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CASE REPORT
Coronary intervention

Simultaneous ST-elevation myocardial infarction in monozygotic twins: a case report of entangled twins

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Background The development of coronary artery disease (CAD) is strongly influenced by genetic and environmental factors. Monozygotic twins represent a unique population that provides insights into the interaction of genetic, environmental, and social factors and their effects on the development of CAD.

Case summary Two 54-year-old identical twins presented to an outside hospital with acute chest pain. Twin B developed chest pain after witnessing Twin A in distress from an acute chest pain episode. Electrocardiogram performed on each of them was diagnostic of ST-elevation myocardial infarction. Upon arrival at the angioplasty centre, Twin A was taken for emergency coronary angiography yet his pain subsided on the way to the catheterization lab hence, Twin B was taken for angiography instead. Twin B angiography demonstrated acute occlusion of the proximal left anterior descending coronary artery and was treated with percutaneous coronary intervention. Twin A coronary angiogram demonstrated 60% ostial first diagonal branch stenosis with a normal distal flow. He was diagnosed with possible coronary vasospasm.

Conclusion This is the first report of a simultaneous presentation of monozygotic twins with ST-elevation acute coronary syndrome. While genetic and environmental contributions to the development of CAD have been described, this case highlights the strong social bond that exists between monozygotic twins. Once CAD is diagnosed in one twin, aggressive risk factor modification and screening should be implemented in the other.

Keywords Myocardial infarction • Twins • Coronary artery disease • Case report

ESC Curriculum 3.1 Coronary artery disease • 3.2 Acute coronary syndrome • 3.4 Coronary angiography

Learning points

- Understand the prevalence of concordance in coronary anatomy and disease between monozygotic twins, and between evident genetic factors and close environmental influences.
- Understand the importance of social factors that influence disease expression in twins.
- Recognize the importance of screening and prevention in twin pairs once one of them is diagnosed with coronary artery disease.

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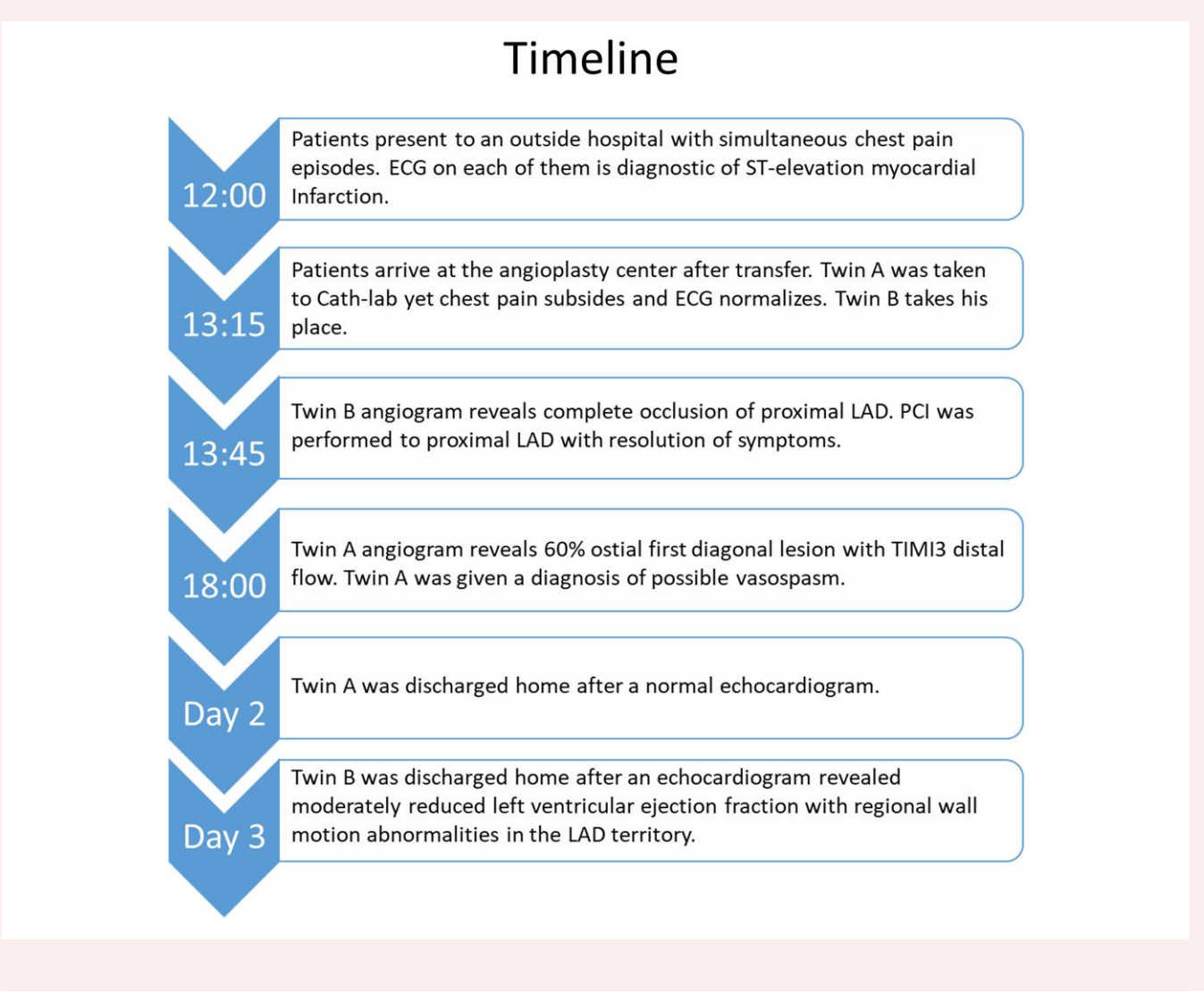
Introduction

The development of coronary artery disease (CAD) is strongly influenced by genetic and environmental factors.[1] The heritability of CAD has been estimated between 40% and 60% with CAD incidence increasing by >2-fold after adjustment for conventional CAD risk factors in participants with a family history of premature disease in the Framingham study.[2] Twin studies provide insight into the differential influences that those factors have on the development of CAD and into the heritability patterns of morphological characteristics of the coronary tree. Currently, very few reports of angiographic comparison between twin pairs are documented.[3] We describe a very rare presentation of identical twins with simultaneous ST-elevation myocardial infarction (STEMI). The case highlights not only the hereditary concordance of CAD but also the contribution of a strong social bond between a pair of identical twins where an acute coronary syndrome in one twin potentially triggered a myocardial infarction (MI) in the other.

Timeline

Case summary

Two 54-year-old Caucasian identical twin males, never smokers, with no known history of diabetes mellitus, and with a history of CAD with prior percutaneous coronary interventions (PCIs) to mid left anterior descending coronary artery (LAD) for stable angina symptoms, presented to the emergency department (ED) with acute chest pain. Twin A started having chest pain after lifting weights at the gym. Twin B, who was with Twin A, drove his brother to the nearest hospital when he started having crushing chest pain himself. They arrived at the nearest ED at an outside hospital, and an electrocardiogram (ECG) was performed on each one of them (6 min apart). Electrocardiogram of Twin A showed ST-segment elevation in high lateral leads with reciprocal ST-segment depressions in inferior leads while that of Twin B revealed ST-segment elevation in inferior leads (*Figure 1A and B*). Initial troponin-I levels on both twins were measured at 0.03 ng/mL. They were both diagnosed with STEMI but refused to be transferred to different hospitals for emergency coronary angiography (CA) as they lived together and refused to be separated. They were loaded with aspirin, started on heparin drips, and transferred to our centre. Upon arrival, both of the twins were still having active chest pain. Twin B appeared



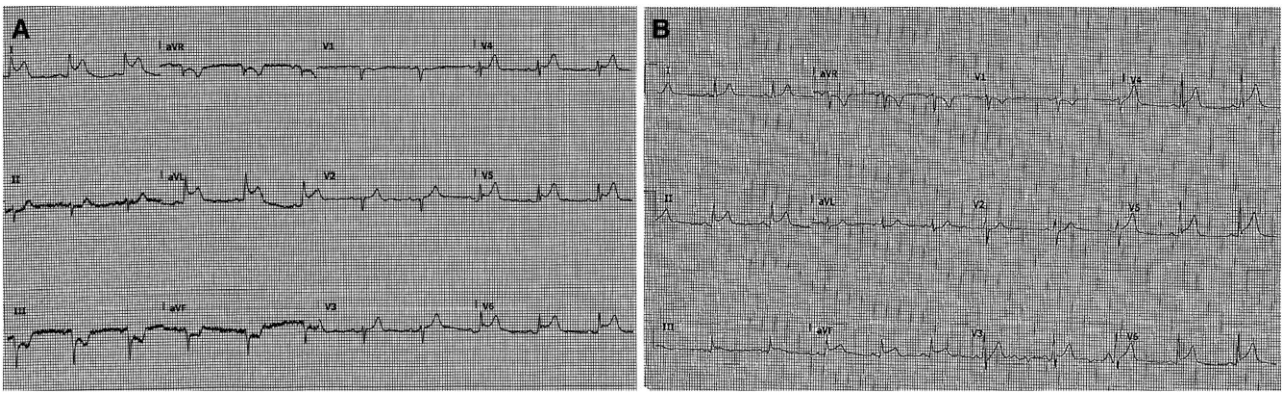


Figure 1 Electrocardiogram of Twin A on arrival to outside hospital revealed ST-segment elevation in high lateral leads with reciprocal ST-segment depressions in inferior leads (*A*). Electrocardiogram of Twin B revealed ST-segment elevation in inferior leads with some peaking of T waves in lateral leads (*B*).

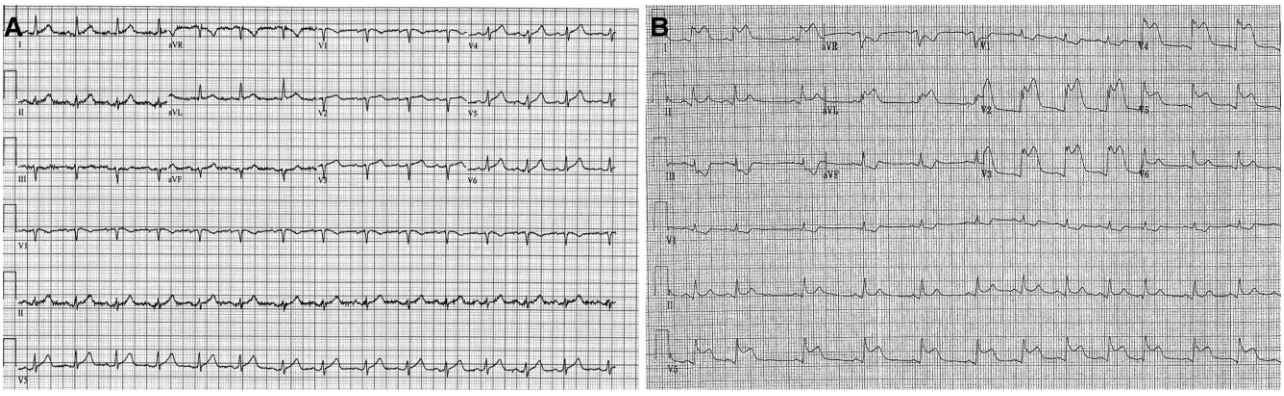


Figure 2 Repeat electrocardiogram of Twin A on arrival to our hospital revealed resolution of ST-segment elevations (*A*). Repeat electrocardiogram of Twin B now revealed ST-segment elevations in anterior and anterolateral leads with reciprocal changes in the inferior leads (*B*).

in greater distress than Twin A. Rest of the physical exam on both twins was rather unremarkable without any abnormal cardiovascular or pulmonary findings. The catheterization lab could accommodate only one person at a time and Twin A with anterior STEMI was taken to the lab first. However, his chest pain subsided on the way to the lab, and a repeat ECG demonstrated resolution of ST-segment elevations (*Figure 2A*). Meanwhile, Twin B was having worsening chest pain, and ST-segment elevations became more prominent in the anterior leads (*Figure 2B*). A decision was made to swap the patients and Twin B was taken for emergent CA instead.

Coronary angiography of Twin B via the right femoral approach revealed complete occlusion of the proximal LAD with TIMI 0 distal flow (see Supplementary material online, *Video S1A*). The patient underwent PCI to proximal LAD with implantation of a 3.5 × 18 drug-eluting stent and restoration of TIMI3 distal flow (see Supplementary material online, *Video S1B*). He developed multiple episodes of polymorphic ventricular tachycardia during the procedure requiring synchronized cardioversion. At the end of the procedure, he was chest pain-free and had an unremarkable post-procedural course. Twin A was taken to CA after Twin B the same evening. Coronary angiography via the right femoral approach demonstrated mild in-stent restenosis in the mid-LAD and first diagonal bifurcation with TIMI3 distal flow. There was an ostial first diagonal lesion leading to 60% stenosis that persisted after the administration of intracoronary nitroglycerine (see Supplementary material online, *Video S2*). He was managed conservatively with medical therapy and had an unremarkable hospital course. Further work up is summarized in *Table 1*. Both twins were found to have pre-diabetes with an HgbA1C of 6%. They had a normal lipid panels, haemoglobin levels, and renal function. Echocardiogram showed normal left ventricular ejection fraction on Twin A and moderately reduced ejection fraction of Twin B at 35–40%. Troponin-I level peaked at 38 ng/mL on Twin B and at 0.09 ng/mL on Twin A. Twin B was treated with dual antiplatelet therapy including 81 mg of Aspirin and 10 mg of Prasugrel for a year, high-intensity statin therapy, beta-blocker, and angiotensin-converting enzyme inhibitor. Twin A was treated with 81 mg of aspirin, high-intensity statin therapy, and a beta-blocker. At 6 months of follow-up, both patients have been doing well, without recurrence of angina, chest pain symptoms, or any heart failure symptoms. Repeat echocardiogram on Twin B demonstrated improvement of left ventricular ejection fraction to 45–50%.

Table 1 Inpatient work up with labs drawn upon arrival to our centre

Test	Twin A	Twin B
WBC	12k	16k
Haemoglobin	13.8 gm/dL	13.6 gm/dL
Creatinine	0.9 mg/dL	0.9 mg/dL
Troponin I	0.03 ng/mL —> 0.09 ng/mL	0.03 ng/mL —> 38 ng/mL
HgbA1C	6%	6%
LDL cholesterol	57 mg/dL	45 mg/dL
Triglycerides	50 mg/dL	47 mg/dL
TSH	0.52 mU/L	0.54 mU/L
Echocardiography	Ejection fraction 60–65%. No regional wall motion abnormality.	Ejection fraction 35–40%. Dyskinesis of the apical myocardium; severe hypokinesis of the mid-apical anterior, basal-mid anteroseptal, mid inferoseptal, and apical septal myocardium.
Urine drug screen	Negative	Negative

Discussion

This is an unusual case of simultaneous presentation of identical twins with anterior STEMI. To our knowledge, this is the first description of such a presentation. While there have been previous descriptions of identical or fraternal twins presenting with CAD several months apart and having similar CAD anatomy,[4,5] none presented with MI at the same time. Both twins had CAD despite lacking traditional risk factors such as smoking or hypertension. Four years prior to the current presentation, both of the twins underwent stenting of their mid-LAD for stable angina symptoms after abnormal stress tests. They did have a strong family history of premature CAD in their father, who had coronary artery bypass surgery in his early 50 s. Both of the twins were single, lived together, and spent a lot of their time together, thus sharing similar environmental factors. Interestingly, their laboratory work up revealed very similar lipid panel, HgbA1C, haemoglobin, and creatinine levels. Neither had substance use issues that could explain simultaneous presentation; drug screens were negative. Both of the twins were taking baby aspirin and moderate-intensity statin therapy. What is notable about the current case is that Twin B started having chest pain after witnessing his twin brother in significant distress. While Twin B had angiographic evidence of acute vessel closure with a resolution of symptoms upon revascularization, Twin A had a different coronary pathology. Twin A's ECG did reveal ST-segment elevations in the lateral leads with inferior reciprocal changes suggesting a coronary event in the diagonal distribution. Due to the transient nature of the ST-segment elevations, the more likely differential of the coronary event in Twin A is coronary vasospasm in the first diagonal branch. Although the possibility of thrombosis with recanalization could not be fully excluded without intracoronary imaging, angiography did not suggest such an event. Genetic factors are strong contributors to the development of CAD yet, there remains little support for a role of single-gene disorders in coronary atherosclerosis or plaque rupture events. The genetic basis of CAD is predominantly the cumulative effect of multiple common risk alleles individually of small effect size rather than rare variants with large effects on CAD risk.[2] While genetic and hereditary similarities between identical twins have been previously described,[6] this case highlights the strong emotional and social bond that exists between twins, especially the ones who share a large portion of their lives together. The effect of such a bond on the phenotypic expression of a disease is not well known and is not practical to measure, hence remains a postulation. However, what is well described are the hereditability of morphological patterns of CAD and the risk that CAD in one twin confers on the other. Fischer *et al.*[7] demonstrated in a cohort of 882 siblings that significant heritabilities are identified for proximal stenosis, particularly left main but not for distal disease. Monozygotic twin studies, however, are much smaller and predominantly limited to case reports. While most reports argued for concordance of coronary anatomy and lesions between the twin pairs arguing for predominant genetic heritability, others found significant discordance between twin pair coronary circulation (*Table 2*).

In one of the larger case series, Frings *et al.*[10] compared the coronary circulation of three monozygotic and three dizygotic twin pairs and reported more concordance in coronary dominance among the dizygotic twins. In addition, lesion concordance was only 35% among the monozygotic twins. The authors concluded that the pattern of coronary blood supply is not predominantly affected by shared genes but rather by local factors acting during cardiac development. In our case, both twins had significant prior lesions involving the mid-LAD segments. Strong hereditary factors may determine other coronary lesion characteristics, such as calcifications and ectasia. This latter finding has also been confirmed by the BUDAPEST-GLOBAL classic twin study, which showed that environmental factors predominantly determined non-calcified plaque volume while coronary artery calcification score and calcified plaque volumes had a relatively strong genetic heritability.[3] In addition, it is important to realize that there is probably publication bias towards reporting concordant twin cases. Hence, it remains unclear if coronary circulation is predominantly genetically determined or under the influence of epigenetic modifiers including those occurring during cardiac development and the environmental factors acquired throughout the lifespan. Of note, although the current twin pair had similar coronary lesions, their coronary anatomy was not fully concordant. Twin A had a more dominant right coronary circulation (*Figure 3*) compared with Twin B (*Figure 4*). In terms of the conferred risk, a large Swedish registry demonstrated that if a male twin dies of myocardial infarction, his living twin has a 50% chance of dying from CAD by the time he is 55 years of age. This is a 20-fold increase when compared with the general population.[16] This risk is age-dependent with the risk being higher the younger the age of the twin with MI. This emphasizes the importance of aggressive screening and preventative therapies for CAD once one of the twins is diagnosed with CAD or suffers an MI, specifically at a younger age. While male monozygotic twins tend to have a similar lifespan and longer than the general population,[17] it is unclear how the current presentation would affect the lifespan gap between both twins. One would expect Twin A, who had no significant evidence of myocardial damage (see Supplementary material online, *Video S3A*), to have a longer lifespan than Twin B, who sustained a significant myocardial injury (see Supplementary material online, *Video S3B*). However,

Table 2 **Prior reported monozygotic twin cases and their major findings**

Author	Case description	Finding
Singh *et al.*[8]	Monozygotic male twins presenting with angina in their mid-30s.	Angiography demonstrated similar coronary anatomy along with lesion subset. Authors postulated the predominant play of genetic factors in the development of CAD.
Smith *et al.*[9]	Monozygotic male twin presenting with ischaemic cardiomyopathy in his early 40s.	Work up showed similar coronary anatomy and disease between the presenting twin and his twin brother who suffered a fatal myocardial infarction 2 years prior.
Gullu *et al.*[3]	Monozygotic male twins in their early 60s presenting with angina.	Angiography demonstrated similar coronary anatomy and lesions despite having different CAD risk factors.
Frings *et al.*[10]	Three pairs of monozygotic twins and three pairs of dizygotic twins presenting with symptomatic premature CAD.	Coronary dominance was more concordant among the dizygotic twins. Only 38% of coronary lesions were concordant among the monozygotic twins, more so in dizygotic twins.
Samuels *et al.*[11]	Two monozygotic female twins presented with stable angina 2 years apart.	Coronary angiography revealed similar coronary anatomy and disease. Both sisters underwent coronary artery bypass surgery.
Schilling *et al.*[12]	Monozygotic female twin presenting with angina at 28.	Presenting twin found to have severe CAD and right dominant system. Her asymptomatic twin sister was found to have no CAD and a left dominant system.
Herrington *et al.*[13]	Two pairs of male monozygotic twins. One presented with symptoms of MI, the other with stable disease.	Side-by-side comparison of twin-pair angiograms showed close similarity in location and character of the lesions. Clinicians should maintain a high index of suspicion for occult CAD in an asymptomatic twin whose co-twin has documented CAD.
Holmes *et al.*[14]	Described two pairs of identical twins presenting with angina symptoms. One pair in early 30s, the other mid-40s.	Coronary anatomy demonstrated some similarities and some differences. Authors argued for interaction of genetic and environmental factors.
Kreulen *et al.*[15]	Two 30-year-old monozygotic twins presenting with stable angina.	The first group to present multiple selective coronary cine-angiographic studies in identical twins with premature CAD. They demonstrated significant similarities in coronary anatomy between the two twins.

CAD, coronary artery disease; MI, myocardial infarction.

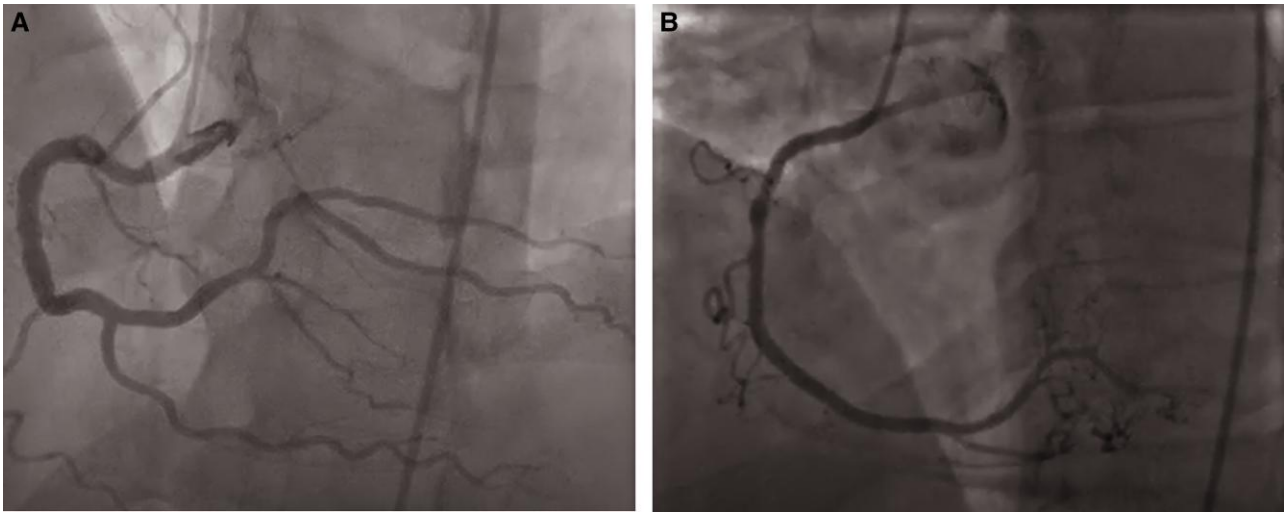


Figure 3 Coronary angiograms of the right coronary artery of Twin A (*A*) and Twin B (*B*) demonstrating some discordance in the coronary anatomy of the right coronary artery.

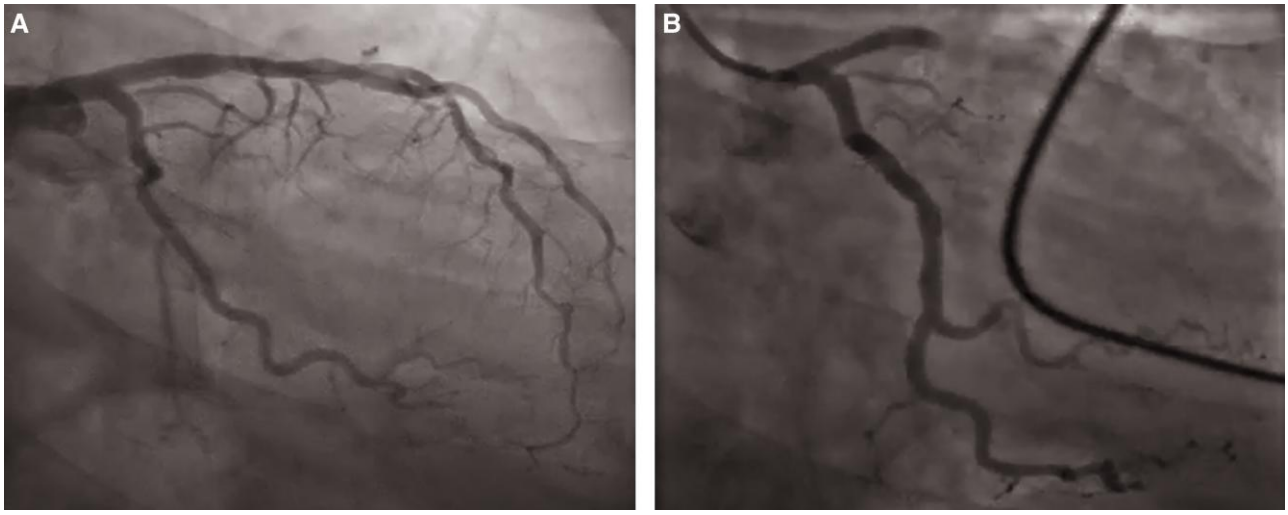


Figure 4 Coronary angiograms of the left coronary artery of Twin A (*A*) and Twin B (*B*) demonstrating some discordance in the coronary anatomy of the left circumflex coronary artery.

the effect of social, environmental, and genetic factors should be weighed against those of biological ones.

Conclusions

This report describes a unique simultaneous presentation of monozygotic twins with MI of different coronary pathology. The differential effect of genetic, epigenetic, and environmental contributions to the development of CAD in monozygotic twins remains unclear. However, what could be observed is early age of onset in a lot of reported cases, similar presentations, and frequently within close timeframe. Once CAD is diagnosed in one twin, aggressive risk factor modification and screening should be implemented in the other.

Lead author biography

Kameel Kassab, MD, is an Interventional Cardiovascular Fellow at Michigan State University/Borgess Heart Institute. He completed his medical training at the American University of Beirut followed by an internal medicine residency at Indiana University and a general cardiology fellowship at Cook County Health in Chicago. His research and clinical interests include coronary artery disease, cardiogenic shock, and multimodality imaging.

Supplementary material

Supplementary material is available at *European Heart Journal – Case Reports* online.

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The authors would like to thank the patients for allowing us to share their cases.

Slide sets: A fully edited slide set detailing this case and suitable for local presentation is available online as Supplementary data.

Consent: The authors confirm that written consent for submission and publication of this case report including image(s) and associated text has been obtained from the patients in line with COPE guidance.

Conflict of interest: None declared.

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