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Research Article

External quality assessment for dual detection of HBsAg and anti-HCV in serum

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ABSTRACT

Hepatitis B surface Antigen (HBsAg) and hepatitis C antibody (anti-HCV) assays have been performed in most laboratories using a variety of analytical methods with different reagents for Hepatitis B virus (HBV) and Hepatitis C virus (HCV) screening[1-2]. The purpose of this study was to develop an EQA program for dual HBsAg and anti-HCV serological testing to ensure the accuracy and reliability of serological assays. A serum panel of 12 samples containing three negative, three positives for each virus and three positives for both of HBsAg and anti-HCV. These panels were distributed to 102 laboratories in the South of Vietnam. They were required to report their results and any problems encountered on EQA panel. The results show that performance of HBsAg and anti-HCV tests is not only different in terms of method used but also in the types of biological products. Rapid tests (RTs) to detect HBsAg and anti-HCV were most commonly used to screen for HBV and HCV in laboratories. The coincidence rates of RTs for HBsAg and anti-HCV serological assays were 88.24% and 89.86% respectively, while electrochemiluminescence (ECLs) and chemiluminescent immunoassays (CLIAs), Enzyme-linked immunosorbent assay (ELISA) showed the best performance for both HBsAg and anti-HCV testing. The most challenging was failed to detect weak positive samples. In conclusion, the differences in test results within and between groups of HBsAg and anti-HCV assay methods indicated a need to improve test conditions at laboratories in Viet Nam.

Keywords:
External quality assessment, Panel, HBsAg, Anti-HCV, Serological testing

1. INTRODUCTION

Hepatitis is a worldwide health problem leading to liver dysfunction, hepatocellular cirrhosis and carcinoma. Hepatitis B caused by the Hepatitis B virus (HBV) is known as a silent disease. Children infected with HBV often have no symptoms, making it difficult to monitor this population[3]. Vietnam is a country with high rates of HBV and Hepatitis C virus (HCV) infection. Many people who have been infected with HBV and HCV without symptoms for a long time. They even do not know that they got infected, and this may risk infecting others[4-6]. Therefore, HBV and HCV infection screening to prevent infection and disease progression is essential. Currently, HBsAg and anti-HCV assays have been performed in most laboratories using a variety of analytical methods with different biological products for HBV and HCV screening such as rapid tests (RTs), electroluminescence immunoassay (ECLIAs, chemiluminescent immunoassay (CLIA) and enzyme-linked immunosorbent assay (ELISA). Rapid test is a rapid chromatographic immunoassay for the detection of HBV and HCV in serum or plasma samples[7]. Electroluminescence (ECL) assay is a technique for converting electrical energy into radiant energy called luminescence[8]. Immunoassays (IAs) are analytical methods based on the antigen-antibody reactions for quantitative or qualitative analysis. The sensitivity and specificity of the ECLIA technique for the anti-HCV detection were 100% and 99.8%, respectively[9]. ELISA is a labeled immunoassay and less sensitive than ECLIAs for HBsAg detection (73% compared to 100%)[9].

CLIA is an immunoassay technique using

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luminescent compounds emitting light during the course of a chemical reaction. This method is very sensitive with quantitative detection of hepatitis B virus of 0.2 ng/mL[11-12]. In small-scale laboratories in Vietnam, the rapid test-card method was used more than the ECL and ELISA assay for HBsAg and anti-HCV screening[2], because ECL and ELISA methods are time-consuming, expensive and require professional technicians[13]. Although RTs are simple, easy to use, cheaper and faster than enzyme immunoassays (EIAs) and ECLs/CLIAs, RTs are less sensitive than these methods[14]. In fact, test results in general and HBsAg and anti-HCV in particular are very important in the screening and treatment of HBV and HCV infections. Furthermore, if the screening tests are positive for HBsAg and anti-HCV, the confirmation tests can be performed on these samples to eliminate false positive test results.

To assess diagnostic quality of viruses, laboratories are recommended to participate in EQA programs that provide an objective assessment of the reliability and accuracy of laboratory test results[15]. Participation in EQA program can contribute to enhance the quality of the laboratory. The ideal samples supplied for EQA program are required for homogeneity and stability[16]. However, EQA programs for HBsAg and anti-HCV have not been widely implemented in Vietnam. The purpose of this study was to develop an EQA program for dual HBsAg and anti-HCV serological testing to ensure the accuracy and reliability of serological assays.

2. MATERIALS AND METHOD

2.1. Chemicals and Instruments

Elecsys HBsAg II reagent kit and HBsAg confirmatory test for HBsAg qualitative assay, Elecsys anti-HCV II reagent kit for anti-HCV qualitative assay were obtained from Roche. Architect HBsAg reagent kit for HBsAg qualitative assay and Architect anti-HCV reagent kit for anti-HCV qualitative assay was purchased from Abbott. Adiva centaur HBsAg and Adiva Centaur HCV reagent kits for HBsAg and anti-HCV qualitative assay, respectively, was obtained from Siemens. Confirmatory test of Inno-Lia™ HCV score was obtained from Fujirebio. ProClin™ 300 was purchased from Sigma-Aldrich.

Cobas E411 analyzer (Roche), Architect (Abbott), Adiva Centaur® XPT (Siemens) which meet IVD certificate were used to detect HBsAg and anti-HCV in human plasma and serum samples with respective reagent kits.

2.2. Sample collection

The plasma samples for the purposes of this study were approved by the Ethics Committee of University of Medicine and Pharmacy at Ho Chi Minh City issued together with Decision No. 422/ĐHYD-HĐĐĐ August 27, 2019. The inclusion of plasma including negative plasma was provided by Blood Transfusion Hematology Hospital Ho Chi Minh city tested negative for HCV, HIV, HBV, HTLV (human T-lymphotropic virus), and syphilis by serological and NAT tests, the positive samples were also donated by volunteer patients who received informed consent and tested positive for HBV and HCV by serological and NAT tests and negative for HIV, HTLV, syphilis by serological tests. All plasma packages are integrity. The exclusion of plasma does not meet inclusion criteria. The collected samples met inclusion criteria were stored at -20ºC.

2.3. Panel preparation and distribution

Defibrination of blood plasma

The negative and positive samples for EQA panels were prepared using the plasma conversed to serum by defibrination with thrombin in $CaCl_2$ 1M according to procedure of Castro AR with minor changes[17]. In brief, 100 mL of plasma were thawed and placed in a hydrothermal pot at 56ºC for 30 minutes. Then, thrombin solution 100 U/mL in $CaCl_2$ 1 M was added into plasma at a rate of 1:100 (v/v). After shaking sharply plasma tube in 10 seconds, samples were incubated at 37ºC for 60 min for precipitation and frozen at -20°C for 24 hours. Plasma samples were thawed at room temperature and then centrifuged at 4,000 rpm at 4ºC for 60 minutes. The supernatant was collected and then filtered through the filter with pore size from 5 μm to 0.22 μm to remove precipitate. After adding Proclin™ 300 0.05% (v/v) to preserve the sample from bacterial and fungal contamination, serological filtration is re-evaluated by 3 automated analyzers including Cobas E411 analyzer (Roche), Architect (Abbott), Adiva Centaur® XPT (Siemens). HBsAg in samples was identified by Elecsys HBsAg II, Architect HBsAg qualitative, Adiva centaur HBsAg reagent kits. Anti-HCV in samples was tested by Elecsys anti-HCV II, Architect anti-HCV, Adiva Centaur HCV reagent kits. Samples with S/CO ≥1.0 are considered reactive. Positive samples with HBsAg and anti-HCV were confirmed using HBsAg confirmatory test and Inno-Lia™ HCV score respectively, prior to packaging and transporting to testing laboratories.

To ensure quality of EQA panels, the homogeneity and stability of samples were evaluated according to ISO Guide 35[18] and ISO 13528[19], respectively.

Panel composition

Each EQA panel consisted of 12 coded specimens from HBC-01 to HBC-12 (Table 1) including three

Table 1. Characteristic specimens in an EQA panel.

Sample	HBsAg	anti-HCV
HBC-01	Negative	Negative
HBC-02	Weak positive	Negative
HBC-03	Positive	Positive
HBC-04	Negative	Negative
HBC-05	Negative	Weak positive
HBC-06	Positive	Negative
HBC-07	Negative	Positive
HBC-08	Negative	Negative
HBC-09	Weak positive	Negative
HBC-10	Negative	Weak positive
HBC-11	Positive	Positive
HBC-12	Positive	Positive

negative and three positive samples for HBsAg, three positive samples for anti-HCV, three positive samples for dual HBsAg and anti-HCV. 0.5 ml of treated plasma was quoted per 2 ml cryotube. The specimens were stored at 2-8^{o}C until distribution.

Validation of EQA panels

Before distribution, the serum panels were sent to five experts in laboratories using ECL/CLIA method as well as ELISA assay. Results from these laboratories validated the quality of panel samples.

Panel distribution

Each EQA panel stored in a box with dry ice pack together information sheet and sealed were shipped by courier service (transit maximum time 72 hours) to participants. They were asked to check the integrity of panel, the status of the samples, and send feedback to the EQA provider.

2.4. Participants

Three hundred and fifty laboratories in the South and Central Highlands of Vietnam that perform HBsAg and anti-HCV serological testing were invited to join the EQA program. Finally, 102 laboratories voluntarily registered in this study. 117 EQA panels were sent to 102 participants, of which fifteen laboratories received two panels and returned one panel to Pasteur Institute in Ho Chi Minh City for re-evaluation as needed. They were required to report their results and any problems encountered on EQA panel.

2.5. Data analysis

The results of HBsAg and anti-HCV tests on EQA panel samples and information from participants were collected and analyzed using Excel 2016 software. Data analysis was based on group-consensus analysis method[20]. The reference result was the result with 80% similar level among participated laboratories in the same method[21]. In case of similar level below 80% or group method testing below 10 participated labs using, the reference result would be from EQA provider. The sensitivity of a screening test is the ability of a screening test to detect a true positive. The specificity of a screening test is the ability of a screening test to detect a true negative. Accuracy is the proportion of true results.

3. RESULTS

3.1. Testing methods

Among 102 laboratories voluntarily registered to participate in EQA program, only 100 participants sent their results. All participants reported that their panels were integrity, no leaking. The performance of HBsAg and anti-HCV tests were not only different in testing method used but also in the types of biological products in laboratories. The testing methods were used to detect HBsAg and anti-HCV consisting of CLIAs/ECLs, ELISA, RTs. However, RTs with a variety of commercial products were most used to screen for HBV and HCV (Figure 1 and Figure 2). For HBsAg testing, the rate of CLIAs/ECLs, ELISA, RTs method used in 100 laboratories were 30.0%, 2.0%, and 68.0%, respectively. For anti-HCV testing, CLIAs/ECLs, RTs methods were used in laboratories at the rate of 31.0% and 69.0%, respectively.

3.2. Assessment of testing results from participants

Based on group-consensus analysis method, the coincidence rates of laboratories using CLIAs/ECLs and ELISA methods for HBsAg detection were absolute. The coincidence rates for RTs (88.24%) were lower than CLIAs/ECLs and ELISA. False-negative results by RTs methods were found in weak positive samples HBC-02, HBC-06 and HBC-09 with the rate of 11.76%, 7.35% and 10.29%, respectively (Table 2).

For anti-HCV testing, the coincidence rate of laboratories using CLIAs/ECLs method for anti-HCV detection was 100% while the rate for RTs was 89.86%. False-positive results by RTs methods were found in

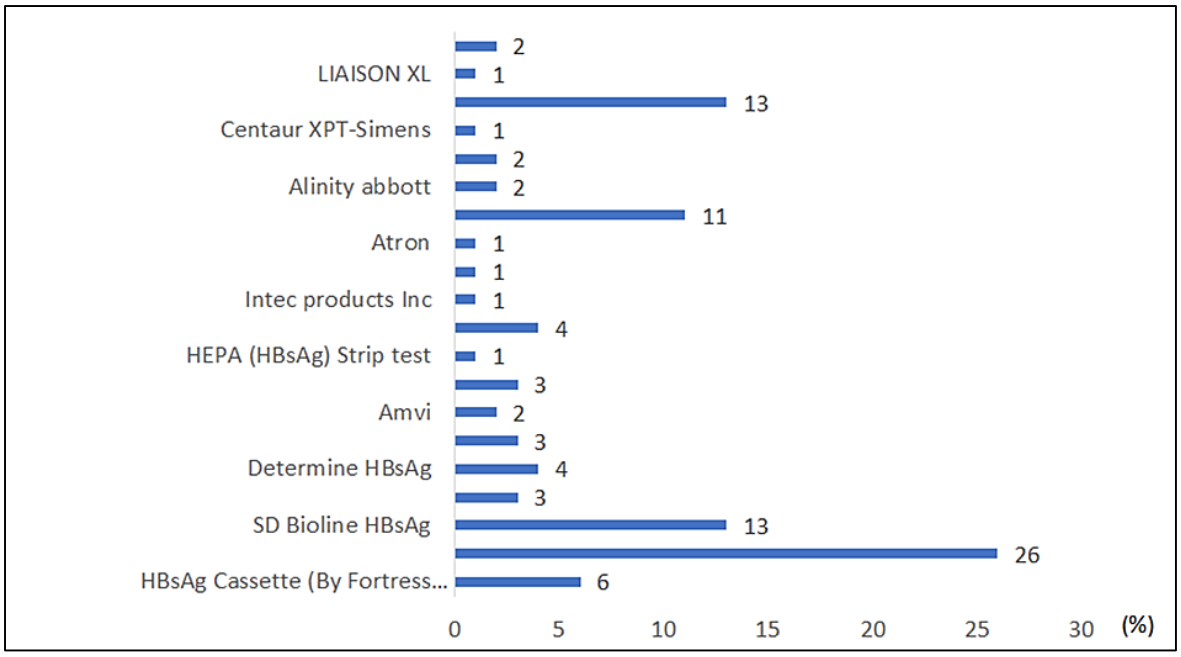

Figure 1. Type and percentage of biological products used for HBsAg testing.

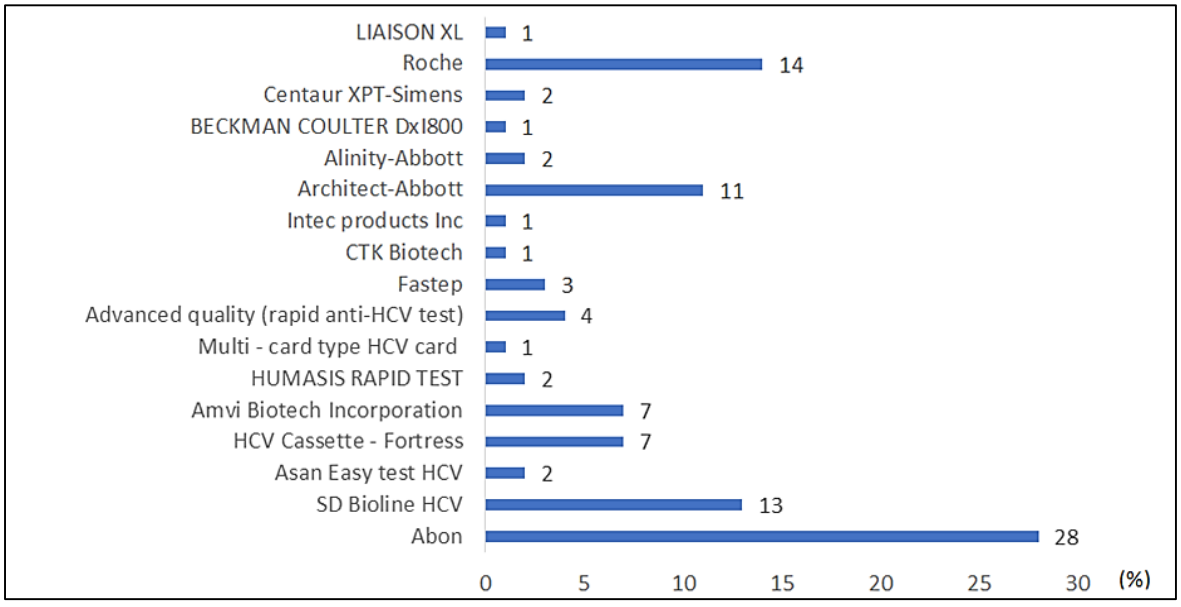

Figure 2. Type and percentage of biological products used for anti-HCV testing.

Table 2. Coincidence rate of HBsAg testing results (%).

Method		CLIAs/ECLs (n=30)	ELISA (n=2)	RTs (n=68)
Samples	**HBsAg**	**(%)**	**(%)**	**(%)**
HBC-01	Negative	100	100	100
HBC-02	Weak positive	100	100	88.24
HBC-03	Positive	100	100	100
HBC-04	Negative	100	100	100
HBC-05	Negative	100	100	100
HBC-06	Positive	100	100	92.65
HBC-07	Negative	100	100	100
HBC-08	Negative	100	100	100
HBC-09	Weak positive	100	100	89.71
HBC-10	Negative	100	100	100
HBC-11	Positive	100	100	100
HBC-12	Positive	100	100	100

Table 3. Coincidence rate of anti-HCV testing results.

Characteristics of panel		Analytical Methods	
		CLIAs/ECLs (n=31)	RTs (n=69)
Samples	Anti-HCV	(%)	(%)
HBC-01	Negative	100	98.55
HBC-02	Negative	100	100
HBC-03	Positive	100	91.30
HBC-04	Negative	100	100
HBC-05	Weak positive	100	89.86
HBC-06	Negative	100	100
HBC-07	Positive	100	92.75
HBC-08	Negative	100	98.55
HBC-09	Negative	100	100
HBC-10	Weak positive	100	91.30
HBC-11	Positive	100	92.75
HBC-12	Positive	100	97.10

Table 4. The sensitivity, specificity and accuracy of analytical methods for HBsAg and anti-HCV detection.

Analytical Methods	Sensitivity	Specificity	Accuracy
		HBsAg detection	
RTs	88.24%* (60/68)	100% (68/68)	94.12%** (128/136)
CLIAs/ECLs	100%* (30/30)	100% (30/30)	100%** (60/60)
ELISA	100%* (2/2)	100% (2/2)	100%** (4/4)
		Anti-HCV detection	
RTs	89.86%*** (62/69)	97.10% (67/69)	93.47%**** (129/138)
CLIAs/ECLs	100%*** (31/31)	100% (31/31)	100%**** (62/62)

(*) RTs vs CLIAs/ECLs/ELISA: p=0.02; (**) RTs vs CLIAs/ECLs/ELISA: p=0.02; (***) RTs vs CLIAs/ECLs: p=0.03; (****) RTs vs CLIAs/ECLs: p=0.02 (Z-test for two proportions)

Table 5. Percentage of correct results for both HBsAg and anti-HCV detection.

Characteristics of panel		Percentage of correct results (%)
Sample	HBsAg/ anti-HCV	(n = 100 participants)
HBC-01	Negative/ Negative	99
HBC-02	Weak positive/ Negative	92
HBC-03	Positive/ Positive	94
HBC-04	Negative/ Negative	100
HBC-05	Negative/ Weak positive	93
HBC-06	Positive/ Negative	95
HBC-07	Negative/ Positive	95
HBC-08	Negative/ Negative	99
HBC-09	Weak positive/ Negative	93
HBC-10	Negative/ Weak positive	94
HBC-11	Positive/ Positive	96
HBC-12	Positive/ Positive	99

weak positive samples HBC-01 and HBC-08 with the rate of 1.45%. False-negative results by RTs methods were found in weak positive samples HBC-03, HBC-05, HBC-07, HBC-10, HBC-11 and HBC-12 with the rate of 8.7%, 10.14%, 7.25%, 8.7%, 7.25% and 2.9%, respectively (Table 3).

The significant differences in sensitivity and accuracy between RTs and CLIAs/ECLs/ELISA were found for HBsAg and anti-HCV detection (p<0.05) (Table 4).

The percentage of laboratories reporting correct results for both HBsAg and anti-HCV detection on EQA panel of 12 samples was presented in Table 5. All participants reported correct results on negative sample HBC-04 for both HBsAg and anti-HCV. The incorrect results (<95%) were found more frequently in weak positive samples HBC-02, HBC-05, HBC-09 and HBC-10 for HBsAg and anti-HCV.

3.3. EQA results for HBsAg and anti-HCV detection using different types of RTs

There are more types of RTs for HBsAg than for anti-HCV testing, 13 types of RTs for HBsAg and 11 for anti-HCV. Laboratories using RTs including Asan Easy Test HBs, Fastep, Determine HBsAg, Amvi Biotech, HBsAg Card, HEPA (HBsAg) Strip test, Humasis HBsAg, Intec products Inc, Onsite Rapid Test performed

an accurate detection of HBsAg on negative or positive samples in EQA panel. However, the correct results for all 12 samples in EQA panel of participants using Abon, HBsAg Cassette, SD Bioline HBsAg were only 92.3%, 83.3%, 69.2%, respectively (Table 6). Eight laboratories used Abon (2 labs), HBsAg Cassette (1 lab), SD Bioline HBsAg (4 labs), and Atron (1 lab) reporting false-negative results for HBsAg detection.

Laboratories using RTs including Asan Easy test HCV, HCV Cassette-Fortress, Amvi Biotech Incorporation, Humasis rapid test, Multi-card type HCV card, Fastep, CTK Biotech, Intec products Inc performed an accurate detection of anti-HCV on negative or positive samples in EQA panel. However, the correct results for all 12 samples in EQA panel of participants using Abon, SD Bioline HCV, Advanced Quality were only 92.8%, 69.2%, and 50%, respectively (Table 7). Nine laboratories used Abon (3 labs), SD Bioline HCV (4 labs) and Advanced Quality products (2 labs) reported false-negative results for anti-HCV detection. One laboratory used Abon gave false-positive result on HBC-01 and one used Advanced Quality reported false-positive result on HBC-08 for anti-HCV testing.

4. DISCUSSION

HBV and HCV usually cause chronic liver disease that may lead to cirrhosis and liver cancer[22]. Currently, HBsAg and anti-HCV assays have been performed in most laboratories using a variety of analytical methods with different reagents for HBV and HCV detection such as EIAs, ECLs, CLIAs, RTs[1-2]. The accuracy and reliability of HBsAg and anti-HCV test results related to the screening and treatment of HBV and HCV infection. To assess diagnostic quality of viruses, laboratories are recommended to participate in EQA programs[15]. However, EQA programs for HBsAg and anti-HCV have not been widely implemented in Vietnam.

HBsAg and anti-HCV tests can be performed with serum or plasma samples. However, the formation of clot in frozen plasma can affect sample homogeneity. Therefore, serum samples are preferred in EQA panel[22]. In this study, the conversion from blood plasma to serum using thrombin was performed for use in serological tests. The homogeneity, stability of HBsAg and anti-HCV positive and negative samples were not affected by this defibrination of plasma.

Most EQA panels for HBsAg and anti-HCV assays are prepared independently. This might increase the cost of the separate EQA programs for HBsAg and anti-HCV, leading to limited involvement of laboratories in the EQA programs. Therefore, we developed an EQA panel containing dual HBsAg and anti-HCV negative and positive serum samples to increase the complexity of the sample as well as to facilitate the participation of laboratories into EQA program for dual HBsAg and anti-HCV serological testing.

According to WHO guidelines, the choice of the HBsAg test method is dependent on the capacity of the laboratory but must give accurate results[22]. The RT is now widely used due to its simple, fast, and low cost[2]. However, RTs are less sensitive than ELISA, CLIAs, and ECLs assays[14]. In the previous study, more types of RTs for HBsAg testing were observed than types of RTs for anti-HCV testing, and their efficacy was assessed as acceptable[23]. This was similar to our study (13 types of

Table 6. Rate of accurate HBsAg testing by RTs (%).

RTs	HBC-01	HBC-02	HBC-03	HBC-04	HBC-05	HBC-06	HBC-07	HBC-08	HBC-09	HBC-10	HBC-11	HBC-12
HBsAg Cassette	100	83.3	100	100	100	100	100	100	83.3	100	100	100
Abon	100	92.3	100	100	100	96.1	100	100	96.1	100	100	100
SD Bioline HBsAg	100	69.2	100	100	100	69.2	100	100	69.2	100	100	100
Asan Easy Test HBs	100	100	100	100	100	100	100	100	100	100	100	100
Determine HBsAg	100	100	100	100	100	100	100	100	100	100	100	100
Fastep	100	100	100	100	100	100	100	100	100	100	100	100
Amvi	100	100	100	100	100	100	100	100	100	100	100	100
HBsAg Card	100	100	100	100	100	100	100	100	100	100	100	100
HEPA HBsAg Strip test	100	100	100	100	100	100	100	100	100	100	100	100
Humasis HBsAg	100	100	100	100	100	100	100	100	100	100	100	100
Intec products Inc	100	100	100	100	100	100	100	100	100	100	100	100
Onsite Rapid Test	100	100	100	100	100	100	100	100	100	100	100	100
Atron	100	0	100	100	100	100	100	100	0	100	100	100

Table 7. Rate of accurate anti-HCV testing by RTs (%).

RTs	HBC-01	HBC-02	HBC-03	HBC-04	HBC-05	HBC-06	HBC-07	HBC-08	HBC-09	HBC-10	HBC-11	HBC-12
Abon	96.4	100	92.8	100	92.8	100	92.8	100	100	92.8	96.4	96.4
SD Bioline HCV	100	100	84.6	100	69.2	100	76.9	100	100	76.9	76.9	100
Asan Easy test HCV	100	100	100	100	100	100	100	100	100	100	100	100
HCV Cassette-Fortress	100	100	100	100	100	100	100	100	100	100	100	100
Amvi	100	100	100	100	100	100	100	100	100	100	100	100
Humasis Rapid test	100	100	100	100	100	100	100	100	100	100	100	100
Multi-card type HCV card	100	100	100	100	100	100	100	100	100	100	100	100
Advanced Quality	100	100	50	100	75	100	100	75	100	75	75	75
Fastep	100	100	100	100	100	100	100	100	100	100	100	100
CTK Biotech	100	100	100	100	100	100	100	100	100	100	100	100
Intec products Inc.	100	100	100	100	100	100	100	100	100	100	100	100

RTs for HBsAg testing and 11 types of RTs for anti-HCV assay have been used in 100 laboratories).

Similar to the findings of other studies, EQA results in this study showed the variability in test results between laboratories using different testing methods for HBsAg and anti-HCV detection[15,22]. RTs were most used to screen for HBV and HCV in laboratories. The coincidence rates of RTs for HBsAg and anti-HCV serological assays were 88.24% and 89.86% respectively, while laboratory-based Immunoassays include ELISA, CLIAs, and ECLs assays showed the best performance for both HBsAg and anti-HCV testing. Additionally, some laboratories using the rapid tests reported false-negative results while other participants using another manufacturer's rapid tests had correctly identified HBsAg or anti-HCV. This demonstrated the different sensitivities of various methods and biological products[24-25]. Furthermore, RTs gave the false testing results mainly with weak positive samples. Thus, the most challenging was the failure to detect weak positive samples. Some of the participants reported false-negative or false-positive results for some specimens while others using the same biological products from the same manufacturer correctly identified the same samples. The reason could be the problems from either testing procedure or biological products[26].

Reporting false negatives may be considered more important than reporting false positives. Positive results are often further verified using the confirmatory tests which are costly and time consuming[15]. Therefore, the sensitivity of the tests used was essential. In many countries with endemic HBV infection, the risk of using an RTs that may be less sensitive than CLIAs/ECLs needs to be considered in the context of providing convenience testing[27].

Overall, participation in an EQA program will help laboratories re-examine problems during testing process. Performing EQAs on a regular basis enables to ensure the reliability of testing results.

In this study, an EQA program was deployed to evaluate the different analytical methods for dual HBsAg and anti-HCV detection used by the participating laboratories. We have not evaluated other factors that may affect HBsAg and anti-HCV detection results such as storage conditions of test kits, samples and reagents. Therefore, these EQA programs should be developed over the coming years so that the quality improvement of HBsAg and anti-HCV test results from these laboratories can be compared.

In conclusion, the EQA program for dual HBsAg and anti-HCV serological testing has been beneficial to participants. The differences in test results within and between groups of HBsAg and anti-HCV assay methods indicated a need to improve test conditions at laboratories in Vietnam. HBsAg and anti-HCV detection methods with high sensitivity and specificity should be used as an alternative to rapid tests. In addition, it is necessary to evaluate the storage conditions of samples, reagents as well as analytical equipment.

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Conflicts of interest

The authors declare no conflict of interest, financial, or otherwise in this study.

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Ethics approval

This study were approved by the Ethics Committee of University of Medicine and Pharmacy at Ho Chi Minh City issued together with Decision No. 422/ĐHYD-HĐĐĐ August 27, 2019.

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REFERENCES

1. Kant J, Kratzsch J, Maier M, Liebert UG, Berg T, Wiegand J. HBsAg and anti-HCV screening in elderly hospitalized patients of a German tertiary referral centre. Z Gastroenterol. 2016;54 (3):231-7.
2. WHO. Guidelines on hepatitis B and C testing. 2017.
3. WHO. Vaccine-Preventable Diseases Surveillance Standards. Hepatitis B. 2018.
4. Weinbaum CM, Mast EE, Ward JW. Recommendations for identification and public health management of persons with chronic hepatitis B virus infection. Hepatology. 2009;49(5):S35-44.
5. WHO. Global Hepatitis Report. 2017.
6. Hammerstad SS, Grock SF, Lee HJ, Hasham A, Sundaramand N, Tomer Y. Diabetes and Hepatitis C: A Two-Way Association. Front Endocrinol (Lausanne). 2015;14(6):134.
7. Lin YH, Wang Y, Loua A, Day GJ, Qiu Y, Nadala Jr. ECB et al. Evaluation of a New Hepatitis B Virus Surface Antigen Rapid Test with Improved Sensitivity. J Clin Microbiol. 2008;46(10): 3319-24.
8. Richter MM. Electrochemiluminescence (ECL). Chem Rev. 2004;104(6):3003-36.
9. Wadood M, Usman M. Comparative Analysis of Electrochemiluminescence Assay and Chemiluminescent Microparticle Immunoassay for the Screening of Hepatitis C. Indian J Hematol Blood Transfus. 2019;35(1):131-6.
10. Wu Y, Ling X, Yu G, Zhu H, Hu W, Pu C, et al. The efficacy of HBsAg detection using electro-chemiluminescence immunoassay for blood donor screening in China. Ann Blood. 2019;4: 30-6.
11. Cinquanta L, Fontana DE, Bizzaro N. Chemiluminescent immunoassay technology: what does it change in autoantibody detection?. Auto Immun Highlights. 2017;8(1):9.
12. Liu YP, Yao CY. Rapid and quantitative detection of hepatitis B virus. World J Gastroenterol. 2015;21(42):11954-63.
13. Cai Y, Yan J, Zhu L, Wang H, Lu Y. A Rapid Immunochromatographic Method Based on a Secondary Antibody-Labelled Magnetic Nanoprobe for the Detection of Hepatitis B preS2 Surface Antigen. Biosensors. 2020;10:161-76.
14. Cruz HM, Scalioni LP, Paula VS, Miguel JC, Rodrigues do Ó KM, Milagres FAP, et al. Poor sensitivity of rapid tests for the detection of antibodies to the hepatitis B virus: implications for field studies. Mem Inst Oswaldo Cruz. 2017;112(3):209-13.
15. Escadafal C, Avsic-Zupanc T, Vapalahti O, Niklasson B, Teichmann A, Niedrig M, et al. Second External Quality Assurance Study for the Serological Diagnosis of Hantaviruses in Europe. PLoS Negl Trop Dis. 2012;6(4):e1607.
16. ISO/IEC 17043:2011. Conformity assessment-General requirements for proficiency testing.
17. Castro AR, Kikkert SE, Fears MB, Pope V. Defibrination of blood plasma for use in serological tests for syphilis. Clin Diagn Lab Immunol. 2002;9(6):1376-8.
18. ISO Guide 35:2017. Reference materials-guidance for characterization and assessment of homogeneity and stability.
19. ISO 13528:2015. Statistical methods for use in proficiency testing by interlaboratory comparison.
20. Sollip Kim, Kyung Lee, Hyung-Doo Park. Schemes and performance Evaluation Criteria of Korean Association of External Quality Assessment (KEQAS) for improving laboratory testing. Ann Lab Med. 2020;41:230-9.
21. Alqahtani SA, Colombo M. Viral hepatitis as a risk factor for the development of hepatocellular carcinoma. Hepatoma Res. 2020; 6:58.
22. Bloch EM, Shah A, Kaidarova Z, Laperche S, Lefrere JJ, van Hasselt J, et al. A pilot external quality assurance study of transfusion screening for HIV, HCV and HBsAg in 12 African Countries. Vox Sang. 2014;107:333-42.
23. WHO. How to test-testing strategy HBV. 2017;Annex 4.5:76-85.
24. Tang W, Chen W, Amini A, Boeras D, Falconer J, Kelly H, et al. Diagnostic accuracy of tests to detect Hepatitis C antibody: a meta-analysis and review of the literature. BMC Infect Dis. 2017;17(1):695.
25. Dembele B, Affi-Aboli R, Kabran M, Sevede D, Goha V, Adiko AC, et al. Evaluation of Four Rapid Tests for Detection of Hepatitis B Surface Antigen in Ivory Coast. Journal of Immunology Research. 2020:1-6.
26. WHO, WHO manual for organizing a national external quality assessment programme for health laboratories and other testing sites. 2016. p. 49.
27. WHO. Improving the qualily of and access to HIV, syphilis and hepatitis B and C testing. 2015. p. 19.