The Blueprint Genetics Arrhythmogenic Right Ventricular Cardiomyopathy (ARVC) Panel is a 14 gene test for genetic diagnostics of patients with clinical suspicion of arrhythmogenic right ventricular cardiomyopathy (ARVC).

In addition to classical autosomal dominant inheritance in some cases recessive forms of arrhythmogenic right ventricular cardiomyopathy/dysplasia (ARVC/D) have been established, and there is increasing evidence of digenic heterozygosity (a heterozygous mutation in two different genes). Despite the complexity genetic testing in ARVC/D is becoming a standard procedure in the diagnostic workup of ARVC/D patients. Identifying the molecular genetic cause for the affected patient allows risk stratification, life style guidance and prevention among family members tested positive for the genetic defect or defects. Genetic information may help to decrease morbidity and mortality among ARVC/D families. Predictive testing should be offered in the context of formal genetic counseling. If the patient structural defects are mild and a channelopathy could be the underlying cause consider selecting the Blueprint Genetics Arrhythmia Panel that provides comprehensive differential diagnostics for ARVC/D and channelopathies. In complex phenotypes you may select Blueprint Genetics Comprehensive Cardiology Panel, which includes all cardiomyopathy and channelopathy genes.

About Arrhythmogenic Right Ventricular Cardiomyopathy (ARVC)

ARVC/Dy is a progressive disease of the myocardium that predisposes to ventricular tachycardia and sudden death in young individuals and athletes. It primarily affects the right ventricle, although left ventricle is often also affected (Saguner et al. 2014). The presentation of disease is highly variable even within families, and some affected individuals may not meet established clinical criteria. In addition to the genetic defects certain environmental factors can be critical in the disease manifestation. For example competitive sports can be a significant risk factor to a person carrying ARVC-associated variants/mutations. To date at least 14 genes, covered by this panel, have been scientifically proven to associate with ARVC/D. Estimated prevalence of ARVC in general population ranges from 1:2,000 to 1:5,000. The prevalence of ARVC may increase, similarly to HCM and DCM, through increased understanding of the disease variability and molecular genetics of the disease. To date a familial background has been demonstrated in 30-50% of cases. The mean age at diagnosis is 31 years and it is more common in males. ARVC is recognized as a leading cause of sudden cardiac death (SCD) in young adults under 35 years of age and may even account for up to 10% of cardiovascular deaths in individual below 65 years.

Availability

Results in 3-4 weeks. We do not offer a maternal cell contamination (MCC) test at the moment. We offer prenatal testing only for cases where the maternal cell contamination studies (MCC) are done by a local genetic laboratory. Read more: http://blueprintgenetics.com/faqs/#prenatal

Gene set description

<table>
<thead>
<tr>
<th>Gene</th>
<th>Associated phenotypes</th>
<th>Inheritance</th>
<th>ClinVar</th>
<th>HGMD</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTNNA3</td>
<td>Arrhythmogenic right ventricular dysplasia</td>
<td>AD</td>
<td>5</td>
<td>39</td>
</tr>
<tr>
<td>DES</td>
<td>Dilated cardiomyopathy (DCM), Myopathy, myofibrillar</td>
<td>AD/AR</td>
<td>51</td>
<td>95</td>
</tr>
<tr>
<td>DSC2</td>
<td>Arrhythmogenic right ventricular dysplasia with palmoplantar keratoderma and woolly hair, Arrhythmogenic right ventricular dysplasia</td>
<td>AD/AR</td>
<td>16</td>
<td>66</td>
</tr>
<tr>
<td>DSG2</td>
<td>Arrhythmogenic right ventricular dysplasia, Dilated cardiomyopathy (DCM)</td>
<td>AD</td>
<td>32</td>
<td>102</td>
</tr>
</tbody>
</table>
DSP  Cardiomyopathy, dilated, with wooly hair, keratoderma, and tooth agenesis, Arrhythmogenic right ventricular dysplasia, familial, Cardiomyopathy, dilated, with wooly hair and keratoderma  AD/AR  101  195

JUP  Arrhythmogenic right ventricular dysplasia, Naxos disease  AD/AR  10  28

LDB3  Dilated cardiomyopathy (DCM), Myopathy, myofibrillar  AD  10  11

LMNA  Heart-hand syndrome, Slovenian, Limb-girdle muscular dystrophy, Muscular dystrophy, congenital, LMNA-related, Lipodystrophy (Dunnigan), Emery-Dreifuss muscular dystrophy, Malouf syndrome, Dilated cardiomyopathy (DCM), Mandibuloacral dysplasia type A, Progeria Hutchinson-Gilford type  AD/AR  183  458

PKP2*  Arrhythmogenic right ventricular dysplasia  AD  94  229

PLN  Hypertrophic cardiomyopathy (HCM), Dilated cardiomyopathy (DCM)  AD/AR  8  21

RYR2  Ventricular tachycardia, catecholaminergic polymorphic, Arrhythmogenic right ventricular dysplasia  AD  114  287

TGFB3  Loeys-Dietz syndrome (Reinhoff syndrome), Arrhythmogenic right ventricular dysplasia  AD  8  18

TMEM43  Arrhythmogenic right ventricular dysplasia, Emery-Dreifuss muscular dystrophy  AD  5  15

TTN*  Dilated cardiomyopathy (DCM), Tibial muscular dystrophy, Limb-girdle muscular dystrophy  AD  437  226

*Some regions of the gene are duplicated in the genome leading to limited sensitivity within the regions. Thus, low-quality variants are filtered out from the duplicated regions and only high-quality variants confirmed by other methods are reported out. Read more.

Gene, refers to HGNC approved gene symbol; Inheritance to inheritance patterns such as autosomal dominant (AD), autosomal recessive (AR) and X-linked (XL); ClinVar, refers to a number of variants in the gene classified as pathogenic or likely pathogenic in ClinVar (http://www.ncbi.nlm.nih.gov/clinvar/); HGMD, refers to a number of variants with possible disease association in the gene listed in Human Gene Mutation Database (HGMD, http://www.hgmd.cf.ac.uk/ac/). The list of associated (gene specific) phenotypes are generated from CDG (http://research.nhgri.nih.gov/CGD/) or Orphanet (http://www.orpha.net/) databases.

Non-coding disease causing variants covered by the panel

<table>
<thead>
<tr>
<th>Gene</th>
<th>Genomic location HG19</th>
<th>HGVS</th>
<th>RefSeq</th>
<th>RS-number</th>
<th>Comment</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>LMNA</td>
<td>Chr1:156100609</td>
<td>c.513+45T&gt;G</td>
<td>NM_1707073</td>
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<tr>
<td>TGFB3</td>
<td>Chr14:76425035</td>
<td>c.*495C&gt;T</td>
<td>NM_0032392</td>
<td>rs387906514</td>
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</tr>
<tr>
<td>TGFB3</td>
<td>Chr14:76447266</td>
<td>c.-30G&gt;A</td>
<td>NM_0032392</td>
<td>rs770828281</td>
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<td></td>
</tr>
</tbody>
</table>

Test performance

Blueprint Genetics offers a comprehensive Arrhythmogenic Right Ventricular Cardiomyopathy (ARVC) Panel that covers classical genes associated with arrhythmogenic right ventricular cardiomyopathy (ARVC) and unspecified arrhythmia. The genes are carefully selected based on the existing scientific evidence, our experience and most current mutation databases. Candidate genes are excluded from this first-line diagnostic test. The test does not recognise balanced translocations or complex inversions, and it may not detect low-level mosaicism. The test should not be used for analysis of sequence repeats or for diagnosis of disorders caused by mutations in the mitochondrial DNA.

Analytical validation is a continuous process at Blueprint Genetics. Our mission is to improve the quality of the sequencing process and each modification is followed by our standardized validation process. Average sensitivity and specificity in
Blueprint NGS Panels is 99.3% and 99.9% for detecting SNPs. Sensitivity to for indels vary depending on the size of the alteration: 1-10bps (96.0%), 11-20 bps (88.4%) and 21-30 bps (66.7%). The longest detected indel was 46 bps by sequence analysis. Detection limit for Del/Dup (CNV) analysis varies through the genome depending on exon size, sequencing coverage and sequence content. The sensitivity is 71.5% for single exon deletions and duplications and 99% for three exons’ deletions and duplications. We have validated the assays for different starting materials including EDTA-blood, isolated DNA (no FFPE) and saliva that all provide high-quality results. The diagnostic yield varies substantially depending on the used assay, referring healthcare professional, hospital and country. Blueprint Genetics' Plus Analysis (Seq+Del/Dup) maximizes the chance to find molecular genetic diagnosis for your patient although Sequence Analysis or Del/Dup Analysis may be cost-effective first line test if your patient’s phenotype is suggestive for a specific mutation profile.

Bioinformatics

The sequencing data generated in our laboratory is analyzed with our proprietary data analysis and annotation pipeline, integrating state-of-the art algorithms and industry-standard software solutions. Incorporation of rigorous quality control steps throughout the workflow of the pipeline ensures the consistency, validity and accuracy of results. The highest relevance in the reported variants is achieved through elimination of false positive findings based on variability data for thousands of publicly available human reference sequences and validation against our in-house curated mutation database as well as the most current and relevant human mutation databases. Reference databases currently used are the 1000 Genomes Project (http://www.1000genomes.org), the NHLBI GO Exome Sequencing Project (ESP; http://evs.gs.washington.edu/EVS), the Exome Aggregation Consortium (ExAC; http://exac.broadinstitute.org), ClinVar database of genotype-phenotype associations (http://www.ncbi.nlm.nih.gov/clinvar) and the Human Gene Mutation Database (http://www.hgmd.cf.ac.uk). The consequence of variants in coding and splice regions are estimated using the following in silico variant prediction tools: SIFT (http://sift.jcvi.org), Polyphen (http://genetics.bwh.harvard.edu/pph2/), and Mutation Taster (http://www.mutationtaster.org).

Through our online ordering and statement reporting system, Nucleus, the customer can access specific details of the analysis of the patient. This includes coverage and quality specifications and other relevant information on the analysis. This represents our mission to build fully transparent diagnostics where the customer gains easy access to crucial details of the analysis process.

Clinical interpretation

In addition to our cutting-edge patented sequencing technology and proprietary bioinformatics pipeline, we also provide the customers with the best-informed clinical report on the market. Clinical interpretation requires fundamental clinical and genetic understanding. At Blueprint Genetics our geneticists and clinicians, who together evaluate the results from the sequence analysis pipeline in the context of phenotype information provided in the requisition form, prepare the clinical statement. Our goal is to provide clinically meaningful statements that are understandable for all medical professionals, even without training in genetics.

Variants reported in the statement are always classified using the Blueprint Genetics Variant Classification Scheme modified from the ACMG guidelines (Richards et al. 2015), which has been developed by evaluating existing literature, databases and with thousands of clinical cases analyzed in our laboratory. Variant classification forms the corner stone of clinical interpretation and following patient management decisions. Our statement also includes allele frequencies in reference populations and in silico predictions. We also provide PubMed IDs to the articles or submission numbers to public databases that have been used in the interpretation of the detected variants. In our conclusion, we summarize all the existing information and provide our rationale for the classification of the variant.

A final component of the analysis is the Sanger confirmation of the variants classified as likely pathogenic or pathogenic. This does not only bring confidence to the results obtained by our NGS solution but establishes the mutation specific test for family members. Sanger sequencing is also used occasionally with other variants reported in the statement. In the case of variant of uncertain significance (VUS) we do not recommend risk stratification based on the genetic finding. Furthermore, in the case VUS we do not recommend use of genetic information in patient management or genetic counseling. For some cases Blueprint Genetics offers a special free of charge service to investigate the role of identified VUS.

We constantly follow genetic literature adapting new relevant information and findings to our diagnostics. Relevant novel discoveries can be rapidly translated and adopted into our diagnostics without delay. These processes ensure that our diagnostic panels and clinical statements remain the most up-to-date on the market.
CPT codes

SEQ ○ 81479
DEL/DUP ○ 81479

ICD codes

Commonly used ICD-10 codes when ordering the Arrhythmogenic Right Ventricular Cardiomyopathy (ARVC) Panel

<table>
<thead>
<tr>
<th>ICD-10</th>
<th>Disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>I42.8</td>
<td>Arrhythmogenic right ventricular cardiomyopathy (ARVC)</td>
</tr>
</tbody>
</table>

Accepted sample types

- EDTA blood, min. 1 ml
- Purified DNA, min. 5μg
- Saliva (Oragene DNA OG-500 kit)

Label the sample tube with your patient's name, date of birth and the date of sample collection.

Note that we do not accept DNA samples isolated from formalin-fixed paraffin-embedded (FFPE) tissue.

Resources

- American Foundation for Cardiomyopathy
- Cardiomyopathy UK
- Children’s Cardiomyopathy Association
- Sudden Cardiac Arrest Foundation
- NORD
- GeneReviews