Screening for Hereditary Hemochromatosis: A Clinical Practice Guideline from the American College of Physicians

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Hereditary hemochromatosis is a genetic disorder of iron metabolism. Diagnosis of hereditary hemochromatosis is usually based on a combination of various genetic or phenotypic criteria. Decisions regarding screening are difficult because of the variable penetrance of mutations of the HFE gene and the absence of any definitive trials addressing the benefits and risks of therapeutic phlebotomy in asymptomatic patients or those with only laboratory abnormalities. The purpose of this guideline is to increase physician awareness of hereditary hemochromatosis, particularly the variable penetrance of genetic mutations; aid in case finding; and explain the role of genetic testing. This guideline provides recommendations based on a review of evidence in the accompanying background paper by Schmitt and colleagues. The target audience for this guideline is internists and other primary care physicians. The target patient population is all persons who have a probability or susceptibility of developing hereditary hemochromatosis, including the relatives of individuals who already have the disease.

Recommendations

Recommendation 1: There is insufficient evidence to recommend for or against screening for hereditary hemochromatosis in the general population.

There is currently insufficient evidence to determine whether the benefits of screening the general population outweigh the risks. The C282Y mutation is prevalent in certain populations, particularly white men, and treatment is not costly nor is it associated with any significant harm. Although patients homozygous for C282Y are more likely to have elevated serum ferritin level and transferrin saturation percentage, there is currently no way of predicting which patients will progress to overt disease. For clinicians who choose to screen, 1-time phenotypic screening of asymptomatic non-Hispanic white men with serum ferritin level and transferrin saturation would have the highest yield (1).

Recommendation 2: In case-finding for hereditary hemochromatosis, serum ferritin and transferrin saturation tests should be performed.

There is no information available on risk-stratifying in patients with an associated condition or conditions such as type 2 diabetes, cardiac arrhythmias and cardiomyopathies, liver failure, hepatocellular carcinoma, arthritis, hypogonadism, or changes in skin pigmentation. The initial symptoms associated with iron overload might be nonspecific, and the decision to perform tests should be based on clinical judgment regarding what may cause such protein manifestations. If testing is performed for these patients, the cutoff values for serum ferritin level of more than 200 μg/L in women or more than 300 μg/L in men and transferrin saturation greater than 55% may be used as criteria for case-finding; however, there is no general agreement about diagnostic criteria. Case-finding may also be considered if there is a family history of hereditary hemochromatosis for an individual, as the risk for developing the disease may be higher than that of the general population.

Recommendation 3: Physicians should discuss the risks, benefits, and limitations of genetic testing in patients with a positive family history of hereditary hemochromatosis or those with elevated serum ferritin level or transferrin saturation.

Before genetic testing, individuals should be made aware of the benefits and risks of genetic testing. This should include discussing available treatment and its efficacy; costs involved (2); and social issues, such as impact of disease labeling, insurability and psychological well-being, and the possibility of as-yet-unknown genotypes associated with hereditary hemochromatosis.

Recommendation 4: Further research is needed to establish better diagnostic, therapeutic, and prognostic criteria for hereditary hemochromatosis.

The lack of information on the natural history of the disease makes it difficult to manage patients with hered-
Hereditary hemochromatosis is a genetic disorder of iron metabolism and is characterized by tissue injury resulting from an abnormal accumulation of iron in various organs. This disease is usually a consequence of an increased absorption of iron from the gastrointestinal tract, which results in increased iron deposition in tissue, particularly in the liver, heart, and pancreas. If left untreated, it can lead to organ damage, such as cirrhosis, as well as hepatocellular cancer. However, early diagnosis of hereditary hemochromatosis is difficult because of variability in the case definition and diagnostic standard used.

Diagnosis of hereditary hemochromatosis is usually based on a combination of various genetic or phenotypic criteria. Genetically, it can be based on direct DNA testing for the 2 HFE gene mutations (C282Y and H63D) associated with hereditary hemochromatosis. The mutation of C282Y in the HFE gene on chromosome 6 is present in almost 90% of those affected. Most patients are homozygous, and mutation transmission is autosomal recessive. The H63D mutation may be associated with hereditary hemochromatosis, but the actual clinical effects of this mutation are uncertain (3). Although in a small proportion, compound heterozygotes (C282Y/H63D) can develop iron overload. Phenotypic markers of hereditary hemochromatosis may be used to identify the disease. Percentage of transferrin saturation and serum ferritin level have been used to confirm the diagnosis of hereditary hemochromatosis. Transferrin saturation determines how much iron is bound to the protein that carries iron in the blood. Serum ferritin level is elevated in patients with hereditary hemochromatosis and correlates with liver iron and development of cirrhosis. Liver biopsy to measure hepatic iron concentration by staining is considered the gold standard to test for hereditary hemochromatosis. However, with the advent of genetic testing, liver biopsy is not widely used to confirm the diagnosis. There is a consensus on the various diagnostic tests that could be used to diagnose hereditary hemochromatosis. However, the threshold levels that should be used to define the disease remain controversial. On the basis of the review of the background paper by Schmitt and colleagues (4), also in this issue, and considering that lower cutoffs are more sensitive and less specific, serum ferritin level greater than 200 μg/mL and transferrin saturation greater than 55% suggest an increased risk for hereditary hemochromatosis and the need for further investigation (5).

Hereditary hemochromatosis is the most common recessive genetic trait in white persons. However, estimating the prevalence of this disease is difficult. Genetic testing of populations originating in northern Europe showed that approximately 0.5% are homozygous for the C282Y mutation (6). The Hemochromatosis and Iron Overload Screening (HEIRS) Study showed that the prevalence of C282Y homozygotes was highest among non-Hispanic white persons (0.44% [95% CI, 0.42% to 0.47%]) (1). Phenotypic screening of the population in the United States demonstrated that 1% to 6% have elevated transferrin saturation and 11% to 22% of this group have an increased serum ferritin level (7). Hereditary hemochromatosis has been estimated to be present in 3 to 5 people per 1000 in the general population (8). Decisions regarding screening are difficult because of the variable penetrance of mutations of the HFE gene and the absence of any definitive trials addressing the benefits and risks of therapeutic phlebotomy in asymptomatic patients or those with only laboratory abnormalities.

The purpose of this guideline is to increase physician awareness of hereditary hemochromatosis, particularly the variable penetrance of genetic mutations; aid in case finding; and explain the role of genetic testing. The target audience for this guideline is internists and other primary care physicians. The target patient population is all persons who have a probability or susceptibility of developing hereditary hemochromatosis, including the relatives of individuals who already have the disease. This guideline is based on the systematic review of the evidence in the background paper (4).

This guideline attempts to answer the following questions: 1) What is the prevalence of hereditary hemochromatosis in the primary care setting? 2) In asymptomatic patients with hereditary hemochromatosis, what is the risk for end-organ damage or death? 3) How diagnostically useful are transferrin saturation and serum ferritin in identifying patients with hereditary hemochromatosis in the primary care setting? 4) Is phlebotomy efficacious in reducing morbidity or fatal complications in asymptomatic patients with hereditary hemochromatosis? 5) Do the benefits of screening primary care patients for hereditary hemochromatosis outweigh the risks?

PREVALENCE

Estimates of the prevalence of hereditary hemochromatosis in the general population vary widely because no set criteria define what constitutes hereditary hemochromatosis (5, 9, 10). Some argue that genotyping should be used as the gold standard and that the sensitivity and specificity of phenotyping should be calculated and compared with those of genotyping. Others support the use of persistently elevated serum ferritin level and percentage of transferrin saturation as the case definition of hereditary hemochromatosis. Studies of differing populations, using strict criteria recommended in the HEIRS Study (11), have esti-
hereditary hemochromatosis (or resulting disease or death) remains asymptomatic. Even death. However, most persons with the mutated gene manifest signs or symptoms related to the disease. Although clinical examination for treatment of the disease. Clinical outcomes that can be associated with hereditary hemochromatosis are cirrhosis, hepatocellular carcinoma, type 2 diabetes, congestive heart failure, arthritis, hypogonadism in males, and even death. However, most persons with the mutated gene remain asymptomatic.

The literature that discusses the relationship between biochemical primary iron overload (elevated serum ferritin level and transferrin saturation) and the development of hereditary hemochromatosis (or resulting disease or death) does not consistently identify increasing transferrin saturation and serum ferritin level over time in hereditary hemochromatosis (12–14). The studies that discuss the correlation between iron excess and cirrhosis indicate that a ferritin level less than 1000 μg/L was not associated with cirrhosis on liver biopsy (15–17). The National Health and Nutrition Examination Survey I (NHANES I) database (18) was used to analyze the association between transferrin saturation and all-cause mortality. The results showed that all-cause mortality significantly increased for persons whose transferrin saturation was above 55% compared with persons who had lower transferrin saturation (hazard ratio, 1.60 [CI, 1.17 to 2.21]).

**Table. Prevalence of Hereditary Hemochromatosis in Primary Care Settings**

<table>
<thead>
<tr>
<th>Study, Year of Reference</th>
<th>Setting</th>
<th>Sampling Approach</th>
<th>Sample Characteristics</th>
<th>Definitive Hereditary Hemochromatosis†</th>
<th>Reported Hereditary Hemochromatosis</th>
<th>Ceiling Estimate of Hereditary Hemochromatosis‡</th>
<th>Cirrhosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phatak et al., 1998 (5)</td>
<td>22 primary care practices in Rochester, New York</td>
<td>All adults ≥ 18 y of age</td>
<td>16 031 patients (19%–94% of eligible patients across practices); median age, 54 y in white patients and 43–45 y in nonwhite patients; 42% men</td>
<td>Overall: 29 of 16 031 (0.18%); white men: 20 of 5356 (0.37%); nonwhite men: 0 of 1349 (0%); white women: 9 of 7099 (0.13%); nonwhite women: 0 of 2227 (0%)</td>
<td>Overall: 47 of 16 031 (0.29%); white men: 28 of 5356 (0.52%); nonwhite men: 1 of 1349 (0.07%); white women: 18 of 7099 (0.25%); nonwhite women: 0 of 2227 (0%)</td>
<td>Overall: 59 of 16 031 (0.37%); white men: 41 of 5356 (0.77%); nonwhite men: 0 of 1349 (0%); white women: 18 of 7099 (0.25%); nonwhite women: 0 of 2227 (0%)</td>
<td>Overall: 3 of 16 031 (0.019%)</td>
</tr>
<tr>
<td>Baer et al., 1995 (9)</td>
<td>Oakland Kaiser Permanente</td>
<td>Consecutive men &gt;age 30 y</td>
<td>3977 patients; median age, 54 y</td>
<td>Overall: 12 of 3977 (0.3%); white men: 9 of 1974 (0.46%); mean age, 54.4 y; black men: 2 of 1148 (0.17%); other: 1 of 725 (0.14%)</td>
<td>Overall: 8 of 3977 (0.2%); white men: 7 of 1974 (0.35%); black men: 0 of 1148 (0%); other: 1 of 725 (0.14%)</td>
<td>Overall: 15 of 3977 (0.38%); white men: 11 of 1974 (0.56%); black men: 3 of 1148 (0.26%); other: 1 of 725 (0.14%)</td>
<td>Overall: 0 of 3977 (0%)</td>
</tr>
<tr>
<td>Niederau et al., 1998 (10)</td>
<td>9 primary care practices in the former West Germany</td>
<td>Every third primary care patient</td>
<td>3027 patients (95% eligible; age NA; 40.6% men)</td>
<td>Overall: 18 of 3027 (0.59%); mean age, 54.5 y; men: 13 (0.05%); mean age, 55 y; women: 5 (0.28%); mean age, 53 y</td>
<td>Overall: 53.4 of 3027 (1.8%); men: 19.5 (1.6%); women: 33.9 (1.9%)</td>
<td>Overall: 24 of 3027 (0.79%); not designated by sex</td>
<td>Overall: 4 of 3027 (0.13%); 1 with hepatocellular cancer</td>
</tr>
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</table>

*NA = not available; ND = not determined.
† Definitive hereditary hemochromatosis requires liver biopsy with hepatic iron concentration > 30 μmol/g dry weight or >2000 mg iron stores by phlebotomy.
‡ Determined by application of hereditary hemochromatosis criteria to those with repeated elevations of transferrin saturation and serum ferritin level who did not undergo liver biopsy or phlebotomy.
of 9 studies identified compared the screening tests for iron overload (transferrin saturation and serum ferritin) with the gold standard.

In a study by Phatak and associates (5) in the primary care setting, 311 of 747 patients had an elevated transferrin saturation greater than 45%. Liver biopsy was offered to 35 patients with transferrin saturation greater than 55% and a serum ferritin level greater than 200 μg/L. Hereditary hemochromatosis was diagnosed in 18 of 21 patients who underwent biopsy. Another study (10) included 3027 outpatients and used transferrin saturation values greater than 50% in men and greater than 60% in women, and serum ferritin values of 250 μg/L. The results showed that 235 of 3027 patients had an elevated serum ferritin level, 139 had elevated transferrin saturation, and 44 had both elevated serum ferritin level and elevated transferrin saturation. Hereditary hemochromatosis was diagnosed in 18 of 23 persons who were further evaluated. Baer and coworkers (9) showed that the diagnostic cutoff levels of 500 μg/L for serum ferritin and 62% for transferrin saturation identified a subgroup of patients in which all individuals had hereditary hemochromatosis.

**Efficacy of Phlebotomy**

The efficacy of phlebotomy for improving survival in patients without cirrhosis is based on the results of large uncontrolled case series and is accepted as the standard of care by a majority of hepatologists (19). None of the studies (19, 20) meets a standard of evidence that clearly establishes the efficacy of therapeutic phlebotomy; however, the studies do support the existing model of disease and suggest a benefit. In the presence of current opinion and lack of significant side effects, the prospect of having randomized, controlled trials is low and perhaps unethical.

**Benefits versus Risks of Screening**

No available data can definitively determine whether phlebotomy will delay or deter the development of cirrhosis over the lifetime of an asymptomatic patient. The value of detecting individuals who are homozygous for the mutation but do not develop iron overload is controversial. The psychological and social implications of identifying such individuals must be considered. Issues such as the impact on insurability and the anxiety of being labeled with a hereditary illness need to be considered when comparing the benefits and risks of screening (21). The recently published HEIRS Study indicates that C282Y mutation does not explain high transferrin saturation and serum ferritin level in nonwhite persons. The number of newly identified genes participating in the regulation of iron homeostasis has increased at a remarkable pace. Therefore, consideration of false reassurance in the setting of a negative genetic test result is not unreasonable.

**Summary**

The prevalence of hereditary hemochromatosis varies in the general population, depending on race, sex, age, and case definition of the disease. It is more commonly found in white men of northern European descent and older than 40 years of age. Some evidence shows that patients with a serum ferritin level greater than 1000 μg/L are more likely to develop cirrhosis.

The case definition has an impact on measuring the sensitivity and specificity of the tests. However, serum ferritin level and transferrin saturation have been useful in identifying patients who are prone to or already have hereditary hemochromatosis. The available literature supports the benefits of adequate phlebotomy. However, this benefit has not been proven for all end-organ damage, only for cirrhosis. Finally, there is insufficient evidence to support genetic testing because HFE mutations may not progress to overt disease.

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**Note:** Clinical practice guidelines are “guides” only and may not apply to all patients and all clinical situations. Thus, they are not intended to override clinicians’ judgment. All ACP clinical practice guidelines are considered automatically withdrawn or invalid 5 years after publication, or once an update has been issued.

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**References**

6. Olynuk JK, Cullen DJ, Aquila S, Rossi E, Sumberville L, Powell LW.


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