Seminars in Perinatology 39 (2015) 230–237

Available online at www.sciencedirect.com

ScienceDirect

www.elsevier.com/locate/semperi

Detection of critical congenital heart defects: Review of contributions from prenatal and newborn screening

Richard S. Olney, MD, MPH[a,*], *Elizabeth C. Ailes, PhD, MPH*[a], *and Marci K. Sontag, PhD*[b]

[a]*National Center on Birth Defects and Developmental Disabilities, Centers for Disease Control and Prevention (CDC), 1600 Clifton Rd, Mailstop E86, Atlanta, GA 30333*

[b]*Department of Epidemiology, Colorado School of Public Health at University of Colorado Denver at Anschutz Medical Campus, Aurora, CO*

ARTICLE INFO

Keywords:
Neonatal screening
Prenatal diagnosis
Heart defects
Congenital
Population surveillance
Public health

ABSTRACT

In 2011, statewide newborn screening programs for critical congenital heart defects began in the United States, and subsequently screening has been implemented widely. In this review, we focus on data reports and collection efforts related to both prenatal diagnosis and newborn screening. Defect-specific, maternal, and geographic factors are associated with variations in prenatal detection, so newborn screening provides a population-wide safety net for early diagnosis. A new web-based repository is collecting information on newborn screening program policies, quality indicators related to screening programs, and specific case-level data on infants with these defects. Birth defects surveillance programs also collect data about critical congenital heart defects, particularly related to diagnostic timing, mortality, and services. Individuals from state programs, federal agencies, and national organizations will be interested in these data to further refine algorithms for screening in normal newborn nurseries, neonatal intensive care settings, and other special populations; and ultimately to evaluate the impact of screening on outcomes.

Published by Elsevier Inc.

Introduction

In this review, we define critical congenital heart defects (CCHD) as structural malformations of the heart that are present at birth and require intervention in the first year of life, and we focus on prenatal and postnatal screening for CCHD in the United States (U.S.). Seven categories of CCHD that usually present in newborns with hypoxemia were considered by the Secretary of Health and Human Service's Advisory Committee on Heritable Disorders in Newborns and Children (SACHDNC) as the primary targets for pulse oximetry screening.[1] These seven types are (1) dextro-transposition of the great arteries; (2) hypoplastic left heart syndrome; (3) pulmonary atresia (with intact ventricular septum); (4) tetralogy of Fallot; (5) total anomalous pulmonary venous return; (6) tricuspid atresia; and (7) truncus arteriosus. The National Birth Defects Prevention Network (NBDPN), an organization of state and population-based birth defects programs partially

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

*Corresponding author.
E-mail address: rsolney@aap.net (R.S. Olney).

http://dx.doi.org/10.1053/j.semperi.2015.03.007
0146-0005/Published by Elsevier Inc.

funded by the Centers for Disease Control and Prevention (CDC), has developed case definitions for these primary targets.[2] These definitions include inclusion and exclusion terminology for each category of defects, coding lists to be used by birth defects programs for ascertainment of records from population-based sources, and diagnostic criteria used in reviewing records of prenatally and postnatally diagnosed defects. Other types of CCHD that sometimes present with hypoxemia and are considered "secondary targets" include critical aortic coarctation, atresia/hypoplasia/interruption of the aortic arch, double outlet right ventricle, Ebstein anomaly, severe aortic valve stenosis, severe pulmonic stenosis, and single ventricle complex.[3]

Public health importance of CCHD and early detection

The importance of CCHD in the perinatal context results from the frequency of detection in both prenatal and neonatal settings, the necessity of early detection to prevent complications, and the contribution of these defects to infant mortality. Practicing maternal-fetal medicine specialists and neonatologists are well aware of the impact of malformations in general, and practitioners are involved with many of the approximately 3% of newborns affected with birth defects. Nearly 1% of newborns have congenital heart defects, and approximately one-quarter of those defects are in the CCHD category.[4–6] Some newborns with CCHD will have obvious clinical signs in the nursery, but since a subset of affected infants depend on circulation through the ductus arteriosus, closure of the ductus after nursery discharge can be catastrophic and is a major impetus for hospital-based screening in order to avoid unexpected deaths. Congenital heart disease has been reported to be responsible for 30–50% of infant mortality due to birth defects, and from 1999 to 2006 (before the advent of CCHD newborn screening), more than 13,000 infant deaths resulting from congenital heart defects were reported in the U.S.[7] These deaths occurred most commonly with diagnoses of hypoplastic left heart syndrome, transposition of the great arteries, or tetralogy of Fallot, in that order of severity, and these three types of CCHD (in reverse order of reported frequency) also have the highest rates among live births in NBDPN surveillance data (Fig.).

In spite of the relatively common occurrence of CCHD among children with birth defects and the adverse consequences they have for cardiac physiology, newborns are often unsuspected of having CCHD before transitional events from fetal circulation occur. Cardiac defects might not be suspected if there is no multiple malformation syndrome, no prenatal cardiac diagnoses by screening ultrasound and/or fetal echocardiography (discussed below), or in the absence of any family history that would alert parents and providers about the need to investigate for CCHD. Among infants with any congenital heart defect, conventional cytogenetic abnormalities such as trisomies have only been reported in approximately one-tenth of those affected.[8,9] In isolated CCHD, physical examination might not detect cyanosis or other clinical signs before transitions from fetal circulation are completed, which can occur after nursery discharge.

Implementing CCHD newborn screening in the United States

Statewide newborn screening for CCHD has developed rapidly after a series of events in recent years. Pilot screening programs for subclinical cyanosis related to CCHD had been reported from normal newborn nurseries in the U.S. for more than 10 years.[10] The centerpiece of these early programs was pulse oximetry, already with a well-established presence in hospitals for noninvasive hypoxemia screening. As pilot data accumulated internationally, in 2009 the American Heart Association (AHA) and the American Academy of Pediatrics (AAP) published a scientific statement reviewing pulse oximetry screening studies with recommendations for larger and more diverse studies.[3] This statement and other published data such as a prospective study from Sweden led to considerations for population-based screening implementation.[11] After further evidence reviews in 2010–2011, the U.S. Secretary of Health and Human Services adopted the SACHDNC's endorsement of CCHD screening for the Recommended Uniform Screening Panel (RUSP) for newborns. Subsequently, an expert panel published an algorithm for pulse oximetry screening that was endorsed by the AAP, AHA, and the American College of Cardiology (ACC).[1,12,13]

U.S. public health departments began implementing statewide CCHD newborn screening programs in 2011.[14,15] The earliest statewide programs were legislatively mandated, while other programs initiated over the 3 years subsequent to the RUSP addition came about through changes in state screening rules and regulations, with or without legislation or recommendations from state newborn screening advisory boards. Examples of these developments were summarized in a 2013 Issue Brief published online by the Association of Maternal and Child Health Programs: http://www.amchp.org/programsandtopics/CHILD-HEALTH/projects/newborn-screening/Documents/AMCHP_Screening_for_CCHD_Issue_Brief_FINAL-Oct2013.pdf. Adding to the clinical evidence that led to the RUSP decision, results of a subsequent study indicated that CCHD screening appeared to be cost-effective, using modeled data and survey results from one of the early-adopting states.[16] With the exception of just a few states, screening is either in the process of statewide implementation or has already been adopted statewide in U.S. birth hospitals; readers can find specific state status updates at http://www.aap.org/en-us/advocacy-and-policy/state-advocacy/Documents/Newborn%20Screening%20for%20Critical%20Congenital%20Heart%20Disease.pdf or links to state-specific websites for local mandates and guidance at http://www.babysfirsttest.org/newborn-screening/conditions/critical-congenital-heart-disease-cchd. Even without mandates or regulations including CCHD screening on state panels, newborn screening programs in most of the states without a current screening requirement report that pulse oximetry screening is occurring (in a few such states, all hospitals are reportedly screening) (Hudson et al., submitted). In these states without requirements, the influence of the endorsements by national organizations such as AAP might be leading to screening practices that are based on "standards for care delivery."[17]