CLINICAL AND LABORATORY STANDARDS INSTITUTE®

June 2001

C40-A

Analytical Procedures for the Determination of Lead in Blood and Urine; Approved Guideline

This document provides guidelines for the measurement of lead in blood and urine, including specimen collection, measurement by graphite furnace atomic absorption spectrometry (GFAAS) and anodic stripping voltammetry (ASV), quality assurance, and quality control.

A guideline for global application developed through the Clinical and Laboratory Standards Institute consensus process.

Clinical and Laboratory Standards Institute

Setting the standard for quality in clinical laboratory testing around the world.

The Clinical and Laboratory Standards Institute (CLSI) is a not-for-profit membership organization that brings together the varied perspectives and expertise of the worldwide laboratory community for the advancement of a common cause: to foster excellence in laboratory medicine by developing and implementing clinical laboratory standards and guidelines that help laboratories fulfill their responsibilities with efficiency, effectiveness, and global applicability.

Consensus Process

Consensus—the substantial agreement by materially affected, competent, and interested parties—is core to the development of all CLSI documents. It does not always connote unanimous agreement, but does mean that the participants in the development of a consensus document have considered and resolved all relevant objections and accept the resulting agreement.

Commenting on Documents

CLSI documents undergo periodic evaluation and modification to keep pace with advancements in technologies, procedures, methods, and protocols affecting the laboratory or health care.

CLSI's consensus process depends on experts who volunteer to serve as contributing authors and/or as participants in the reviewing and commenting process. At the end of each comment period, the committee that developed the document is obligated to review all comments, respond in writing to all substantive comments, and revise the draft document as appropriate.

Comments on published CLSI documents are equally essential, and may be submitted by anyone, at any time, on any document. All comments are addressed according to the consensus process by a committee of experts.

Appeals Process

If it is believed that an objection has not been adequately addressed, the process for appeals is documented in the CLSI Administrative Procedures.

All comments and responses submitted on draft and published documents are retained on file at CLSI and are available upon request.

Get Involved—Volunteer!

Do you use CLSI documents in your workplace? Do you see room for improvement? Would you like to get involved in the revision process? Or maybe you see a need to develop a new document for an emerging technology? CLSI wants to hear from you. We are always looking for volunteers. By donating your time and talents to improve the standards that affect your own work, you will play an active role in improving public health across the globe.

For further information on committee participation or to submit comments, contact CLSI.

Clinical and Laboratory Standards Institute
950 West Valley Road, Suite 2500
Wayne, PA 19087 USA
P: 610.688.0100
F: 610.688.0700
www.clsi.org
standard@clsi.org

C40-A
Vol. 21 No. 9
ISBN 1-56238-437-6
Replaces C40-P
ISSN 0273-3099
Vol. 18 No. 4

Analytical Procedures for the Determination of Lead in Blood and Urine; Approved Guideline

Volume 21 Number 9

Patrick J. Parsons, Ph.D., C.Chem., FRSC, Chairholder
J. Julian Chisolm, Jr., M.D.
H. Trevor Delves, Ph.D., C.Chem., FRSC
Reginald Griffin, Ph.D.
Elaine W. Gunter, M.T.(ASCP)
Walter Slavin
Noel V. Stanton, M.S.
Robert Vocke, Ph.D.

Abstract

Analytical Procedures for the Determination of Lead in Blood and Urine; Approved Guideline (CLSI document C40-A) is intended for use by the clinical laboratory testing community involved in the collection and measurement of lead in blood and urine. The guideline addresses the clinical significance of lead measurements, specimen collection, lead determination by graphite furnace atomic absorption spectrometry and anodic stripping voltammetry, reference materials, quality control procedures, and laboratory policy.

Clinical and Laboratory Standards Institute (CLSI). *Analytical Procedures for the Determination of Lead in Blood and Urine; Approved Guideline*. CLSI document C40-A (ISBN 1-56238-437-6 [Print]). Clinical and Laboratory Standards Institute, 950 West Valley Road, Suite 2500, Wayne, Pennsylvania 19087 USA, 2001.

Suggested Citation

CLSI. *Analytical Procedures for the Determination of Lead in Blood and Urine; Approved Guideline.* CLSI document C40-A. Wayne, PA: Clinical and Laboratory Standards Institute; 2001.

Proposed Guideline
April 1998

Approved Guideline
June 2001

ISBN 1-56238-437-6
ISSN 0273-3099

Committee Membership

Area Committee on Clinical Chemistry and Toxicology

W. Gregory Miller, Ph.D. **Chairholder**	**Virginia Commonwealth University** **Richmond, Virginia**
Gary L. Myers, Ph.D. **Vice-Chairholder**	**Centers for Disease Control and Prevention** **Atlanta, Georgia**

Subcommittee on Determination of Lead

Patrick J. Parsons, Ph.D., C.Chem, FRSC **Chairholder**	**New York State Department of Health** **Albany, New York**
J. Julian Chisolm, Jr., M.D.	Kennedy Krieger Institute Baltimore, Maryland
H. Trevor Delves, Ph.D., C.Chem., FRSC	Southampton General Hospital Southampton, United Kingdom
Reginald Griffin, Ph.D.	ESA Laboratories Chelmsford, Massachusetts
Elaine W. Gunter, M.T.(ASCP)	Centers for Disease Control and Prevention Atlanta, Georgia
Walter Slavin	Bonaire Technologies Ridgefield, Connecticut
Noel V. Stanton, M.S.	WI State Lab of Hygiene Madison, Wisconsin
Robert Vocke, Ph.D.	National Institute of Standards and Technology Gaithersburg, Maryland

Advisors

Derek P. Baker, Ph.D.	Utak Laboratories Agoura Hills, California
Glen Carnrick	Perin-Elmer Corporation Wilton, Connecticut
V. Michelle Chenault, Ph.D., M.T.(ASCP)	Food and Drug Administration Rockville, Maryland
John W. Erickson, Jr.	Bio-Rad Laboratories Anaheim, California
Robert Jones, Ph.D.	Centers for Disease Control and Prevention Atlanta, Georgia

Advisors (Continued)

Fred Y. Leung, Ph.D.	University Hospital, Ontario
Gillian Lockitch, M.D., FRCPC	Children's & Women's Health Center Vanouver, British Columbia
John D. Osterloh, M.D.	San Francisco General Hospital San Francisco, California
Daniel Paschal, Ph.D.	Centers for Disease Control and Prevention Atlanta, Georgia
Amadeo J. Pesce, Ph.D.	University Hospital Cincinnati, Ohio
Petrie Rainey, M.D., Ph.D.	Yale School of Medicine New Haven, Connecticut
Sandy Roda	University of Cincinnati Cincinnati, Ohio
Kenneth L. Seace	Buck Scientific East Norwalk, Connecticut
Douglas E. Shrader, Ph.D.	Varian Institute Wood Dale, Illinois
John Sotera	Thermo Jarrel Ash Corporation Franklin, Massachusetts
Dr. Andrew Taylor	University of Guildford Surrey, England
Beth Ann Wise, M.T.(ASCP), M.S.Ed. *Staff Liaison*	NCCLS Wayne, Pennsylvania
Patrice E. Polgar *Editor*	NCCLS Wayne, Pennsylvania
Donna M. Wilhelm *Assistant Editor*	NCCLS Wayne, Pennsylvania

Active Membership
(as of 1 April 2001)

Sustaining Members

Abbott Laboratories
American Association for Clinical Chemistry
Bayer Corporation
Beckman Coulter, Inc.
BD and Company
bioMérieux, Inc.
College of American Pathologists
Dade Behring Inc.
GlaxoSmithKline
Nippon Becton Dickinson Co., Ltd.
Ortho-Clinical Diagnostics, Inc.
Pfizer Inc
Roche Diagnostics, Inc.

Professional Members

AISAR-Associazione Italiana per lo Studio degli
American Academy of Family Physicians
American Association for Clinical Chemistry
American Association for Respiratory Care
American Chemical Society
American Medical Technologists
American Public Health Association
American Society for Clinical Laboratory Science
American Society of Hematology
American Society for Microbiology
American Society of Parasitologists, Inc.
American Type Culture Collection, Inc.
Asociacion de Laboratorios de Alta Complejidad
Asociación Española Primera de Socorros (Uruguay)
Asociacion Mexicana de Bioquimica Clinica A.C.
Assn. of Public Health Laboratories
Assoc. Micro. Clinici Italiani-A.M.C.L.I.
Australasian Association of Clinical Biochemists
British Society for Antimicrobial Chemotherapy
CADIME-Camara De Instituciones De Diagnostico Medico
Canadian Society for Medical Laboratory Science—Société Canadienne de Science de Laboratoire Médical
Canadian Society of Clinical Chemists
Clinical Laboratory Management Association
COLA
College of American Pathologists
College of Medical Laboratory Technologists of Ontario
College of Physicians and Surgeons of Saskatchewan
Fundación Bioquímica Argentina
International Association of Medical Laboratory Technologists
International Council for Standardization in Haematology
International Federation of Clinical Chemistry
Italian Society of Clinical Biochemistry
Japan Society of Clinical Chemistry
Japanese Committee for Clinical Laboratory Standards
Joint Commission on Accreditation of Healthcare Organizations
National Academy of Clinical Biochemistry
National Society for Histotechnology, Inc.
Ontario Medical Association Quality Management Program-Laboratory Service
RCPA Quality Assurance Programs PTY Limited
Sociedade Brasileira de Analises Clinicas
Sociedade Brasileira de Patologia Clinica
Sociedad Espanola de Bioquimica Clinica y Patologia Molecular

Government Members

Association of Public Health Laboratories
Armed Forces Institute of Pathology
BC Centre for Disease Control
Centers for Disease Control and Prevention
Chinese Committee for Clinical Laboratory Standards
Commonwealth of Pennsylvania Bureau of Laboratories
Department of Veterans Affairs
Deutsches Institut für Normung (DIN)
FDA Center for Devices and Radiological Health
FDA Center for Veterinary Medicine
FDA Division of Anti-Infective Drug Products
Health Care Financing Administration/CLIA Program
Health Care Financing Administration
Iowa State Hygienic Laboratory
Massachusetts Department of Public Health Laboratories
National Association of Testing Authorities – Australia
National Center of Infectious and Parasitic Diseases (Bulgaria)
National Institute of Standards and Technology
Ohio Department of Health
Ontario Ministry of Health
Saskatchewan Health-Provincial Laboratory
Scientific Institute of Public Health; Belgium Ministry of Social Affairs, Public Health and the Environment
South African Institute for Medical Research
Swedish Institute for Infectious Disease Control
Thailand Department of Medical Sciences

Industry Members

AB Biodisk
Abbott Laboratories
Abbott Laboratories, MediSense Products
Accumetrics, Inc.
Agilent Technologies, Inc.
Ammirati Regulatory Consulting
Asséssor
AstraZeneca
Aventis
Avocet Medical, Inc.
Bayer Corporation – Elkhart, IN

Bayer Corporation – Tarrytown, NY
Bayer Corporation – West Haven, CT
Bayer Medical Ltd.
BD
BD Biosciences – San Jose, CA
BD Consumer Products
BD Diagnostic Systems
BD Italia S.P.A.
BD VACUTAINER Systems
Beckman Coulter, Inc.
Beckman Coulter, Inc. Primary Care Diagnostics
Beckman Coulter K.K. (Japan)
Bio-Development SRL
Bio-Inova Life Sciences International
Bio-Inova Life Sciences North America
BioMedia Laboratories Sdn Bhd
bioMérieux, Inc.
Biometrology Consultants
Bio-Rad Laboratories, Inc.
Bio-Rad Laboratories, Inc. - France
Biotest AG
Bristol-Myers Squibb Company
Canadian External Quality Assessment Laboratory
Capital Management Consulting, Inc.
Checkpoint Development Inc.
Clinical Design Group Inc.
Clinical Laboratory Improvement Consultants
COBE Laboratories, Inc.
Community Medical Center (NJ)
Control Lab (Brazil)
Copan Diagnostics Inc.
Cosmetic Ingredient Review
Cubist Pharmaceuticals
Cytometrics, Inc.
Dade Behring Inc. - Deerfield, IL
Dade Behring Inc. - Glasgow, DE
Dade Behring Inc. - Marburg, Germany
Dade Behring Inc. - Sacramento, CA
Dade Behring Inc. - San Jose, CA
DAKO A/S
Diagnostic Products Corporation
Eiken Chemical Company, Ltd.
Enterprise Analysis Corporation
Fort Dodge Animal Health
General Hospital Vienna (Austria)
Gen-Probe
GlaxoSmithKline
Greiner Bio-One Inc.
Health Systems Concepts, Inc.
Helena Laboratories
Home Diagnostics, Inc.
I-STAT Corporation
International Technidyne Corporation
Kendall Sherwood-Davis & Geck
LAB-Interlink, Inc.
Labtest Diagnostica S.A.
LifeScan, Inc. (a Johnson & Johnson Company)
Lilly Research Laboratories
Medical Device Consultants, Inc.
Medtronic, Inc.
Merck & Company, Inc.
mvi Sciences (MA)
Nabi
Neometrics is.
Nichols Institute Diagnostics (Div. of Quest Diagnostics, Inc.)
Nissui Pharmaceutical Co., Ltd.
Nippon Becton Dickinson Co., Ltd.
Norfolk Associates, Inc.
Organon Teknika Corporation
Ortho-Clinical Diagnostics, Inc. (Raritan, NJ)
Ortho-Clinical Diagnostics, Inc. (Rochester, NY)
Oxoid Inc.
Pfizer Inc
Pharmacia Corporation
Premier Inc.
Procter & Gamble Pharmaceuticals, Inc.
The Product Development Group
Quintiles, Inc.
Radiometer America, Inc.
Radiometer Medical A/S
David G. Rhoads Associates, Inc.
Roche Diagnostics GmbH
Roche Diagnostics, Inc.
Roche Laboratories (Div. Hoffmann-La Roche Inc.)
The R.W. Johnson Pharmaceutical Research Institute
Sarstedt, Inc.
SARL Laboratoire Carron (France)
Schering Corporation
Schleicher & Schuell, Inc.
Second Opinion
Showa Yakuhin Kako Company, Ltd.
Streck Laboratories, Inc.
SurroMed, Inc.
Sysmex Corporation (Japan)
Sysmex Corporation (Long Grove, IL)
The Toledo Hospital (OH)
Trek Diagnostic Systems, Inc.
Vetoquinol S.A.
Visible Genetics, Inc.
Vysis, Inc.
Wallac Oy
Wyeth-Ayerst
Xyletech Systems, Inc.
YD Consultant
Yeongdong Pharmaceutical Corporation

Trade Associations

AdvaMed
Association of Medical Diagnostic Manufacturers
Japan Association Clinical Reagents Ind. (Tokyo, Japan)
Medical Industry Association of Australia

Associate Active Members

20th Medical Group (SC)
67th CSH Wuerzburg, GE (NY)
121st General Hospital (CA)
Academisch Ziekenhuis-VUB (Belgium)
Acadiana Medical Laboratories, LTD (LA)
Adena Regional Medical Center (OH)
Advocate Laboratories (IL)
The Aga Khan Hospital & Medical College, Karachi (Pakistan)
Akershus Central Hospital and AFA (Norway)
Albany Medical Center Hospital (NY)
Albemarle Hospital (NC)
Allegheny General Hospital (PA)
Allegheny University of the Health Sciences (PA)
Allina Laboratories (MN)
Alton Ochsner Medical Foundation (LA)
American Medical Laboratories (VA)
Arkansas Department of Health
ARUP at University Hospital (UT)
Armed Forces Research Institute of Medical Science (APO, AP)
Associated Regional & University Pathologists (UT)
Aurora Consolidated Laboratories (WI)
Bay Medical Center (MI)
Baystate Medical Center (MA)
Bbaguas Duzen Laboratories (Turkey)
Bo Ali Hospital (Iran)
Bonnyville Health Center (Alberta, Canada)

Boulder Community Hospital (CO)
Brantford General Hospital (Ontario, Canada)
Brazileiro De Promocao (Brazil)
Brookdale Hospital Medical Center (NY)
Brooke Army Medical Center (TX)
Brooks Air Force Base (TX)
Broward General Medical Center (FL)
Calgary Laboratory Services
Carilion Consolidated Laboratory (VA)
Cathay General Hospital (Taiwan)
CB Healthcare Complex (Sydney, NS, Canada)
Central Kansas Medical Center
Central Texas Veterans Health Care System
Centro Diagnostico Italiano (Milano, Italy)
Champlain Valley Physicians Hospital (NY)
Chang Gung Memorial Hospital (Taiwan)
Children's Hospital (LA)
Children's Hospital (NE)
Children's Hospital & Clinics (MN)
Children's Hospital King's Daughters (VA)
Children's Hospital Medical Center (Akron, OH)
Children's Hospital of Philadelphia (PA)
Clarian Health–Methodist Hospital (IN)
Clendo Lab (Puerto Rico)
CLSI Laboratories (PA)
Columbus County Hospital (NC)
Commonwealth of Kentucky
CompuNet Clinical Laboratories (OH)
Covance Central Laboratory Services (IN)
Danish Veterinary Laboratory (Copenhagen, Denmark)
Danville Regional Medical Center (VA)
Deaconess Hospital (MO)
Delaware Public Health Laboratory
Department of Health & Community Services (New Brunswick, Canada)
Detroit Health Department (MI)
Diagnostic Laboratory Services, Inc. (HI)
Duke University Medical Center (NC)
Durham Regional Hospital (NC)
Dynacare Laboratories - Eastern Region (Ottawa, ON, Canada)
Dynacare Memorial Hermann Laboratory Services (TX)
E.A. Conway Medical Center (LA)
Eastern Maine Medical Center
East Side Clinical Laboratory (RI)
Elyria Memorial Hospital (OH)
Emory University Hospital (GA)
Esoterix Center for Infectious Disease (TX)
Fairfax Hospital (VA)
Fairview-University Medical Center (MN)
Foothills Hospital (Calgary, AB, Canada)
Fort St. John General Hospital (Fort St. John, BC, Canada)
Fox Chase Cancer Center (PA)
Franklin Square Hospital Center (MD)
Fresenius Medical Care/Spectra East (NJ)
Fresno Community Hospital and Medical Center
Gambro Healthcare Laboratory (FL)
GDS Technology, Inc (IN)
Geisinger Medical Center (PA)
Grady Memorial Hospital (GA)
Guthrie Clinic Laboratories (PA)
Harris Methodist Erath County (TX)
Harris Methodist Fort Worth (TX)
Harris Methodist Northwest (TX)
Hartford Hospital (CT)
Headwaters Health Authority (Alberta, Canada)
Health Network Lab (PA)
Health Sciences Centre (Winnipeg, MB, Canada)
Heartland Health System (MO)
Highlands Regional Medical Center (FL)
Hoag Memorial Hospital Presbyterian (CA)
Holmes Regional Medical Center (FL)
Holy Spirit Hospital (PA)
Holzer Medical Center (OH)
Hospital for Sick Children (Toronto, ON, Canada)
Hospital Israelita Albert Einstein (Brazil)
Hotel Dieu Hospital (Windsor, ON, Canada)
Huddinge University Hospital (Sweden)
Hurley Medical Center (MI)
Indiana State Board of Health
Indiana University
Instituto Scientifico HS. Raffaele (Italy)
International Health Management Associates, Inc. (IL)
Jersey Shore Medical Center (NJ)
Joel T. Boone Branch Medical Clinic (VA)
John F. Kennedy Medical Center (NJ)
John Randolph Hospital (VA)
Kaiser Permanente (CA)
Kaiser Permanente (MD)
Kantonsspital (AG, Switzerland)
Kenora-Rainy River Regional Laboratory Program (Ontario, Canada)
Kern Medical Center (CA)
King Fahad National Guard Hospital (Saudi Arabia)
King Khalid National Guard Hospital (Saudi Arabia)
Kings County Hospital Center (NY)
Klinični Center (Slovenia)
LabCorp (NC)
Laboratories at Bonfils (CO)
Laboratório Fleury S/C Ltda. (Brazil)
Laboratory Corporation of America (MO)
LAC and USC Healthcare Network (CA)
Lakeland Regional Medical Center (FL)
Lancaster General Hospital (PA)
Langley Air Force Base (VA)
LeBonheur Children's Medical Center (TN)
Lewis-Gale Medical Center (VA)
Libero Instituto Univ. Campus BioMedico (Italy)
Licking Memorial Hospital (OH)
Long Beach Memorial Medical Center (CA)
Louisiana State University Medical Center
Maccabi Medical Care and Health Fund (Israel)
Magee Womens Hospital (PA)
Magnolia Regional Health Center (MS)
Martin Luther King/Drew Medical Center (CA)

Massachusetts General Hospital (Microbiology Laboratory)
Massachusetts General Hospital (Pathology Laboratory)
Mayo Clinic Scottsdale (AZ)
MDS Metro Laboratory Services (Burnaby, BC, Canada)
Medical College of Virginia Hospital
Medicare/Medicaid Certification, State of North Carolina
Memorial Hospital (CO)
Memorial Medical Center (Napoleon Ave., New Orleans, LA)
Memorial Medical Center (N. Jefferson Davis Pkwy., New Orleans, LA)
Memorial Medical Center (IL)
Mercy Health System (PA)
Mercy Hospital (NC)
Mercy Medical Center Des Moines (IA)
Mescalero Indian Hospital (NM)
Methodist Hospitals of Memphis (TN)
Michigan Department of Community Health
Mississippi Baptist Medical Center
Monmouth Medical Center (NJ)
Monte Tabor – Centro Italo - Brazileiro de Promocao (Brazil)
Montreal Children's Hospital (Canada)
Montreal General Hospital (Canada)
Morton Plant Mease Health Care (FL)
Mount Sinai Hospital (NY)
Mount Sinai Medical Center (FL)
MRL Pharmaceutical Services, Inc. (VA)
MRL Reference Laboratory (CA)
National University Hospital (Singapore)
Naval Surface Warfare Center (IN)
New Britain General Hospital (CT)
New England Fertility Institute (CT)
New England Medical Center Hospital (MA)
New York Hospital Medical Center of Queens
New York State Department of Health
NorDx (ME)
North Carolina Laboratory of Public Health
North Mississippi Medical Center
North Shore – Long Island Jewish Health System Laboratories (NY)
Northridge Hospital Medical Center (CA)
Northwestern Memorial Hospital (IL)
Ohio Valley Medical Center (WV)
O.L. Vrouwziekenhuis (Belgium)
Ordre professionnel des technologists médicaux du Québec
Ospedali Riuniti (Italy)
The Ottawa Hospital (Ottawa, ON, Canada)
Our Lady of Lourdes Hospital (NJ)
Our Lady of the Resurrection Medical Center (IL)
Pathology and Cytology Laboratories, Inc. (KY)
Pathology Associates Laboratories (CA)
The Permanente Medical Group (CA)
Pocono Hospital (PA)
Presbyterian Hospital of Dallas (TX)
Prodia Clinical Laboratory (Indonesia)
Providence Health System (OR)
Providence Seattle Medical Center (WA)
Queen Elizabeth Hospital (Prince Edward Island, Canada)
Queensland Health Pathology Services (Australia)
Quest Diagnostics, Incorporated (AZ)
Quest Diagnostics Incorporated (CA)
Quintiles Laboratories, Ltd. (GA)
Reading Hospital and Medical Center (PA)
Regions Hospital
Research Medical Center (MO)
Rex Healthcare (NC)
Rhode Island Department of Health Laboratories
Riyadh Armed Forces Hospital (Saudi Arabia)
Royal Columbian Hospital (New Westminster, BC, Canada)
Saint Mary's Regional Medical Center (NV)
St. Alexius Medical Center (ND)
St. Anthony Hospital (CO)
St. Barnabas Medical Center (NJ)
St. Boniface General Hospital (Winnipeg, Canada)
St. Elizabeth Hospital (NJ)
St-Eustache Hospital (Quebec, Canada)
St. John Hospital and Medical Center (MI)
St. John Regional Hospital (St. John, NB, Canada)
St. Joseph Hospital (NE)
St. Joseph Mercy – Oakland (MI)
St. Joseph's Hospital – Marshfield Clinic (WI)
St. Joseph's Medical Center (CA)
St. Luke's Regional Medical Center (IA)
St. Mark's Hospital (UT)
St. Mary Medical Center (IN)
St. Mary of the Plains Hospital (TX)
St. Mary's Hospital & Medical Center (CO)
St. Paul's Hospital (Vancouver, BC, Montreal)
Ste. Justine Hospital (Montreal, PQ, Canada)
Salina Regional Health Center (KS)
San Francisco General Hospital (CA)
Santa Cabrini Hospital (Montreal, PQ Canada)
Santa Clara Valley Medical Center (CA)
Seoul Nat'l University Hospital (Korea)
Shanghai Center for the Clinical Laboratory (China)
Shands Healthcare (FL)
South Bend Medical Foundation (IN)
Southern California Permanente Medical Group
South Western Area Pathology Service (Australia)
Speciality Laboratories, Inc. (CA)
Stanford Hospital and Clinics (CA)
State of Washington Department of Health
Stormont-Vail Regional Medical Center (KS)
Sun Health-Boswell Hospital (AZ)
Sunrise Hospital and Medical Center (NV)
T.A. Sourasky Medical Center (Israel)
Temple University Hospital (PA)
Tenet Odessa Regional Hospital (TX)
The Toledo Hospital (OH)
Touro Infirmary (LA)
Tri-City Medical Center (CA)

Trident Regional Medical Center (SC)
Tripler Army Medical Center (HI)
Truman Medical Center (MO)
UCSF Medical Center (CA)
UNC Hospitals (NC)
Unilab Clinical Laboratories (CA)
University Hospital (Gent) (Belgium)
University Hospital (TX)
The University Hospitals (OK)
University of Alabama-Birmingham Hospital
University of Alberta Hospitals (Canada)
University of Chicago Hospitals (IL)
University of Florida
University of the Ryukyus (Japan)
University of Texas M.D. Anderson Cancer Center
University of Virginia Medical Center
University of Washington
UPMC Bedford Memorial (PA)
UZ-KUL Medical Center (Belgium)
VA (Dayton) Medical Center (OH)
VA (Denver) Medical Center (CO)
VA (Kansas City) Medical Center (MO)
VA (Martinez) Medical Center (CA)
VA (San Diego) Medical Center (CA)
VA (Tuskegee) Medical Center (AL)
VA Outpatient Clinic (OH)
Vejle Hospital (Denmark)
Virginia Department of Health
Viridae Clinical Sciences, Inc. (Vancouver, BC, Canada)
Washoe Medical Center Laboratory (NV)
Watson Clinic (FL)
Wilford Hall Medical Center (TX)
William Beaumont Hospital (MI)
Williamsburg Community Hospital (VA)
Winn Army Community Hospital (GA)
Wishard Memorial Hospital (IN)
Yonsei University College of Medicine (Korea)
York Hospital (PA)
Zale Lipshy University Hospital (TX)

Contents

Contents (Continued)

Foreword

The primary impetus for this document was the pivotal statement on childhood lead poisoning prevention published by the U.S. Centers for Disease Control and Prevention (CDC) in 1991 which lowered the concentration of lead in blood (BPb) deemed harmful to children from 25 µg/dL to 10 µg/dL (0.48 µmol/L).[1] At this lower BPb level, a widely used biochemical screening test for lead exposure, the erythrocyte protoporphyrin (EP) test, became redundant because EP is insensitive to such low-level lead exposure. The statement recommended that EP screening for lead exposure be discontinued in favor of a direct BPb test. The worldwide impact of the 1991 CDC statement is still being felt as private and public health laboratories continue to respond to the need for inexpensive BPb testing on small capillary blood specimens.

In November 1997, CDC updated its recommendations for screening young children for lead poisoning.[2] The CDC document addresses specific concerns about the extent to which universal screening of all children should be, or can be, implemented. As part of the release of the 1997 document, CDC is providing specific advice and materials to blood lead laboratories (see Appendix C in the CDC document) that complement the guidelines proposed in C40-A. These materials may be downloaded from the CDC's worldwide website at the following URL address:

http://www.cdc.gov/nceh/lead/lead.htm

Because CDC recommendations are often adopted internationally, updated tables from the 1997 document as well as appropriate follow-up actions for confirmed, elevated, blood-lead levels are included here in Appendix C. Information on laboratory accreditation in the U.S. is also provided in Appendix B, along with details of proficiency testing (or external quality assessment) programs for blood lead in the U.S., Canada, and the European Union.

In 1991, established proficiency testing requirements for BPb accuracy were tightened to reflect the improvements in current analytical methodology and the lower concentrations of BPb deemed harmful. Some laboratories using older methods for BPb were unable to maintain proficiency, and were required to improve their analytical method performance. Many were understandably concerned that the analytical technology for making accurate, contamination-free measurements of low levels of lead in capillary blood specimens did not exist. In the years since the 1991 CDC statement was released, it has been shown that current analytical methods can easily measure BPb concentrations below 10 µg/dL with good accuracy and precision. Analytical accuracy continues to improve as evidenced by the performance of participating laboratories in numerous quality assurance and proficiency testing programs. Many laboratories have succeeded in setting up the BPb analysis in-house.

This document addresses many concerns and questions that laboratories have about BPb measurements. Issues of accuracy, interferences, contamination control, and troubleshooting affect all analytical methods. Two analytical methods for blood lead are in routine use at the current time: graphite furnace atomic absorption spectrometry (GFAAS) and anodic stripping voltammetry (ASV). Instrumentation for GFAAS is available from many commercial sources, and a recommended analytical method is described in some detail here. Commercial ASV instrumentation specifically for the BPb analysis is currently available from a single manufacturer. A detailed ASV procedure, which includes use of a proprietary reagent, is provided by the manufacturer. In keeping with NCCLS policy, details of the commercial ASV method are *not* duplicated here; rather, the procedure is summarized, and specific recommendations are given that can help with troubleshooting performance problems. Several other methods are reviewed for their application to BPb measurements, including Delves-cup microsampling flame AAS and inductively coupled-plasma mass spectrometry (ICP-MS). As a relatively high-cost, multielement technique, ICP-MS is unlikely to be used for BPb measurements in most routine situations.

Foreword (Continued)

Analytical chemistry is an evolving science, with new innovative technologies appearing continually. It is quite likely that new, inexpensive, portable technologies for BPb will appear in the future. While it is not possible to address these emerging technologies in the current document, they will no doubt be included in future revisions.

In producing C40-A, the intention of the NCCLS Subcommittee on Lead was to reach a consensus, so an approved guideline can be distributed to laboratories that carry out lead determinations in blood and urine specimens. The subcommittee also intended for the document to be broad in perspective and, thus, an educational resource for laboratorians.

Standard Precautions

Because it is often impossible to know what might be infectious, all human blood specimens are to be treated as infectious and handled according to "standard precautions." Standard precautions are new guidelines that combine the major features of "universal precautions and body substance isolation" practices. Standard precautions cover the transmission of any pathogen and thus are more comprehensive than universal precautions which are intended to apply only to transmission of blood-borne pathogens. Standard precaution and universal precaution guidelines are available from the U.S. Centers for Disease Control and Prevention (*Guideline for Isolation Precautions in Hospitals*. Infection Control and Hospital Epidemiology. CDC. 1996;Vol 17;1:53-80.), [MMWR 1987;36(suppl 2S):2S-18S] and (MMWR 1988;37:377-382, 387-388). For specific precautions for preventing the laboratory transmission of blood-borne infection from laboratory instruments and materials; and recommendations for the management of blood-borne exposure, refer to NCCLS document M29—*Protection of Laboratory Workers from Instrument Biohazards and Infectious Disease Transmitted by Blood, Body Fluids, and Tissue*.

Key Words

Analysis, anodic stripping voltammetry, blood, electrothermal atomic absorption spectrometry, graphite furnace, lead poisoning, quality control, reference materials, urine

Abbreviations

AAS	Atomic absorption spectrometry
APDC	Ammonium pyrrolidine dithiocarbamate
ASV	Anodic stripping voltammetry
BPb	Blood lead
CDC	Centers for Disease Control and Prevention
CRM	Certified reference material
CV	Coefficient of variation (synonymous with RSD)
DL	Detection limit
DMSA	2,3-dimercaptosuccinic acid
EDL	Electrodeless discharge lamp
EDTA	Ethylenediaminetetraacetic acid
EP	Erythrocyte protoporphyrin
ETAAS	Electrothermal atomic absorption spectrometry
FAAS	Flame atomic absorption spectrometry
FPP	False-positive proportion
GFAAS	Graphite-furnace atomic absorption spectrometry
HCL	Hollow-cathode lamp
ICP-MS	Inductively coupled plasma mass spectrometry

Abbreviations (Continued)

ID	Isotope dilution
IFCC	International Federation of Clinical Chemistry
ISO	International Organization for Standards
IUPAC	International Union of Pure and Applied Chemistry
LC	Liquid chromatography
LDC	Lowest determinable concentration
MIBK	Methylisobutylketone
m_o	Characteristic mass
NHANES	National Health and Nutrition Examination Surveys
NIST	National Institute of Standards and Technology
NRSCL	National Reference System for the Clinical Laboratory
PT	Proficiency test(ing)
OSHA	Occupational Safety and Health Administration
QC	Quality control
RM	Reference material
RSD	Relative standard deviation (synonymous with CV)
SD	Standard deviation
SI	Système International d'Unités
SRM	Standard reference material
STPF	Stabilized temperature platform furnace
TCA	Trichloracetic acid
TIMS	Thermal ionization mass spectrometry
UPb	Urine lead
ZPP	Zinc protoporphyrin

Analytical Procedures for the Determination of Lead in Blood and Urine; Approved Guideline

1 Introduction

The primary aim of this document is to provide clinical laboratories with concise guidelines for measuring lead in blood and urine. It includes specimen collection and measurement by the two principal analytical methods currently in routine use: electrothermal atomic absorption spectrometry (ETAAS), also widely known as graphite furnace atomic absorption spectrometry (GFAAS); and anodic stripping voltammetry (ASV). The document also includes guidelines for quality assurance, quality control, and information on proficiency testing programs and laboratory certification. In developing this guideline the subcommittee recognizes that a single-standard method for GFAAS may not be possible given the complexity of the analytical instrumentation required and the different ways in which manufacturers implement similar features. Furthermore, there is currently only one commercial source of ASV equipment available specifically for BPb measurements. The analyst is free to choose which technique best suits the laboratory's needs, and may modify the recommended procedure to achieve successful analyses. However, whether following the recommended procedure or a modified version, the analyst is responsible for ensuring that the procedure adopted in the laboratory is validated as described under the relevant section.

2 Scope

This document is provided for all laboratories attempting the determination of lead in blood or urine. Laboratories new to the analysis will benefit from the many years of experience accumulated in the laboratories of the committee members, advisors, and observers. A background section on the clinical significance of lead measurements is included to help laboratorians and others understand the context in which these measurements are made. Recommended procedures for collecting blood (both capillary and venous) and urine specimens are given. A detailed analytical procedure is recommended for use with GFAAS equipment. Since an ASV method for BPb is provided by the equipment manufacturer, a detailed procedure is not duplicated here but is summarized. Furthermore, some useful information is included in the ASV section to help users avoid performance problems. Other analytical methods are referenced either within a historical context (e.g., Delves-cup AAS) or with respect to specialized applications (e.g., ICP-MS).

The International Federation of Clinical Chemistry (IFCC) and the International Union of Pure and Applied Chemistry (IUPAC) recommend the exclusive use of the liter as unit of volume when reporting laboratory results using the SystΠme International d'Unitϑs (SI). Many published BPb values are universally reported as mass concentration (unit µg/dL, µg/100 mL) rather than as substance concentration (unit µmol/L). Pediatric urine lead (UPb) measurements are also reported as mass concentration (unit µg/L) and, given the total volume of urine collected, the total lead excreted is calculated and reported (unit µg). In this document, the units for BPb are µg/dL; the units for UPb are µg/L. The IUPAC/IFCC-recommended units of substance (elemental) concentration (µmol/L, µM) are included in parentheses, where appropriate. Conversion factors are given below:

blood lead (µg/dL) x 0.04826 = blood lead (µmol/L)

urine lead (µg/L) x 0.004826 = urine lead (µmol/L)