Turk Gogus Kalp Dama 2015;23(4):700-707
doi: 10.5606/tgkdc.dergisi.2015.10736

Original Article / Özgün Makale

Is isolated dextrocardia a feature of left-sided Poland's syndrome?

İzole dekstrokardi sol taraflı Poland sendromunun bir özelliği midir?

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ABSTRACT

Background: In this study, we investigate the relationship between Poland's syndrome and dextrocardia.

Methods: The diagnosis of Poland's syndrome with dextrocardia was made in eight male patients (mean age 21 years; range 19 to 25 years) between January 2005 and December 2013. All patients had left-sided syndrome. The patients were evaluated in terms of additional anomalies.

Results: Isolated dextrocardia, the absence of the left pectoral muscle, and breast anomalies were detected in all patients. The absence or hypoplasia of the left serratus anterior muscle in three patients, partial rib agenesis in five patients, contralateral pectus carinatum deformity in three patients, scoliosis in one patient, brachysyndactyly in one patient, and palmar hyperhidrosis in one patient were identified. Three patients had Poland's syndrome with dextrocardia without rib agenesis. Left-sided Sprengel's deformity was observed in three patients.

Conclusion: Our case series may support the view that dextrocardia may be a feature of left-sided Poland's syndrome and the combination of Poland's syndrome and isolated dextrocardia may be present without rib agenesis.

Keywords: Dextrocardia; partial rib agenesis; Poland's syndrome.

ÖZ

Amaç: Bu çalışmada, Poland sendromu ve dekstrokardi arasındaki ilişki araştırıldı.

Çalışma planı: Ocak 2005 - Aralık 2013 tarihleri arasında sekiz erkek hastaya (ort. yaş 21 yıl; dağılım 19-25 yıl) dekstrokardi ile birlikte Poland sendromu tanısı konuldu. Tüm hastalarda sol taraflı sendrom vardı. Hastalar ek anormallikler açısından değerlendirildi.

Bulgular: İzole dekstrokardi, sol pektoral kas yokluğu ve meme anomalileri tüm hastalarda tespit edildi. Sol serratus anterior kasının yokluğu veya hipoplazisi üç hastada, kısmi kaburga agenezisi beş hastada, kontralateral pektus karinatum deformitesi üç hastada, skolyoz bir hastada, brakisindaktili bir hastada ve palmar hiperhidroz bir hastada tespit edildi. Üç hastada kaburga agenezisi olmaksızın dekstrokardi ve Poland sendromu birlikteliği vardı. Sol taraflı Sprengel deformitesi üç hastada gözlendi.

Sonuç: Olgu serimiz dekstrokardinin sol taraflı Poland sendromunun bir özelliği olabileceği ve Poland sendromu ile izole dekstrokardi kombinasyonunun kaburga agenezisi olmaksızın da seyredebileceği görüşünü desteklemektedir.

Anahtar sözcükler: Dekstrokardi; kısmı kaburga agenezisi; Poland sendromu.

Poland's syndrome is an extremely rare congenital anomaly. The classical definition of Poland's syndrome is the unilateral absence of the pectoral muscles with hand anomalies and various chest deformities.[1,2] Subsequently, very different variants of the syndrome have been reported. The most common features are agenesis of the pectoralis major and minor muscles, agenesis of the costal cartilages, and the absence of the anterior parts of the ribs, abnormalities of the breast, hypoplasia of the subcutaneous tissue, and unilateral

Available online at
www.tgkdc.dergisi.org
doi: 10.5606/tgkdc.dergisi.2015.10736
QR (Quick Response) Code

Received: August 03, 2014 *Accepted:* October 02, 2014

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brachysyndactyly.[2] The main features of Poland's syndrome is unilateral absence of the pectoralis major muscle. Patients with at least one of the other associated features are considered to suffer from this syndrome.[2] Additionally, many other anomalies including dextrocardia, vertebral defects, renal aplasia or hypoplasia, undescended testes, Moebius syndrome, lung herniation, or tumors may accompany this syndrome.[3] The association of Poland's syndrome with dextrocardia is very uncommon and, to date, 48 cases have been reported (Table 1). All these patients had left-sided Poland's syndrome associated with isolated dextrocardia. Herein, we report eight cases of left-sided Poland's syndrome with dextrocardia to discuss the relationship between Poland's syndrome and dextrocardia.

PATIENTS AND METHODS

Between January 2005 and December 2013, eight male patients with Poland's syndrome associated with dextrocardia (mean age 21 years; range 19 to 25 years) were evaluated in our clinic (Table 2). In the same period, 79 patients with Poland's syndrome were admitted to our clinic due to asymmetric chest wall appearance. Among 79 patients, 36 (45.5%) were diagnosed with the right-sided syndrome, 35 (44.3%) with the left-sided one, and eight (10.1%) with bilateral. The first patient was previously reported as a case report.[3] Patients who had an isolated absence of the pectoralis major muscle were not considered to have Poland's syndrome. However, the patients with complete or partial absence of the pectoral muscles and at least two additional components were accepted as having Poland's syndrome (Figure 1).

The patients with Poland's syndrome and dextrocardia, as evidenced by radiologically, were included in our case series (Figures 2, 3). A detailed physical examination was obtained from all patients. The patients were evaluated in terms of associated anomalies, such as Sprengel's deformity (congenitally elevated and small scapula). The patients underwent complete blood counts (CBC) and routine biochemical tests, chest X-rays, and thoracic computed tomography. Possible accompanying abdominal and cardiac anomalies were investigated with both abdominal ultrasonography and echocardiography.

Although surgical treatment was recommended to correct the deformity of the anterior chest wall on the affected side in all patients, only one patient was willing. The left latissimus dorsi muscle flap was transferred to the left pectoral region to restore the contour deformity due to the absence of the pectoral muscle. The patient had an uncomplicated postoperative period and postoperative satisfaction of the patient was relatively high.

RESULTS

None of the patients had a family history of Poland's syndrome. In all patients, the features of Poland's syndrome appeared on the left side and in the pectoral region of the affected side, compared to the opposite side, which was found to be depressed. The unilateral pectoral muscle was unable to be palpated in any of the patients on physical examination. Left-sided Sprengel's deformity was observed in three patients, while there was asymmetry and hypoplasia of the left breast in six patients. Compared to the unaffected side, the nipples were in a superior localization in each case, and the nipple-areolar complex was absent in one patient. While two patients had both axillary and pectoral alopecia, the others had only pectoral alopecia. Furthermore, there was a pectus carinatum deformity in the opposite side in three patients, brachysyndactyly in one patient, and palmar hyperhidrosis in one patient (Table 2).

Complete blood counts and routine biochemical tests of the patients were within the normal limits. In all of the patients, the chest X-rays showed dextrocardia (Figures 2a, 3a). It was assumed that they did not have situs inversus totalis due to the gastric air bubbles which were seen on the left side of their chest X-rays. In addition, five patients had partial agenesis of the ribs and one patient had scoliosis (Figure 2). All patients underwent computed tomography to identify the pathologies accompanying the physical examination findings. A complete absence of the major pectoral muscle was detected in five patients, while an absence of the sternocostal head of the major pectoral muscle was found in three patients (Figures 2b, c, 3b, d). The left pectoralis minor muscle was absent in all cases (Figures 2b, 3b). The left serratus anterior muscle was absent in two patients and it was hypoplastic in one.

All of the patients had left-sided rib deformities, a depressed anterior chest wall (sunken chest), and a small left hemithorax, compared to the right side (Figures 2b, 3b). Although the agenesis of the anterior part of the ribs on the left side was detected in five patients, the other three patients had only left-sided rib hypoplasia (Figures 2b, d, 3b, c). Three patients had second, third, and fourth rib agenesis, and two patients had third and fourth rib agenesis. Distinctively, the absence of the lower part of the sternum without rib agenesis was observed in only one patient. Abdominal ultrasonography showed rectus abdominis muscle hypoplasia in one patient and an

Table 1. A summary of previously reported patients with Poland's syndrome and isolated dextrocardia

No	Authors	Clinical features of patients
1	David[13]	Left-sided Poland's syndrome and dextrocardia
2	Walters et al.[14]	Left-sided Poland's syndrome, dextrocardia and leukemia
2	Sugarman and Stark[15]	Left-sided Poland's syndrome, dextrocardia and Moebius syndrome
4	Hanka and Fox[16]	Left-sided Poland's syndrome, dextrocardia and absence of permanent incisors
5	McGillivray and Lowry[17]	Left-sided Poland's syndrome and dextrocardia
6	Bosch-Banyeras et al.[18]	Left-sided Poland's syndrome, dextrocardia and Moebius syndrome
7	Gugliantini et al.[19]	Left-sided Poland's syndrome, dextrocardia, diaphragmatic defect, aplasia of subtotal sternal body and hypoplasia of scapula, humerus, forearm bones
8	Lodha et al.[20]	Left-sided Poland's syndrome and dextrocardia
9	Donahue et al.[21]	Left-sided Poland's syndrome, dextrocardia, Moebius syndrome, cleft palate, mandibular hypoplasia, and diffuse brain volume loss
10	Sabry et al.[22]	Five patients with left-sided Poland's syndrome and dextrocardia
11	Hazir and Malik[23]	Left-sided Poland's syndrome and dextrocardia
12	Burkhardt and Buss[24]	Left-sided Poland's syndrome and dextrocardia
13	Fraser et al.[4]	Two patients with left-sided Poland's syndrome and dextrocardia
14	Pérez Belmonte et al.[25]	Left-sided Poland's syndrome and dextrocardia
15	Eroglu et al.[3]	Left-sided Poland's syndrome, dextrocardia, and bilateral palmary hyperhydrosis
16	Mutlu et al.[26]	Left-sided Poland's syndrome and dextrocardia
17	Cordero Garcia et al.[27]	Left-sided Poland's syndrome and dextrocardia
18	Sepulveda[10]	Left-sided Poland's syndrome and dextrocardia
19	Torre et al.[1]	Fourteen patients with left-sided Poland's syndrome and dextrocardia (additionally undescended testes and splenomegaly in one patient, intrahepatic biliary duct dilatation and hypertelorism in one patient, IgA deficiency in one pateint, sylvian duct stenosis in one patient, convergent squint in one patient, congenital occipital vascular anomaly and vertebral schisis in one patient)
20	Lacorte et al.[28]	Left-sided Poland's syndrome and dextrocardia
21	Galiwango et al.[29]	Left-sided Poland's syndrome and dextrocardia
22	Srivastava et al.[30]	Left-sided Poland's syndrome, dextrocardia and off-pump coronary artery bypass operation
23	Kim and Morelli[31]	Left-sided Poland's syndrome and dextrocardia
24	Li et al.[32]	Left-sided Poland's syndrome, dextrocardia, scoliosis, diaphragmatic hernia, and ipsilateral lipoma
25	Iyer and Parisi[33]	Left-sided Poland's syndrome, dextrocardia, microscapula, and hypoplastic left posterior thoracic musculature
26	Flores et al.[34]	Left-sided Poland's syndrome, dextrocardia, Moebius syndrome, micrognathia, swallowing difficulty, hypotonia, lung herniation, and clubfoot.
27	Chadran et al.[35]	Left-sided Poland's syndrome, dextrocardia, and lung herniation
28	Raval et al.[36]	Left-sided Poland's syndrome, dextrocardia, and pulmonary hypertension
29	Sunitha et al.[37]	Left-sided Poland's syndrome, dextrocardia, spina bifida and diaphragmatic hernia
30	Panda et al.[38]	Left-sided Poland's syndrome, dextrocardia, and herniation of the spleen
31	*Our study*	Eight patients with left-sided Poland's syndrome and dextrocardia (additionally left-sided Sprengel's deformity in three patients, pectus carinatum deformity in the opposite side in three patients, palmar hyperhidrosis in one patient, rectus abdominis muscle hypoplasia in one patient, ectopic spleen in one patient, serratus anterior muscle absence or hypoplasia in three patients)

Table 2. Clinical presentations of patients

Patients	Age/gender	Side	Pectoralis major muscle	Pectoralis minor muscle	Affected ribs	Dextrocardia	Additional anomaly
1	20/M	L	Absence of sternocostal head	Absence	2, 3, 4	Yes	Pectoral alopecia, hypoplasia of breast and nipple, hypoplasia of subcutaneous tissue, asymmetric areola, palmar hyperhidrosis, hypoplasia of rectus abdominis muscle
2	24/M	L	Complete absence	Absence	–	Yes	Hypoplasia of the breast and nipple, hypoplasia of subcutaneous tissue, asymmetric areola, persistent left superior vena cava
3	21/M	L	Complete absence	Absence	2, 3, 4	Yes	Pectoral alopecia, hypoplasia of breast and nipple, hypoplasia of subcutaneous tissue, asymmetric areola
4	20/M	L	Complete absence	Absence	–	Yes	Pectoral alopecia, paucity of axillary hair, hypoplasia of breast and nipple, asymmetric areola, hypoplasia of subcutaneous tissue, brachysyndactyly, absence of lower part sternum, pectus carinatum
5	19/M	L	Complete absence	Absence	2, 3, 4	Yes	Pectoral alopecia, hypoplasia of breast and nipple, asymmetric areola, hypoplasia of subcutaneous tissue, scoliosis
6	19/M	L	Complete absence	Absence	3, 4	Yes	Pectoral alopecia, paucity of axillary hair, absence of breast and nipple, hypoplasia of subcutaneous tissue, pectus carinatum, absence of serratus anterior muscles, Sprengel's deformity
7	20/M	L	Absence of sternocostal head	Absence	3, 4	Yes	Hypoplasia of breast and nipple, asymmetric areola, hypoplasia of subcutaneous tissue, hypoplasia of serratus anterior muscles, Sprengel's deformity, ectopic spleen
8	25/M	L	Absence of sternocostal head	Absence	–	Yes	Hypoplasia of breast and nipple, asymmetric areola, hypoplasia of subcutaneous tissue, pectoral alopecia absence of serratus anterior muscles, Sprengel's deformity, pectus carinatum

M: Male; L: Left.

ectopic spleen in one patient. Isolated dextrocardia was confirmed by echocardiography in all patients. Additionally, a persistent left superior vena cava was noted in one patient, as evidenced by echocardiography.

DISCUSSION

Poland's syndrome was first described in 1841 in a case with unilateral pectoral muscle absence and a hand anomaly, as reported by Alfred Poland.[2] It is characterized by the absence of the major pectoral muscle and absence or hypoplasia of the minor pectoral muscle, anomaly of the breast and/or nipple, hypoplasia of the subcutaneous tissue, chest wall deformities, pectoral and/or axillary alopecia, and hand anomalies.[2-4] Relatively distinct variants of this syndrome have been reported, to date, and it is extremely rare for a case to have all of the features together. Major criteria include the absence of the major pectoral muscle and the presence of at least one of the other components.[2,3] The complete absence of the pectoral muscle or the absence of the sternocostal head of the muscle may be observed.[2]

All patients in our case series fulfilled at least two components, in addition to the affected pectoral muscles, to be diagnosed with Poland's syndrome. Many other anomalies accompanying Poland's syndrome have been described so far and one of the most common is dextrocardia. To date, 48 patients with the

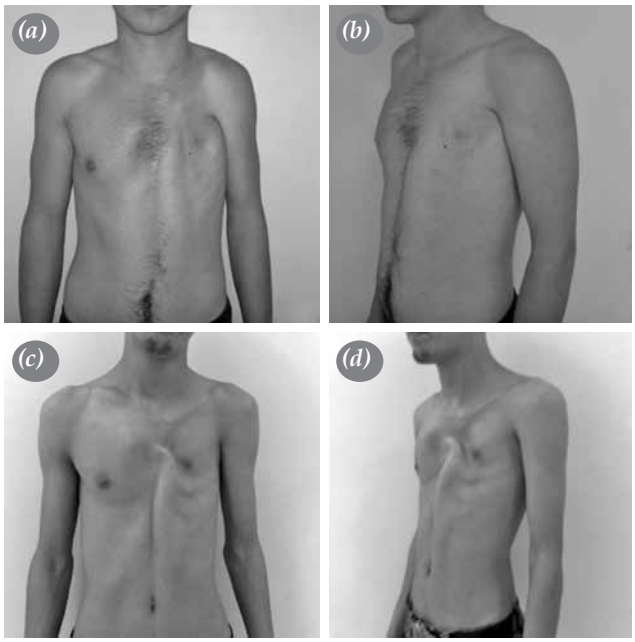

Figure 1. (a, b) The appearence of patient with left-sided Poland's syndrome, dextrocardia and partial rib agenesis (Case 6). **(c, d)** The appearence of a patient with left-sided Poland's syndrome and dextrocardia without rib agenesis (Case 4).

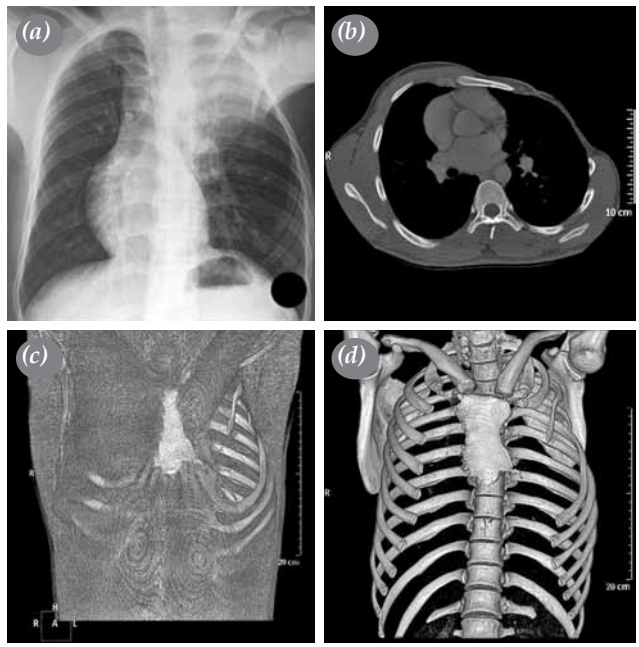

Figure 2. (a) Posteroantrior chest radiograph demonstrating dextrocardia with partial rib agenesis. **(b)** Axial computed tomography images showing a sunken chest, the absence of left pectoral muscles, and partial rib agenesis, **(c, d)** volume rendering images of computed tomography scan showing partial absence of left pectoral muscles, and partial rib agenesis (Case 7).

combination of Poland's syndrome and dextrocardia have been reported (Table 1). Although Poland's syndrome is most often right-sided, all patients had the left-sided syndrome with rib defects and isolated dextrocardia. Similarly, most of our patients had right-sided syndrome, whereas all with the combination of Poland's syndrome and isolated dextrocardia had left-sided syndrome. There is the exception of two patients with right-sided anomalies and situs inversus totalis, which were reported by Atasoy et al.[5] and Lee et al.[6] as having the combination of dextrocardia and right-sided Poland's syndrome. Both reported patients had right-sided thoracic depression without the absence of the pectoral muscle. The major diagnostic component of Poland's syndrome is the absence of a part of the pectoralis major muscle or its complete absence.[2] It is still controversial whether these patients had Poland's syndrome. Anterior thoracic hypoplasia and Poland's syndrome are similar congenital chest wall deformities; however, thoracic wall depression without absent pectoral muscles is typical for anterior thoracic hypoplasia.[7] We believe that a diagnosis of anterior thoracic hypoplasia would be more appropriate for those two patients. However, although all patients previously presented suffered from a combination of isolated dextrocardia and Poland's syndrome, there was situs inversus totalis, instead of isolated dextrocardia, in those two patients.

Dextrocardia is the displacement of the heart to the right hemithorax.[1,3,4,6] It can be a part of situs inversus totalis, which is the complete mirror-image transposition of the thoracic and abdominal viscera.[3,6,8] The incidence of dextrocardia with situs inversus totalis is 1:10.000, while the incidence of cardiac defects is relatively low in this patient population (about 5%).[3] Isolated dextrocardia or situs solitus is a right-sided heart position with normal situs. Due to both the abdominal and thoracic viscera being in normal situs in patients with situs solitus, the gastric air bubble is localized on the left side. According to several reports, the incidence of Poland's syndrome ranges from 1:10,000 to 1:100,000, whereas the incidence of isolated dextrocardia is 1:30,000 in live births. The incidence of isolated dextrocardia is 1:900,000 in adults, since there is congenital heart disease in 98% of these patients.[1,3,4] These two extremely rare anomalies are seen together in 11.5% of the patients with this syndrome.[1] In our case series, 10.1% patients had dextrocardia in addition to Poland's syndrome. More importantly, cardiovascular anomalies are rare in patients with the combination of the syndrome and dextrocardia. The high rate of comorbidity of Poland's syndrome and isolated dextrocardia along with the low rate of cardiovascular anomalies support the

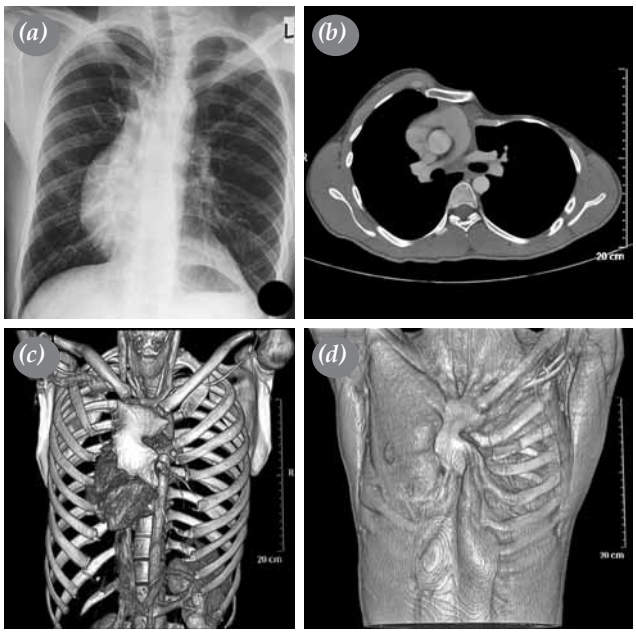

Figure 3. (a) Posteroanterior chest radiograph demonstrating dextrocardia without rib agenesis. **(b)** Axial computed tomography images show depressed chest and the absence of the left pectoral muscles, **(c, d)** volume rendering images of computed tomography scan, demonstrating absence of the left pectoral muscles, and no rib agenesis (Case 4).

hypothesis that isolated dextrocardia is a component of Poland's syndrome.[1,3]

Patients with Poland's syndrome may have a normal rib cage; however, a sunken chest (depressed chest wall), scoliosis, hypoplasia or agenesis of the ribs, and contralateral pectus carinatum may also present.[9] The sunken chest is a common feature for patients with Poland's syndrome and dextrocardia and the affected ribs were responsible for this deformity in all of the previously reported cases, as in our patients.[1] The sternum may rotate towards the affected side due to aplastic and hypoplastic ribs, thereby, leading to contralateral carinatum deformity.[9] Case 4, 6, and 8 had pectus carinatum deformities in our series and scoliosis was detected in only one patient (Case 5).

Furthermore, Torre et al.[1] reported the largest case series including 14 patients with left-sided Poland's syndrome and dextrocardia. Their patients were referred from three medical centers. However, our case series is relatively small due to the fact that our patients were from a single center. Torre et al.[1] and Eroglu et al.[3] reported that dextrocardia was always associated with left-sided Poland's syndrome and left-sided partial rib agenesis of two or more ribs. In contrast to the patients reported to date, three of our patients did not have rib agenesis and there was an absence of the lower part of the sternum in one of these three patients. For three cases without rib agenesis, it cannot be assumed that rib agenesis necessarily accompanies the combination of Poland's syndrome and dextrocardia.

One of the most important topics discussed in previous reports is that which comes first: dextrocardia or Poland's syndrome? According to one explanation, dextrocardia occurs first. The shifted vascular structures due to the dextroposition of the heart may lead to a deficient blood supply and some defects including agenesis and hypoplasia, which are specific for Poland's syndrome. Another explanation is that dextrocardia is a cardiac malposition caused by deformation of the chest wall. This claim is based on the observation that all of the reported patients have depressions of the anterior chest wall.[1,4] Sepulveda[10] reported a patient with left-sided Poland's syndrome and dextrocardia, which was demonstrated by an ultrasonographic scan at the 31st week of gestation. There was no cardiac malposition at the 21st gestational week of this patient, which suggests that the cardiac dextroposition develops secondarily to left-sided Poland's syndrome.

In another study, Torre et al.[1] hypothesized that dextrocardia was a result of the mechanical intrauterine displacement of the heart due to insufficient protection of the chest wall against external pressures and single rib agenesis was not enough for the external pressures to displace the heart. According to their hypothesis, if two or more agenesis of the ribs exist, dextrocardia always occurs.[1] This hypothesis is reasonable, when our three patients without rib agenesis are excluded. However, a sunken chest and small hemithorax were identified in all patients. We believe that, therefore, the probable cause of the isolated dextrocardia is the displacement of the heart to increase the volume of the left hemithorax, which has a reduced volume because of the chest deformity.

Although it is rare, in some cases, Sprengel's deformity may accompany this syndrome.[9] Sprengel's deformity is defined as the congenital elevation of the scapula,[11] and in general, the affected serratus anterior muscle is responsible for this elevation.[9] Bavinck and Weaver[12] presented a hypothesis to explain the pathogenesis of some anomalies including Poland's, Sprengel's, Klippel-Feil's, and Moebius' anomalies, isolated absence of the pectoralis major muscle and breast hypoplasia, and isolated limb defects. According to this hypothesis, an interruption of the early embryogenic blood supply in the subclavian arteries, the vertebral arteries or their branches may

cause such defects. It is the most adopted hypothesis for the pathogenesis of Poland's syndrome, as well as of Sprengel's deformity.[12] Sprengel's deformity may accompany Poland's syndrome, as they share same pathogenesis and the serratus anterior muscle is affected, which can be also observed in some patients with Poland's syndrome.[9,11] Three of our patients (Case 5, 7, and 8) had left-sided Sprengel's deformities in addition to the syndrome. These patients also had an affected left serratus anterior muscle. To the best of our knowledge of the English literature, these patients are the first reported patients with the association of Poland's syndrome, dextrocardia, and Sprengel's deformity.

In conclusion, our case series and all previously reported cases support that isolated dextrocardia is a feature of left-sided Poland's syndrome. However our case series show that the combination of isolated dextrocardia and left-sided Poland's syndrome may develop without rib agenesis.

Declaration of conflicting interests

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding

The authors received no financial support for the research and/or authorship of this article.

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