Multicenter evaluation of EIAs and CLIAs in the detection of hepatitis C virus antibody among blood donors in China

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Research article

Abstract

Background: Recent data on anti-HCV screening assays among large population of blood donors is limited. The present study aimed to perform a multicenter evaluation of EIAs and CLIAs for detection of anti-HCV among blood donors in 16 different Chinese blood establishments.

Methods: A total of 1,309 samples including 582 anti-HCV screening negatives and 727 positives collected from 15 blood establishments all over China. Ten different anti-HCV assays (eight EIAs and two CLIAs) were evaluated in 16 different blood centers/banks. Confirmatory testing was performed using recombinant immunoblot assay and HCV RNA tests.

Results: The plasma panel contained 963 negative samples, 261 positives, and 85 indeterminate samples, based on the results of confirmatory test. False positive rate of screening tests was 39.67% (382/963) and the positive prediction value was only 35.76% (260/727). Among ten anti-HCV assays, Roche and InTec had the highest sensitivity (98.47%), while KHB and Wantai (indirect) had the highest specificity (99.23%). Then we analyzed the combined performance of these assays with two assays' strategy widely used in China: Ortho or Abbott together with InTec could find all the true positives and Wantai (indirect) with Livzon (sandwich) got a highest specificity of 97.80%. Indeterminate samples showed quite different signal to cutoff (S/CO) ratios tested by Roche compared with confirmed positives (4.84 vs 19.36, p<0.0001), and higher S/CO ratios than confirmed negatives (4.84 vs 2.94, p=0.020).

Conclusion: False reactivity in anti-HCV screening should be treated as urgent issue. RIBA indeterminate donations may be a special group, while it still worth to be further studied.

Background

Hepatitis C virus (HCV) infection is of special concern due to a rising burden of its related cirrhosis, hepatocellular carcinoma (HCC), and liver related death worldwide [1-3]. In 2015, the global prevalence of viremia HCV is estimated to be 1.0%, which means approximately 71.1 million population worldwide are suffering from Hepatitis C and HCV-related diseases [4]. Especially in China, the proportion is about 0.7% (more than 9 million people are infected).

HCV is also a blood-borne virus. Laboratory diagnosis of HCV infection is usually made on the basis of the detection of circulating antibodies and/ or HCV RNA [5]. Serological tests are of great importance to preventing transfusion transmitted infections, especially because large majority of HCV infection are anti-HCV reactive and HCV RNA negative [6]. Enzyme immunoassay (EIA) and chemiluminescent immunoassay (CLIA) are two kinds of widely used serological screening methods. In China, serological screening strategy of HCV infection involves two different anti-HCV EIA assays that are approved by National Medical Products Administration (NMPA) and if they show inconsistent results, twice repeated tests using the reactive one are performed. When any of the two EIAs is repeatedly reactive, the donation is disqualified regardless of the NAT results and the donor is deferred for safety [7]. CLIA, which has been

widely used in recent years, can automatically and quickly test anti-HCV antibodies from serum/plasma samples with higher sensitivity and specificity but haven't been used in Chinese blood establishments yet.

Recent data on anti-HCV screening assays among large population of blood donors is limited.. This infomation is of critical value to analyze and find difference among different assays and improve assays' performance. The present study aimed to perform a multicenter evaluation of enzyme immunoassays and chemiluminescent immunoassays for detection of antibodies against hepatitis C virus among blood donors in 16 different Chinese blood establishments.

Methods

Plasma panel

A total of 1,309 plasma samples collected by 15 different blood establishments during Apr 2015 to Sep 2015, including Changchun (abbreviated as CC), Chongqing (CQ), Hebei (HB), Heilongjiang (HLJ), Henan (HN), Heze (HZ), Jining (JN), Jiangsu (JS), Kuming (KM), Liaoning (LN), Shandong (SD), Shenzhen (SZ), Tianjin (TJ), Tongzhou (TZ), Xiangyang (XY) blood center/blood bank. Among them, there were 582 anti-HCV negative randomly selected donations (HBsAg, anti-HCV, anti-HIV, and anti-TP antibodies were all negative with unqualified ALT level) and all the 727 anti-HCV positive donations detected in blood establishments during the period were included. All the plasma bags were sent to the Chinese National Center for Clinical Laboratories (NCCL), confirmed, split, numbered, stored at -40°C, and then sent back to all the participants. The transportation of the plasma panel was at 2-8°C and within 3 days. Sample source were listed in Table 1. All these samples were from 1,309 blood donors, no consecutive samples from one donor included.

Study design

16 different blood centers or blood banks over China participated into this multicenter evaluation, including CC, CQ, Cangzhou (CZ), HB, HLJ, HN, JN, JS, KM, LN, SD, Shanghai (SH), SZ, TJ, TZ, XY blood center/bank. The moment all these establishments above received the panel, they used one or two different EIAs to test it within 3 days by automated detection systems. Each sample was only tested once by one assay. All the results were sent back to NCCL within 10 days. Besides, NCCL tested all the samples once by two different CLIA assays simultaneously. All results were performed according to the manufacturers' instructions.

Confirmatory tests and evaluated assays

All the donation samples were subjected to confirmatory testing with anti-HCV recombinant immunoblot assay (Mikrogen Diagnostic, Martinsried, Germany), which showed the results as positive, negative, and indeterminate (IND). All the indeterminate samples were further tested HCV RNA by Cobas Taqscreen MPX Test, Version 2 (Roche Molecular systems, Branchburg, NJ). All results were performed according to the manufacturers' instructions. Technical specifications of confirmatory assay see Table 2. There were

10 different commercially available anti-HCV assays in this study. Technical specifications of evaluated assays see Table 2.

Data and Statistical analysis

Since plasma panel was tested by different blood establishments and different evaluated assays in the study, majority results on one sample would be treated as a "true value", if not all results from different blood establishments were consistent.

The sensitivity, specificity, Youden's index (The formula was below) and Kappa coefficient of each assay and combined assays were calculated by SPSS software (v.21.0). Results were analyzed with One-Way ANOVA analysis and Chi-square test. $p<0.05$ was considered as statistically significance.

Sensitivity = number of positive results/ number of confirmed positive in %;

Specificity = number of negative results/ number of confirmed negative in %;

Youden's index = Sensitivity+Specificity-1

Results

Confirmatory results of plasma panel

In 1,309 plasma samples, 963 were true negative, 261 were true positive by confirmatory testing. 85 samples were indeterminate by immunoblot and HCV RNA were also undetectable. The final results and validation algorithm see Figure 1. In 727 anti-HCV initial reactive samples only 260 were true positive, indicating the average positive prediction value (PPV) of anti-HCV screening tests was only 35.76% (260/727) and the average false positive rate was as high as 39.67% (382/963). Besides, we also found one true positive samples from Liaoning blood center were undetected by screening assays. The confirmatory results from each establishments was listed in Table 1.

Performance of evaluated assays

Among all the true negatives, 724 (724/963, 75.18%) were detected negative by all 10 assays. 209 (209/261, 80.08%) positives were detected positive by all assays. 376 samples showed discrepant results, among which there were 52 confirmed positive samples could not be detected by all evaluated assays (Table S1). InTec and Roche detected 48 samples, while Abbott only detected 29 ones. All samples had positive results of antibody against HCV protein Core 1, while other antibodies were weaker than confirmed positive samples with consistent results by all evaluated assays. On the basis of assay's results of 963 true negatives and 261 true positives, we calculated the sensitivity, specificity, Youden's index and Kappa Coefficient. The results showed assays' sensitivity varied from 91.19% to 98.47%, InTec and Roche owned the highest sensitivity (98.47%), while sensitivity of Abbott was the lowest (91.19%). As a routine strategy in China, two different kinds of EIAs are used simultaneously. Thus we calculated the

combined performance index between two different assays. The combined sensitivity showed that when we use InTec and Ortho, 100% positives could be detected. Similarly, different assays showed different specificity (92.94%-98.23%), KHB was the highest, while InTec was the lowest. When Wantai (sandwich) and Wantai (indirect) were used together, we could get the highest combined specificity (97.92%). Youden's index, a way of summarizing the performance of a diagnostic test, equals sensitivity plus specificity minus 1. Roche got the highest index (96.08%) and the two EIAs, KHB and Livzon (indirect), owned the highest combined Youden's index. Results of Kappa coefficient, a statistic which measures inter-rater agreement, indicated that Wantai (indirect) had perfect agreement with confirmatory results, and Wantai (indirect) and Livzon (sandwich) together owned the highest kappa coefficient. As a whole, CLIAs didn't perform better than EIAs on the detection of anti-HCV in this study. All the detail results see Table 3.

Indeterminate samples

There were 85 samples indeterminate by confirmatory testing and HCV RNA undetected. We further explored the antigen distribution and found there were six different formats: core1 single, helicase single, helicase/NS3, NS3/NS4, NS4/NS5 and NS4/NS5, among which core1 single was the majority (53/85, 62.35%), next was helicase single (17/85, 20%). Only three samples belong to last three formats. Different assays showed quite different results on these indeterminate samples: of all the indeterminate samples, 45 were detected by Abbott, while Wantai (sandwich) and Murex got only 25 positives. In the aspect of antigen distribution among different assays, most assays showed similar results as the total, except Murex. Helicase single in Murex positive indeterminate samples accounted for a main proportion (40%), next is core1 single (32%) and Helicase/NS3 format (28%).

Besides, we also analyzed the S/CO ratios of Roche and Abbott among 367 samples with discrepant results. There was statistically significant between the indeterminate and positive (4.84 vs 19.36, $p<0.0001$), between negative and positive (2.94 vs 19.36, $p<0.0001$) and between determinate and negative (4.84 vs 2.94, $p=0.020$) detected by Roche. However, we didn't find any difference among the three groups when detected by Abbott (positive 1.40 vs indeterminate 1.74 vs negative 1.55, $p=0.567$) (Figure 2)

PPV of CLIAs on different S/CO ratios

In order to determine the relationship between PPV and S/CO ratio on two CLIAs, we analyzed the assays results when different S/CO ratios were as the cutoff values of the two CLIAs. When S/CO ratio went to 1.0, Roche's PPV on detection of anti-HCV was 92.09% (256/278), and Abbott was only 78.55% (238/303). When PPV was above 95% (246/258 on Roche, 196/205 on Abbott), cutoff S/CO ratios need to be more than 8.2 on Roche, and more than 4.2 on Abbott. When PPV was 100% (65/65 on Roche, 177/177 on Abbott), cutoff S/CO ratios need to be 46.8 on Roche, and 8.0 on Abbott. Results of ROC and AUC indicated that the two assays both showed a good AUC: Roche was 0.994 and Abbott was 0.984. However, the best S/CO was quite different on the two: S/CO ratio=1.515 was the best cutoff for Roche,

on this S/CO the assay's sensitivity was 98.08% and the specificity was 97.82%. Since the relatively low sensitivity of Abbott, the best S/CO was only 0.385 (sensitivity=99.23%, specificity=86.50%).

Discussion

False positive reactions in anti-HCV screening assays is a well-known concern and an obstacle to improve assays' performance all along. In the present study, we found that the average false positive rate of anti-HCV screening assays was as high as 52.54%, which meant large amount of donations were discarded and qualified donors were deferred unfortunately. It is reported in Uganda, 7.6% (76/1000) were serologically reactive by Ortho, but none were confirmed [8]. Similarly, Schroter M, et al [9] also found false positive results by widely used anti-HCV EIAs were at least 10%, which, compared to other virus screening assays, was unacceptable. In another study in Africa, only 13% of initial anti-HCV positive samples were confirmed by NAT or immunoblot and 2.46% (409/16,613) of blood donations were wrongly discarded [10].

Whereas the false positive rate in this study might partly result from the serological screening strategy in China. Use of two EIAs no doubt would relatively increase the sensitivity but sacrifice the specificity to a certain extent. In addition, among all screened positive samples in the panel, 40% were repeated reactive by single assay, which contributing only 1% confirmed positivity and leading to the high false positive rate. In the next place, samples used in screening tests were directly from blood collection tubes, while samples in the plasma panel were from plasma bag, which contained about 20% blood preserving fluid, diluting the samples and resulting in missing detection of some weak positives. Besides, researchers also found in low risk populations, 40–50% of screening reactives were negative in supplemental immunoblot tests, which was similar to our results [11].

Secondly, performance analysis of ten different assays indicated that generally all assays' performance was worse than reported [12-20] or claimed by their instructions, which may be mainly due to sample source. Large amount of false positive samples increased the difficulty of testing a lot and false positive results of an assay during the first screening are likely to be false positives again. Specifically, Roche got the highest sensitivity (98.47%) and Youden's index (0.961) but specificity (97.61%) was lower than four EIAs (KHB 98.23%, Wantai (indirect) 98.23%, Wantai (sandwich) 98.03% and Livzon (sandwich) 98.13%). The other CLIA, Abbott didn't perform well: it had the lowest sensitivity, but its results were highly comparable to those of Ortho, which also has been shown in other studies [18-21]. Therefore, Two CLIAs especially in the respect of specificity didn't show much better performance than EIAs, no matter imported assays or domestic ones.

We then analyzed the combined performance of any two EIAs assays. Interestingly, not two assays both with good sensitivity had the best combined sensitivity, but Ortho or Abbott together with InTec had a 100% sensitivity indicating these two assays just made up for each other's missing detection. In the terms of specificity, though use of two assays would definitely decrease detection specificity, we found that Wantai (indirect) together with Livzon (sandwich) got a 97.80% specificity, even better than only using

one assay (InTec 92.94%, Ortho 90.13%, Livzon(indirect) 93.15%, Murex 97.20%, Roche 97.61%, Abbott 93.25%).

Based on the performance of ten evaluated assays in the study, we recommended Roche for screening anti-HCV in blood donations and to those could only use EIA assays, Wantai (indirect), Wantai (sandwich), and Livzon (sandwich) also performed well. If blood establishments use two assays' strategy when testing anti-HCV antibody, Wantai (indirect) with KHB, Wantai (indirect) with Livzon (sandwich), or Wantai (sandwich) with Livzon (sandwich) would be a better choice. In addition, a confirmatory testing is necessary for the initial positive samples.

Usually, an immunoblot test and/or NAT are served as a way to confirm screening reactive samples. However, the recombinant immunoblot assay as a confirmatory method for serological screening test of HCV, is of high cost and laborious to be used in every laboratory in China and these confirmatory tests often give many indeterminate and/or HCV RNA negative results, indicating the donor may be a resolved HCV infection, infection with a different genotype, early seroconversion, occult HCV infection or just non-specific reactivity [22], which makes us much difficult to estimate the donors' true status. Like our results, we got 85 (6.49%, 85/1,309) indeterminate/HCV RNA negative samples, and most (53/85, 62.35%) were due to isolated reactivity to antigens from the core1 region of the HCV genome. We also found these indeterminate samples showed quite different average S/CO ratios detected by Roche compared with confirmed positives (4.84 vs 19.36, p<0.0001), and higher S/CO ratios than confirmed negatives (4.84 vs 2.94, p=0.020). Similarly to Kiely P's results [22], the antigen distribution and band intensity were different between indeterminate samples and confirmed positives. All these results indicated indeterminate samples were a special group different from negative and positives.

Finally, we evaluated the corelationship between PPV and S/CO ratio on two CLIAs. When S/CO was 8.2 on Roche and 4.2 on Abbott, the PPV could achieve more than 95%. The S/CO ratio of ARCHITECT anti-HCV established for FDA−approved is more than 5.0 [5], similar to our results. But there is no such approved ratio on Elecsys Anti-HCV II. Some studies suggested that the value predictive of a true positive ≥95% of the time with the assay could be set at an S/CO ratio of 20.0, much higher than our study [14, 16], which meant it was required to verify the value in further study.

There were some limitations in the study. First, not all the information of anti-HCV positive donors were available in this study, therefore we didn't know the true infection status of these donors. Secondly, different automated sampling and testing equipment were used in the 16 different blood establishments involved in the evaluation study, and all these difference may influence the detection accuracy.

Conclusion

Based on the multicenter evaluation of 10 common used anti-HCV screening assays, false reactive problem of anti-HCV screening should be solved urgently. Assays showed different performance on sensitivity and specificity and CLIAs didn't performed better than EIAs, especially on specificity. Indeterminate samples may be a special group, should be further studied.

Abbreviations

HCV, Hepatitis C virus; EIA, Enzyme immunoassay; CLIA, Chemiluminescent immunoassay; NCCL, National Center for Clinical Laboratories.

Declarations

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Tables

Table 1. Sample source and confirmatory results

Samples source (blood olishments)	screening assays	anti-HCV- by screening assays			anti-HCV+ by screening assays				False negative %	False positive %
		total	-	+	total	-	+	+/-		
NCCL	a-h	0	0	0	129	87	33	9	0.00	67.44
CC	a, e	11	11	0	35	9	23	3	0.00	25.71
CQ	b, h	22	22	0	48	24	16	8	0.00	50.00
HB	b, f	18	18	0	48	31	12	5	0.00	64.58
HLJ	a, e	76	76	0	30	12	16	2	0.00	40.00
HN	d, e	111	111	0	66	31	23	12	0.00	46.97
HZ	a, e	21	21	0	5	2	3	0	0.00	40.00
JN	a, b	0	0	0	4	4	0	0	0.00	100.00
JS	b, f	50	50	0	50	33	14	3	0.00	66.00
KM	f, h	15	15	0	11	3	6	2	0.00	27.27
LN	a, b	50	49	1	37	12	19	6	2.00	32.43
SD	d, f	50	50	0	49	23	21	5	0.00	46.94
SZ	c, d	50	50	0	50	30	13	7	0.00	60.00
TJ	c, e	49	49	0	101	43	42	16	0.00	42.57
TZ	c, h	50	50	0	35	20	11	4	0.00	57.14
XY	a, b	9	9	0	29	18	8	3	0.00	62.07
Total		582	581	1	727	382	260	85	0.17	52.54

Note: a,KHB Diagnostic Kit for Antibody to Hepatitis C virus (Shanghai Kehua Bioengineering co., Shanghai, China); b, InTec Diagnostic Kit for Antibody to Hepatitis C virus (InTec Products, Inc., Xiamen, China); c, ORTHO HCV Version 3.0 ELISA (Ortho-Clinical Diagnostics, Raritan, New Jersey); d, Livzon Diagnostic Kit for Antibody to Hepatitis C virus (indirect) (Zhuhai Livzon Diagnostics Inc., Zhuhai, China); e, Wantai Diagnostic Kit for Antibody to Hepatitis C virus (indirect) (Beijing Wantai Biological Pharmacy, Beijing, China); f, Wantai Diagnostic Kit for Antibody to Hepatitis C virus (sandwich) (Beijing Wantai Biological Pharmacy, Beijing, China); g, Livzon Diagnostic Kit for Antibody to Hepatitis C virus (sandwich) Zhuhai Livzon Diagnostics Inc., Zhuhai, China); h, Murex anti- HCV (version 4.0) (Diasorin, Saluggia, Italy). -: true negative; +: true positive; +/-: indeterminate.

Table 2. Technical specifications of evaluated assays and confirmatory assay

No.	Abbreviations of assays	Test format †	Antigens	Blood establishments
a	KHB	EIA, indirect	core, non-structure antigen	CQ, HLJ, HN, XY
b	InTec	EIA, indirect	*N/M* ‡	CC, HB, JN, JS, XY
c	Ortho	EIA, indirect	core(c22-3), NS3+NS4(c200), NS5	CQ, SZ, TJ
d	Livzon (indirect)	EIA, indirect	*N/M*	CC, JS, SD
e	Wantai (indirect)	EIA, indirect	*N/M*	CZ, LN, SD
f	Wantai (sandwich)	EIA, sandwich	*N/M*	CZ, HB, HLJ, HN, LN, TJ
g	Livzon (sandwich)	EIA, sandwich	*core, NS3, etc.*	JN, LN
h	Murex	EIA, indirect	core, NS3, NS4, NS5	KM, SH, TZ
i	Roche	ECLIA, sandwich	core, NS3, NS4	NCCL
j	Abbott	CMIA, indirect	core, NS3(33c), NS4(c100-3)	NCCL
k	Mikrogen	recombinant immunoblot assay	core1, core2, helicase, NS3, NS4, NS5	NCCL

Note:

† EIA: enzyme immunoassay; ECLIA: electrochemiluminescence immunoassay; CMIA: chemiluminescent microparticle immunoassay.

‡ *N/M: not mentioned in the package inserts.*

Table 3. Performance index of different assays

Sensitivity (%)	KHB	InTec	Ortho	Livzon (indirect)	Wantai (indirect)	Wantai (sandwich)	Livzon (sandwich)	Murex	Roche	Abbott
KHB	95.02%									
InTec	99.23%	98.47%								
Ortho	98.08%	100.00%	92.72%							
Livzon (indirect)	99.23%	98.85%	99.23%	91.95%						
Wantai (indirect)	98.85%	98.85%	99.62%	99.23%	97.70%					
Wantai (sandwich)	98.47%	98.85%	99.23%	99.23%	97.70%	97.32%				
Livzon (sandwich)	98.47%	98.85%	99.23%	99.23%	97.70%	97.32%	97.32%			
Murex	96.17%	99.23%	96.55%	99.23%	98.08%	97.70%	97.70%	92.72%		
Roche	98.85%	98.85%	100.00%	99.23%	98.47%	98.50%	98.47%	98.85%	98.47%	
Abbott	96.93%	100.00%	94.25%	98.85%	99.62%	99.23%	99.23%	95.79%	99.62%	91.19%

Specificity (%)	KHB	InTec	Ortho	Livzon (indirect)	Wantai (indirect)	Wantai (sandwich)	Livzon (sandwich)	Murex	Roche	Abbott
KHB	98.23%									
InTec	91.80%	92.94%								
Ortho	89.72%	84.53%	90.13%							
Livzon (indirect)	92.21%	87.23%	84.74%	93.15%						
Wantai (indirect)	96.88%	91.80%	88.79%	92.32%	98.23%					
Wantai (sandwich)	96.68%	91.59%	88.58%	92.00%	97.80%	98.03%				
Livzon (sandwich)	96.78%	91.69%	88.79%	92.32%	97.92%	97.72%	98.13%			
Murex	95.85%	90.55%	88.06%	91.07%	95.74%	95.53%	95.64%	97.20%		
Roche	96.26%	91.17%	88.27%	91.80%	97.40%	97.30%	97.40%	95.22%	97.61%	
Abbott	92.94%	86.71%	87.75%	87.54%	91.90%	91.69%	91.80%	91.38%	91.48%	93.25%

Youden's index	KHB	InTec	Ortho	Livzon (indirect)	Wantai (indirect)	Wantai (sandwich)	Livzon (sandwich)	Murex	Roche	Abbott
KHB	0.933									
InTec	0.910	0.914								
Ortho	0.878	0.845	0.829							
Livzon (indirect)	0.914	0.861	0.840	0.851						
Wantai (indirect)	0.957	0.906	0.884	0.915	0.959					
Wantai (sandwich)	0.951	0.904	0.878	0.912	0.955	0.953				
Livzon (sandwich)	0.952	0.905	0.880	0.915	0.956	0.950	0.954			
Murex	0.920	0.898	0.846	0.903	0.938	0.932	0.933	0.899		
Roche	0.951	0.900	0.883	0.910	0.959	0.958	0.959	0.941	0.961	
Abbott	0.899	0.867	0.820	0.864	0.915	0.909	0.910	0.872	0.911	0.844

Kappa Coefficient	KHB	InTec	Ortho	Livzon (indirect)	Wantai (indirect)	Wantai (sandwich)	Livzon (sandwich)	Murex	Roche	Abbott
KHB	0.927									
InTec	0.822	0.839								
Ortho	0.776	0.700	0.749							
Livzon (indirect)	0.830	0.737	0.698	0.801						
Wantai (indirect)	0.923	0.819	0.769	0.832	0.945					
Wantai (sandwich)	0.916	0.816	0.763	0.826	0.936	0.938				
Livzon (sandwich)	0.918	0.818	0.767	0.832	0.938	0.931	0.940			
Murex	0.883	0.799	0.737	0.808	0.893	0.887	0.889	0.889		
Roche	0.909	0.808	0.762	0.822	0.931	0.929	0.931	0.887	0.936	
Abbott	0.829	0.736	0.717	0.743	0.826	0.820	0.822	0.792	0.818	0.798

Sensitivity (red), specificity (green), Youden's index (blue), and Kappa Coefficient (purple) of single assay and two combined assays were shown. The darker the color, the better performance the assays have. The number in the black box shows the best performance (sensitivity, specificity, Youden's index, or Kappa Coefficient) of all the combined assays.

Figures
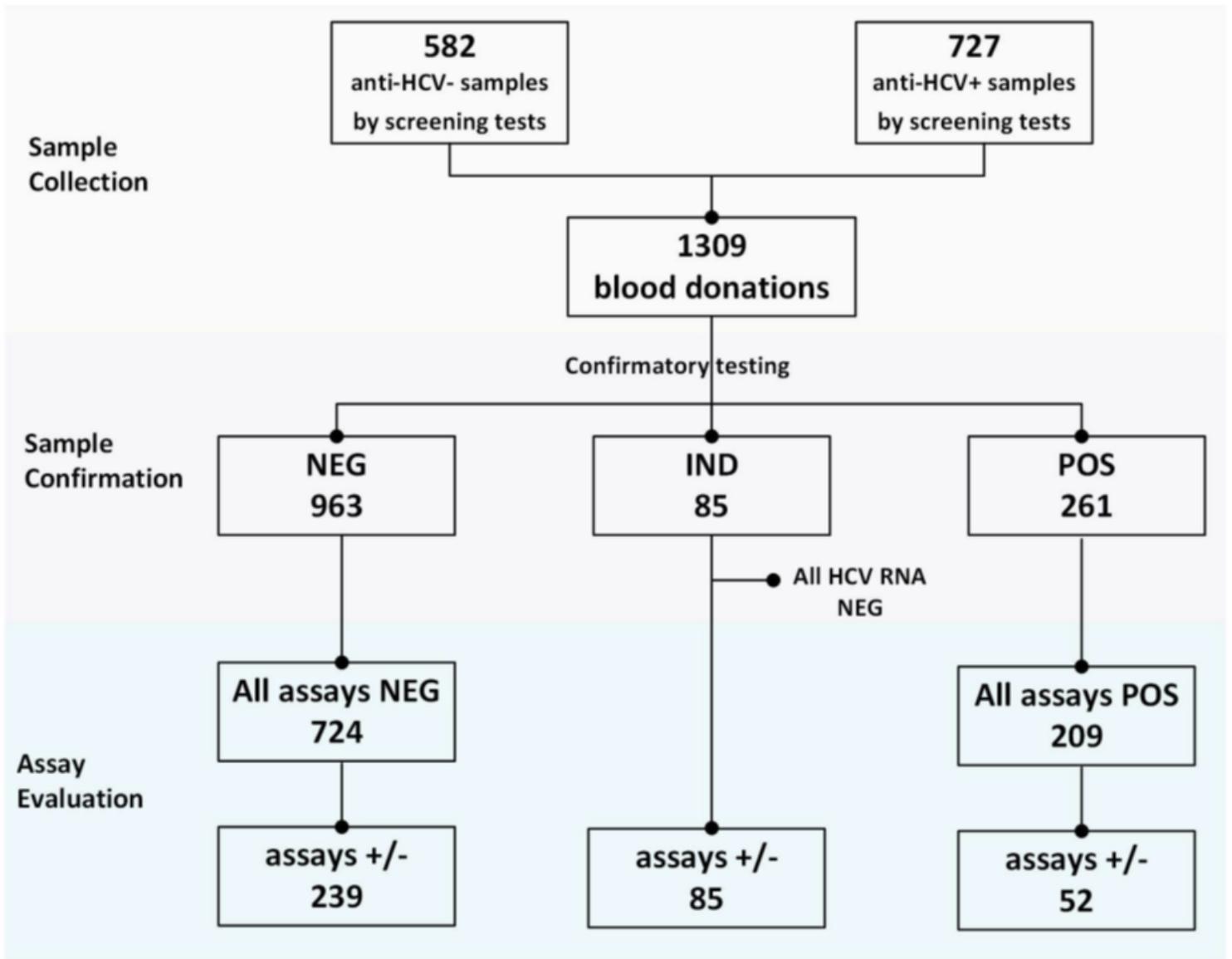
Figure 1

Confirmatory results of plasma panel Note: +, POS: positive/reactive; -, NEG: negative/non-reactive; +/-, IND: indeterminate; R: Elecsys Anti-HCV II (Roche Diagnostics GmbH, Penzberg, Germany); A: ARCHITECT anti-HCV (Abbott, Illinois, US).
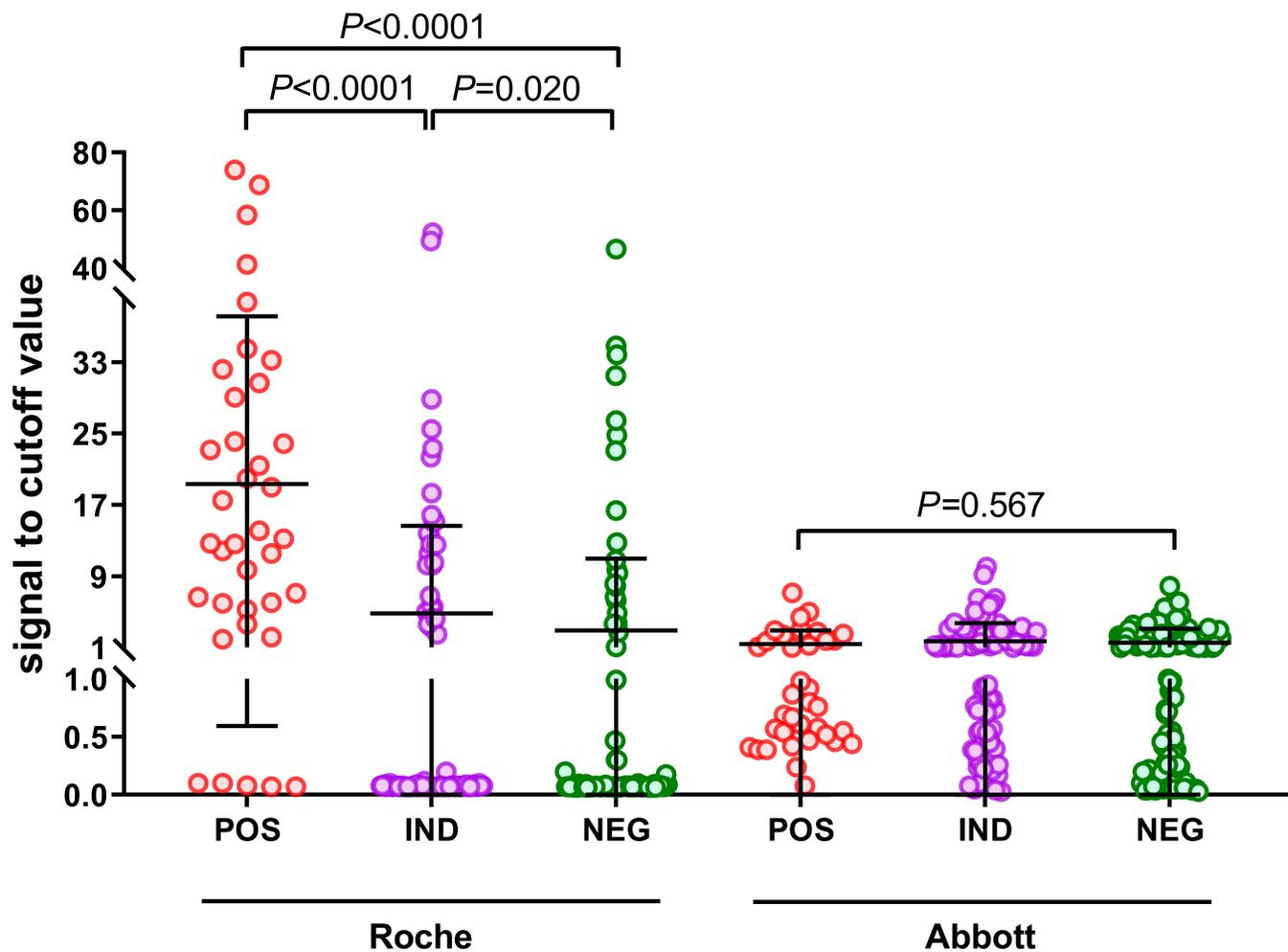
Figure 2

S/CO ratio distribution among confirmed positive, indeterminate and negative samples Note: +: positive/reactive; -: negative/non-reactive; +/-: indeterminate; Roche: Elecsys Anti-HCV II (Roche Diagnostics GmbH, Penzberg, Germany); Abbott: ARCHITECT anti-HCV (Abbott, Illinois, US).

Supplementary Files

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- SupplementaryMaterial.docx