glycerol in plasma. Glycerol is generated as part of normal metabolic processes, but the concentration is usually less than 5-20 mg/dL. Certain conditions, however, may lead to elevated free glycerol levels, such as in some rare genetic diseases such as glycerol kinase deficiency, intravenous administration of drugs or nutrients, or prolonged storage of blood without refrigeration. A clear plasma sample with TG >200 mg/dL should be assayed for glycerol. Although not widely available, some TG assays perform a 'blanked' TG measurement, which refers to the TG concentration obtained by measuring glycerol levels in the sample before and after the complete hydrolysis of existing TG. Overall, accuracy and precision of most TG assays are relatively good and appear to meet current clinical requirements, but it is important to realize there is a high biological variability for TG.

LDL cholesterol (LDL-C): The most common method for reporting LDL-C level is by use of the Friedewald formula, which estimates the cholesterol content in TG-rich lipoproteins (VLDL particles) as 0.2 x TG, whereby (LDL-C) = (TC) – (HDL-C) – (0.2 x TG) in mg/dL units. Because of a negative bias associated with elevated TG levels, fasting specimens are preferred for the Friedewald calculation and the LDL-C estimate is considered inaccurate for TG ≥ 400 mg/dL. As discussed in more detail below, alternative LDL-C equations that are less affected by TG have been developed.[14-17]

LDL-C can also be directly measured, but it is not routinely performed by many clinical laboratories, in part because of the additional cost. Ultracentrifugation to assay LDL-C has been used in the past, but that method is not commonly used today. Homogeneous assays that directly measure LDL-C with proprietary chemicals that mask the non-LDL particles have become popular, but the methods vary in performance. As with direct HDL-C assays, the accuracy of direct LDL-C assays depends on the specificity of the masking reagents. The accuracy of these LDL-C measurements decreases with increasing TG levels.[18]

Non-HDL-C: Non-HDL-C is calculated from the standard lipid panel where [Non-HDL-C] = [TC] – [HDL-C]. Non-HDL-C levels are very highly correlated with apoB measurements. Non-HDL-C does not require TG measurement and thus it is accurately determined in samples from fasting or nonfasting individuals.[4,19-21]

Key Points

- **LDL cholesterol can be estimated from total cholesterol, HDL-C, and TG determinations, using the approach of Friedewald, Martin/Hopkins, or Sampson.**
- **Non-HDL-C is determined reliably when fasting or nonfasting**
- **Advanced lipoprotein tests (e.g., LDL particle number, small dense LDL-C, remnant cholesterol) lack appropriate standardization and cross comparison of these tests utilizing different measurement techniques is difficult.**

Recommendations Laboratory Measurement and Reporting	Class of Recommendation (strength)	Levels of Evidence
It is recommended that lipid laboratories participate in programs that monitor accuracy and precision [4,7]	I	B-NR

Laboratory post analytic issues

Question: *What information should laboratories include in lipid lab reports to optimize clinical utility?*

Table 3 shows a recommended format for laboratories to report lipid measurements for adults. The reference values for the clinically common values as well as those that are sufficiently outside normal limits should cause the clinician to be alerted. These were developed from a variety of published sources.[4,22,23] Unlike many other laboratory tests, lipid measurements are best reported based on the "ideal" range in terms of cardiovascular disease risk prevention. The 2018 AHA/ACC Multi-Society Cholesterol Guideline, coauthored by representatives from many leading medical organizations, including the National Lipid Association, specifically delineated specific goals or cut points for lipid tests across different patient domains, including primary prevention, familial hypercholesterolemia, and secondary prevention, with consideration of the magnitude of each patient's individual risk and tolerance for therapy.[4]

Clinical laboratories often lack patient-specific information to inform clinical decisions and care, which makes it difficult to know how to best report the result. At this time there is no consensus, but a common practice is to report an abbreviated table of cut points for each analyte. This approach can cause the laboratory report to be cluttered, which may inhibit the identification of abnormal test results. Therefore, some clinical laboratories have elected to use criteria based on the general population or on patients at intermediate ASCVD risk. In the effort to prevent the advancement of vascular disease, the clinician should assess the individual patient and provide a range of acceptable values for the circumstances.

Clinically relevant cut points are much lower for pediatric versus adult populations.[4,24,25] In addition, HDL-C concentrations in adults are typically higher in women than in men, and in Blacks versus Whites. For Lp(a), there are also significant racial/ethnic differences and significantly higher levels in Blacks than in other ancestral groups. Results can vary across different methods, particularly for some more advanced lipid tests; therefore, the clinical laboratory should make available the name and/or vendor of the specific test used. For LDL-C reporting, the specific method used should also be noted.

Unlike other laboratory tests, lipid and lipoprotein test results usually do not require prompt medical action, but the NLA does recommend reporting some alert values. *Adults with LDL-C ≥ 190 mg/dL should be flagged* to alert the pa-