SCREENING AND TREATING CHILDREN WITH RISK FACTORS THAT PROMOTE CORONARY HEART DISEASE

By

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To the Faculty of Washington State University:

The members of the Committee appointed to examine the clinical project of Jolie E. Ewart find it satisfactory and recommend that it be accepted.

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Mary Kay Tucker
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FOR CORONARY HEART DISEASE

Abstract

by Jolie E. Ewart, M.N.
Washington State University
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The process of atherosclerosis can begin in children and therefore, childhood should be the time to start primary prevention. Selectively screening children for hypercholesterolemia, based on family history and other risk factors, is currently recommended. Studies were analyzed to investigate the current screening recommendations and treatment options for children at risk. A brief review of coronary heart disease (CHD) and risk factors is presented. Family history is not always a reliable tool for screening children for CHD. Diet restrictions are the first line of treatment for high cholesterol. Physical activity and lifestyle change are helpful in reducing blood cholesterol. Medication should be used in high risk children when other interventions fail.
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2. Classification, Education and Follow-up Based on LDL Cholesterol
Cardiovascular disease is the number one cause of death in America. Autopsies of men and women ages 15-34 who have died by accident, homicide or suicide have revealed the early formation of coronary artery plaques (McGill, 1997). Fatty streaks are thought to be precursors to the development of atherosclerosis. The Bogalusa study found that extensive aortic fatty streaks were present in young children and furthermore, in male subjects, the amount of fatty deposition correlated with the child’s serum lipids, triglycerides, and blood pressure (Berenson et al., 1992). Since the process of atherosclerosis can begin in childhood, it is recommended that practitioners begin screening and primary prevention early to decrease the early onset of coronary heart disease (CHD). The purpose of this manuscript is to discuss the pathophysiology of plaque formation including the proposed role of cholesterol, hypertension, and other risk factors in children and adolescents. Guidelines for screening and treating children for atherosclerotic risk factors will be suggested based on current research.

Review of Coronary Heart Disease

The primary role of the coronary arteries is to provide for the metabolic needs of the heart by delivering oxygen and fuel for myocardial work. Coronary atherosclerosis or CHD, causes a disruption in the delivery system by reducing the lumen of the blood vessels. The process of plaque formation usually takes many years to occur. Hypertension, infection, or trauma can cause the initial endothelial injury to the coronary vessels (Baxendale, 1992). When this injury occurs, the body responds by triggering repair processes. These repair processes can cause the vasculature to thicken at the inner aspect of the arterial wall(s). According to Baxendale (1992), “if the injury is transient,
the lesion will regress and not evolve into a plaque. Chronic injury, however, promotes
the formation of a plaque via reinforcement of the repair cascade” (p. 145).

The repair cascade begins when monocytes and platelets aggregate at the site of injury
and release growth factors which stimulate DNA synthesis and proliferation of smooth
muscle cells and fibrous tissue (Baxendale, 1992). The release of other toxic substances
known as free radicals, along with the release of growth factors, contributes to the
development of plaques and the deposition of lipids (Baxendale, 1992). Low density
lipoproteins (LDL-Cs) and very low density lipoproteins (VLDL-Cs) are the major
cholesterol carrying lipoproteins in plasma (Rotter et al., 1996). They are associated with
increased plaque formation when elevated. As the inner walls of the arteries become
congested with plaques, the blood cannot pass through smoothly. With greater than
75% occlusion, the person may begin to experience symptoms of atherosclerosis, such as
angina. A rough or fractured plaque may stimulate thrombus formation, resulting in
complete occlusion and myocardial infarction. High density lipoproteins (HDL-Cs) on
the other hand, are thought to be protective against CHD. HDL-C primarily functions to
transport cholesterol from the extrahepatic organs and the arterial walls to the liver for
excretion (Dietsch, 1997).

Risk Factors

Many risk factors (see Table 1) thought to increase the likelihood of developing CHD
have been identified. Although family history of CHD is an important indicator of risk,
studies have found that increased total cholesterol and LDL-C, along with low levels of
HDL-C, maybe better indicators of increased risk for CHD (Filer, Lauer & Luepker,
High blood pressure, obesity, smoking, high fat and high cholesterol diet, and inactivity are all modifiable risk factors associated with increased risk for CHD.

**Hypercholesterolemia**

The Bogalusa Heart Study, a longitudinal, descriptive study of biracial children from birth through the age of 31 that began in 1973, found significant relationships between total cholesterol and LDL cholesterol level and the extent of aortic fatty streaks in children (Filer, Lauer & Luepker, 1994). Diets that are high in cholesterol and saturated fatty acids are thought to be the major contributors to increased blood cholesterol in children (Filer et al., 1994).

Some children have increased cholesterol that is resistant to diet and activity changes, as the result of a dominant genetic predisposition. Children with familial hypercholesterolemia, for example, have LDL cholesterol levels that are elevated two to three-fold, and in rare cases, five to six-fold (Kwiterovich, 1995). This is a rare condition and not the topic of this paper.

An expert panel has recommended that target total cholesterol should be below 170 mg/dL and LDL-C should be below 110 mg/dL in children. The acceptable, borderline and high lipid values for children and adolescents are shown in Table 2 (National Cholesterol Education Program (NCEP), 1991).

**High Blood Pressure**

Hypertension increases stress on the arterial walls, compromising permeability and increasing the deposition of lipids (Baxendale, 1992). High blood pressure in children is defined as systolic blood pressure consistently above the 95th percentile. High blood pressure can be caused by renal, vascular, endocrine, or neurologic disorders, certain
medications, or evolve from other etiologies (Kwiterovich, 1995, p. 317). In children older than ten years, the cause is often unknown and referred to as primary or essential hypertension. High blood pressure frequently occurs in offspring of parents with high blood pressure (Purath, 1995). Age related values for high blood pressure are outlined in Table 3.

**Obesity**

Obesity is a growing problem among children and adolescents. Since the 1960s, the proportion of six through eleven year olds with obesity has increased 48% and the proportion of twelve through seventeen-year olds with obesity has increased 42% (Troiano, Flegal, Kuczmarski, Campbell & Johnson, 1995). There are correlations for obesity with elevated cholesterol and elevated blood pressure. This makes obesity a strong contributing factor for CHD (Taubert, Moller & Washington, 1996). Obesity is often associated with inactivity and a high fat diet which are additional CHD risk factors. According to Nicklas (1995), the average energy intake of ten-year old children between the years 1973 and 1988 has remained the same. Individuals in the latter years of this 20-year study however, were on average, three pounds heavier. More than 75% of children consume more total fat, saturated fat and cholesterol than the recommended amount. The reported change in weight may be due to a decrease in activity and an increase in the number of youths with a sedentary lifestyle. Kolin and Jacobson (1996) state that 36% of total calories come from fat in the typical diet of children in the United States. The recommendation by the Expert Panel on Blood Cholesterol Levels from the NCEP (1991) is that total fat be less than 30% of total calories.
Hayman, Meininger, Coates, and Fallagher (1995) studied twins during the school-aged years and at adolescence to examine non-genetic influences on obesity, lipid profile and blood pressure. Obesity was assessed by measuring body mass index (BMI) and skinfold thickness. Children with a skinfold thickness ≥ 75th percentile were considered obese. The change in obesity measurements over time between the twins was calculated. The authors found that from the school age years to adolescence, environmental influences were substantial with a mean intrapair weight difference of 1.11 kg. The results suggested that influences other than genetics, had an effect on obesity and contributed to the variability in HDL cholesterol and the triglyceride levels. Unfortunately, the authors did not identify the other influences or control for them. However, the authors suggested that overweight or obese children should be monitored closely for elevated cholesterol and elevated blood pressure throughout childhood and adolescence.

**Smoking**

Tobacco is a major risk factor for CHD and stroke along with lung disease and cancer. Despite the known risk involved with smoking, substantial numbers of children and adolescents continue to begin smoking at early ages. Between 80 to 90% of smokers begin before the age of 21 (Torabi & Nakornkhet, 1996). Torabi and Nakornkhet (1996) also state that “tobacco is the single most preventable cause of death in the United States and is responsible for one in five deaths” (p. S-40). Tobacco reportedly is the only legal substance that if used as intended will cause addiction, disease and early death (Taubert, Moller & Washington, 1996). Although the total cholesterol of youths that smoke has been found to be lower than non-smokers, the beneficial HDL cholesterol is also lower
and thus creates the lower total cholesterol value (Bermingham, Jones, Steinbeck & Brock, 1995).

Guidelines for Screening

According to the Expert Panel on Blood Cholesterol Levels in Children and Adolescents of the NCEP (1991) selective screening rather than universal screening for elevated cholesterol levels should be done. The panel recommends that children with a family history of CHD have a complete lipid profile evaluated. However, the panel does not state at what age to begin screening. A significant family history includes parents and grandparents that have had either an arteriogram that indicated atherosclerosis or who suffered a documented myocardial infarction, angina pectoris, peripheral vascular disease, cerebrovascular disease or sudden cardiac death before age 55 (p. 5). The panel also recommends that children of a parent with high blood cholesterol (>240 mg/dl) have their total cholesterol measured. Primary care providers may choose to screen individuals with other risk factors including high fat diet, high blood pressure, obesity and/or smoking. Screening should be repeated based on the initial results within one to five years (p. 8). An example of an appropriate screening protocol for children with increased cholesterol is included in Figure 1 (NCEP, 1991). This protocol determines the necessity of general cholesterol screening versus the more extensive lipoprotein analysis. Figure 2 (NCEP, 1991), provides further guidelines for follow-up based on the LDL cholesterol.

Ali, Bandh and Hasson (1995) found that children of parents with CHD had significantly higher levels of cholesterol, triglycerides and LDL cholesterol by 31.8%, 6.8% and 36% respectively, compared to children with no family history of CHD.
Children with a family history of CHD should be screened for both lipoproteins and triglycerides. “Children of parents with combination of CHD and hyperlipidemia are at increased risk of developing early atherosclerosis and need lipid estimation screening” (p. 289).

Gagliano, Emans and Woods (1993) suggest that adolescents over age 11 be screened rather than children, to avoid testing during the years of significant cholesterol level fluctuations and to do so when a change in diet would have less impact on the growing child. There are multiple reasons for the controversy regarding who should be screened and when. The advantages and disadvantages of universal screening are discussed below.

**Advantages of Universal Screening**

Gagliano et al. (1993) concluded from their study that individualized screening is not adequate and that family history is not always predictive of hypercholesterolemia. Forty eight percent of adolescents with increased cholesterol would have been missed if screening was based on a family history of CHD or cholesterol levels over 240 mg/dL. Gagliano et al. (1993) also found that many parents were unaware of their own or their parents’ cholesterol levels. Most of the parents were in their early 40s and had not yet experienced any symptoms of CHD. This is not to say that they did not have hypercholesterolemia, but that they had not yet been diagnosed. Often, there was a significant difference in adolescents’ report of positive family history of either elevated lipids or early myocardial infarction, when compared with the history given by the parent, with only a 17% positive-predictive value. A positive family history given by either the parent or adolescent had a 19% positive-predictative value.
Purath, Lansinger and Ragheb (1995) screened for family diseases, and cholesterol levels in school aged children (N = 357). There was no significant relationship between family history and elevated cholesterol. "If the recommended guidelines of screening only those children with a positive family history of CHD had been followed, 66.2% of children with cholesterol levels greater than 170 mg/dL would not have been identified" (p. 193).

The advantage of universal screening is that the likelihood of missing a child with elevated cholesterol is decreased. When children are identified for risk early, primary prevention can be instituted. Risk factors can potentially be lowered, if children learn healthy habits at a young age. By reducing fat in their diet, avoiding obesity, inactivity and smoking, habits are established that may decrease the risk for developing CHD in adulthood. Ideally, these health habits should be taught to all children regardless of cholesterol level.

Disadvantages of Universal Screening

Some disadvantages of universal screening include the fear that some children may inappropriately be labeled as having a disease that does not later develop. The potential for overuse of cholesterol lowering drugs in childhood and adolescence is another concern, especially with children who are having transitional fluctuations. Furthermore, the expense of screening everyone, cannot be overlooked in this era of health care cost reduction. The cost of screening for total cholesterol is approximately $10.00. The complete lipid panel which includes total cholesterol, triglycerides, high and low density lipids and their ratio is on average $30.00.
Treatment

Generally children and adolescents with hypercholesterolemia are treated initially with a modified diet. NCEP (1991) recommends the Step One diet for borderline and high levels of LDL cholesterol. The Step One diet is listed in Table 4.

Goals of treatment, as stated previously, are to lower total cholesterol and LDL cholesterol below 170 mg/dL and 110 mg/dL. Behavioral risk factor reduction should be implemented, including increased exercise, diet modification if necessary, attempts to prevent or quit smoking and identification and treatment of high blood pressure.

Exercise and Diet Education

Kahle et al. suggest that “a modest change in chronic physical exertion, planned as a routine exercise program for obese adolescent males, is associated with improvements in glucose homeostasis and decreases in peripheral insulin levels” (Kahle, Zipf, Lamb, Horswill & Ward, 1996, p. 5). In their study of seven obese males, the authors observed a consistent reduction in LDL cholesterol (25%), total cholesterol to HDL cholesterol ratio, and resting systolic blood pressure throughout the 15 week study. However, this trend was not statistically significant. The authors suggest that if the study continued, the positive effects on cholesterol and blood pressure may have continued (Kahle, et al., 1996).

The effects of physical training versus lifestyle education on childhood risk factors for CHD were studied over a 10-week period by Gutin, Cucuzzo, Islam, Smith and Stachura (1996). Percent body fat, aerobic fitness, lipid profile, glucose and insulin values and diet intake were all measured pre- and post-intervention in 22 obese, black females, ages 7-11. Aerobic fitness was measured on a treadmill with an electrocardiograph measuring heart
rate. Body composition was assessed by measuring percent body fat with dual x-ray absorptiometry. Both groups reduced total cholesterol/HDL cholesterol ratio and triglycerides. The physical training group improved in aerobic fitness and body composition. The lifestyle education group improved their diets. The authors suggested that “a combination of physical training and lifestyle education may be more effective than either alone” (p.22). However, the small sample size and lack of control group should be noted in this study.

Adherence to a restricted diet is very difficult for young people to accomplish. Children ages 7-17 with familial hypercholesterolemia were studied to determine factors successful in maintaining a healthy diet (Tonstad & Sivertsen, 1997). Psychosocial function of the child and parental education level were factors associated with increased adherence to a healthy diet. Psychosocial function and behavioral problems were measured using questionnaires, filled out by both the parents and the child. Other factors such as parental CHD, baseline serum cholesterol, age, sex, and BMI did not predict adherence to diet. Children that did well, may have done so because of their ability to function well overall and perhaps because of family support.

Howard, Bindler, Syneground and Van Gemert (1996) studied the effectiveness of teaching about physiology of the heart and cardiovascular risk factors on knowledge and cholesterol levels in 51 fourth through sixth graders, compared with 47 fourth through sixth graders who received no intervention. After one year, the five 40-minute educational programs did not result in higher test scores on the physiology of the heart and cardiovascular risk factors compared to the control group. Total cholesterol and LDL cholesterol levels in both groups were lower than baseline at one year. The total
cholesterol was between the 75th and 95th percentile initially for most participants in both groups and dropped to the 5th to 25th percentile for most participants in the control group and to the 25th to 50th percentile for those in the experimental group at one year. The authors suggest that perhaps the cholesterol levels of children in this age group fluctuate regardless of intervention or that being in a study motivates all children to make changes that lower cholesterol levels.

**Medication**

Treating children with cholesterol lowering medications should be considered only after unsuccessful reductions in cholesterol with diet and exercise modification. Medication should be considered when a parent has died or had severe atherosclerotic sequelae in their 40s or younger, or the adolescent’s LDL cholesterol is greater than 190 mg/dL in the absence of other risk factors or greater than 160 mg/dL with concurrent smoking, hypertension, xanthomas, diabetes or clinical signs of atherosclerosis (Kohn & Jacobson, 1996, p. 820).

NCEP (1991) recommends drug therapy in children 10 years and older who do not adequately respond to diet changes over six months to one year and have LDL cholesterol levels $\geq 190$ mg/dL or LDL $\geq 160$ mg/dL and have a positive family history of premature CHD (before age 55) or have two or more other CHD risk factors. Bile acid sequestrants, cholestyramine and colestipol, are currently being used with children due to their relatively low side effects and apparent safety. Bile acid sequestrants work by binding bile acids in the intestinal lumen. Nicotinic acid has not been proven to be safe in children and should be used cautiously and only after referral to a lipid specialist (NCEP, 1991).
Most of the statin drugs are not recommended in children. However, atorvastatin (Lipitor) has been used in a limited number of children nine years of age and older for one year with no unusual adverse effects (American Hospital Formulary Service, 1998). Although atorvastatin has been shown to reduce cholesterol levels in adults ("What's New in Drugs", 1997), caution should be taken with prescribing this to children until further studies have been done.

**Smoking Prevention and Cessation**

For smoking cessation guidelines and packets, the National Cancer Institute at 1-800-4CANCER may be contacted. They offer “Clearing the air: A guide to quitting smoking” and “How to help your patients stop smoking: A National Cancer Institute manual for physicians.” Smoking prevention is a challenge for parents, schools and health care providers that must continue to be addressed.

**Conclusion and Implications**

The studies reviewed indicate that family history is not always a reliable tool for determining which children should be screened for elevated cholesterol and triglycerides. Other risk factors including high fat diet, high blood pressure, obesity, inactivity, and smoking should be part of the assessment for CHD risk. When these factors are present, health care providers should consider assessing total cholesterol or a lipid panel, if indicated. The advantage of screening all children and adolescents is to ensure that certain children who fall into the high-risk group do not get missed. This is not the current recommendation however, and may not be realistic due to issues of cost and also the fact that not all children have access to health care. Other disadvantages of screening all children and adolescents include, falsely diagnosing disease in children who will not
later develop CHD as adults and the potential for overuse of cholesterol lowering drugs in children. Furthermore, all children should receive guidance and education on CHD and risk reduction regardless of whether they have elevated cholesterol or a family history of CHD.

Diet intervention is the first line of treatment for children shown to be at risk for CHD. Lifestyle change and physical activity also have been shown to decrease cholesterol levels. Smoking prevention and cessation should be routinely addressed at health care visits. Health care providers have the opportunity to detect the early development of CHD and by intervening before the disease progresses, can potentially reduce morbidity and mortality.

A need for future research studies in children has been identified. Effects of varying amounts of cigarettes on the risk for CHD, need further study. Also, longitudinal studies on the effects of routine exercise on cholesterol levels in youths would be beneficial. The benefits and risks involved with treating children with cholesterol reducing medications is important. Studies should also evaluate how well interventions for cholesterol reduction in children influence CHD incidence in adulthood. Identification of interventions helpful to motivate children to actively try to lower their cholesterol levels is also needed.
References


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<tr>
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</tr>
<tr>
<td>Hypercholesterolemia</td>
</tr>
<tr>
<td>High blood Pressure</td>
</tr>
<tr>
<td>Obesity</td>
</tr>
<tr>
<td>Smoking</td>
</tr>
<tr>
<td>High Fat Diet</td>
</tr>
<tr>
<td>Inactivity</td>
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**Table 1:** Risk factors for CHD
<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>TOTAL CHOLESTEROL (mg/dl)</th>
<th>LDL-CHOLESTEROL (mg/dl)</th>
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<tbody>
<tr>
<td>Acceptable</td>
<td>&lt; 170</td>
<td>&lt;110</td>
</tr>
<tr>
<td>Borderline</td>
<td>170-199</td>
<td>110-129</td>
</tr>
<tr>
<td>High</td>
<td>≥ 200</td>
<td>≥ 130</td>
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Table 2: Lipid levels for children and adolescents
<table>
<thead>
<tr>
<th>AGE</th>
<th>SYSTOLIC BLOOD PRESSURE</th>
<th>DIASTOLIC BLOOD PRESSURE</th>
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<tr>
<td>6-9 years</td>
<td>≥ 122 mm Hg</td>
<td>≥ 78 mm Hg</td>
</tr>
<tr>
<td>10-12 years</td>
<td>≥ 126 mm Hg</td>
<td>≥ 82 mm Hg</td>
</tr>
<tr>
<td>13-15 years</td>
<td>≥ 133 mm Hg</td>
<td>≥ 86 mm Hg</td>
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Table 3: Elevated values of blood pressure (>95th percentile)
<table>
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<tr>
<th>Nutrient</th>
<th>Recommended Intake</th>
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<tbody>
<tr>
<td>Total fat</td>
<td>No more than 30% of total calories</td>
</tr>
<tr>
<td>Saturated fatty acids</td>
<td>Less than 10% of total calories</td>
</tr>
<tr>
<td>Polyunsaturated fatty acids</td>
<td>Up to 10% of total calories</td>
</tr>
<tr>
<td>Monounsaturated fatty acids</td>
<td>Remaining total fat calories</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>Less than 300 mg/day</td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>About 55% of total calories</td>
</tr>
<tr>
<td>Protein</td>
<td>About 15-20% of total calories</td>
</tr>
<tr>
<td>Calories</td>
<td>To promote normal growth and development and to reach or maintain desirable body weight</td>
</tr>
</tbody>
</table>

Table 4: Step One Diet
Risk assessment

Measure total blood cholesterol

Parental High Blood Cholesterol ≥240 mg/dL

Positive family history*

Do lipoprotein analysis

Repeat cholesterol measurement within 5 years

Acceptable Blood Cholesterol <170 mg/dL

Borderline Blood Cholesterol 170-199 mg/dL

Repeat measurement and average with previous measurement

<170 mg/dL

≥170 mg/dL

High Blood Cholesterol ≥200 mg/dL

Do lipoprotein analysis

* Defined as a history of premature (before age 55 years) cardiovascular disease in a parent or grandparent

Figure 1: Risk assessment for blood cholesterol screening in children and adolescents from the National Cholesterol Education Program, 1991.
Do lipoprotein analysis
- 12-hour fast
- Measure total cholesterol, HDL cholesterol, and triglyceride
- Estimate LDL cholesterol = total cholesterol - HDL cholesterol - (triglyceride/5)

<table>
<thead>
<tr>
<th>Acceptable LDL Cholesterol</th>
<th>Borderline LDL Cholesterol</th>
<th>High LDL Cholesterol</th>
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<tr>
<td>&lt;110 mg/dL</td>
<td>110-129 mg/dL</td>
<td>≥130 mg/dL</td>
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Repeat lipoprotein analysis and average with previous measurement

<table>
<thead>
<tr>
<th>Acceptable LDL Cholesterol</th>
<th>Borderline LDL Cholesterol</th>
<th>High LDL Cholesterol</th>
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<tr>
<td>&lt;110 mg/dL</td>
<td>110-129 mg/dL</td>
<td>≥130 mg/dL</td>
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Repeat lipoprotein analysis within 5 years
Provide education on recommended eating pattern and risk factor reduction

Risk factor advice
Provide Step-One Diet and other risk factor intervention
Re-evaluate status in 1 year

Do clinical evaluation (history, physical exam, lab tests)
- Evaluate for secondary causes
- Evaluate for familial disorders

Intensive clinical intervention
Screen all family members

Set goal LDL cholesterol
- Minimal: <130 mg/dL
- Ideal: <110 mg/dL

Step-One then Step-Two Diet

Figure 2: Classification, education, and follow up based on LDL cholesterol from the National Cholesterol Education Program, 1991.