NEWBORN BLOOD SCREENING

I. DEFINITION:

Newborn screening consists of tests performed on blood specimen spots collected on filter paper to identify rare hidden disorders and a test performed by the birthing facility to identify critical congenital heart disease (CCHD) utilizing pulse oximetry screening. According to Oklahoma law 63 O.S.1981, Sections 1-533 and 1-534 and the Oklahoma State Department of Health (OSDH) *Newborn Screening Program Regulations* (2004), all infants born in Oklahoma are required to be screened for phenylketonuria (PKU) and other Amino Acid disorders (started May 27, 2008), congenital hypothyroidism, classic galactosemia, sickle cell diseases, congenital adrenal hyperplasia (started February 14, 2005), cystic fibrosis (started February 14, 2005) and medium chain acyl coenzyme A dehydrogenase deficiency (started June 5, 2006) and other Fatty acid disorders (started September 15, 2008), Organic acid disorders (started October 20, 2008), Biotinidase deficiency (started November 1, 2010), and CCHD via pulse oximetry screening. Due to the time sensitivity for pulse oximetry screening for CCHD, the county health departments are not responsible for screening or providing follow-up measures related to CCHD. For information regarding time of screening, please review Time of Screening & Follow-up Fact Sheet.

II. ETIOLOGY AND EPIDEMIOLOGY:

A. **Amino Acid Disorders** (see attached fact sheets)

1. Amino acid disorders are caused by the body's inability to breakdown or metabolize certain amino acids in proteins, or by the inability to detoxify the by-product of amino acids (ammonia) through the urea cycle. The buildup of amino acids and/or by-products of amino acid metabolism in the blood cause severe medical complications.

2. The presentation of the various aminoacidopathies varies from no obvious clinical symptoms for months (phenylketonuria), to acute encephalopathy (maple syrup urine disease, citrullinemia, argininosuccinic aciduria) within days following birth.

3. Lack of early identification and treatment may result in serious medical consequences, including mental retardation, developmental delays, failure to thrive, and/or death.

4. The most common found amino acid disorder is phenylketonuria (PKU). PKU screening began in 1963 and became law in 1967. PKU occurs at rates of 1 in 23,244 among Oklahoma live births. The disease is characterized by the body's failure to convert the amino acid phenylalanine to tyrosine due to a deficiency or lack of the enzyme phenylalanine hydroxylase. This disorder can lead to mental retardation if not treated with a low phenylalanine diet beginning within the first month of life.

5. Screening for other Amino Acid disorders began in May of 2008. They include Argininemia (ARG), Arginosuccinic aciduria (ASA), Citrullinemia type 1 (CIT), Citrullinemia type II (CIT II), Homocystinuria (HCY), Hypermethioninemia (MET), Maple Syrup Urine Disease (MSUD), Tyrosinemia type I, Tyrosinemia type II, and Tyrosinemia type III.

6. Amino acid disorders are autosomal recessive, which means that an amino acid disorder is inherited when both parents pass an abnormal amino acid gene to their child. This means that both parents are carriers of a particular amino acid disorder.

7. When two carriers of a particular amino acid disorder have children together, there is a 1 in 4 (25%) chance for each baby to have the amino acid disorder.

B. **Congenital Hypothyroidism (CH)**

1. Screening began in 1979. CH is a condition characterized by a lowered rate of metabolism due to deficiency of thyroid hormone (thyroxine) production.
2. This disorder occurs in 1 out of 3,000 infants born in Oklahoma. This disorder can lead to mental retardation and growth delays if not treated with daily thyroid hormone replacement within the first month of life.

C. **Classic Galactosemia**

1. Screening began in 1991.

2. Galactosemia is an inherited disorder (autosomal recessive) characterized by the body's failure to break down galactose due to a deficiency or lack of the enzyme galactose-1-phosphate uridyl transferase. This defect in carbohydrate metabolism can lead to failure to thrive, liver disease, cataracts, mental retardation and death if not treated with a lactose-free diet beginning within the first month of life.

3. This disorder occurs in 1 in 40,000 among Oklahoma live births.

D. **Sickle Cell Disease** and hemoglobinopathies

1. Screening began in 1991.

2. Hemoglobinopathies refers to trait conditions, sickle cell diseases, or hemoglobin diseases (see PHYSICIAN APPROVED PROTOCOL: HEMOGLOBINOPATHY SCREENING).

3. Sickle cell disease is the term used to identify disorders in which the red blood cells sickle under stress. Sickle cell diseases are a group of genetic disorders that are autosomal recessive. For disease to occur, the individual must receive a non-working hemoglobin gene from each parent.

4. A "Trait" or "Carrier" condition indicates that the individual has inherited one working hemoglobin gene (A) and one non-working hemoglobin gene. Individuals with trait can pass on the non-working gene to their offspring. The most common trait conditions are sickle cell trait and hemoglobin C trait, which occur at rates of 1:16 and 1:47 respectively among the African-American population in Oklahoma.

5. If the patient inherits non-working genes from both parents, he or she is not able to make any normal hemoglobin and has a disease state.

Sickle cell diseases vary in severity, but can result in sepsis and death if treatment with prophylactic penicillin is not started within the first two months of life.

6. The most common forms are sickle cell anemia (hemoglobin SS disease) and hemoglobin SC disease, which occur in 1:400 and 1:900 among African-American births in Oklahoma.

E. **Cystic Fibrosis (CF)**

1. Screening began February 14, 2005 (see attached fact sheet).

2. CF is an inherited disorder (autosomal recessive) that occurs in approximately 1 in every 3,200 Caucasian births (1 in 3,900 live births of all Americans).

3. Genetic alterations in both CF genes (CFTR) affect the normal passage of chloride in certain cells. This produces thick, sticky mucus that clogs the lungs and leads to breathing problems and frequent lung infections. It may also obstruct the pancreas preventing digestive enzymes from reaching the intestines causing malnutrition.

4. Early treatment with special formulas, supplemental feedings, pancreatic enzymes and vitamins prevents or ameliorates malnutrition and improves growth.

5. Carriers for CF have a genetic alteration in one of the two CF genes.

F. **Congenital Adrenal Hyperplasia (CAH)**

1. Screening began February 14, 2005 (see attached fact sheet).

2. CAH is a group of inherited (autosomal recessive) disorders that affects the adrenal glands.

3. It is caused by a deficiency of an enzyme needed for the adrenal glands to function properly. There are two main forms of the disorder: Classical CAH and Non-Classical.

4. Screening is designed to detect classical CAH due to 21-hydoxylase enzyme deficiency. In Classic CAH 21-hydroxylase deficiency, newborns have excessive adrenal androgen biosynthesis which results in genital virilization (enlargement of the clitoris/ambiguous genitalia) and some will have salt-wasting. Classical CAH (severe enzyme deficiency) occurs in approximately 1 in 15,000 births and is a potentially life-threatening disorder that requires life-long management.

5. The classic form is further divided into the simple virilizing form (25% of affected) and the salt-wasting form in which aldosterone production is inadequate (75% of affected). Screening may detect non-classical CAH (moderate enzyme deficiency), a milder form of CAH that is not life-threatening. Females with the non-classic form are not virilized at birth.

6. Early treatment with hormones prevents death due to salt wasting crisis and in girls prevents incorrect sex assignment.

G. **Fatty Acid Oxidation Disorders**

1. Screening for MCAD began in 2005 and then expanded to other fatty acid oxidation disorders in September 2008 (see attached fact sheet).

2. Fatty acid oxidation disorders including Medium **chain acyl coenzyme A dehydrogenase deficiency (MCAD)** prevent the body from using certain fats for energy, particularly during periods without food (fasting).

3. The most common found fatty acid oxidation disorder is medium chain acyl coenzyme A dehydrogenase deficiency (MCAD). MCAD screening began on June 5, 2006. MCAD is an inherited disorder (autosomal recessive) that occurs at rates of 1 in 15,000 to 1 in 20,000 live births. The disease is characterized by the body's failure to convert medium chain fatty acids into energy due to a lack of the enzyme medium chain acyl coenzyme A dehydrogenase.

4. Fatty acid oxidation disorders can lead to metabolic crisis, respiratory failure, cardiac arrest and death if not treated.

5. Screening for other fatty acid oxidation disorders began in September 2009.

6. They include Carnitine Uptake Defect (CUD), Short-chain acyl-Co-A dehydrogenase Deficiency (SCAD), Glutaric Acidemia Type II (GAII), Medium-chain Ketoacyl-Co-A thiolase deficiency (MCAT), Very long-chain acyl-CoA dehydrogenase deficiency (VLCAD), Carnitine acylcarnitine translocase deficiency (CACT). Carnitine palmitoyltransferase I deficiency (CPT IA), Carnitine palmitoyltransferase II deficiency (CPT II), Long chain L-3-hydroxyacyl- CoA dehydrogenase deficiency (LCHAD), and Trifunctional protein deficiency (TFP).

7. Fatty acid disorders are autosomal recessive, which means that a fatty acid disorder is inherited when both parents pass an abnormal fatty acid gene to their child. This means that both parents are carriers of a particular fatty acid disorder.

8. When two carriers of a particular fatty acid disorder have children together, there is a 1 in 4 (25%) chance for each baby to have the fatty acid disorder.

H. **Organic Acid Disorders**

1. Screening for Organic Acid disorders began in October 2008 (see attached fact sheet).

2. Organic acid disorders are caused by the body's inability to process certain proteins and/or fats properly.

3. Treatment includes strict dietary management and may include medication.

4. These disorders can lead to metabolic crisis, respiratory failure, cardiac arrest and death if not treated.

5. They include Propionic Acidemia (PROP), Methylmalonic academia (MUT), Malonic Acidemia (MAL), Isobutyrylglycinuria (Isobutyrylglycinuria CoA dehydrogenase deficiency (IBG), Isovaleric Acidemia (IVA), 2-Methylbutyrlglycinuria (2MBG), 3-Methylcrotonyl-CoA carboxylase deficiency (3MCC), 3-Methylglutaconic aciduria (3MGA), 3-Hydroxy-3-methyglutaric aciduria (HMG), Holocarboxylase synthetase deficiency (multiple carboxylase deficiency) (MCD), 2-Methyl-3 hydroxybutyric aciduria (2M3HBA), Beta ketothiolase deficiency (βKT), and Glutaric acidemia type 1 (GA1).

6. Organic acid disorders are autosomal recessive, which means that an organic acid disorder is inherited when both parents pass an abnormal organic acid gene to their child. This means that both parents are carriers of a particular organic acid disorder.

7. When two carriers of a particular organic acid disorder have children together, there is a 1 in 4 (25%) chance for each baby to have the organic acid disorder.

I. Biotinidase Deficiency.

1. Biotinidase Deficiency screening began November 1, 2010.

2. Biotinidase deficiency is an inherited disorder (autosomal recessive) that occurs in approximately 1 in 60,000 newborns.

3. Biotinidase deficiency characterized by the body's inability to reuse and recycle the vitamin biotin.

4. Bitinidase deficiency is also known as late-onset multiple carboxylase deficiency. Partial biotinidase deficiency is a milder form of this condition.

5. Treatment includes oral biotin supplementation.

6. Biotinidase deficiency disorder is autosomal recessive, which means that a biotinidase deficiency disorder is inherited when both parents pass an abnormal biotinidase deficiency gene to their child. This means that both parents are carriers of biotinidase deficiency disorder.

7. When two carriers of biotinidase deficiency disorder have children together, there is a 1 in 4 (25%) chance for each baby to have the biotinidase deficiency disorder.

J. Critical Congenital Heart Disease (CCHD)

1. Critical Congenital Heart Disease screening began July 1, 2013.

2. Critical congenital heart disease is characterized by an abnormal structure to the heart which creates abnormal blood flow patterns.

3. Treatment may include surgical repair or cardiac catheterization.

4. CCHD occurs in approximately 8 out of every 1,000 babies born.

III. CLINICAL FEATURES:

A. **Amino Acid Disorders including Phenylketonuria (PKU)**

1. The newborn may have no signs or symptoms.

2. Symptoms of an untreated infant or child may include failure to thrive, irritability, urine with a musty odor, developmental delay, and impaired postnatal physical growth affecting head circumference (microcephaly) and height.
3. Dermatology symptoms include eczema, hypopigmentation, and scleroderma.

4. Older males have reduced semen volume and sperm count.

5. Untreated or inadequately treated patients may present with developmental delay, behavioral disorders, hyperactivity, impaired thinking, altered perception, memory problems, depression, agoraphobia, anxiety, aggression, self-abuse, and mental retardation.

6. An affected patient who never received treatment from infancy to adulthood will suffer profound mental retardation.

7. Amino acid disorders that affect the urea cycle may exhibit the following symptoms: hyperammonemia, tachypnea, vomiting, and respiratory alkalosis. Severe hyperammonemia in a newborn is a medical emergency.

8. If symptoms present after neonatal period they are very like that of Reye Syndrome.

9. These disorders are autosomal recessive genetic conditions. Most infants are born to parents who are both unknowingly asymptomatic carriers and have NO known history of an amino acid disorder in their family.

10. The aggregate incidence of these disorders is approximately 1/10,500 with some disorders that are rarer in the population. Newborns with these disorders often appear normal initially but can rapidly develop life threatening symptoms.

11. Lifelong treatment includes a special diet and special care during times of illness or stress.

B. **Congenital Hypothyroidism**

1. The affected newborn appears normal at birth and may not present clinically with symptoms until the hypothyroidism is severe and long standing.

2. Clinical symptoms include a large posterior fontanel, prolonged jaundice, macroglossia, hoarse cry, distended abdomen, umbilical hernia, puffy face, cold extremities, persistent constipation, and hypotonia.

3. Inadequate or delayed treatment can result in developmental disability.

Not treating an affected patient will result in mental and growth retardation.

C. **Classic Galactosemia**

1. Infants may have no signs or symptoms, but frequently have vomiting and formula intolerance.

2. Without treatment, affected infants will exhibit failure to thrive, jaundice, enlarged liver, liver failure, kidney failure, sepsis, and cataracts.

3. Although children with galactosemia are started on diet restriction at birth, there continues to be a high incidence of long term complications involving speech and language, fine and gross motor skill delays, and specific learning disabilities. Ovarian failure may occur in girls.

4. Not treating the affected newborn may result in mental retardation or death.

D. **Sickle Cell Disease** and hemoglobinopathies

1. Infants with sickle cell disease usually have no signs or symptoms at birth.

2. The first manifestations of the disease usually include anemia, colic-like symptoms, and feeding difficulties.

3. Painful episodes in young children are often precipitated by an acute febrile illness.

4. Without newborn screening, presentation of symptoms commonly occurs at one to three years of age. The affected child may present with acute anemia, hand-foot syndrome, splenic sequestration, pain or devastating infection.

5. No treatment may result in severe illness or death.

Note: Penicillin prophylaxis for sickle cell disease should begin at 1 or 2 months of age.

Fever Alert: If a child with sickle cell disease has a fever of 101^0 or greater immediate, medical intervention is required. The child must be referred promptly to an emergency room for a septic workup and IV antibiotics. For a copy of the Fever Management Guidelines for Infants with Sickle Cell Disease, please contact the newborn screening program at (405) 271-6617 or Sickle Cell Program at (405) 271-5311.

E. **Cystic Fibrosis (CF)**

1. Approximately 10-20% of newborns with CF have meconium ileus.

2. Symptoms can vary greatly with the most common clinical symptoms including recurrent cough, wheezing, frequent lung infections, chronic abdominal pain, loose stools and failure to thrive. Often, infants have very salty-tasting skin.

3. Failure to treat an affected patient can result in severe malnutrition and impaired growth.

F. **Congenital Adrenal Hyperplasia (CAH)**

1. Salt wasting (Classical CAH) symptoms include poor feeding, weight loss, failure to thrive, vomiting, dehydration, hypotension, hyponatremia, and hyperkalemia progressing to adrenal crisis (azotemia, vascular collapse, shock and death).

2. Adrenal crisis can occur as early as one to four weeks of age.

3. Simple virilizing (Classical CAH) has prenatal virilization of external genitalia without salt-wasting.

4. Without newborn screening, males are at greatest risk for being discharged home without a diagnosis and experience a salt-wasting crisis at home. Females are usually identified due to the clinical presentation of ambiguous genitalia; however, screening has prevented missed sex assignment.

5. Non-classical CAH (mild form of CAH) symptoms can occur at any time from infancy through adulthood and include premature puberty, rapid growth in childhood with ultimate short stature, hirsutism, oily hair and skin, severe cystic acne, polycystic ovary syndrome and infertility.

G. **Fatty Acid Oxidation Disorders including Medium chain acyl coenzyme A dehydrogenase deficiency (MCAD)**

1. The affected newborn appears normal at birth.

2. Infants are typically asymptomatic until the infant is weaned from nighttime feeds and experiences a period of fasting (in an infant defined as more than 3 to 4 hours without feeding).

3. Clinical symptoms are notable during periods of acute illness or fasting and include hypoglycemia (often hypoketotic hypoglycemia), lethargy, hepatomegaly and hyperammonemia.

4. During the intervals between episodes of illness, patients typically appear completely well. There is no muscle weakness, however some patients are impressively hypotonic and display a reluctance to exercise or poor muscle strength.

5. Inadequate or delayed treatment can result in metabolic crisis resulting is developmental disability or death.

6. Not treating an affected patient will result in metabolic crisis causing severe brain damage, developmental delay, respiratory failure, cardiac arrest and death.

7. These disorders are autosomal recessive genetic conditions. Most infants are born to parents who are both unknowingly asymptomatic carriers and have NO known history of a Fatty Acid disorder in their

family. The aggregate incidence of these disorders is approximately 1/7100 with some disorders that are rarer in the population.

8. Newborns with these disorders often appear normal initially but can rapidly develop life threatening symptoms.

9. Lifelong treatment includes a special diet and special care during times of illness or stress.

H. **Organic Acid Disorders**

1. The affected newborn appears normal at birth.

2. Organic acid disorders can manifest as a life-threatening sepsis-like picture of feeding difficulties, lethargy, vomiting, and seizures.

3. Metabolic acidosis almost always accompanies this presentation and hyperammonemia is common.

4. These disorders are autosomal recessive genetic conditions. Most infants are born to parents who are both unknowingly asymptomatic carriers and have NO known history of an organic acid disorder in their family. The aggregate incidence of these disorders is approximately 1/11,500 with some disorders that are rarer in the population.

5. Newborns with these disorders often appear normal initially but can rapidly develop life threatening symptoms.

6. Lifelong treatment includes a special diet and special care during times of illness or stress.

I. **Biotinidase Deficiency**

1. The affected newborn appears normal at birth.

2. Clinical symptoms begin over a few weeks to several years.

3. Children with profound biotinidase deficiency may exhibit ataxia, hypotonia, developmental delay, conjunctivitis, skin rash, alopecia, seizures, hearing loss, breathing problems and optic atrophy.

4. Not treating an affected patient will lead to metabolic ketoacidosis and organic aciduria.

5. Clinical symptoms may vary depending of the amount of dietary biotin intake.

J. Critical Congenital Heart Disease (CCHD)

1. The affected newborn appears normal at birth.

2. Clinical symptoms begin over a few days to weeks.

3. Children with a critical congenital heart disease have an abnormal structure to their heart which creates abnormal blood flow patterns.

4. Not treating an affected infant may lead to developmental delays, neurologic injury, cardiogenic shock, or death.

IV. MANAGEMENT PLAN:

A. Laboratory Studies:

1. All infants seen by a health care provider in the first 3 months of life should have results of the newborn dried blood spot screen documented in the medical record. If unable to verify that a screen occurred, a specimen should be obtained immediately.

   a. Ideally screen results should be documented in the medical record by one - two weeks of age. This may require the infant enter into a tracking system.

   b. To obtain screening results call the 24 hours a day, 7 day a week automated **Voice Response System (VRS)** at 405-271-4774 (local area) or 1-877-542-9111 (toll-free). To access the VRS, a submitter ID and PIN number are required. To access individual test results, the mother's social security number or the infant's filter paper serial number are required.

   c. To obtain or verify a submitter ID and/or PIN number, please call the Newborn Screening Laboratory 405-271-5070 or the Follow-up Program at 405-271-6617 or 1-800-766-2223.

2. **All infants with unsatisfactory initial filter paper screen must have a repeat test done within 48 hours.**

3. All infants tested prior to 24 hours of age should have a repeat test done at 3 to 5 days of age. For premature or sick infant testing, please review the Time of Screening Fact Sheet.

4. All newborns must be tested for amino acid disorders including phenylketonuria, congenital hypothyroidism, galactosemia, sickle cell disease, congenital adrenal hyperplasia, cystic fibrosis, and fatty acid disorders including medium- chain acyl coenzyme A dehydrogenase deficiency, organic acid disorders, and biotinidase deficiency. For time of testing, reference Time of Screening & Follow-up Fact Sheet.

5. The OSDH Public Health Lab will provide hemoglobin trait testing for parents of newborns identified with a hemoglobin trait or disease.

6. Testing is done using the Newborn Screening Kit ODH #450. To order kits, please contact the Public Health Laboratory Service, Oklahoma State Department of Health, P.O. Box 24106, Oklahoma City, Oklahoma 73124, by phone at (405) 271-5070, or utilize the OSDH website.

7. It is essential that all information on the Newborn Screening Kit laboratory requisition be completed. Omitted information may cause the specimen to be discarded or may delay testing. Fill out all demographic information completely and accurately.

8. Instructions on how to draw, handle and mail is listed on the filter paper

laboratory requisition. It is important that the specimen be horizontally air dried for 3 hours. Do not place the specimen in a plastic bag. Specimens must be sent within 24 hours of collection. For an in-service on how to collect specimens or a parent education video, please contact the follow-up program at (405) 271-6617 or 1-800-766-2223.

9. Blood transfusions affect all screen results. Ideally, all newborns should have an initial screen collected prior to a blood transfusion. See Time of Screening and Follow-up Fact Sheet for more information.

B. Abnormal Laboratory Results:

1. Contact short term follow up at (405) 271-6617.

2. For follow-up of abnormal test results see Follow-up Procedures for Amino Acid Disorders including PKU, Hypothyroidism, Galactosemia, Sickle Cell Disease, Congenital Adrenal Hyperplasia, Cystic Fibrosis, and Fatty Acid Disorders including MCAD, Organic Acid Disorders, and Biotinidase Deficiency.

3. The OSDH Public Health Lab will provide routine monitoring of phenylaline levels for all cases identified with phenylketonuria (PKU).

4. All infants who have a positive pulse oximetry screen for CCHD must have additional testing and an evaluation performed by a physician prior to being discharged from the birthing facility.

C. A parent or guardian may refuse newborn screening or the pulse oximetry screening for their infant on the grounds that such examination conflicts with their religious tenets and practices. The refusal (see attached form) should be in writing and documented in the newborn's medical record with a copy sent to the OSDH Newborn Screening Nurse Coordinator.

D. **County Health Departments are not responsible for performing pulse oximetry screening or obtaining refusal for CCHD screening.**

V. RESOURCES:

A. Contact the Newborn Screening Short-term Follow-up Program for information regarding follow-up, formula program, publications, statistics and test results:

Oklahoma State Department of Health
Prevention & Preparedness Services
Screening & Special Services
1000 N.E. Tenth Street – Room 709
Oklahoma City, Oklahoma 73117-1299

Sharon Vaz, MSGC, RN
Director of Genetics
(405) 271-6617
Fax: (405) 271-4892
Voicemail: (405) 271-9444 ext. 56750
E-mail: SharonAV@health.ok.gov

Debbie Hines, RN
Newborn Screening Nurse Coordinator
(405) 271-6617
Fax: (405) 271-4892
Voicemail: (405) 271-9444 ext. 56822
E-mail: DeborahLH@health.ok.gov

Paula Vann, BSN, RN
Special Populations Nurse

(405) 271-6617
Fax: (405) 271-4892
Voicemail: (405) 271-9444 ext. 56752
E-mail: PaulaV@health.ok.gov

Lisa Caton, BSN, RN
Newborn Screening Quality Assurance and Education
(405) 271-6617
Fax: (405) 271-4892
Voicemail: (405) 271-9444 ext. 56737
E-Mail: LisaRC@health.ok.gov

B. Contact the Newborn Screening Laboratory for information regarding testing methods, filter paper orders, specimen collection, mailing instructions, submitted information and test results:

Oklahoma State Department of Health
Public Health Laboratory Service
Metabolic Disease Screening (MDS)
P.O. Box 24106
Oklahoma City, Oklahoma 73124-0106

Tonya McCallister, MS, MPH
Clinical Laboratory Scientist III
(405) 271-5070
Fax: (405) 271-4850
Email: TonyaJ@health.ok.gov

Soheila Haddad, MS
Clinical Laboratory Scientist III
(405) 271-5070
Fax: (405) 271-4850
Email: SoheilaH@health.ok.gov

C. For Fact Sheets on diseases, see OSDH website (http://nsp.health.ok.gov)

VI. TREATMENT:

A. **Amino Acid Disorders including Phenylketonuria (PKU)**

1. Treatment for Amino Acid disorders includes strict dietary management and may include medication. The diet needs to be managed by a metabolic specialist and a metabolic dietician. Special care may be required during times of stress or illness.

2. Urea cycle disorders (ARG, CIT) and MSUD are life threatening. Immediate intervention is warranted to prevent hyperammonemia, neurological deterioration, and death.

3. For PKU a low-phenylalanine diet is required for life. The PKU diet consists of limited amounts of certain fruits, vegetables, specially formulated low-protein food products and a medical formula that supplies the essential protein needed for normal growth and good health. A low-phenylalanine diet should begin before the infant is one to four weeks of age and continue for life. Treatment for other amino acid disorders should begin immediately after identifying a possible disorder and continue throughout life once the disorder has been confirmed.

4. Affected women of childbearing age must be on treatment prior to conception and during pregnancy to prevent mental retardation of the fetus.

5. Life-long comprehensive care by a metabolic specialist and nutritionist is essential for optimal neurological health.

B. **Congenital Hypothyroidism**

1. Daily thyroid hormone replacement is required. Treatment for the affected newborn should begin by one to four weeks of age and continue for life. Once on therapy, these children will require regular monitoring to ensure that they remain euthyroid during the rapid growth and development of infancy.

2. **Please be aware that L-thyroxine (synthroid) should not be mixed with soy formula as this product interferes with absorption.**

3. Comprehensive medical care in collaboration with a pediatric endocrinologist is necessary to ensure adequate treatment for normal growth and development.

C. **Classic Galactosemia**

1. Treatment requires strict exclusion of lactose/galactose from the diet.

2. Treatment for the affected newborn should begin by two to four weeks of age and continue for life.

3. Comprehensive care by a metabolic specialist and nutritionist is essential to ensure optimal health.

D. **Sickle Cell Disease**

1. To avoid sepsis and possible death, children with confirmed or suspected sickle cell disease must be on prophylactic penicillin within the first two months of life.

2. Comprehensive care by a pediatric hematologist is essential to ensure optimal health.

E. **Cystic fibrosis (CF**)

1. Treatment for the affected newborn should begin by 14 days of age and continue for life.

2. Nutritional therapies to treat and prevent malnutrition include special formulas, supplemental feedings and fat-soluble vitamins.

3. Pancreatic enzyme replacement may be required and is used to treat pancreatic insufficiency.

4. Current therapies to treat and prevent pulmonary complications may include chest physiotherapy and use of antibiotics, bronchodilators, anti-inflammatory drugs and mucolytic agents.

5. Comprehensive care provided by a CF Care Center is essential to ensure optimal health.

F. **Congenital Adrenal Hyperplasia (CAH)**

1. Treatment of CAH depends on the age of diagnosis and the clinical form

of CAH and must be continued for life.

2. An affected female fetus can avoid virilization of genitalia with prenatal administration of dexamethasone to the mother. Newborns with either the salt wasting or simple virilizing forms may require plastic surgery to restore the external genitalia to normal.

3. A multidisciplinary team of specialist in pediatric endocrinology, pediatric urology/surgery, medical genetics and psychology is essential for the diagnosis and management of the newborn with ambiguous genitalia.

4. The salt-wasting forms are treated with mineralocorticoid replacement (fludrocortisone) and sodium chloride to retain sodium and glucorticosteroids to stop the effects of androgen overproduction.

5. The simple virilizing forms are treated with glucocorticoids.

6. For the non-classical forms, treatment addresses pseudoprecocious puberty and growth acceleration.

7. In adult females the symptoms of concern are hirsutism, menstrual disorder and infertility.

8. Comprehensive care in collaboration with a pediatric endocrinologist is needed for optimal health outcomes.

G. **Fatty Acid Oxidation Disorder including Medium chain acyl coenzyme A dehydrogenase deficiency (MCAD)**

1. Treatment for fatty acid disorders should begin immediately after identifying a possible disorder and continue throughout life once the disorder has been confirmed.

2. Treatment of Fatty Acid disorders consists primarily of the avoidance of fasting. Feeding precautions are required and include scheduled feeding throughout the day and night. Parents are educated to keep a plentiful supply of readily accepted and tolerated oral carbohydrates in the home and to set an alarm during the night to ensure periods of fasting are avoided.

3. To prevent metabolic crisis and death, admission to a hospital and parenteral glucose are mandatory to manage vomiting or anorexia that prevents oral intake.

4. In some cases carnitine supplementation is recommended.

5. Lifelong comprehensive care in collaboration with a metabolic specialist and nutritionist is needed for optimal health outcomes.

H. **Organic Acid Disorders**

1. Treatment for organic acid disorders should begin immediately after identifying a possible disorder and continue throughout life once the disorder has been confirmed.

2. Treatment of Organic Acid disorders consist primarily of carnitine and/or glycine supplementation, protein restriction, and a disorder appropriate formula. Feeding precautions are required and include scheduled feeding throughout the day and night. Parents are educated to set an alarm during the night to ensure periods of fasting are avoided. The diet needs to be managed by a metabolic specialist and a metabolic dietician.

3. To prevent metabolic crisis affected infants need to have frequent feedings and special care during times of stress or illness.

I. **Biotinidase Deficiency**

1. Treatment for Biotinidase deficiency consists primarily of biotin supplementation. Treatment for the affected newborn should begin by two weeks of age.

2. Lifelong comprehensive care in collaboration with a metabolic specialist and nutritionist is needed for optimal health outcomes.

J. **Critical Congenital Heart Disease (CCHD)**

1. Treatment may include surgical repair or cardiac catheterization.

VII. NEWBORN BLOOD SCREENING FOLLOW-UP PROGRAMS:

A. The primary function of the follow-up component is to locate infants with screening results that are screen positive and to facilitate the entry of those infants into the diagnostic and management components of the newborn screening system in a timely fashion.

B. The newborn screening system consists of short-term and long-term follow-up.

C. To enhance effectiveness of the programs, the short and long-term follow-up programs require evaluation components including tracking and reporting of outcomes.

D. **Short term follow-up** begins when the laboratory obtains an initial result that is screen out-of-range and ends with a definitive diagnosis and documentation that appropriate treatment has been initiated regardless of the family's ability to pay.

E. **Long-term follow-up** begins with treatment and continues throughout life. Long-Term tracking and outcome evaluation are the responsibilities of the newborn screening program.

F. Short-term Follow-Up Program Staff

Newborn Screening Nurse Coordinator	Debbie Hines	(405) 271-6617
Newborn Screening Quality Assurance and Education Coordinator	Lisa Caton, BSN, RN	(405) 271-6617

Newborn Screening Nurse Special Populations Coordinator	Paula Vann, BSN, RN	(405) 271-6617
Newborn Screening LPN Consultant	Terry Geisler, LPN	(405) 271-6617
Director of Genetics & State Genetics Coordinator	Sharon Vaz, MSGC, RN	(405) 271-6617
Genetic Counselor	Sharon Vaz, MSGC, RN	(405) 271-6617

G. **Long Term Follow-Up Program Staff**

Metabolic Nurse Coordinator	Mary Monks BSN, RN	(405) 271-8001 ext. 42074 or (405) 271-8685
Metabolic Dietician	Ashley Ethriedge, RD, LD	(405) 271-8001 ext. 42450 or (405) 271-8685
Endocrine Newborn Screening Nurse Coordinator	Traci Schaffer, BSN, RN	(405) 271-8001 ext. 43051 or Pager (405) 575-8228
Sickle Cell Disease Nurse Coordinator (OKC)	Joyce Clytus, BSN, RN	(405) 271-5311
Sickle Cell Disease Clinic Coordinator (Tulsa)	Joyce Clytus, BSN, RN	(405) 271-5311
Healthy & Ready to Work; Sickle Cell Disease Coordinator	Delphine Dorsey, MPH, RN	(405) 271-8001 ext. 42527 or (405) 271-5311

VIII. PHYSICIAN REFERRALS:

The *Newborn Screening Program Regulations*, 2004, states all confirmed cases (congenital hypothyroidism, galactosemia, amino acid disorders including phenylketonuria, sickle cell disease, congenital adrenal hyperplasia, cystic fibrosis fatty acid disorders including medium-chain acyl coenzyme A dehydrogenase deficiency, organic acid disorders, and Biotinidase deficiency) should have a referral to a pediatric sub-specialist. The following pediatric sub-specialists and staff are available for consultation:

A. **Pediatric Endocrinologists**

Oklahoma City:	David Domek, M.D.	(405) 945-4525
	Piers Blackett, M.D.	(405) 271-6764
	Kenneth Copeland, M.D.	(405) 271-6764
	Steven Chernausek, M.D.	(405) 271-6764
	Minu George, M.D.	(405) 271-6764
	Sowmya Krishnan, M.D.	(405) 271-6764
	Jeanie Tryggestad, M.D.	(405) 271-6764
Tulsa:	David Jelley, M.D.	(918) 619-4803
	Laura Chalmers, M.D.	(918) 619-4803

B. **Metabolic Specialists**

Specialist:	Klaas Wierenga, M.D.	(405) 271-8685
	Susan Palmer, M.D.	(405) 271-8685
Dietician:	Ashley Ethriedge, R.D., L.D.	(405) 271-8001 Ext. 42450

C. **Pediatric Hematologists**

Oklahoma City:	Joan Cain, M.D.	(405) 271-5311
	Ashley Baker, M.D.	(405) 271-5311
Tulsa:	Ashraf Mohamed, M.D.	(918) 502-6720

D. **Pediatric Pulmonologist**

Oklahoma City:	James Royall, M.D.	(405) 271-6390
	Nighat Mehdi, M.D.	(405) 271-6390
Tulsa:	Joseph Walter, M.D.	(918) 502-2000
	Lee Droemer, M.D.	(918) 502-2000

IX. COUNSELING:

A. A newborn screening parent pamphlet has general information about the newborn screening blood test and the filter paper kit's detachable parent education slip has a brief description of each disorder. To order pamphlets send a request in writing (order form ODH 15) to OSDH, Shipping and Receiving, 1000 N.E. Tenth, Oklahoma City, OK, 73117-1299. **(Catalog Number: P-652-English and P652A-Spanish).**

B. For assistance in counseling health professionals or parents, utilize program educational materials located on the OSDH website or contact the Newborn Screening Program. Also refer to the PHYSICIAN APPROVED PROTOCOL: HEMOGLOBINOPATHY SCREENING.

C. Consultation regarding newborn screening results or follow-up can be obtained by contacting the Short-Term Follow-Up Program Staff at (405) 271-6617 or 1-800-766-2223.

D. All infants with confirmed Sickle Cell Disease, Sickle Cell Trait, Hemoglobin C Trait, Hemoglobin D/G Trait, and Hemoglobin E/O Trait should be referred for counseling:

- OUHSC Genetics Program (405) 271-8685 (Oklahoma City area)
- State Health Department Director of Genetics (405) 271-6617

E. For further information on hemoglobinopathies, please refer to the PHYSICIAN APPROVED PROTOCOL: HEMOGLOBINOPATHY SCREENING. The following are hemoglobinopathy pamphlets that can be utilized as counseling guides:

Hemoglobin C Trait:	Catalog Number P-545
Sickle Cell Trait:	Catalog Number P-547
About Sickle Cell Disease and Sickle Cell Trait:	Catalog Number P-562

F. **To order pamphlets send a request in writing (order form ODH 15)** to OSDH, Shipping and Receiving, 1000 N.E. Tenth, Oklahoma City, OK, 73117-1299 or fax request to (405) 271-4892.

REFERENCES:

OSDH - Newborn Screening Program Regulations, 2004.

Oklahoma State Department of Health Newborn Screening Program (NSP)

TIME OF SCREENING & FOLLOW-UP

Health Care Provider Fact Sheet - 2008

When should a **HEALTHY** NEWBORN be screened?

- **Ideal**: 24 hours plus one minute **OR**
- Immediately prior to discharge, whichever comes **first**.

What if baby is discharged prior to 24 hours of age?

- Collect specimen immediately prior to discharge.
- Notify parent/guardian that a repeat screen is required at 3-5 days of age.
- Distribute the blood collection kit's blue information sheet to the parent/guardian.

Special Care

Nursery

When should the **PREMATURE** or **SICK** newborn be screened? (Includes blood transfusion recipients)

- **Ideal**: 24 hours of age plus one minute
- **Maximum:** 3-7 days of age
- Prior to red blood cell transfusion if possible
- If screened prior to 24 house of age a repeat screen is required at 7-14 days of life.
- **Repeat screen** is also recommended at 14 days of age for **all** premature or sick infants.

What if baby is t**ransfused prior** to the collection of an Initial Screen? Ideally, **all** newborns should have an initial screen collected prior to a blood transfusion even if they are less than 24 hours old.

- Collect **initial** screen by the 7th day of life.
- Collect **TWO** Repeat screens:
  1. **7 days post transfusion** (recommended by Newborn Screening Program (NSP) consultants because plasma and/or red cells will again reflect the infant's own metabolic processes)
  2. **90 to 120** days of life (recommended by NSP consultants to evaluate Sickle Cell Disease)
- **Blood transfusions affect ALL screen results**

FOLLOW-UP REQUIREMENTS

- Record screen result in infant's chart (pertains to any infant examined in the first 3 months of life).
- If infant was on soy or a lactose-free formula at time of testing, the galactosemia screen is invalid:
  - Contact the NSP and request a GALT enzyme on initial specimen. (Specimens are destroyed 42 days after collection. If you suspect galactosemia **DO NOT** place the infant back on regular formula).
- Upon notification by the NSP, obtain required repeat testing in the timeframe specified so that therapy, when indicated, can be initiated expediently:
  - Report laboratory results not performed by the Public Health Laboratory, diagnosis, treatment date (if applicable), and referral information to the NSP within 7 days after completion of the medical evaluation.
  - Refer diagnosed cases to a pediatric sub-specialist and to the designated newborn screening long-term follow-up services.
  - If the parents cannot be contacted after a reasonable search, the NSP must be notified.

The Newborn Screening Program Blood Test Screens for congenital hypothyroidism, classic galactosemia, phenylketonuria (PKU) and other amino acid disorders, sickle cell disease, cystic fibrosis, congenital adrenal hyperplasia, medium-chain acyl coenzyme A dehydrogenase deficiency (MCAD) and other fatty acid disorders, organic acid disorders, biotinidase deficiency. Screening can detect healthy carriers of cystic fibrosis and sickle cell disease. Screening test are not diagnostic, false positives are expected and false negatives may occur.

INFORMATION (405) 271-6617 • 1-800-766-2223 • http://nsp.health.ok.gov

(Revised July 29, 2011)

Amino Acid Disorder (AA) Screening Fact Sheet for Health Care Providers
Newborn Screening Program of the Oklahoma State Department of Health

What are the characteristics of Amino Acid Disorders (AA)?

- Amino acid disorders are caused by the body's inability to breakdown or metabolize certain amino acids in proteins, or by the inability to detoxify the by-products of amino acids (ammonia) through the urea cycle.
- The buildup of amino acids and/or by products of amino acid metabolism in the blood cause severe medical complications.
- Autosomal recessive genetic conditions. Most infants are born to parents who are both unknowingly asymptomatic carriers and have NO known history of an Amino Acid disorder in the family.
- The incidence of all AA's are approximately 1/8000 live births with some disorders (PKU) occurring more frequently than others.
- Symptoms vary by disorder. Clinical symptoms vary from no clinical symptoms for months (phenylketonuria), to acute encephalopathy (maple syrup urine disease, citrullinemia, argininosuccinic aciduria) within in hours/days following birth. In each of these disorders, the lack of early identification and treatment may result in serious medical consequences, including mental retardation, developmental delays, failure to thrive and /or death.
- Treatment involves a special diet managed by a metabolic specialist and a metabolic dietician, frequent feedings, and special care during times of illness or stress.

What is the screening methodology for Amino Acid disorders?
An amino acid profile by Tandem Mass Spectrometry (MS/MS) is performed on each filter paper.
Analytes are simultaneously tested on each filter paper.
Analyte results are used to establish results requiring follow-up. All out-of-range analyte results require follow-up.

What are the follow-up needs?
The follow-up program will provide detailed guidance on needed actions. The following metabolic specialists have approved all recommendations:

- Klaas Wierenga, M.D. (405) 271-8685
- Susan Palmer, M.D. (405) 271-8685

Metabolic Nurse Specialist – Mary Monks RN – pager (405) 559-1378 phone (405) 271-8001 ext 42074

What is my role in screening?
If you are listed as the infant's planned health care provider on the filter paper requisition, you are required by the *Newborn Screening Program Regulations* to initiate follow-up activities.

Summary of out of range Amino Acid Analytes and follow-up recommendations.

Primary Marker (µmol/L)	Secondary Marker (µmol/L)	Potential Disorder	Risk*	Recommendation
Arginine 100 - <200	NA	ARG	LR	Repeat Filter paper. Consult metabolic specialist as needed.
Arginine ≥ 200	NA	ARG	HR	**Immediate** referral to metabolic specialist. Confirmatory testing
Citrulline ≥ 55	Cit/Arg ratio ≥ 6.5	CIT-I & CIT-II & ASA	HR	**Immediate** referral to metabolic specialist. Confirmatory testing
Methionine 100 - <160	NA	HCY & MET	LR	Repeat Filter paper. Consult metabolic specialist as needed.
Methionine ≥ 160	Met/Phe ratio ≥ 1.2	HCY & MET	HR	**Immediate** referral to metabolic specialist. Confirmatory testing
Leucine ≥ 300	Valine ≥ 280	MSUD	HR	**Immediate** referral to metabolic specialist. Confirmatory testing
Leucine ≥ 300	Leu/Phe ratio ≥ 4.8	MSUD	HR	**Immediate** referral to metabolic specialist. Confirmatory testing
Phenylalanine 150 - <182	NA	PKU & H-Phe& BIOPT	LR	Repeat Filter paper. Consult metabolic specialist as needed.
Phenylalanine ≥ 182	NA	PKU & H-Phe& BIOPT	HR	**Immediate** referral to metabolic specialist. Confirmatory testing
Tyrosine ≥ 400 & infant < 14 days of age	NA	TYR-I & TYR-II & TYR III	LR	Repeat Filter paper. Consult metabolic specialist as needed.
Tyrosine ≥ 400 & infant > 14 days of age	NA	TYR-I & TYR-II & TYR III	HR	**Immediate** referral to metabolic specialist. Confirmatory testing

Cut off values may change. Please contact the OK NBS Program for clarification if needed. More information is available on OSDH website or call (405) 271-6617.

*HR-High Risk
*LR-Low Risk

Newborn Screening Program (405) 271-6617 or 1-800-766-2223
Metabolic Nurse Specialist (405) 271-8685
http://nsp.health.ok.gov
Revised September 10, 2013
AA General Info- 1.1.1

AA Screening (ARG, CIT-I, CIT-II, ASA, HCY, MET, MSUD, PKU, H-Phe, BIOPT, TYR-I, TYR-II, TYR-III)
Oklahoma State Department of Health Newborn Screening Program – June, 2008

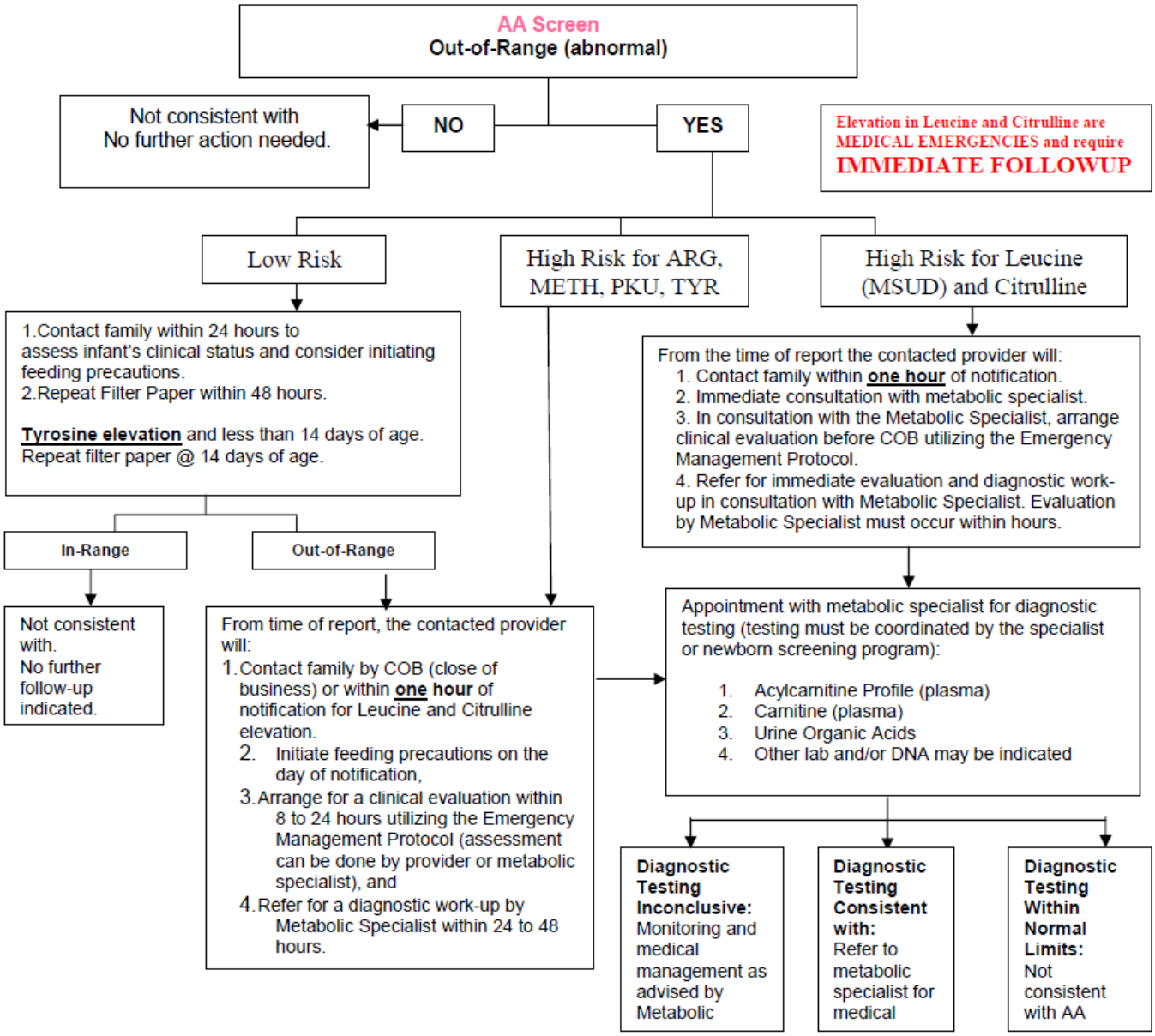

Table 1. In-range AA Screen Results[1]

Disorder	Primary Analyte (µmol/L)	Secondary Analyte (µmol/L)
ARG	Arginine < 100	NA
CIT-I, CIT-II, ASA	Cit < 55	Cit/Arg ratio < 6.5
HCY & METH	Methionine < 100	Met/Phe ratio < 1.2
MSUD	Leucine < 300	Valine < 280 & Leu/Phe ratio < 4.8
PKU, H-Phe, & BIOPT	Phenylalanine < 150	NA
TYR-I, TYR-II, TYR-III	Tyrosine < 400	NA

[1]These values are utilized for newborns less than 60 days old.
[2]Elevations of the secondary anylytes are reported as "not consistent with AA" if primary analyte is in range.

CONGENITAL HYPOTHYROIDISM FOLLOW-UP PROCEDURES

FILTER PAPER RESULTS	INDICATED PROCEDURES
TSH – Normal Range	If specimen was collected before the infant was 24 hours of age, a **Repeat Filter Paper (FP)** specimen should be collected and submitted to the Oklahoma State Department of Health (OSDH) Laboratory for testing when the infant is 3 to 5 days of age. Indicate specimen is a **repeat** on the filter paper requisition. Mark **"ALL TEST"**.
Abnormal TSH **30 - < 50 μIU/ml**	**Repeat Filter Paper** specimen should be collected and sent to the OSDH laboratory within 48 hours. Indicate specimen is a **repeat** on the filter paper requisition. Mark **"ALL TEST"**.
Abnormal TSH **≥ 50 μIU/ml**	**Serum Free T4 & TSH** should be drawn within 48 hours. This test cannot be done at the OSDH Laboratory. If serum results are abnormal, immediate referral to a pediatric endocrinologist is indicated.
Two Abnormal TSH Results on Filter Paper	**Serum Free T4 & TSH** should be drawn within 48 hours. This test cannot be done at the OSDH Laboratory. If serum results are abnormal, evaluation by a pediatric endocrinologist is indicated.

LABORATORY PROCEDURE:

Normal Filter Paper Result: TSH < 30 μIU/ml

A filter paper specimen refers to the Newborn Screening Kit ODH #450. Filter Paper Kits may be ordered from the Public Health Laboratory Service, OSDH, P.O. Box 24106, Oklahoma City, OK 73124-0106, call (405) 271-5070, or the OSDH website.

If a **Serum** Free T4 and TSH is indicated, a reference or hospital laboratory will have to be utilized. Serum Free T4 & TSH testing is not a service provided by the OSDH Laboratory.

For a **Pediatric Endocrinologist:**

Oklahoma City

David Domek, M.D.	(405) 945-4525
Kenneth Copeland, M.D.	(405) 271-6764
Piers Blackett, M.D.,	(405) 271-6764
Minu George, M.D.	(405) 271-6764
Sowmya Krishnan, M.D.	(405) 271-6764
Jeanie Tryggestad, M.D.	(405) 271-6764

Tulsa

David Jelley, M.D.	(918) 619-4803
Laura Chalmers, M.D.	(918) 619-4803

Questions regarding follow-up, please contact the Newborn Screening Short-term Follow-up Program at (405) 271-6617 or 1-800-766-2223 or fax to (405) 271-4892. Questions regarding laboratory procedure should be directed to the OSDH Lab at (405) 271-5070 or fax to (405) 271-4850.

GALACTOSEMIA FOLLOW-UP

FILTER PAPER RESULTS	INDICATED PROCEDURES
Total Galactose – Normal Range	If specimen was collected before the infant was 24 hours of age, a specimen should be collected and submitted to the Oklahoma State Department of Health (OSDH) Laboratory for testing when the infant is 3 to 5 days of age. Indicate specimen is a **repeat** on the filter paper requisition. Mark **"ALL TEST"**.
Total Galactose ≥ 10 mg/dl Enzyme Present	**Not consistent with classic galactosemia**. May indicate a variant form of galactosemia, carrier, or normal genotype. Repeat testing is at the discretion of the provider. Options may include a repeat filter paper or confirmation testing through a metabolic specialist. Free confirmation Galactose-a-Phosphate Uridyl Transferase (GAL-1-PUT) testing through OSDH is no longer available for this test result.
Galactose ≥ 17 mg/dl Enzyme Present	**Not consistent with classic galactosemia**. May indicate a variant form of galactosemia, carrier, or normal genotype. Since the galactose is significantly elevated, treatment (soy formula/lactose free-diet) and further testing may be indicated. Referral to a metabolic specialist indicated. Free confirmation GAL-1-PUT testing through OSDH is no longer available for this test result.
Total Galactose ≥ 7 mg/dl Low Enzyme	A repeat filter paper within 48 hours is recommended; however, if clinically indicated (i.e., a family history of classic or Duarte galactosemia and/or infant is symptomatic) treatment with soy formula and confirmatory testing may be needed. Indicate specimen is a **repeat** on the filter paper requisition. Mark **"ALL TEST"**.
Total Galactose ≥ 7 mg/dl No Enzyme	Start infant on a **soy formula** within 48 hours. Immediate referral to a metabolic specialist is indicated.
Two Abnormal Total Galactose Results on Filter Paper With Enzyme Low or Absent on Repeat	Start infant on a **soy formula** within 48 hours. Immediate referral to a metabolic specialist is indicated.

LABORATORY PROCEDURE
A two-tier screen is utilized:
1. Total Galactose level is tested on each filter paper.
2. If the Total Galactose level is elevated (i.e., ≥ 7 mg/dl) then GALT (enzyme testing) is performed**.**

Normal Filter Paper Result: Total Galactose < 7 mg/dl or
Total Galactose < 10 mg/dl with Enzyme Present

Note: If infant was on soy or a lactose-free formula at time of testing, a two-tier screen is required. To request an enzyme screen on an initial specimen, contact the Newborn Screening Program (NSP).

A filter paper specimen refers to the Newborn Screening Kit ODH #450. Filter paper kits may be ordered from the: Public Health Laboratory Service, OSDH, P.O. Box 24106, Oklahoma City, OK, 73124-0106, call (405) 271-5070, or the OSDH website.

For free GAL-1-PUT testing: Contact the Newborn Screening Program for free testing (405) 271-6617 or 1-800-766-2223. The Newborn Screening Nurse Coordinator must be contacted for arrangements and approval. **This is not a service routinely offered.**

For a **Metabolic Specialist:**

Klass Wierenga, M.D. (405) 271-8685
Susan Palmer, M.D. (405) 271-8685

Questions regarding follow-up, please contact the Newborn Screening Short-term Follow-up Program at (405) 271-6617 or 1-800-766-2223 or fax to (405) 271-4892. Questions regarding laboratory procedure should be directed to the OSDH Lab at (405) 271-5070 or fax to (405) 271-4850.

CYSTIC FIBROSIS FOLLOW-UP

FILTER PAPER RESULTS	INDICATED PROCEDURES
Immunoreactive Trypsinogen (IRT) **Normal Range**	If specimen was collected before the infant was 24 hours of age, a specimen should be collected and submitted to the Oklahoma State Department of Health (OSDH) Laboratory for testing when the infant is 3 to 5 days of age. Indicate specimen is a **repeat** on the filter paper requisition. Mark **"ALL TEST"**.
IRT ≥ 65 ng/ml & no (0) mutations*	**Not consistent with cystic fibrosis (CF) unless symptomatic or if there is a family history of Cystic Fibrosis**. Most consistent with a normal genotype. Approximately 1% of newborns with this type of test result will have CF. Confirmatory newborn sweat testing and genetic counseling indicated within 1 to 2 weeks **only if** symptomatic or if there is a family history of Cystic Fibrosis.
IRT ≥ 65 ng/ml & one (1) mutation	**Probable Carrier for CF or possible CF.** Confirmatory newborn sweat testing and genetic counseling indicated within 1 to 2 weeks. Confirmation testing and genetic counseling must be performed at a designated Newborn Screening Program (NSP) sweat testing site: OU Medical Center Sweat Testing Laboratory (405) 271-6161 Warren Clinic (918) 494-6568 To meet the special needs of newborns, these sites have an assigned day to perform the testing. Newborns should only be tested on the designated sweat test day for newborns.
IRT ≥ 65 ng/ml & two (2) mutations	**Consistent with CF.** Confirmatory newborn sweat testing and genetic counseling indicated within 1 to 2 weeks. Confirmation testing and genetic counseling must be performed at a designated Newborn Screening Program (NSP) sweat testing site: - OU Medical Center Sweat Testing Laboratory (405) 271-6161 - Warren Clinic (918) 494-6568 **To meet the special needs of newborns, these sites have an assigned day to perform the testing**. Newborns should only be tested on the designated sweat test day for newborns.

* There are over 1,200 CF mutations. The newborn screening program screens for 39+4 CF mutations. To view DNA testing panel, visit OSDH Web site **www://gp.health.ok.gov** . Please note, only newborns with an elevated IRT (i.e., ≥ 65 ng/ml) or if special request is made receive DNA testing.

LABORATORY PROCEDURE:

A two-tier screen is utilized: (1) Immunoreactive Trypsinogen (IRT) level is tested on each filter paper.
(2) If the IRT level is elevated, DNA testing is performed. This test is performed on the same sample by a contract laboratory.

Normal Filter Paper Result: IRT < 65 ng/ml OR IRT ≥ 65 ng/ml to < 170 ng/ml with no (zero) mutations.

A filter paper specimen refers to the Newborn Screening Kit ODH #450. Filter paper kits may be ordered from the: Public Health Laboratory Service, OSDH, P.O. Box 24106, Oklahoma City, OK, 73124-0106, call (405) 271-5070, utilize the OSDH website.

Free confirmatory sweat testing and genetic counseling, call Follow-up Program: (405) 271-6617 or 1-800-766-2223

For a **Sweat Test** Center:

Oklahoma City
OU Medical Center Laboratory Client Services (405) 271-6161

Tulsa
The Children's Hospital at Saint Francis (918) 494-6572

Newborn Screening Short-term Follow-up Program: (405) 271-6617 or 1-800-766-2223 or fax to (405) 271-4892
Public Health Laboratory: (405) 271-5070 or fax to (405) 271-4850

CONGENITAL ADRENAL HYPERPLASIA DUE TO 21-HYDROXYLASE DEFICIENCY FOLLOW-UP

FILTER PAPER RESULTS	INDICATED PROCEDURES
Birth Weight ≥ 2500 grams: **17 OHP ng/ml Steroid Profile** <30 & Not performed <55 & Normal Birth Weight < 2500 grams: **17 OHP ng/ml Steroid Profile** <50 & Not performed ≥50 & Normal	If specimen was collected before the infant was 24 hours of age, a specimen should be collected and submitted to the Oklahoma State Department of Health (OSDH) Laboratory for testing when the infant is 3 to 5 days of age. Indicate specimen is a **repeat** on the filter paper requisition. Mark **"ALL TEST".** If the newborn was premature or sick, a repeat screen at 14 days of age is recommended. Indicate specimen is a **repeat** on the filter paper requisition. Mark **"ALL TEST"**.
Birth Weight ≥2500 grams: **17 OHP ng/ml Steroid Profile** ≥55 to 80 & Pending 30 to 54 & Abnormal Birth Weight < 2500 grams: **17 OHP ng/ml Steroid Profile** ≥75 & Abnormal	**Borderline Congenital Adrenal Hyperplasia (CAH) Protocol:** - Monitor Basic Metabolic Panel (BMP) daily until final screen results are reported (if BMP is abnormal, promptly consult with a pediatric endocrinologist), - Repeat filter paper within 24 – 48 hours. Indicate specimen is a **repeat** on the filter paper requisition. Mark **"ALL TEST"**, - Monitor for signs and symptoms (S&S) of adrenal insufficiency (change in feeding patterns, poor weight gain, vomiting, diaphoresis, tachypnea, pale mucous membranes, hypoglycemia,and dehydration), and - Consult with a Pediatric Endocrinologist (within 24 hours) for any of the following: Abnormal BMP, Ambiguous genitalia, signs and symptoms of adrenal insufficiency, or abnormal repeat filter paper.
Birth Weight ≥ 2500 grams: **17 OHP ng/ml Steroid Profile** ≥55 & Abnormal >80 & Pending	**Presumptive for Congenital Adrenal Hyperplasia (CAH) Protocol:** - Contact family within 8 hours, - Clinically evaluate infant within 24 hours, - Lab work must include serum 17-OHP by DLO laboratories and Stat Basic Metabolic Panel (BMP), - Repeat filter paper (not required), - Assess infant for ambiguous genitalia and signs and symptoms of adrenal insufficiency, - After assessment and review of BMP results, consult with a pediatric endocrinologist (PE) for medical management recommendations (key information includes gestational age, steroid therapy, BMP values, and clinical assessment findings), - Refer to the OSDH ***Emergency Management Guidelines for Newborns with Abnormal CAH Screen Results,*** and - Inform family of signs and symptoms of adrenal insufficiency and course of action if symptoms present, utilizing the ***Parent Information Handout for Congenital Adrenal Hyperplasia*.** **Monitoring Protocol Pending Confirmatory Test Results:** 1. Immediately notify Pediatric Endocrinologist if infant becomes clinically unstable. 2. Upon receipt of 17-OHP results, contact the PE for management recommendations and final diagnosis.

LABORATORY PROCEDURE:

Normal Filter Paper Result: Birth Weight ≥ 2500 grams:

17 OHP ng/ml		**Steroid Profile**
<30	&	Not performed
<55	&	Normal

Birth Weight < 2500 grams:

17 OHP ng/ml		**Steroid Profile**
<50	&	Not performed
≥50	&	Normal

A two-tier screen is utilized:

1. 17-hydroxyprogesterone (17-OHP) level is tested on each filter paper.
2. If the 17-OHP level is elevated, the filter paper (same specimen) is sent to Mayo Laboratories for a steroid profile. The steroid profile includes testing for 17-OHP, androstenedione, and cortisol with determination of the following ratio: 17-OHP + androstenedione ÷ cortisol. Not all specimens receive steroid profile testing.

NOTE: Steroid (glucocorticoid) therapy may result in a false negative result, please contact program if newborn was on steroid therapy at time of testing.

A filter paper specimen refers to the Newborn Metabolic Disorder Screening Kit ODH #450. Filter paper kits may be ordered from the: Public Health Laboratory Service, OSDH, P.O. Box 24106, Oklahoma City, OK, 73124-0106, call (405) 271-5070, or utilize the OSDH website.

For a **Pediatric Endocrinologist**:

Oklahoma City		**Tulsa**	
David Domek, M.D.	(405) 945-4525	David Jelley, M.D.	(918) 619-4803
Kenneth Copeland, M.D.	(405) 271-6764	Laura Chalmers, M.D.	(918) 619-4803
Piers Blackett, M.D.,	(405) 271-6764		
Minu George, M.D.	(405) 271-6764		
Sowmya Krishnan, M.D.	(405) 271-6764		
Jeanie Tryggestad, M.D.	(405) 271-6764		

To contact the Newborn Screening Endocrinology Nurse:
Traci Schaeffer, R.N. (405) 271-6764 or Pager: (405) 575-8228

Questions regarding follow-up, please contact the Newborn Screening Short-term Follow-up Program at (405) 271-6617 or 1-800-766-2223 or fax to (405) 271-4892. Questions regarding laboratory procedure should be directed to the OSDH Lab at (405) 271-5070 or fax to (405) 271-4850.

Fatty Acid Oxidation Disorder (FAOD) Screening Fact Sheet for Health Care Providers
Newborn Screening Program of the Oklahoma State Department of Health

What are the characteristics of FAOD?

- Autosomal recessive genetic conditions. Most infants are born to parents who are both unknowingly asymptomatic carriers and have NO known history of a fatty acid oxidation disorder in the family.
- The incidence of FAOD's ranges from 1:10,000 to 1:100,000. MCAD is one of the most common with an incidence of 1:10,000. VLCAD and LCHAD are more rare.
- Symptoms vary by disorder. These disorders can lead to metabolic crisis, especially in infants and children. This crisis can lead to seizures, respiratory failure, cardiac arrest and death. Crisis survivors may experience significant developmental disabilities. Some infants will present during the neonatal period with life threatening symptoms.
- Treatment involves a special diet managed by a metabolic specialist and a metabolic dietician, frequent feedings, and special care during times of illness or stress.

What is the screening methodology for FAOD disorders?

An acylcarnitine profile by Tandem Mass Spectrometry (MS/MS) is performed on each filter paper.
Primary and secondary analytes are simultaneously tested on each filter paper.
Primary analyte results are used to establish results requiring follow-up. All out-of-range primary analyte results require follow-up.
Secondary analyte are used in conjunction with primary analyte results to assign risk.
Elevations of the secondary analytes are reported as "not consistent with FAOD" if the primary analyte is in range.

What are the follow-up needs?

The follow-up program will provide detailed guidance on needed actions. The following metabolic specialists have approved all recommendations:

- Klaas Wierenga, M.D. (405) 271-8685
- Susan Palmer, M.D. (405) 271-8685

Metabolic Nurse Specialist – Mary Monks, RN – pager (405) 559-1378 phone: (405) 271-8001 ext 42074

What is my role in screening?

If you are listed as the infant's planned health care provider on the filter paper requisition, you are required by the *Newborn Screening Program Regulations* to initiate follow-up activities.

Summary of out of range FAO Analytes and follow-up recommendations.

Primary Marker (μmol/L)	Secondary Analyte (μmol/L)	Potential Disorder	Risk*	Recommendation
C0 > 2.00 & ≤ 10.0	NA	CUD	LR	Repeat filter paper. Consult with metabolic specialist as needed.
C0 ≤ 2.00	NA	CUD	HR	**EMERGENCY. Immediate** referral to the metabolic specialist is required.
C4 ≥ 1.27	C4/C2 < 0.06	SCAD & GAII	LR	Repeat filter paper. Consult with metabolic specialist as needed.
C4 ≥ 1.27	C4/C2 ≥ 0.06	SCAD & GAII	HR	**Immediate** referral to the metabolic specialist is required.
C4 ≥ 2.00	NA	SCAD & GAII	HR	**Immediate** referral to the metabolic specialist is required.
C8 ≥ 0.40	C8/C10 < 3.0	MCAD & MCAT	LR	Repeat filter paper. Consult with metabolic specialist as needed.
C8 ≥ 0.40	C8/C10 ≥ 3.0	MCAD & MCAT	HR	**Immediate** referral to the metabolic specialist is required.
C14:1 ≥ 0.70	NA	VLCAD	HR	**Immediate** referral to the metabolic specialist is required.
C16 ≥ 7.46	C18:1 < 2.73	CACT & CPTII	LR	Repeat filter paper. Consult with metabolic specialist as needed.
C18:1 ≥ 2.73	C16 < 7.46	CACT & CPTII	LR	Repeat filter paper. Consult with metabolic specialist as needed.
C18:1 ≥ 2.73	C16 ≥ 7.46	CACT & CPTII	HR	**Immediate** referral to the metabolic specialist is required.
C0 ≥ 128	C0/(C16+C18)< 90	CPT1	LR	Repeat filter paper. Consult with metabolic specialist as needed.
C0 ≥ 128	C0/(C16+C18)≥ 90	CPT1	HR	**Immediate** referral to the metabolic specialist is required.
C16OH ≥ 0.16	C18:1 OH < 0.15	LCHAD/TFP	LR	Repeat filter paper. Consult with metabolic specialist as needed.
C18:1 OH ≥ 0.15	C16OH < 0.16	LCHAD/TFP	LR	Repeat filter paper. Consult with metabolic specialist as needed.
C18:1 OH ≥ 0.15	C16OH ≥ 0.16	LCHAD/TFP	HR	**Immediate** referral to the metabolic specialist is required.

Cut off values may change. Please contact the OK NBS Program for clarification if needed. More information is available on the OSDH website or call (405) 271-6617.

*HR-High Risk
*LR-Low Risk

Newborn Screening Program (405) 271-6617 or 1-800-766-2223
Metabolic Nurse Specialist (405) 271-8685
http://nsp.health.ok.gov

Revised Sept. 10, 2013
General Info- 2.1.1a

FAOD Screening (CUD, SCAD, GAII, MCAT, VLCAD, CACT, CPTII, CPT1A, LCHAD, TFP)
Oklahoma State Department of Health Newborn Screening Program – June, 2008

FAOD Screen
Out-of-Range (abnormal)

NO: Not consistent with FAOD. No further action needed.

YES

LOW RISK

1. PCP to contact family within 24 hours to assess infant's clinical status.
2. Consider initiating feeding precautions.
3. Repeat Filter Paper within 48 hours.

In-Range: Not consistent with FAOD. No further follow-up indicated.

Out-of-Range

HIGH RISK

From time of report, the contacted provider will:

1. Contact family by COB (close of business),
2. Initiate feeding precautions on the day of notification,
3. Arrange for a clinical evaluation within 8 to 24 hours utilizing the Emergency Management Protocol (assessment can be done by provider or metabolic specialist).
4. **Low C0: Assessment must occur on the date of notification.**
5. Refer for a diagnostic work-up by Metabolic Specialist within 24 to 48 hours. Metabolic nurse specialist will assist with scheduling patient.

Appointment with metabolic specialist for diagnostic testing (testing must be coordinated by the specialist or newborn screening program):

1. Acylcarnitine Profile (plasma)
2. Carnitine (plasma)
3. Urine Organic Acids
4. Other lab and/or DNA may be indicated

Diagnostic Testing Inconclusive: Monitoring and medical management as advised by metabolic specialist.

Diagnostic Testing Consistent with FAOD: Refer to metabolic specialist for medical management.

Diagnostic Testing Within Normal Limits: Not consistent with FAOD. No further follow-up indicated.

From the time the screen is reported to the provider, the Metabolic Nurse Specialist will monitor follow-up by:

1. Confirming the provider contacts family before COB.
2. Facilitating and confirming a clinical evaluation by a provider or metabolic specialist is achieved before COB.
3. Facilitating and confirming infant presents for a diagnostic workup with a metabolic specialist within 24 to 48 hours.
4. Coordinating collection and processing of diagnostic tests and communicating test results to provider and short-term follow-up program (STFU).
5. Communicating with STFU if the above timelines are not met.

Table 1. In-range FAOD Screen Results[1]:

DISORDER	Primary Analyte (µmol/L)	Secondary Analyte (µmol/L)	DISORDER	Primary Analyte (µmol/L)	Secondary Analyte (µmol/L)
CUD	C0 > 10.0	NA	VLCAD	C14:1 < 0.70	C14 < 0.71
SCAD & GAII	C4 < 1.27	C4/C2 ratio < 0.06			C16 < 7.46
CACT & CPTII	C16 < 7.46	C18 <2.15	MCAD & MCAT	C8 < 0.40	C8/C10 ratio < 3.0
	C18:1 < 2.73	C18:2 < 1.58			C6 < 0.25
CPT1	C0 < 128.00	C0/(C16+C18) < 90			C10 < 0.40
LCHAD/TFP	C16OH < 0.16	C16:1OH < 0.47			C10:1 < 0.30
	C18:1 OH < 0.15	C18 OH < 0.12			C8/C10 ratio < 3.00

[1]These values are utilized for newborns less than 60 days old.
[2] Elevations of the secondary analytes are reported as "not consistent with FAOD" if primary analyte is in range in-range.

Revised August 5, 2011
General Info- 2.1.2

Organic Acid Disorder (OAD) Screening Fact Sheet for Health Care Providers
Newborn Screening Program of the Oklahoma State Department of Health

What are the characteristics of Organic Acid Disorders (OA)?

- Autosomal recessive genetic conditions. Most infants are born to parents who are both unknowingly asymptomatic carriers and have NO known history of an Organic acid disorder in the family.
- The incidence of OA's ranges from 1/75,000 – 1/100,00.
- Symptoms vary by disorder. These disorders can lead to metabolic crisis, especially in infants and children. This crisis can lead to seizures, respiratory failure, cardiac arrest and death. Crisis survivors may experience significant developmental disabilities. Some infants may present in the neonatal period without any symptoms
- Symptoms of a metabolic crisis can be trigged by fever, infection or illness.
- Treatment involves a special diet managed by a metabolic specialist and a metabolic dietician, frequent feedings, and special care during times of illness or stress.

What is the screening methodology for Organic Acid disorders?

An acylcarnitine profile by Tandem Mass Spectrometry (MS/MS) is performed on each filter paper.
Primary and secondary analytes are simultaneously tested on each filter paper.
Primary analyte results are used to establish results requiring follow-up. All out-of-range primary analyte results require follow-up.
Secondary analyte are used in conjunction with primary analyte results to assign risk.
Elevations of the secondary analytes are reported as "not consistent with OA" if the primary analyte is in range.

What are the follow-up needs?

The follow-up program will provide detailed guidance on needed actions. The following metabolic specialists have approved all recommendations:

- Klaas Wierenga, M.D. (405) 271-8685
- Susan Palmer, M.D. (405) 271-8685

Metabolic Nurse Specialist – Mary Monks RN – pager (405) 559-1378 phone (405) 271-8001 ext 42074

What is my role in screening?

If you are listed as the infant's planned health care provider on the filter paper requisition, you are required by the *Newborn Screening* to initiate follow up activities.

Summary of out of range OA Analytes and follow-up recommendations.

Primary Marker (µmol/L)	Secondary Analyte (µmol/L)	Potential Disorder	Risk*	Recommendation
C3 ≥ 7.21	C3/C2 <0.25 & C4DC<1.71	PROP / MUT / CBL-C,D / CBL- A,B	LR	Repeat Filter paper. Consult metabolic specialist as needed.
C3 ≥ 7.21	C3/C2 ≥0.25	PROP / MUT / CBL-C,D / CBL- A,B	HR	**Immediate** referral to metabolic specialist. Confirmatory testing
C3 ≥ 7.21	C4DC ≥1.71	PROP / MUT / CBL-C,D / CBL- A,B	HR	**Immediate** referral to metabolic specialist. Confirmatory testing
C3DC 0.42-0.59	NONE	MAL	LR	Repeat Filter paper. Consult metabolic specialist as needed
C3DC ≥ 0.60	NONE	MAL	HR	**Immediate** referral to metabolic specialist. Confirmatory testing
C4 1.27 - 1.99	C4/C2 <0.06	IBG	LR	Repeat Filter paper. Consult metabolic specialist as needed.
C4 1.27 - 1.99	C4/C2 ≥0.06	IBG	HR	**Immediate** referral to metabolic specialist. Confirmatory testing
C4 ≥ 2.00		IBG	HR	**Immediate** referral to metabolic specialist. Confirmatory testing
C5 0.87-2.99	C5/C2 <0.05	IVA / 2MBG	LR	Repeat Filter paper. Consult metabolic specialist as needed.
C5 0.87-2.99	C5/C2 ≥0.05	IVA / 2MBG	HR	**Immediate** referral to metabolic specialist. Confirmatory testing
C5 ≥3.00		IVA / 2MBG	HR	**Immediate** referral to metabolic specialist. Confirmatory testing
C5:1 ≥0.18	C5OH <0.80	βKT	LR	Repeat Filter paper. Consult metabolic specialist as needed.
C5:1 ≥0.18	C5OH ≥0.80	βKT	HR	**Immediate** referral to metabolic specialist. Confirmatory testing
C5DC ≥0.33	C5DC/C8 <4.00 & C5DC/C16 <0.16	GA1	LR	Repeat Filter paper. Consult metabolic specialist as needed.
C5DC ≥0.33	C5DC/C8 ≥4.00	GA1	HR	**Immediate** referral to metabolic specialist. Confirmatory testing
C5DC ≥0.33	C5DC/C16 ≥0.16	GA1	HR	**Immediate** referral to metabolic specialist. Confirmatory testing
C5OH ≥0.80	C6DC <0.27	HMG / 3MCC / 3MGA / MCD / 2M3HBA	LR	Repeat Filter paper. Consult metabolic specialist as needed.
C5OH ≥0.80	C6DC ≥0.27	HMG / 3MCC / 3MGA / MCD / 2M3HBA	HR	**Immediate** referral to metabolic specialist. Confirmatory testing
C5OH ≥2.0	C6DC <0.27	HMG / 3MCC / 3MGA / MCD / 2M3HBA	HR	**Immediate** referral to metabolic specialist. Confirmatory testing

Cut off values may change. Please contact the OK NBS Program for clarification if needed. More information available on OSDH website or call (405) 271-6617.

*HR-High Risk
*LR-Low Risk

Newborn Screening Program (405) 271-6617 or 1-800-766-2223
Metabolic Nurse Specialist (405) 271-8685
http://nsp.health.ok.gov

Revised Sept. 10, 2013
Gen Info- 3.1.2a

OA Screening (PROP/MUT/MAL/IBG/IVA/2MBG/ßKT/GA1/3MCC/HMG/2MGA/MCD)
Oklahoma State Department of Health Newborn Screening Program – May 2009

OA Screen
Out-of-Range (abnormal)

NO → Not consistent with OA. No further action needed.

YES

LOW RISK

1. PCP to contact family within 24 hours to assess infant's clinical status.
2. Repeat Filter Paper within 48 hours.

In-Range → Not consistent with OAD. No further follow-up indicated.

Out-of-Range →

HIGH RISK

From time of report, the contacted provider will:
1. Contact family by COB with in one hour of notification.
2. Immediate consultation with Metabolic Specialist.
3. Arrange for a clinical evaluation immediately utilizing the OSDH Emergency Management Protocol (assessment can be done by provider or metabolic specialist).
4. **PROP / MUT immediate admission**
5. **MAL / IBG / IVA / GA1 / ßKT / HMG etc evaluation must occur on day of notification.**
6. Refer for a diagnostic work-up by Metabolic Specialist within 24 to 48 hours. Metabolic nurse specialist will assist with appointment

Appointment with metabolic specialist for diagnostic testing (testing must be coordinated by the specialist or newborn screening program):
1. Acylcarnitine Profile (plasma)
2. Carnitine Free and Total (plasma)
3. Urine Organic Acids
4. Other lab and/or DNA may be indicated

Diagnostic Testing Inconclusive: Monitoring and medical management as advised by metabolic specialist.

Diagnostic Testing Consistent with OA: Refer to metabolic specialist for medical management.

Diagnostic Testing Within Normal Limits: Not consistent with OA. No further follow-up indicated.

From the time the screen is reported to the provider, the Metabolic Nurse Specialist will monitor follow-up by:
1. Confirming the provider contacts family within one hour of notification.
2. Facilitating and confirming a clinical evaluation by a provider or metabolic specialist is achieved on day of notification.
3. Facilitating and confirming infant presents for a diagnostic workup with a metabolic specialist within 24 hours.
4. Coordinating collection and processing of diagnostic tests and communicating test results to provider and short-term follow-up program (STFU).
5. Communicating with STFU if the above timelines are not met.

Table 1. In-range OAD Screen Results[1]:

DISORDER	Primary Analyte (µmol/L)	Secondary Analyte (µmol/L)	DISORDER	Primary Analyte (µmol/L)	Secondary Analyte (µmol/L)
PROP / MUT	C3 < 7.21	C3/C2 < 0.25 & C4DC <1.71	GA1	C5DC < 0.33	C5DC/C8 < 4.00 & C5DC/C16< 0.16
MAL	C3DC < 0.42	NONE	ßKT	C5:1 < 0.18	C5OH < 0.80
IBG	C4 < 1.27	C4/C2 < 0.06	HMG	C5OH < 0.80	C6DC < 0.27
IVA / 2MBG	C5 < 0.87	C5/C2 < 0.05	3MGA		for HMG &3MGA only
			3MCC		
			MCD		

[1]These values are utilized for newborns less than 60 days old.
[2]Elevations of the secondary analytes are reported as "not consistent with FAOD" if primary analyte is in range in-range.

Abbreviations for Amino Acid Disorders include:

ARG	**Argininemia**
ASA	**Argininosuccinic aciduria**
CIT	**Citrullinemia type I**
CIT II	**Citrullinemia type II**
HCY	**Homocystinuria**
MET	**Hypermethioninemia**
MSUD	**Maple Syrup Urine Disease**
PKU	**Phenylketonuria**
H-PHE	**Benign hyperphenylalaninemia**
BIOPT (BS)	**Biopterin defect in cofactor biosynthesis (BIOPT [BS])***
BIOP (REG)	**Biopterin defect in cofactor regeneration (BIOPT [REG])***
TYR I	**Tyrosinemia Type I**
TYR II	**Tyrosinemia Type II**
TYR III	**Tyrosinemia Type III**

Abbreviations for Fatty Acid Oxidation Disorders include:

CUD	**Carnitine uptake defect**
SCUD	**Short-chain acyl-CoA thiolase deficiency**
GAII	**Glutaric academia Type II**
MCAT	**Medium-chain ketoacyl-CoA dehydrogenase deficiency**
MCAD	**Medium-chain acyl-CoA dehydrogenase deficiency**
VLCAD	**Very long-chain acyl-CoA dehydrogenase deficiency**
CACT	**Carnitine acylcarnitine translocase deficiency**
CPT IA	**Carnitine palmitoyltransferase I deficiency**
CPT II	**Carnitine palmitoyltransferase II deficiency**
LCHAD	**Long-chain L-3-hydroxyacyl- CoA dehydrogenase deficiency**
TFP	**Trifunctional protein deficiency**

Abbreviations for Organic Acid Disorders include:

PROP	**Propionic acidemia**
MUT	**Methylmalonic academia**
MAL	**Malonic academia**
IBG	**Isobutyrylglycinuria (Isobutyryl- CoA dehydrogenase deficiency)**
IVA	**Isovaleric academia**
2MBG	**2-Methylbutyrylglycinuria**
3-MCC	**3- Methylcrotonyl- CoA carboxylase deficiency**
3MGA	**3- Methylglutaconic aciduria**
HMG	**3- Hydroxy-3-methyglutaric acidemia**
MCD	**Holocarboxylase synthetase deficiency (multiple carboxylase deficiency)**
2M3HBA	**2-Methyl-3-hydroxybutyric aciduria**
βKT	**Beta ketothiolase deficiency**
GA I	**Glutaric academia type I**

Updated August 10, 2009

Biotinidase Deficiency FOLLOW-UP

FILTER PAPER RESULTS	INDICATED PROCEDURES
Biotinidase Enzyme Present **≥ 57 U**	If specimen was collected before the infant was 24 hours of age, a specimen should be collected and submitted to the Oklahoma State Department of Health (OSDH) Laboratory for testing when the infant is 3 to 5 days of age. Indicate specimen is a **repeat** on the filter paper requisition. Mark **"ALL TEST"**.
Biotinidase Enzyme Decreased **≥ 20 – 56.9 U**	**Repeat Filter Paper** specimen should be collected and sent to the OSDH laboratory within 48 hours. Indicate specimen is a **repeat** on the filter paper requisition. Mark **"ALL TEST"**.
Biotinidase Enzyme Low **< 20 U**	Immediate referral to a metabolic specialist is indicated.
Two Abnormal Biotinidase Results on Filter Paper	Immediate referral to a metabolic specialist is indicated.

LABORATORY PROCEDURE

1. Biotinidase enzyme activity is tested on each filter paper.

Normal Filter Paper Result: Biotinidase Enzyme Activity Present

A filter paper specimen refers to the Newborn Screening Kit ODH #450. Filter paper kits may be ordered from the: Public Health Laboratory Service, OSDH, P.O. Box 24106, Oklahoma City, OK, 73124-0106, call (405) 271-5070, or utilize the OSDH website.

For a **Metabolic Specialist:**

Klaas Wierenga, M.D. (405) 271-8685

Susan Palmer, M.D. (405) 271-8685

Questions regarding follow-up, please contact the Newborn Screening Short-term Follow-up Program at (405) 271-6617 or 1-800-766-2223 or fax to (405) 271-4892. Questions regarding laboratory procedure should be directed to the OSDH Lab at (405) 271-5070 or fax to (405) 271-4850.

REFUSAL FORM

Oklahoma State Department of Health
Refusal of the Newborn Screening Blood Test
Religious Tenets and Practices Refusal

Infant's Name:_____ Medical Record Number:_____

Date of Birth: __ __ / __ __ / __ __

Attending Physician or Provider, print name:_____

Place of Birth:
__ Hospital, print name_____

__ Birthing Facility, print name_____

__ Home Birth

Type of Screen Refused: _____Newborn Blood Test _____Pulse Oximetry Screen

I have received and read the parent educational brochure printed by the Oklahoma Department of Health on the Newborn Screening blood test and pulse oximetry screening. I understand that these disorders are easily detected by testing a small blood sample from my baby's heel or by measuring the amount of oxygen in my baby's blood.

I have been informed that all newborns are required by law (under 63 O.S. 2002, Sections 1-533 and 1-534) to have a newborn screening test collected and pulse oximetry screen performed.

I have been informed and I understand that this screening is done to detect these disorders because symptoms sometimes do not appear for several weeks or months, and irreversible damage can occur before symptoms become apparent to a family or a physician.

I have been informed and I understand that, if untreated, these conditions may cause permanent damage to my child, including mental retardation, growth failure, and even death. This permanent health damage can be prevented through early detection and treatment.

I have discussed the newborn screening test and pulse oximetry screening with my physician or health care provider and I understand the risks to my child if the screening test is not completed.

I understand that the law allows a parent or guardian to refuse newborn screening and pulse oximetry screening based on the grounds that such examination conflicts with a person's religious tenets and practices. I elect to refuse newborn screening on that such testing of my infant conflicts with my religious tenets and practices. My decision was made freely and I accept the legal responsibility for the consequences of this decision.

_____	_____	__ __ / __ __ / __ __
Print Parent/legal Guardian's Name	Signature of Parent/legal Guardian	Date
_____	_____	__ __ / __ __ / __ __
Print Witness Name	Signature of Witness	Date

Original to infant's record, provide a copy to parent, and forward copy by fax or mail to: Oklahoma State Department of Health, Newborn Screening Program Coordinator, 1000 NE Tenth Street, Oklahoma City, OK 73117-1299, (405) 271-6617 or 1-800-766-2223; Fax (405) 271-4892.