiac troponins are presently regarded as the most cardiac-specific of currently available biochemical markers for the diagnosis of myocardial injury [1]. In particular, cardiac troponin I (cTnI) and cardiac troponin T (cTnT) have been identified. These proteins are associated with specific amino acid sequences encoded by genes different from those encoding skeletal muscle isoforms. While cTnI has been shown to have complete specificity for cardiac muscle, cTnT is present in small amounts in skeletal muscle during human fetal development and is reexpressed during diseases that involve skeletal muscle regeneration [2].

The redefined biochemical criterion proposed to classify acute coronary syndrome patients presenting with ischemic symptoms as patients with acute myocardial infarction (AMI) is heavily predicated on an increased cardiac troponin concentration in blood [3]. This necessitates the availability of highly specific, sensitive, and precise troponin assays [4]. Some assays, however, are inadequately appraised before their implementation in the laboratories [5]. More peer-reviewed studies are needed, and only well-documented assays should be considered for clinical use. The design control loop is indeed not closed until the finished in vitro diagnostic system is adequately validated to meet the customer needs, including the laboratory's analytical quality specifications [6].

The Committee on Standardization of Markers of Cardiac Damage (C-SMCD) of the IFCC recently proposed detailed quality specifications for cardiac troponin assays with the objective to urge the scientific community to select and design research projects on the major issues in troponin

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determination [7]. In this international multicenter study, we checked the conformity of the characteristics of a new automated immunoassay for the determination of cTnI (Liaison cTnI assay, DiaSorin—formerly Byk-Sangtec Diagnostica-Saluggia VC, Italy) to quality issues addressed in the above mentioned document.

Materials and methods

The evaluation study was carried out at four European centers located in Belgium (BE), France (FR), Germany (GE), and Italy (IT). The Liaison analyzers and all other materials used within the study were strictly handled according to the manufacturer's instructions. Unless otherwise stated, fresh serum was used as sample. Human (leftover) samples needed for different parts of the study were provided by each participating center. If not otherwise stated, all measurements were done in singlicate.

Assay method

The Liaison cTnI assay is a two-site immunoluminometric assay that uses a combination of a murine monoclonal antibody (directed to amino acids 80–110 of cTnI molecule) coated on paramagnetic particles (Dynabeads®, Dynal Biotech, Oslo, Norway) and an affinity-purified polyclonal goat antibody (directed to amino acids 27–39) labeled with isoluminol, used for the tracer. One hundred-microliter sample is added to 200-μl tracer and 20-μl antibody-coated magnetic particles. After 10-min incubation, the particles are separated and washed, and the chemiluminescent signal is generated by injection of ready-to-use trigger solutions. Time to the first result is approximately 15 min. The assay calibration is performed by a two-point recalibration using a stored master curve. The master curve covers the range from 0 to 100 μg/l. A recombinant cTnI-troponin C binary complex (cTnI stable fragment 28–110 linked to the full-length troponin C) is used as calibration antigen [8].

Detection limit

The minimum detectable cTnI concentration was assessed by 20 replicate measurements of the zero calibrator in a single run and defined as the cTnI value corresponding to a signal 3 SD greater than the mean found for this sample. The experiment was performed at each of the four institutions.

Antibody specificity

Reactivity against different forms of cTnI

Buffered stock solutions of both free cTnI and troponin IC complex (IC), as obtained from Scripps Laboratories (San Diego, CA), were serially diluted in appropriate buffers to produce 5, 10, 20, and 100 μg/l solutions of cTnI and tested in duplicate. The ratio IC/I was calculated, and the degree of equimolarity was estimated. Buffered stock solutions of both phosphorylated (ph) and dephosphorylated (dp) cTnI, as obtained from HyTest Ltd. (Turku, Finland), were serially diluted in appropriate buffer to produce 1.5 and 3.0 μg/l solutions of cTnI and analyzed in duplicate. The ratio ph/dp was calculated, and the degree of equimolarity was estimated. These experiments were performed in IT.

Cross-reaction with skeletal muscle troponin I

Three serum samples from patients with acute rabdomyolysis [with total creatine kinase activity (measured at 37 °C according to the IFCC-recommended method) of 42,900 U/l; 70,230 U/l; and 289,260 U/l, respectively] and no overt cardiac involvement were determined in duplicate in IT.

Linearity on dilution

Nine cTnI-rich serum samples (native concentrations, from approximately 5 μg/l to 80 μg/l) were serially diluted with serum pools having undetectable cTnI concentrations, that is, lower than the detection limit of the Liaison assay. The undiluted sample and three separate dilutions (3:4, 1:2, 1:4) were assayed in duplicate in the same analytical run. The curve obtained was tested for linearity as suggested by Burnett [9]. Linear regression analysis of the data was also calculated. The experiments were carried out in BE, FR, and IT.

Imprecision and calculation of 10% CV concentration

On the basis of NCCLS guideline EP5-A [10], each of the four institutions tested the two Liaison control sera (low and high, cat. no. 319119) in duplicate in 1 run/day for 20 days, using two lots of reagents and at least four calibrations during the experiment. Within-run and total imprecision were calculated for each control at each site. In a second experiment (performed at IT), seven human serum pools were prepared and stored at −80 °C until used. The corresponding cTnI concentrations were approximately 0.030, 0.050, 0.10, 0.40, 1.0, 5.0, and 10.0 μg/l. Two replicates per specimen per run and 1 run/day for 20 working days, by including two reagent lots (10 working days × lot) and nine calibrations, were performed. Pools were randomly analyzed to reflect any carryover effect. The total CV at different concentrations was calculated, and the CV values reported for the seven pools were used to construct the imprecision profile for the method [7]. The cTnI concentration corresponding to a total CV of 10% was calculated by interpolating the obtained imprecision profile. The same type of protocol (using only four human serum pools with cTnI concentrations between 0.025 and 0.070 μg/l) was repeated in BE to confirm the 10% CV cTnI concentration obtained in the previous experiment.

Method comparison

The Liaison cTnI was compared with the Access AccuTnI™ (Beckman Coulter, Brea, CA) [11] using 134 serum samples randomly selected to represent the range of cTnI values likely to be encountered in clinical practice. The comparison data were analyzed by Deming regression and bias plot.

Interference studies

All participating centers contributed to this part.

Endogenous interferents

Sera containing high concentrations of potentially interfering substances, that is, hemoglobin, bilirubin, and triglycerides, were diluted with cTnI-rich sera, and the recovery of cTnI was calculated. To test possible interference by paraproteins, three serum samples from patients with multiple myeloma, total protein concentrations in serum from 98 to 128 g/l (monoclonal protein concentrations in γ-region at electrophoresis from 45.4 to 87.8 g/l), and no overt cardiac involvement were determined in duplicate. To test interferences by rheumatoid factor (RF) and human anti-mouse antibodies (HAMA), 10 samples with high RF concentrations [634–2480 kU/l, when determined with a rate-nephelometric latex method—previously established upper reference limit (URL), 20 kU/l] and 19 samples containing HAMA (obtained by Scantibodies Laboratory, Inc., Santee, CA) were analyzed in duplicate before and after the treatment with heterophilic blocking tubes (HBT) (Scantibodies Laboratory). Treatment of samples with HBT was performed according to the manufacturer's instructions. Briefly, 500-μl sample was added to HBT and mixed with the blocking reagent present in the form of a lyophilized pellet at the bottom of the tube. cTnI measurement was performed after 1-h incubation at room temperature (RT). A high cTnI sample from a patient with AMI was also used by each participating center as a negative control of the HBT treatment, by measuring it before and after the treatment. All the measurements related to the same sample (before and after the treatment) were carried out in the same run.

Sample type

A total of 124 paired samples, obtained from AMI patients in both early, that is, <12 h, and late phases after symptom onset, were studied. After informed consent, three separate tubes were collected for each patient in random order during the same phlebotomy to prepare serum, heparin (lithium) plasma, and EDTA plasma specimens. cTnI assay was performed in duplicate on each of the three different specimens in the same analytical run. The mean results on plasma samples were compared with the paired serum values, and the significance of the differences was evaluated (Wilcoxon rank sum test). Linear regression analyses and bias plots were also performed.

In vitro sample stability

Two pooled cTnI-rich serum specimens were analyzed within 2 h of collection (T_0). The samples were then divided into four aliquots. Aliquot A was kept at RT, and small aliquots from this sample A were analyzed after 8, 24, 48, and 72 h. Another aliquot (B) was placed in a refrigerator (+4 °C) and analyzed after 24, 48, 96, and 168 h. The third aliquot (C) was maintained at −20 °C and analyzed after 2, 7, 14, 21 days and 1, 3, and 6 months. The fourth aliquot (D) was kept at −80 °C and analyzed after 3 and 6 months. Before analysis, the frozen samples were thawed at RT, mixed, and centrifuged to remove any particulate material. All measurements were done in duplicate in IT. Recovery of cTnI was calculated as percentage of the initial value obtained on fresh samples by dividing the concentrations at any storage time (T_h) by the concentration at T_0. The statistical analysis of trend was also done. Recoveries for fresh serum samples ($n = 4$) and samples frozen for 1, 3, and 6 months at −20 °C were also performed in GE and IT.

Reference values

Serum specimens from 128 apparently healthy individuals (53 women and 75 men; age range, 40–80 years) were analyzed. The subjects were drawn from a population of Caucasian blood donors and a priori selected using the IFCC recommendations for the production of reference values [12]. cTnI was measured, and the 99th percentile of the value distribution was calculated using nonparametric determination of percentiles. This study was performed in IT.

Results

Detection limit

The detection limit ranged from 0.019 to 0.023 μg/l (no. of experiments, 7) with a median of 0.021 μg/l.

Antibody specificity

The assay equally measured free cTnI and cTnI complexed with troponin C (mean IC/I ratio ± SE, 1.01 ± 0.05; $P = 0.87$; $n = 4$). No difference in the reactivity of the antibodies used in the kit against ph and dp cTnI was also demonstrated (mean ph/dp ratio ± SE, 1.06 ± 0.05; $P = 0.46$; $n = 2$). In all three samples from patients with rabdomyolysis, cTnI by Liaison was undetectable, that is, <0.02 μg/l.

Linearity on dilution

The results of linearity studies are shown in Table 1. As can be seen, the hypothesis of a linear fit was accepted for all the samples tested.

Table 1
Results of linearity studies

Sample ID	cTnI native concentration, μg/l	*F* test	*P*[a]	*r*
1 BE	83.1	80.0	0.11	0.9997
3 IT	79.6	78.6	0.11	0.9977
2 FR	52.3	0.06	0.82	0.9999
2 IT	41.9	0.61	0.57	0.9995
1 FR	38.3	1268	0.07	0.9990
4 FR	20.1	12.3	0.20	0.9973
3 FR	14.5	0.15	0.75	0.9986
1 IT	9.0	33.2	0.14	0.9951
2 BE	4.5	5.14	0.27	0.9916

[a] The hypothesis of a linear fit is rejected with $P < 0.05$.

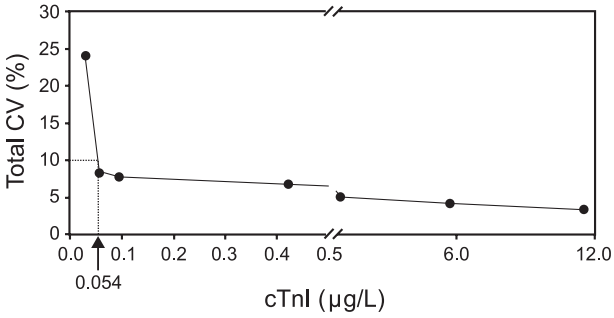

Fig. 1. Imprecision results for human serum pools measured with Liaison cardiac troponin I (cTnI) assay. The cTnI concentration corresponding to the 10% total CV is shown by the arrow.

Imprecision studies

The within-run and total imprecision (CV) of the two controls (company's established ranges, 0.035–0.051 and 0.87–1.07) were 1.3–11.1% and 2.8–11.6%, respectively, across two lots of reagents and four institutions (Table 2).

Fig. 1 displays the imprecision profile (total % CV vs. pools having increasing cTnI concentrations) obtained for Liaison cTnI method. The cTnI concentration corresponding to a total CV of 10%, calculated by interpolating the obtained imprecision profile, was 0.054 μg/l. From the data of a second similar experiment, we also calculated the cTnI concentration at 10% CV which was found to be 0.057 μg/l.

Method comparison

Method comparison produced evidence of proportional (slope, 0.38 ± 0.03) and constant bias (intercept, 0.24 ± 0.13 μg/l), underscoring the need of cTnI standardization (Fig. 2). Although the compared methods showed a significant systematic bias, there was good correlation when assays were compared ($r = 0.978$).

Table 2
Imprecision data from four institutions with two lots of reagents over 20 analytical runs

	Site			
	BE[a]	FR[b]	GE[c]	IT[a]
Control 1 (lot 7201), μg/l	0.045	0.039	0.044	0.043
Within-run CV, %	7.7	11.1	7.6	7.9
Total CV, %	8.6	11.6	8.3	9.2
Control 2 (lot 7201), μg/l	0.95	0.99	0.95	0.96
Within-run CV, %	2.1	1.3	2.9	1.6
Total CV, %	2.8	4.0	3.6	3.4

[a] Nine calibrations performed.
[b] Four calibrations performed.
[c] Eight calibrations performed.

Interfering substances

No interferences with test results were seen by concentrations of bilirubin <12.5 mg/dL, hemoglobin <5 g/l, and triglycerides <1200 mg/dL. cTnI recoveries were within 95–105%. In samples from patients with myeloma, cTnI by Liaison was always undetectable, that is, <0.02 μg/l. None of 10 RF samples tested above 0.02 μg/l. Only one HAMA sample (0.08 μg/l) tested above the detection limit of the assay. However, incubation of this sample in HBT did not cause a decrease of the cTnI value. As in a recent study, in 21% of cases, the interference by heterophilic antibodies was demonstrated only by showing nonlinearity in dilution studies and not by blocking studies [13], the sample was diluted with a negative (undetectable) cTnI serum pool to give separate 3:4 and 1:2 serial dilutions. The undiluted and diluted samples were then reanalyzed in the same run. Good linearity on dilution was, however, demonstrated ($r = 0.989$). Thus, it does not appear that this case of nonnegative cTnI was the result of the presence of an interfering antibody, but it was likely enough that this sample contained true cTnI.

Sample type

Table 3 shows the results of the comparison studies performed on anticoagulant samples in each institution. Since different types of sampling tubes and different times of blood collection after AMI (data not shown) did not influence the obtained results, the data were evaluated all together (Fig. 3). On average, the difference (95% confidence interval) for heparin samples was −26.7% (−29.0% to −24.4%; $P < 0.0001$), and the difference for EDTA was 4.7% (1.7% to 7.6%; $P = 0.63$).

Sample stability

Serum samples (pooled) were stable for at least 72 h at RT (mean cTnI recovery ± SE, 106.0% ± 9.7%, $P \geq 0.06$), 7 days at 4 °C (mean cTnI recovery ± SE, 98.5% ±

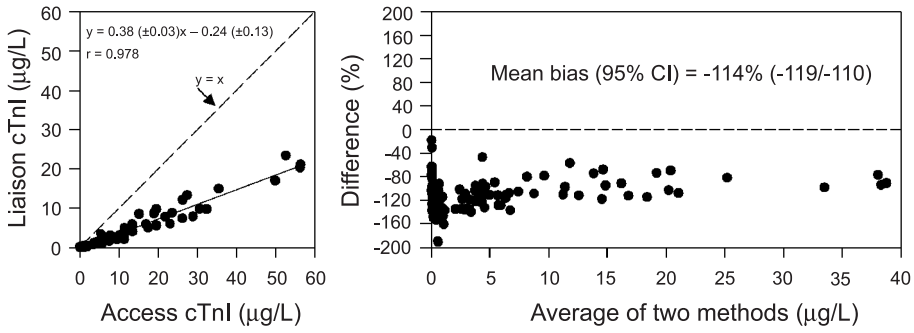

Fig. 2. Method comparison and plot of the differences (in percentage) between Liaison and Access cardiac troponin I (cTnI) assays (n = 134). CI, confidence interval.

4.3%, $P \geq 0.05$), 1 month at −20°C (mean cTnI recovery ± SE, 104.5% ± 4.9%, $P \geq 0.14$), and 6 months at −80°C (mean cTnI recovery ± SE, 102.7% ± 0.8%, $P \geq 0.83$). For one sample (cTnI concentration at T_0, 6.63 µg/l), a significant positive trend (P = 0.0004) was observed when stored for more than 1 month at −20°C. To further evaluate stability at −20°C, four additional samples from individual patients were studied. Again, all samples were stable for 1 month (mean cTnI recovery ± SE, 105.2% ± 2.6%); however, two samples from two different centers (cTnI concentrations at T_0, 12.9 and 23.3 µg/l, respectively) showed a significant cTnI increase (P = 0.00004 and P = 0.021, respectively) during prolonged storage.

Reference values

Ninety-three percent of cTnI values from the selected subjects were undetectable, that is, <0.02 µg/l, and only nine subjects (four males and five females) showed a measurable cTnI concentration. The calculated 99th percentile of the cTnI value distribution was 0.036 µg/l, with no sex- or age-related differences. From data of imprecision studies, the total CV corresponding to this concentration was 13.5%.

Table 3
Evaluation of anticoagulant interferences

Site	n	Sampling tubes	cTnI range, µg/l	Regression equation[a]	r	P[b]
BE	38	Terumo (heparin)/ Becton Dickinson (EDTA)	0.073–92.7	Heparin vs. serum: $y = 0.82 \times -0.52$	0.9981	<0.001
				EDTA vs. serum: $y = 0.96 \times -0.14$	0.9975	0.12
FR	43	Becton Dickinson	0.028–49.7	Heparin vs. serum: $y = 0.75 \times -0.01$	0.9705	<0.001
				EDTA vs. serum: $y = 0.91 \times +0.10$	0.9973	0.08
GE	30	Sarstedt	0.022–21.4	Heparin vs. serum: $y = 0.68 \times +0.12$	0.9970	<0.001
				EDTA vs. serum: $y = 0.93 \times +0.13$	0.9949	0.13
IT	13	Sarstedt	0.052–48.8	Heparin vs. serum: $y = 0.40 \times +0.44$	0.9918	<0.001
				EDTA vs. serum: $y = 0.85 \times +0.57$	0.9980	0.02

[a] Serum in x-axis.
[b] Wilcoxon rank sum test for paired samples.

Discussion

Despite the overt clinical advantages, important analytical and preanalytical obstacles to cardiac troponin analysis and interpretation remain, such as assay standardization, antibody specificity, interferences, preanalytical factors, and assay imprecision [4,5]. Some commercial assays are released without collecting and publishing thorough information related to these sources of variability. The quality of a method and its analytical performance characteristics should be judged against objective quality specifications, for example, published state-of-the-art data or recommendations documented by expert professional groups. On this particular topic, a document on quality specifications for cardiac troponin assays has been prepared by C-SMCD of the IFCC [7]. The goals of this document were that (a) manufacturers address the enclosed recommendations; (b) package inserts include adequate information on method design, as well as on preanalytical and analytical performance characteristics; and (c) the scientific community selects research projects that are primarily concerned with the addressed issues. The present study, evaluating the analytical performance of the new Liaison cTnI assay, has been designed and performed to fulfill these recommendations.

The assay calibration strictly followed the IFCC specifications, which recommend the use of a material representing the natural and major form of cTnI in blood after tissue release, that is, the complexed form [7]. A recombinant single-chain cTnI-troponin C polypeptide, previously very well characterized [8], was selected by the manufacturer and employed as calibration material to obtain the 10-point calibration curve.

The specificity of the antibody pairs used in the assay was examined with respect to the major circulating forms of cTnI, that is, the free protein, its binary IC complex, and the ph and dp forms, demonstrating that the assay has an

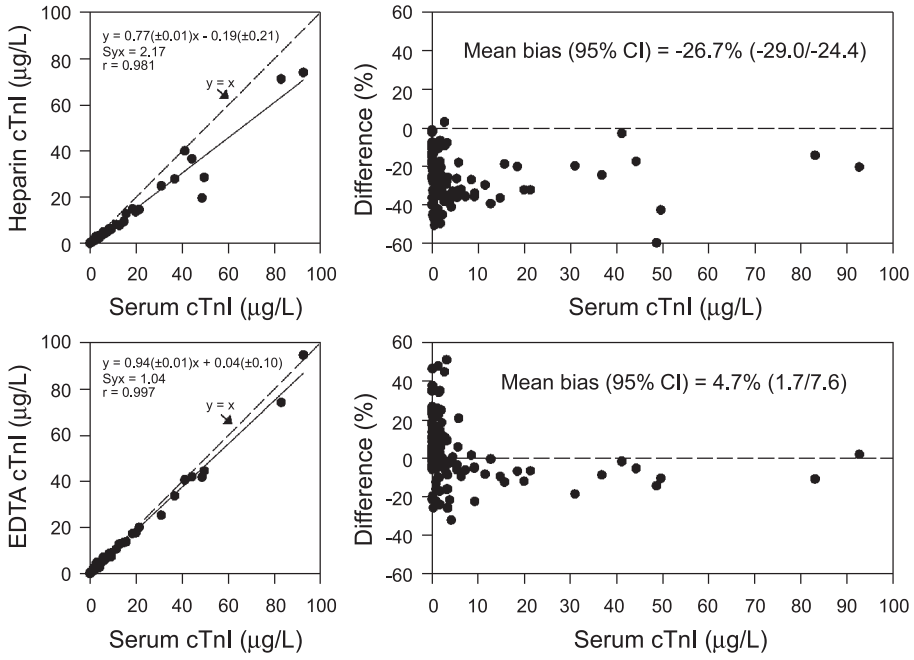

Fig. 3. Correlation studies and difference plots (in percentage) of serum and plasma samples (n = 124) measured by Liaison cardiac troponin I (cTnI) assay. CI, confidence interval.

equimolar response to these forms. This characteristic of Liaison antibodies, associated with their ability to recognize epitopes located in the stable part of cTnI, warrants optimal assay performance with regard to the antibody specificity. We did not test the effect of oxidation, because the oxidized cTnI form is not commercially available for experiments. However, the stability data at RT reported in our study imply that this should not be a significant source of assay variation.

Linearity of response was demonstrated with no significant deviations along the entire dynamic range of the assay. Cross-reactivity and assay interference were minimal. In particular, since the lack of in vitro cross-reaction with other troponin molecules, that is, skeletal muscle troponin I, cTnT, and troponin C, had already been demonstrated by the manufacturer [14], we focused on possible in vivo interferences. The absence of measurable cTnI in sera from patients with severe rabdomyolysis and no cardiac involvement demonstrates no cross-reaction with noncardiac troponins, such as skeletal muscle troponins, and other potentially interfering muscular proteins.

The Liaison® assay provided reproducible results within the run and from run to run, lot to lot, and site to site. The imprecision was evaluated in two ways. One using commercial controls showed good imprecision even for the low control, which was close to the 99th percentile URL. The other approach was to define the imprecision profile using the protocol recommended by IFCC to obtain a realistic indication of the variation of cTnI measurements especially at low-range concentrations [7,15]. For this latter study, pools of human sera were used. Since the C-SMCD recommends a total imprecision (CV) of ≤10% at the AMI decision limit, the lowest concentration with this imprecision was derived, that is, 0.056 µg/l (mean of two independent experiments). This value exceeds the 99th percentile URL (0.036 µg/l), the theoretically defined AMI cut-off in the Joint European Society of Cardiology/American College of Cardiology document [3]. As recently shown in a comprehensive study [15], there are currently no commercial assays that can achieve the 10% CV recommendation at 99th percentile URL, so that, in the context of clinical practice, the use of a predetermined cTnI concentration that meets the 10% imprecision goal as an AMI cut-off has been suggested [16,17]. The use of the actual 10% CV concentration instead of 99th percentile URL as a decision cut-off could slightly decrease the clinical sensitivity of the biochemical criterion used for the AMI diagnosis but should permit the physician to avoid the occasional increase in serum cTnI in the absence of myocardial damage [18]. The Liaison® cTnI assay revealed excellent performance if compared with data published for other commercial systems [15] and was quite close to meet the 10% CV at URL, demonstrating a 10%/99th ratio of 1.6. Our results corroborate those from a recent collaborative study in which the imprecision experiments directly performed by the assay manufacturer gave a 10% CV value of 0.065 µg/l and a ratio of 2.2 [15]. Conversely, our findings from the imprecision studies are different from those published in a study showing a 10% CV at 0.027 µg/l [19]. However, these authors calculated the imprecision profile from duplicates, thus considering only within-run variation. Although higher precision at lower cTnI concentrations does not automati-

cally equate to higher clinical sensitivity, it has been shown that the use of a high sensitivity cTnI assay would identify a substantial and additional proportion of patients with AMI compared with a less sensitive cTnI assay [20].

In the current study, the Liaison® assay detected cTnI in 7% of healthy people, whereas in a separate clinical study, the same assay was able to detect cTnI in 37% of the healthy individuals [19]. Aspects such as criteria for individual selection, sample size, or statistical data analysis should be considered to explain this difference. However, two additional analytical aspects should also be noted in the mentioned study: the use of EDTA samples, potentially giving higher cTnI results in the low-range concentrations (see Fig. 3), and the acritical acceptance of the manufacturer-declared detection limit (0.005 μg/l), possibly too low if compared with the data experimentally obtained in this multicenter evaluation (0.021 μg/l).

The in vitro stability of cTnI appears to be method-dependent, creating a need for data for each commercially available new assay [7]. We appropriately studied the effect of storage on apparent cTnI concentrations, giving information on stability at different storage temperatures. In particular, we confirmed and extended previous preliminary data evaluating stability only at RT and in the refrigerator [21].

The use of plasma instead of serum samples for cTnI determination can be very useful because it eliminates the extra time needed for clotting, thereby reducing the overall preanalytical time [22]. However, there can be significant differences between serum and plasma concentrations of cTnI, so that the use of anticoagulants should be studied and validated thoroughly before it can be recommended for practical use [7]. According to previous preliminary results [23], the use of heparinized plasma samples in the Liaison® assay led to significantly lower recoveries for cTnI. It is well known that binding of heparin to cardiac troponins may reduce their immunoreactivity to various degrees, depending on the assay epitopes and conformational changes in the molecule, and that these losses of troponin immunoreactivity can be dependent upon time elapsed from onset of myocardial necrosis to sample collection [24]. However, the epitope recognition of the Liaison® antibodies, which is not affected by heparin, and the lack of the time dependence of heparin interference on this assay seem to indicate that the effect of this negatively charged glycosaminoglycan is primarily indirect, possibly induced by changes within the sample matrix itself [25]. We also showed that values in EDTA plasma were on average approximately 5% higher than in matched serum samples. The mechanism for this slight (not significant) bias is not completely understood, even if the classic effect of EDTA as calcium chelator, splitting the calcium-dependent troponin complexes, was excluded on the basis of our data showing assay equimolarity. The significant scattering of the data points at low cTnI concentrations could partly explain this result. For practical use, EDTA plasma samples are acceptable for Liaison® cTnI, but different decision limits may be required for this sample type.

In conclusion, the Liaison® cTnI assay system provides sensitive, specific, and precise determination of cTnI, meeting current requirements to aid in the AMI diagnosis. As already shown [19], the robustness of this assay at low-range concentrations can also permit its profitable utilization in the prognostic assessment of patients with unstable coronary disease.

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