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‘Barrier dysfunction in Atopic newBorns studY’ (BABY): protocol of a Danish prospective birth cohort study

Trine Gerner,1,2 Anne-Sofie Halling,1,2 Maria Rasmussen Rinnov,1,2 Nina Haarup Ravn,1,2 Mette Hjorslev Knudgaard,1,2 Charlotte Menné Bonefeld,3 Caroline Ewertsen,4 Simon Trautner,5 Ivone Jakaša,6 Sanja Kezic,7 Lone Skov,1,2 Jacob P Thyssen1,2

ABSTRACT

Introduction  Skin barrier development and dysfunction in premature and mature newborns is important for the risk of atopic dermatitis (AD).

Methods and analysis  The Barrier dysfunction in Atopic newBorns studY (BABY) Cohort is a prospective birth cohort study of 150 preterm children (gestational age (GA) below 37+0) and 300 term children (GA 37+0 to 41+6). Skin barrier is assessed through transepidermal water loss, tape stripping, Raman-spectroscopy and microbiome sampling. Clinical examinations are done and DNA from buccal swabs is collected for genetic analyses. Thymus size is assessed by ultrasound examination. Information on pregnancy, delivery, parental exposures and diseases are collected, and structured telephone interviews are conducted at 18 and 24 months to assess exogenous exposures in the child and onset of AD. Hanifin and Rajka criteria as well as The UK Working Party’s Diagnostic Criteria for Atopic Dermatitis are used to diagnose AD. Severity of AD is assessed using the Eczema Area and Severity Index (EASI) and Patient Oriented Eczema Measure (POEM).

Ethics and dissemination  The study is approved by the scientific Ethical Committee of the Capital Region (H-16042289 and H-16042294).

Outcomes will be presented at national and international conferences and in peer-reviewed publications.

INTRODUCTION

Atopic dermatitis (AD) is a chronic and relapsing, inflammatory skin disease, characterised by dry and itchy skin that affects up to 20% of children in Northern Europe.1 About 60% to 80% develop the disease in their first 2 years of life, and children with early onset are at increased risk of having severe and persistent disease.2 3 The risk of AD is increased in children of parents with atopic disorders such as AD, asthma and allergic rhinitis.4 6

Genetic and environmental risk factors contribute to the development of AD through skin barrier dysfunction and immune dysregulation.2 While loss-of-function mutations in the filaggrin gene (FLG) have been identified as the strongest genetic risk factor for AD,7 genome-wide association studies have only identified a relatively small proportion of the genetic risk effect.8 The inflammation in AD is characterised by overexpression of Th2 cytokines, including interleukin (IL)-4 and IL-13.9 That, together with IL-1, may lead to increased secretion of thymic stromal lymphopoietin, decreased epidermal antimicrobial peptides and filaggrin levels, which, in turn, can worsen skin inflammation and epidermal barrier functions.10 Changes in the skin microbiome is also associated with worsening of AD, showing reduced bacterial diversity11 and increased colonisation with Staphylococcus aureus.12

While several environmental risk factors have been identified, for example, winter birth and exposure to hard domestic water, this has not yet led to prophylactic solutions.13 Interestingly, the risk of AD is decreased in premature newborns and infants undergoing heart surgery, which often includes partial or total thymectomy, perhaps due their reduced number of total lymphocytes and circulating T-cells, resulting in an inappropriate immune response to antigens encountered in the skin.14 16

Strengths and limitations of this study

► This is a Danish prospective birth cohort study assessing skin barrier functions and risk factors for atopic dermatitis.
► The study includes both preterm and term newborns from the general population.
► Repeated and comprehensive measurements of skin barrier will be performed at several time points.
► A limitation is the lack of blood measurements as this study is strictly non-invasive.
There is a need for birth cohort studies that closely examine the skin of newborns at several time points to identify infants at risk of developing AD early in life. The Barrier dysfunction in Atopic newBorns studY (BABY) Cohort is a prospective birth cohort study that investigates early skin barrier development in preterm and term newborns to identify early prognostic skin barrier changes for the development of AD.

OBJECTIVES
Primary objective
To identify early predictors of AD during the first 2 years of life, including skin barrier dysfunction and exogenous exposures during pregnancy and in infancy. The study will assess patient and parental characteristics, family history of atopic comorbidities, exposures during pregnancy and in infancy, and skin barrier function and development.

Secondary objectives
To closely describe the normal skin barrier development, including immune activity and skin microbiome, in preterm and term newborns during the first 2 years of life.

METHODS AND ANALYSIS
Study population and setting
The BABY Cohort is an ongoing prospective and observational birth cohort study recruiting 150 preterm and 300 term newborn infants. Recruitment began in August 2017. Parents of eligible children are recruited at the maternity and neonatal wards at Rigshospitalet, Copenhagen and Nordsjællands Hospital, Hillerød, Denmark. Children eligible for enrolment are preterm newborns (gestational age (GA) below 37+0), excluding preterm newborns with severe congenital abnormality or conditions affecting their life expectancy, and full-term healthy singleton newborns (GA 37+0 to 41+6), excluding mature newborns receiving antenatal steroids for fetal lung maturation. Children with parents unable to communicate in Danish are excluded, since it is not possible to use (for practical and financial reasons) interpreters right after birth, given that we have to be very flexible and recruit at odd hours. Children are included independent of their hereditary risk for AD.

Cohort design
All study procedures are summarised in figures 1 and 2, and each component of the visit is detailed below. Preterm children are scheduled for two study visits: during the first 31 days of life and approximately 2 months after their scheduled due date (figure 1). Term children are scheduled for four study visits: during the first 3 days of life and approximately at 2, 6 and 12 months of age (figure 2). Many prematurely born children continue to have many hospital visits after their discharge, and many of the families live far away from the hospital, that is, other parts of Denmark. Therefore, preterm children are only scheduled to participate in one follow-up visit. We can therefore only make certain comparisons across the two groups.

If a child develops AD during the first 2 years of life, an additional follow-up visit is performed. Overall, all children are recruited and examined as soon as possible after their delivery. Very prematurely born children often receive intensive medical care, and we wait until the child is stable to perform the examinations.

For all study visits, the time of the study visit is registered, to be able to adjust for any effects that occur due to age differences. All parents participate in a structured telephone interview when the child is 18 and 24 months old. All study visits are conducted by trained medical doctors.

Baseline interview
During the first study visit, parents are interviewed to obtain information about the pregnancy and birth, including the type of delivery and maternal intrapartum antibiotic treatment. Furthermore, information about GA at birth, weight, height and head circumference, 1 and 5 min APGAR scores, and medical treatment at the neonatal ward is obtained.

Study interview
At every study visit, we obtain detailed information about the child’s health, vaccination status, method of feeding, admittance to hospital, medical treatments, bathing habits and skin care.

Parental questionnaires
Parents complete an online questionnaire on family structure, residential situation, pet exposure, occupation, maternal exposures during pregnancy, smoking and drinking habits, history about current and previous skin diseases, and atopic diseases in the family.

Telephone interviews
At 18 and 24 months, parents participate in a structured telephone interview about the child’s health, vaccination status, method of feeding, admittance to hospital, medical treatments, bathing habits, skin care, ultraviolet exposures and AD assessment using a modification to the UK Working Party’s Diagnostic Criteria for Atopic Dermatitis, with parental assessment of visible flexural dermatitis in the elbows or knees. If AD is diagnosed during the telephone interview, an extra study visit in the clinic is scheduled.

Anthropometric measures
At the first visit, birth information on height, weight and head circumference is retrieved from the birth record. At all follow-up visits, anthropometric measurements are made. A digital weight scale is used to record weight in kg without clothing and diaper. Height and head circumference are measured in cm using a flexible non-elastic measuring tape.
Skin barrier measurements

Transepidermal water loss

During all study visits, transepidermal water loss (TEWL) is assessed using a portable, closed condenser-chamber device (AquaFlux model AF200, Biox Systems Ltd, UK). TEWL is measured three times on the same skin area located on the central part of the volar forearm. No preference is given to the left or right arm but depends on how the baby is positioned.

Natural moisturising factors

Using a custom-built device, the level of natural moisturising factors (NMF) is measured on the thenar region using confocal Raman spectroscopy (RiverD International B.V., Rotterdam, The Netherlands). Three values are recorded at all study visits, except the first study visit for the premature children. The thenar region of the child’s hand is placed on the device for approximately 60 s. Scattered light is sent towards the skin surface, exiting the molecules in the skin. Each molecule represents a specific spectrum of light, and the specific composition of molecules is thereby represented in the returned spectrum of light. Again, the most accessible hand is measured, which, in turn, depends on the child’s posture at the time of examination.

Superficial stratum corneum sampling

During all study visits, stratum corneum (SC) is collected by tape stripping as previously described. Eight consecutive tape stripping discs (22 mm) D-squame (CuDerm, Dallas, Texas, USA) are applied on the skin followed by standardised pressure applied by a D-squame.
pressure application pen for 5s and gently removed with tweezers. Tapes are stored at −80°C immediately after sampling. Preterm infants have SC collected from the skin between the shoulder blades, and at 2 months of age from the cheek as well. Term infants have SC collected from cheek skin and the dorsal surface of the hand. No preference is given to the left or right side but depends on the positioning of the child. If a child develops AD, SC is collected from the dorsal surface of the hand and from a lesional skin site, preferably from the cheek, otherwise from a skin site with the most severe AD. SC samples are analysed for biomarkers of the immune response by multiplex immuno-assays, NMF using a liquid chromatography previously described by Kezic et al. and corneocyte surface morphology by atomic force microscopy.

Clinical skin assessment
A complete examination of the skin is performed at each study visit to describe the normal skin barrier development.

Size, number and location of both congenital and acquired naevi are registered. Studies and meta-analysis have shown that the number of naevi is inverse with AD. However, we are not aware of prospective data collection. The palm of the hand is photographed to assess skin hyperlinearity at 2 months of age and in case the child develops AD.

Atopic dermatitis assessment
The skin is evaluated for signs of AD at each study visit. A diagnosis of AD is initially given by a physician and is subsequently diagnosed clinically using the diagnostic criteria of Hanifin and Rajka except for IgE levels and subcapsular cataract. AD severity is assessed using the Eczema Area and Severity Index (EASI). During all following visits, AD severity is assessed using EASI and Patient Oriented Eczema Measure (POEM) tool and treatment for AD is recorded. As mentioned, during the structured telephone interviews, AD is diagnosed using The UK Working Party's Diagnostic Criteria for Atopic Dermatitis.

Genetics
Buccal swabs (Isohelix, Harrietsham, UK) are used to collect DNA to screen for the most common FLG mutations in Northern European populations (R501X,
in general, we decided on a study population of 450 participants in total, that is, 150 preterm and 300 mature children.

Data management
Study data are collected and entered directly into an online REDCap (Research Electronic Data Capture) database hosted at the Capital Region of Denmark.

Patient and public involvement
Patients and the public were not involved in the design of the study. All participants will be acknowledged and thanked for their contribution in future publications.

STRENGTHS AND LIMITATIONS
The major strength of this birth cohort study is the extensive and repeated skin barrier measurements. We will examine the skin barrier with multiple methodologies, including Raman spectroscopy, TEWL and SC biomarkers. We will collect DNA and bacteria for genetic and skin microbiome analyses at several time points, increasing the chance of finding a pathogenic role. We will include both preterm and term newborns, allowing us to study the immature skin barrier and thymus in a large subset of children. We will use internationally accepted definitions to diagnose AD and assess severity. Collectively, the BABY cohort will cover a wide range of parameters with potential importance for the development of AD. Since approximately 80% of AD patients develop their disease within the first 2 years of life, we expect to identify children with both transient and more established AD, as well as being able to differentiate between early features and predictors. Furthermore, we already now plan for future follow-up studies on skin barrier functions, AD and allergic diseases in this birth cohort.

A potential limitation of the BABY Cohort is that all term children are recruited from Copenhagen only, possibly limiting the generalisability of the study to more rural areas. While we will register ambient room conditions, including air humidity and indoor and outside temperature, seasonal and climatic variations, which affect TEWL measurements. Since bathing habits prior to study visits are not standardised, this might impact our skin barrier assessments. Children receiving incubator therapy have all measurements made directly in the incubator and the ambient conditions are recorded. As the study is strictly non-invasive, we will not make any blood measurements, and can therefore not assess the possible role of systemic inflammation. Due to our study design, we cannot discriminate clearly between early features and predictors. A concern in cohort studies is that participants may be lost to follow-up. This is especially a concern for the premature children with many potential comorbidities who are recruited from Rigshospitalet, a highly specialised department responsible for treatment of all extremely premature children in eastern Denmark. To keep track of the included families, we...
gather contact information of both parents and contact them prior to follow-up visits. However, in case a family withdraws from the study, the date and reason for withdrawal will be recorded.

ETHICS AND DISSEMINATION

The study is approved by the scientific Ethical Committee of the Capital Region (H-16042298 and H-16042294) and the local data protection agency (ID-no.: HGH-3017-040, Is-suite no.:05578). Both parents or guardians will give written informed consent prior to entry to the study.

The BABY Cohort is conducted in accordance with the Declaration of Helsinki. All relevant study results will be presented in peer-reviewed publications and presented at national and international conferences.

Author affiliations
1Department of Dermatology and Allergy, Herlev and Gentofte Hospital, University of Copenhagen, Hellerup, Denmark
2Copenhagen Research Group for Inflammatory Skin (CORGIS), Herlev and Gentofte Hospital, Hellerup, Denmark
3Department of Immunology and Microbiology, Skin Immunology Research Center, University of Copenhagen, Copenhagen, Denmark
4Department of Radiology, Rigshospitalet, University of Copenhagen, Copenhagen, Denmark
5Department of Neonatology, Rigshospitalet, University of Copenhagen, Copenhagen, Denmark
6Laboratory for Analytical Chemistry, Department of Chemistry and Biochemistry, Faculty of Food Technology and Biotechnology, University of Zagreb, Zagreb, Croatia
7Coronel Institute of Occupational Health, Amsterdam UMC, Amsterdam Public Health Research Institute, University of Amsterdam, Amsterdam, The Netherlands
8Department of Dermatology and Allergy, Herlev and Gentofte Hospital Research Foundation. The funders had no role in study design, or conduct, or reporting, or dissemination plans of this research.

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ORCID iD
Trine Gerner http://orcid.org/0000-0002-5377-4013

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