Original Contribution

Hepatitis C Virus Screening in Patients With Cancer Receiving Chemotherapy

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Abstract

Purpose: Reactivation of hepatitis C virus (HCV) replication can occur in patients receiving immunosuppressive therapy. We aimed to determine the prevalence and predictors of HCV screening at the onset of chemotherapy among patients with cancer.

Methods: We conducted a retrospective cohort study of adults with cancer who were newly registered at MD Anderson Cancer Center from January 2004 to April 2011 and received chemotherapy. The primary study outcome was HCV antibody (anti-HCV) screening at chemotherapy onset. We calculated screening prevalence and predictors by comparing characteristics of screened and unscreened patients using multivariable logistic regression.

Results: A total of 141,877 new patients with cancer were registered at MD Anderson during the study period, of whom 16,773 (11.8%) received chemotherapy and met inclusion criteria. A total of 2,330 patients (13.9%) were screened for HCV, and 35 (1.5%) tested positive. Only 42% of patients with exposure-type HCV risk factors, such as HIV infection, injection drug use, hemodialysis, or hemophilia, were screened. Birth after 1965, Asian race, HCV risk factors, and anticipated rituximab therapy were significant predictors of HCV screening; black patients and patients with solid tumors were significantly less likely to be screened. The only significant predictor of a positive anti-HCV result was birth during 1945 to 1965.

Conclusion: HCV screening rates were low, even among patients with risk factors, and the groups with the highest rates of screening did not match the groups with the highest rates of a positive test result. Misconceptions may exist about which patients should be screened for HCV infection.

Introduction

Hepatitis C virus (HCV) infection is a major public health problem in the United States, where > 3.2 million persons are chronically infected,[1] and is a major contributor to the rising incidence of primary liver cancer.[2,3] HCV has also been found to be associated with non-Hodgkin lymphoma (NHL).[4-6]

Reactivation of hepatitis B virus (HBV) replication has been reported to occur in 37% (pooled range, 24% to 88%) of HBV-infected persons receiving chemotherapy and may lead to hepatitis, liver failure, and death.[7] HCV reactivation and hepatic flares during immunosuppressive therapy have been reported among patients with hematologic malignancies and those receiving rituximab therapy.[8,9] However, the incidence and outcomes have not been determined, and thus, it is not clear whether all or selected patients with cancer should be screened for HCV infection before chemotherapy.

Previous studies have reported a high proportion of chemotherapy discontinuation among patients with cancer with HCV infection and hepatic flares[9] and a high risk of nonrelapse mortality among those undergoing stem-cell transplantation with HCV infection.[10] Poor outcomes may be attributed to hepatotoxicity in patients with underlying hepatitis C or worsening of hepatitis C because of increased HCV replication.

The Centers for Disease Control and Prevention (CDC) recommends HCV screening for patients with risk factors (risk-based screening) or those who were born during the period from 1945 to 1965 (birth cohort screening).[11] The CDC,[12] along with the American Society of Clinical Oncology,[13] National Comprehensive Cancer Network,[14] and US Food and Drug Administration,[15-17] recommends HBV screening for patients who will be receiving immunosuppressive therapy, including anti-CD20 therapy, to identify those who may benefit from prophylactic antiviral therapy, but similar recommendations have not been made for HCV screening. In this study, we aimed to determine the prevalence and predictors of HCV screening among patients with cancer around the onset of chemotherapy in a single institution.

Methods

Data Sources

We conducted a retrospective cohort study of adults with cancer who were newly registered at MD Anderson Cancer Center (Houston, TX) between January 1, 2004, and April 30, 2011, and received chemotherapy. This study was approved by the MD Anderson Institutional Review Board. We merged patient data from four institutional sources:

Tumor registry. Tumor registry data were used to assess patient demographics, including date of birth, race/ethnicity, and cancer type (hematologic malignancies *v* solid tumors). Primary liver cancer and NHL were separately analyzed because of the potential etiologic relationship with HCV. We removed patients with nonmelanoma skin conditions, because this group (ie, other skin conditions) is not usually treated with systemic

chemotherapy. We divided patients into three cohorts based on date of birth: before January 1, 1945; from January 1, 1945, to December 31, 1965; and after December 31, 1965.

Pharmacy informatics. Pharmacy informatic data were used to determine chemotherapy drugs and dates administered. Chemotherapy was classified according to the American Cancer Society classification.[18] We included intravenous, intramuscular, subcutaneous, intra-arterial, and intraperitoneal routes of chemotherapy but excluded oral chemotherapy, because we could not validate oral medication dispensing dates. We excluded patients in therapeutic clinical trials, because some clinical trials excluded patients with liver disease or hepatitis. Furthermore, screening for HCV was often dictated by protocol and not reflective of investigator decision making.

Patient accounts. Patient account data were used to identify study patients' International Classification of Diseases (ninth edition; ICD-9) codes corresponding to risk factors for HCV infection before the screening period, defined as the period from the time of registration to receipt of the second administration of chemotherapy. Risk factors included HIV, injection drug use, hemodialysis, hemophilia, and other liver conditions.[11] Other liver condition was defined as the presence of an ICD-9 code for alcohol-associated disease, cirrhosis, jaundice, hepatic encephalopathy, hepatomegaly, liver abscess, or nonspecific chronic liver disease. Patients with an ICD-9 code for HCV before the screening period were considered to have a history of HCV infection and were excluded.

Laboratory informatics. Laboratory informatic data were used to determine HCV antibody (anti-HCV) and ALT test dates and results. The HCV risk factor of abnormal liver function[11] was defined as an ALT value $\geq$ 57 IU/L (upper limit of normal defined by our hospital laboratory) before the screening period. We also determined hepatitis B surface antigen (HBsAg) and antibody to hepatitis B core antigen (anti-HBc) test dates and results.

HCV Screening and Infection

The primary outcome of this study was HCV screening among patients receiving chemotherapy. Screening was defined as having an anti-HCV test ordered before or shortly after the start of chemotherapy. MD Anderson has no official HCV screening policy; thus, screening was driven by medical providers as part of a patient's usual medical care.

Statistical Analyses

We calculated the screening prevalence for the study period and compared the characteristics of screened and unscreened patients using logistic regression. Our main outcome variable was screening with an anti-HCV test. Independent variables included birth year cohort (before January 1, 1945; between January 1, 1945 and December 31, 1965; and after December 31, 1965), sex, race/ethnicity, US residency, cancer type (hematologic malignancy *v* solid tumor such as breast, colorectal, lung, or other), and chemotherapy type. Independent variables also included HCV risk factors such as HIV, injection drug use, hemodialysis, hemophilia, other liver conditions, and elevated ALT before the screening period. We created a multivariable logistic regression model to identify predictors of screening using backward elimination to select a final model with a criterion of $P > .05$ for exclusion. Hosmer and Lemeshow goodness-of-fit tests were used to evaluate model fit. We determined the proportion of positive test results among screened patients and compared the rates across patient characteristics using univariable logistic regression. We also examined rates of coinfection with HBV. All analyses were conducted using STATA software (version 12; STATA, College Station, TX).

Results

There were 141,877 new patients with cancer, excluding primary liver cancer and NHL, who were registered at MD Anderson during our study period; of these, 16,773 (11.8%) received chemotherapy that met criteria. We found that HCV screening from the time of registration to the second administration of chemotherapy was performed in 13.9% of the patients in the study population (2,330 of 16,773). Of those, 86% (n = 2,008) underwent HCV screening from 2 months before first administration of chemotherapy until the second chemotherapy.

There were 1,628 patients with NHL, and they had high rates of HCV screening (86%) as well as positive anti-HCV tests (3%). There were 186 patients with primary liver cancer who had high rates of HCV screening (52%) and positive anti-HCV tests (15%).

Characteristics of Patients Who Did and Did Not Undergo HCV Screening

The characteristics of the study population are listed in Table 1. We grouped the ICD-9 codes for HIV, injection drug use, hemodialysis, and hemophilia together as exposure-type risk factors. Patients with HCV risk factors had higher rates of HCV screening than patients without HCV risk factors (Table 1). The rate of HCV screening for patients with at least one type of HCV risk factor—exposure-type risk factor, other liver condition, or elevated ALT level—was 28%, compared with 9% for patients with none of the HCV risk factors ($P \leq .001$; data not shown). HCV screening was more common in men than women (18.7% *v* 10.5%; $P < .001$). Patients born after 1965 had significantly higher rates of HCV screening (25.1%) than those born between 1945 and 1965 (12.2%) or those born before 1945 (11.1%; $P < .001$). HCV screening was most common among patients of other race/ethnicity (19.8%) and least common among black patients (11.5%). Asian and white patients had similar rates of screening: 13.2% and 13.7%, respectively. Nearly 80% of patients with a hematologic malignancy underwent HCV screening, compared with only 7.4% of patients with solid tumors (1,134 of 15,267). The HCV screening rate was significantly higher among patients anticipated to receive rituximab therapy than among those who received chemotherapy regimens that did not contain rituximab (81.0% *v* 11.8%; $P < .001$; Table 1).

Table 1. Characteristics of Study Population by HCV Screening Status

Characteristic	Total Patients (N = 16,773)*		HCV Screening				P
			Yes (n = 2,330)		No (n = 14,443)		
	No.	%	No.	%	No.	%	
Age, years							< .001
Mean	55.53		51.45		56.19		
SD	13.57		15.95		13.02		
Birth year							< .001
Before 1945	5,301	31.6	590	11.1	4,711	88.9	
Between 1945 and 1965	8,811	52.5	1,071	12.2	7,740	87.8	
After 1965†	2,661	15.9	669	25.1	1,992	74.9	
Sex							< .001
Male	6,916	41.2	1,292	18.7	5,624	81.3	
Female†	9,857	58.8	1,038	10.5	8,819	89.5	
Race/ethnicity							< .001
Hispanic	2,103	12.5	336	16.0	1,767	84.0	
Black	1,964	11.7	225	11.5	1,739	88.5	
Asian	517	3.1	68	13.2	449	86.8	
Other	570	3.4	113	19.8	458	80.4	
White†	11,619	69.3	1,589	13.7	10,030	86.3	
US residence							< .001
Yes	16,230	96.8	2,225	13.7	14,005	86.3	
No†	543	3.2	105	19.3	438	80.7	
Exposure-type risk factor‡							< .001
Yes	88	0.5	37	42.1	51	57.9	
No†	16,685	99.5	2,293	13.7	14,392	86.3	
Other liver conditions§							< .001
Yes	979	5.8	270	27.6	709	72.4	
No†	15,794	94.2	2,060	13.0	13,734	87.0	
Abnormal ALT‖							< .001
Elevated (≥ 57 IU/L)	3,697	22.0	1,084	29.3	2,613	70.7	
Unavailable	631	3.8	17	2.7	614	97.3	
Normal (< 57 IU/L)†	12,445	74.2	1,229	9.9	11,216	90.1	
Cancer type							< .001
Breast	4,285	25.5	105	2.5	4,180	97.5	
Colorectal	1,332	7.9	81	6.1	1,251	93.9	
Lung	2,069	12.3	40	1.9	2,029	98.1	
Other solid tumor	7,581	45.2	908	12.0	6,673	88.0	
Hematologic malignancy†	1,506	9.0	1,196	79.4	310	20.6	
Rituximab therapy anticipated							< .001
Yes	505	3.0	409	81.0	96	19.0	
No†	16,268	97.0	1,921	11.8	14,347	88.2	

Abbreviations: HCV, hepatitis C virus; ICD-9, International Classification of Diseases (ninth edition); SD, standard deviation.

* Excludes patients with primary liver cancer or non-Hodgkin lymphoma.

† Reference group.

‡ Exposure-type HCV risk factors included the following conditions and associated ICD-9 codes: HIV: 042, 079.53, V08, 795.71, V08; injection drug use: 305.90, 305.91, 305.92, 305.93; hemodialysis: 39.95; and hemophilia: V83.0, V83.01, V83.02, 286.52.

§ Other liver conditions included the following conditions and associated ICD-9 codes: 571, 571.1, 571.2, 571.3, 571.5, 571.6, 571.8, 571.9, 572, 572.2, 572.8, 782.4, 789.1.

‖ All ALT measures observed from 60 days before beginning of screening period until end of screening period. Normal range of ALT at MD Anderson is 7 to 56 IU/L. Elevated ALT defined as ≥ one ALT value ≥ 57 IU/L.

Predictors of HCV Screening

Multivariable logistic regression (Table 2) showed that birth after 1965 conferred nearly triple the odds of undergoing HCV screening compared with birth during 1945 to 1965. Having one HCV risk factor—exposure-related risk factor, other liver condition, or elevated ALT level—approximately doubled the odds of undergoing screening. The odds increased to four-fold among those with ≥ two HCV risk factors (data not shown). The odds of Asian patients being screened were 1.5-fold that of white patients; however, black patients had lower odds of screening (odds ratio, 0.76; 95% CI, 0.62 to 0.93) than white patients. Patients with solid tumors had lower odds of undergoing HCV screening before chemotherapy (ORs ranging from 0.01 [95% CI, 0.01 to 0.01] to 0.04 [95% CI, 0.03 to 0.04]) compared with patients with hematologic malignancies. Patients who received rituximab had 17× the odds of being screened compared with patients who received chemotherapy regimens that did not contain rituximab.

Factors Associated With Positive Anti-HCV Test Result

The prevalence of positive anti-HCV test results among screened patients was 1.5% (35 of 2,330). The only characteristic significantly associated with a positive anti-HCV test result was birth during 1945 to 1965 (Table 3). Among this cohort, 2.4% of patients tested positive, compared with 0.7% of patients in the cohorts born before or after this period. The prevalence of a positive anti-HCV test result was similar in patients with hematologic and solid malignancies (1.3% *v* 1.8%; $P = .31$) and in patients who received chemotherapy regimens that did or did not contain rituximab (1.5% for both groups).

Among the 35 patients with a positive anti-HCV test result, 31 were tested for HBV; of these, 14 (45%) were positive for anti-HBc, and none were positive for HBsAg. Of the 2,295 patients with a negative anti-HCV test result, 1,869 (81.4%) were tested for HBV; of these, 100 (5.4%) were positive for anti-HBc only, and 16 (1%) were positive for both HBsAg and anti-HBc (Appendix Fig A1, online only).

Table 2. Multivariable Logistic Regression Predicting HCV Screening Status

Characteristic	OR	95% CI	*P*
Birth year			
Before 1945	0.28	0.23 to 0.33	**< .01**
Between January 1, 1945, and December 31, 1965	0.36	0.31 to 0.42	**< .01**
After 1965	1.00	—	Referent
Sex			
Male	1.07	0.95 to 1.21	.27
Female	1.00	—	Referent
Race/ethnicity			
Hispanic	0.94	0.79 to 1.12	.51
Black	0.76	0.62 to 0.93	**.01**
Asian	1.45	1.05 to 2.01	**.02**
Other	1.25	0.91 to 1.70	.17
White	1.00	—	Referent
US residence			
Yes	1.14	0.81 to 1.60	.45
No	1.00	—	Referent
Exposure-type risk factor*			
Yes	2.40	1.29 to 4.46	**.01**
No	1.00	—	Referent
Other liver condition†			
Yes	1.90	1.54 to 2.34	**< .01**
No	1.00	—	Referent
ALT level‡			
Elevated (≥ 57 IU/L)	2.02	1.78 to 2.29	**< .01**
Unavailable	0.73	0.42 to 1.26	.25
Normal (< 57 IU/L)	1.00	—	Referent
Cancer type			
Breast	0.01	0.01 to 0.01	**< .01**
Colorectal	0.02	0.02 to 0.03	**< .01**
Lung	0.01	0.01 to 0.01	**< .01**
Other solid tumor	0.04	0.03 to 0.04	**< .01**
Hematologic malignancy	1.00	—	Referent
Rituximab therapy anticipated			
Yes	17.09	13.00 to 22.46	**< .01**
No	1.00	—	Referent

NOTE. Bold font indicates significance.
Abbreviations: HCV, hepatitis C virus; ICD-9, International Classification of Diseases (ninth edition); OR, odds ratio.
* Exposure-type HCV risk factors included the following conditions and associated ICD-9 codes: HIV: 042, 079.53, V08, 795.71, V08; injection drug use: 305.90, 305.91, 305.92, 305.93; hemodialysis: 39.95; and hemophilia: V83.0, V83.01, V83.02, 286.52.
† Other liver conditions included the following conditions and associated ICD-9 codes: 571, 571.1, 571.2, 571.3, 571.5, 571.6, 571.8, 571.9, 572, 572.2, 572.8, 782.4, 789.1.
‡ All ALT measures observed from 60 days before beginning of screening period until end of screening period. Normal range of ALT at MD Anderson is 7 to 56 IU/L. Elevated ALT defined as ≥ one ALT value ≥ 57 IU/L.

Discussion

In this single-center study, we found that 13.9% patients with cancer underwent HCV screening at the onset of chemotherapy. Although the screening rate was higher among patients with HCV risk factors, < 30% of those with a history of an exposure-related HCV risk factor, other liver condition, or elevated ALT level underwent HCV screening. Earlier recommendations from the CDC called for screening based on HCV risk factors[19]; however, a risk-based strategy can miss many patients with HCV, because patients may not be aware that they are at risk for HCV infection or may be unwilling to disclose risk behaviors, and physicians may not have the time or proper tools to help them identify patients who are at risk. The Institute of Medicine estimated that only 25% of persons in the United States with chronic HCV infection are aware of the diagnosis.[20]

Failure of risk-based screening led the CDC[11] and US Preventive Services Task Force[21] to recommend a one-time screening of the cohort born during the period from 1945 to 1965. This strategy is based on the high prevalence of HCV infection

Table 3. Characteristics of Screened Patients by Anti-HCV Test Results

Characteristic	Total Patients (n = 2,330)		HCV Test Results				P
			Positive (n = 35)		Negative (n = 2,295)		
	No.	%	No.	%	No.	%	
Age, years							.37
Mean	51.5		53.9		51.4		
SD	15.95		10.33		16.02		
Birth year							**< .01**
Before 1945	590	25.3	4	0.7	586	99.3	
Between 1945 and 1965	1,071	46.0	26	2.4	1,045	97.6	
After 1965*	669	28.7	5	0.7	664	99.3	
Sex							.24
Male	1,292	55.5	23	1.8	1,269	98.2	
Female*	1,038	44.5	12	1.2	1,026	98.8	
Race/ethnicity							.21
Hispanic	336	14.4	1	0.3	335	99.7	
Black	225	9.7	5	2.2	220	97.8	
Asian	68	2.9	1	1.5	67	98.5	
Other	112	4.8	2	1.8	110	98.2	
White*	1,589	68.2	26	1.6	1,563	98.4	
US residence							.40
Yes	2,225	95.5	35	1.6	2,190	98.4	
No*	105	4.5	0	0.0	105	100.0	
Exposure-type risk factor†							.43
Yes	37	1.6	1	2.7	36	97.3	
No*	2,293	98.4	34	1.5	2,259	98.5	
Other liver condition‡							.59
Yes	270	11.6	5	1.9	265	98.1	
No*	2,060	88.4	30	1.5	2,030	98.5	
ALT level§							.46
Elevated (≥ 57 IU/L)	1,084	46.5	13	1.2	1,071	98.8	
Unavailable	17	0.7	0	0.0	17	100.0	
Normal (< 57 IU/L)	1,229	52.7	22	1.8	1,207	98.2	
Cancer type							.32
Breast	105	4.5	3	2.9	102	97.1	
Colorectal	81	3.5	2	2.5	79	97.5	
Lung	40	1.7	1	2.5	39	97.5	
Other solid tumor	908	39.0	14	1.5	894	98.5	
Hematologic malignancy*	1,196	51.3	15	1.3	1,181	98.7	
Rituximab therapy anticipated							> .99
Yes	409	17.6	6	1.5	403	98.5	
No*	1,921	82.4	29	1.5	1,892	98.5	

NOTE. Bold font indicates significance.
Abbreviations: anti-HCV, HCV antibody; HCV, hepatitis C virus; ICD-9, International Classification of Diseases (ninth edition); SD, standard deviation.
* Reference group.
† Exposure-type HCV risk factors included the following conditions and associated ICD-9 codes: HIV: 042, 079.53, V08, 795.71, V08; injection drug use: 305.90, 305.91, 305.92, 305.93; hemodialysis: 39.95; and hemophilia: V83.0, V83.01, V83.02, 286.52.
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§ All ALT measures observed from 60 days before beginning of screening period until end of screening period. Normal range of ALT at MD Anderson is 7 to 56 IU/L. Elevated ALT defined as ≥ one ALT value ≥ 57 IU/L.

in this cohort (3.25%), 5× higher than that among adults born in other years,[11] and this strategy of birth cohort screening was found to be cost effective when compared with risk-based screening.[22] Although the CDC and US Preventive Services Task Force recommendations[11,21] were published only recently, in August 2012 and June 2013, respectively, we were surprised that patients in our study born between 1945 and 1965 had lower odds of being screened for HCV than those born after 1965. A previous analysis of 49 patients with hematologic malignancies with a positive anti-HCV test showed that 67% were born between 1945 and 1965.[23] Paradoxically, black patients had lower odds of being screened in our study, even though population-based studies in the United States have shown the prevalence of HCV infection to be higher among black patients (4.51%) than white patients (1.95%).[24] Our results confirm population-based studies showing a significantly higher prevalence of positive HCV test results among patients born from 1945 to 1965 than among those born after 1965 and in black patients compared with white patients. Overall, these findings indicate the need for education of oncologists regarding which patient groups should be targeted for HCV screening.

Although birth cohort–based screening may be more cost effective than risk-based or universal screening in the general population, future work is needed to determine the best screening strategy for patients undergoing immunosuppressive therapy. In addition to cost of screening, morbidity and costs associated with missed screening opportunities and subsequent liver-related complications resulting from HCV reactivation should be explored. Until clear data on the incidence, morbidity, and mortality associated with HCV reactivation is available, we recommend risk-based and birth cohort–based screening as well as education for oncology medical providers.

We found that HCV screening rates were high among selected patient groups—patients with hematologic malignancies and anticipated receipt of rituximab therapy—and this may have reflected practice patterns of medical providers who translated their knowledge about the high incidence of HBV reactivation in these selected groups.[25,26] It is unknown whether all or selected patients with cancer should be screened for HCV infection before chemotherapy. Data on incidence and outcomes of HCV reactivation in patients receiving chemotherapy are limited. Some, but not all, studies have found a higher incidence of ALT elevation during chemotherapy in patients with HCV versus those with no HCV infection. In a prospective study of 274 patients with a hematologic malignancy receiving chemotherapy, there was no significant difference in the degree of ALT elevation (mild, moderate, or severe) during chemotherapy between patients with a positive anti-HCV test result (n = 33) and those with a negative anti-HCV test result (n = 241).[27] Conversely, a retrospective cohort study of 308 patients with chronic HCV infection and either a solid tumor or hematologic malignancy found that 11% of patients had a three-fold increase in ALT level during chemotherapy as compared with the baseline level. However, documentation that the increase in ALT was associated with increase in HCV RNA was available in few patients, and comparison of the frequency of ALT increase with patients without HCV infection was not available.[9] One retrospective case-control study found that the rate of nonrelapsed mortality 1 year after allogeneic stem-cell transplantation was 43% among 31 patients with HCV, compared with 24% among 31 matched controls ($P < .01$).[10]

Our study had inherent limitations resulting from the retrospective nature of the study design. We were not able to fully evaluate each patient's HCV risk, but rather, we used surrogate measures from ICD-9 diagnostic billing codes and ALT laboratory values. Similarly, because screening and diagnostic laboratory tests were ordered by clinicians if deemed necessary, we did not have systematic HCV RNA for all patients with a positive anti-HCV test result to confirm whether patients had chronic HCV infection. Approximately 80% of patients with a positive anti-HCV test result in other settings have chronic infection and detectable HCV RNA.[28] Finally, our retrospective cohort did not include patients who were enrolled onto therapeutic trials at our academic cancer center, received only oral chemotherapeutic agents, or underwent HCV testing before referral to our center. It is unknown whether these inherent limitations introduced any bias with regard to HCV screening–related issues.

Our study is an important early step toward understanding HCV screening patterns before immunosuppressive therapy to treat malignancy and elucidating whether screening is appropriate or necessary to prevent liver-related complications secondary to the underlying liver disease or to HCV reactivation. Future prospective, population-based studies are needed to determine the incidence, risk factors, and outcomes of these complications in patients with cancer and HCV infection receiving immunosuppressive therapies and the impact of HCV infection on cancer treatment and response. These data are necessary to determine whether HCV screening is warranted in patients with cancer before chemotherapy and whether specific management strategies are needed for those who are infected. With the rapid development of direct-acting antiviral agents and the potential for interferon-free and ribavirin-free regimens[29-31] for treatment of most HCV infection in the next 1 to 3 years, it will become possible to cure HCV infection with short (≤ 12 weeks) courses of oral antiviral agents before or during chemotherapy. If the data show that HCV infection significantly worsens outcomes of patients receiving chemotherapy, the case for HCV screening will be yet more compelling.

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Appendix

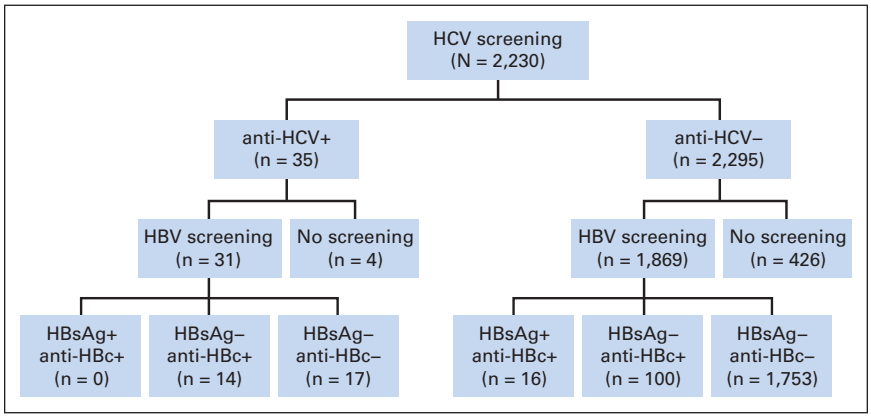

Figure A1. Results of hepatitis C virus (HCV) and hepatitis B virus (HBV) screening tests. HBsAg, hepatitis B surface antigen; anti-HBc, antibody to hepatitis B core antigen.