Case report of malouf syndrome not associated with LMNA gene mutation

Abstract
Malouf syndrome, currently known as dilated cardiomyopathy associated with hypergonadotropic hypogonadism (DCM-HH), is a rare congenital disorder with clinical signs including DCM phenotype, ovary dysgenesis in females or primary testicular failure in males, mental retardation, facial dysmorphism, skin lesions, bone abnormalities and occasionally marfanoid habitus. The disorder can be caused by mutation in the LMNA gene, encoding lamin A and C. In the present manuscript, we report the sporadic case of a young female with dilated cardiomyopathy, hypergonadotropic hypogonadism and primary amenorrhea, cognitive deficiency, body mass deficit, facial dysmorphism and subclinical hypothyroidism. Radiation exposure, mumps, diabetes mellitus, autoimmune diseases, and Turner’s syndrome have been ruled out. Specific features of mandibuloacral dysplasia, like bone dysplasia, are absent. The first-degree relatives are healthy. The clinical data suggested a laminopathy. Targeted next-generation sequencing was used to search for mutations in genes, associated with cardiomyopathy, including LMNA. However, genetic analysis did not confirm the assumption: mutation was not found. This data suggests that molecular mechanism of Malouf syndrome may be associated not only with LMNA mutations, but with other genes, probably functional partners of lamin A/C.

Keywords: lamin A/C gene, dilated cardiomyopathy, hypergonadotropic hypogonadism, cardiogenital syndrome, facial dysmorphism, malouf syndrome, next generation sequencing

Abbreviations: LMNA, lamin A/C gene; DCM, dilated cardiomyopathy; HH, hypergonadotropic hypogonadism; NGS, next generation sequencing; MRI, magnetic resonance imaging; ECG, electrocardiogram; PVCs, premature ventricular contractions; LVEF, left ventricular ejection fraction; MAD, mandibuloacral dysplasia

Introduction
Cardiogenital syndrome (Malouf syndrome) is a very rarely encountered syndrome which was first diagnosed in 1985 upon the examination of two sisters, with findings of hypergonadotropic hypogonadism, dilated cardiomyopathy, blepharoptosis and broad nasal base.1 Later, Narahara et al.,2 diagnosed another sporadic case with the same features. Malouf syndrome, also known as dilated cardiomyopathy–hypergonadotropic hypogonadism (DCMHH, OMIM 212112) syndrome, is a congenital disorder. The clinical features include congestive or dilated cardiomyopathy, ovarian dysgenesis in females or primary testicular failure in males, mental retardation, broad nasal base, blepharoptosis, skin lesions, skeletal abnormalities. The phenotype varies and not all features are present in every individual case. Occasional findings include a metabolic abnormalities, thyroid hemiagenesis, collagenoma, diabetes mellitus, and marfanoid habitus (tall stature with long and thin limbs, little subcutaneous fat, arachnodactyly, joint hyper extensibility, narrow face, small chin).1,4 Cardiogenital syndrome has two main features such as dilated cardiomyopathy and hypogonadism (hypergonadotropic pattern). The clinical symptoms of the disease are predominated by the following features: mental retardation (poor capacity to study and impaired language development in young age are followed by general decline in intellectual potential), abnormal ovary development (premature ovarian failure in females) accompanied by delayed puberty or primary testicular failure (in males), various osteocutaneous abnormalities (Marfan-like habitus) with unusually long and thin digits (arachnodactyly), facial dysmorphism (a narrow face and a small sized chin, retrognathia, blepharoptosis). Additional signs are chest disorder (as a narrow “keeled breast”, sloping shoulders) and adipose tissue deficit. Micrognathia and sloping shoulders may mimic atypical progeroid phenotype. However, patients with Malouf syndrome don’t suffer from severe growth failure, alopecia or rapidly progressive atherosclerosis. The prevalence of the syndrome is not fully defined, less than 1/1000000. About 20 families from around the world, whose members suffer from cardiogenital syndrome, have been described in literature. The cardiogenic Malouf syndrome can be caused by mutation in LMNA gene located on chromosome 1q21.2-21.3. It encodes the structural components of the nuclear lamina–lamin A and C. Remarkably, mutations in LMNA have also been associated with at least 10 clinically distinct syndromes (termed as laminopathies), encompassing a wide variety of phenotypes, including several specific muscular dystrophy, DCM with conduction disorders, the dramatic “premature aging” phenotype of the Hutchinson-Gilford progeria syndrome, mandibuloacral dysplasia, and partial lipodystrophy. Quite frequently the mutations are connected with an overlapping these phenotypes. The LMNA mutation can manifest in various tissues such as cardiac and skeletal muscle, nervous, adipose and cutaneous tissue. LMNA-related DCM usually presents in early to mid-adulthood with symptomatic conduction system disease or arrhythmias. DCM patients with LMNA mutations have poor prognosis due to life-threatening ventricular tachyarrhythmias, progressive heart failure and high risk of sudden cardiac death. In cardiologist’s routine practice, a genetic diagnosis of LMNA mutation associated with DCM is a key aspect to assess the optimal treatment strategy and a timely preventive cardioverter-defibrillator implantation.
Case presentation

We describe a sporadic case of a young female with dilated cardiomyopathy, ovarian dysgenesis, mild mental retardation, body mass deficit, facial dysmorphism, and subclinical hypothyroidism. At the age of 24 years, the patient was admitted to the clinic due to the first cardiac complaints (dyspnoea, fatigue, heart rhythm disturbance) and congestive heart failure. On physical examination she had blood pressure of 105/65 mmHg, heart rate (HR) 110 beat per min (BPM), a solitary crackles over the lung bases, and a systolic murmur at the apex. The height of the patient was 176 cm with a weight 43 kg (body mass index - 13.9 kg/m²). Symptoms of lipodystrophy were observed as uniformly proportional loss of subcutaneous fat. She also had a narrow chest and sloping shoulders, facial dysmorphism as a severe microretrognathia, a small chin, and a prominent beak nose. The patient had primary amenorrhea without the somatic stigma of Turner’s syndrome. The secondary sexual characters of the patient were undeveloped. The medical history was negative for previous mumps, muscular dystrophy, diabetes mellitus, surgery or radiation to the pelvic region or autoimmune disorders. The female patient was the second child born from unrelated parents. The first-degree relatives of the patient (parents and elder sister) had experienced normal puberty and were healthy. There was no family history of menstrual disorders, intellectual deficit, dysmorphic features, congeitive cardiomyopathy or sudden cardiac death.

At examination of the patient a 6-minute walk test was 415 m. The 12-lead electrocardiogram (ECG) showed sinus tachycardia (heart rate 104 BPM) with left axis deviation, left bundle branch block (QRS duration 124 ms), normal corrected QT interval and nonspecific ST-T wave abnormalities. Holter monitoring of ECG showed an intermittent left bundle branch block (to 33%/24 h); frequent premature ventricular contractions (PVCs) to 1960/24 h, coupled PVCs (158 couplets/24 h), ventricular triplets (44/24 h), non-sustained ventricular tachycardia (4 to 7 ventricular complexes with HR max up to 130 BPM). ECG- strip demonstrating ventricular arrhythmia is presented in Figure 1A. The patient underwent echocardiography which demonstrated left ventricular dilatation with global systolic dysfunction, hypokinesis and moderate mitral valvular regurgitation. Diastolic and systolic diameters of the left ventricle were 57 and 47 mm, respectively. The left ventricular (LV) ejection fraction (EF) was 33% and LV global longitudinal strain was -11.6%. Cardiac magnetic resonance imaging (MRI) confirmed criteria of DCM: LV dilatation (LV end-diastolic volume 177 ml, LV end-systolic volume 124 ml) and global systolic dysfunction (LVEF 30%). Hypertrabecular structure of myocardial apex was found also. MRI findings of cardiomegaly are presented in Figure 1B, Figure 1C. Endomyocardial biopsies were examined, and no genetic markers of 8 cardiotoxic viruses using PCR method were detected. Histological findings showed non-specific diffuse changes in myocytes (their size and nuclei varied) and interstitial fibrosis, no genetic markers of 8 cardiotropic viruses using PCR method were detected. Histological findings showed non-specific diffuse changes in myocytes (their size and nuclei varied) and interstitial fibrosis, mild-myocardial pattern of late gadolinium enhancement.

Figure 1 Findings of cardiac examination. (A) ECG strip demonstrates the premature ventricular contractions (to 100 PVCs/1h). (B & C) cardiac MR etc. cardiac MRI features of cardiomegaly (b-long-axis and c-short-axis post contrast views there is no sub-epicardial or mild-mycocardial pattern of late gadolinium enhancement).

Thus, the patient was presented with primary amenorrhea, hypergonadotropic hypogonadism, DCM, hypothyroidism, mental retardation, undeveloped secondary sexual characters, marked body mass deficit due to a significantly reduced adipose tissue; she also had a narrow chest and sloping shoulders, facial dysmorphism (micro retrognathia, prominent beak nose). These clinical data suggested a laminopathy.

Informed consent was obtained from patient for genetic investigation. Genomic DNA was used for next-generation sequencing on MiSeq System (Illumina Inc., San Diego, CA, USA). We used a custom-made panel of 46 genes associated with cardiomyopathies, including LMNA, the TruSight cardiomyopathy sequencing panel (Illumina Inc, San Diego, CA, USA). Coordinates of sequence data ovaries could not be clearly seen. However, the patient was capable to menstruate only with the support of estradiol and progesterone. X-rays examination of collarbones, extremity phalanges and cranium was performed to exclude mandibulocural dysplasia taking into account signs of severe microretrognathia and adipose tissue thinning (lipodystrophy). Mandibulocural dysplasia (MAD; OMIM 248370) is a rare, genetically and phenotypically heterogeneous, autosomal recessive disorder characterized by skeletal abnormalities including hypoplasia of the mandible and clavicles, acroosteolysis, cutaneous atrophy and lipodystrophy. X-rays revealed no evidence of MAD-specific bone dysplasia, i.e. distension of fontanel cranial sutures, dental abnormalities, clavicle hypoplasia and distal phalanx acroosteolysis findings are presented in Figure 2.
were on NCBI build37 (UCSC hg19). We have identified 110 variants, 24 of which were missenses and 1 located in splice site. No changes in LMNA gene were found in our patient. The Minor Allele Frequency (MAF) for all identified missense and splicing variants were greater than 1% in population database. The clinical role of these variants is not confirmed. After 3 and 6-month follow-up with guideline directed medical therapy the patient showed no progression of heart failure (NYHA II) and haemodynamic improvement (LVEF 45%, not clinically significant ventricular ectopy 180 PVCs/24h) therefore the planned cardiac resynchronization defibrillator therapy was delayed.

Figure 2 Findings of X-ray examination. A, B) Cranium tomography (normal cranial suture, micrognatia) with 3-D scans reconstruction. There is no any evidence of MAD-specific bone dysplasia. C) Normal clavicle. (D&E) Absent of distal phalange acroosteolysis.

Discussion

The clinical case has a manifestation typical for cardiogenital syndrome. This rare pathology relates to laminopathies, associated with LMNA mutations and numbering more than a dozen of here dietary disorders. Mutations in the LMNA gene cause a variety of disorders including dilated cardiomyopathy, muscular dystrophy, familial lipodystrophy, progeria, atypical progeroid syndromes, and mandibuloacral dysplasia. Phenotypic features in the present case are very similar to 3 cases reported by McPherson et al.,' Nguyen et al.,' & Chen et al.' The heterozygous missense mutations (L59R, A57P) in LMNA and predicted functional partners (interactive http://string-db.org/cgi/network).


Figure 3 LMNA and predicted functional partners (interactive http://string-db.org/cgi/network).

Conclusion

In conclusion, presented case report of Malouf syndrome is not associated with mutation in the LMNA gene. But the changes in the structural and functional partners of lamins are not excluded. To this day, the cardiogenital syndrome attributed to laminopathies according to the results of LMNA gene analysis. But some cases without LMNA
mutations have already been described. This indicates the existence of cardiogenital syndrome with another genetic background. The low prevalence of Malouf syndrome, the lack of genetic researches in past reports, and the heterogeneity of clinical manifestations complicate the definition of the molecular mechanisms of pathology. We note that thyroid dysfunction already described for the cardiogenital syndrome not associated with LMNA mutations,\(^6\) may play the aetiological role (mental retardation?). We call on clinicians to focus special attention to this feature.

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**Conflict of interest**

The author declares no conflict of interest.

**References**


