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CASE REPORT
Cardiac imaging

Cardioembolic stroke in a young male with cor triatriatum sinister: a case report

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Background Cor triatriatum sinister (CTS) is a rare congenital cardiac anomaly defined by a fibromuscular membrane which bisects the left atrium. Cor triatriatum sinister has been associated with cardioembolic stroke through mechanisms including stagnation of blood flow within the left atrium, an association with atrial fibrillation (AF), and/or an accompanying atrial septal defect (ASD) or patent foramen ovale. We describe a case highlighting the role that CTS may play in cardioembolic stroke, provide high-quality computed tomography angiography and two- and three-dimensional echocardiography of the CTS membrane, and outline management strategies for this uncommon clinical scenario.

Case summary A 35-year-old man with no prior medical history presented with acute onset weakness and aphasia. He was found to have an embolic stroke with left M1 and A1 occlusions and received tissue plasminogen activator followed by mechanical thrombectomy with successful recanalization. A thorough stroke workup revealed CTS with an associated ASD as well as potential protein C deficiency. He was managed with indefinite anticoagulation with apixaban.

Discussion This is the 13th reported case of CTS associated with stroke. In most previous cases evidence of blood stasis or frank thrombus was associated with the CTS membrane, and/or existing AF was noted. In this case, none of these were identified, particularly highlighting the surreptitious risk of CTS. In addition, the presence of potential protein C deficiency in this case compounded the risk for thromboembolism and factored into multidisciplinary management decisions.

Keywords Cardioembolic stroke • Cor triatriatum sinister • Echocardiography • Cardiac computed tomography angiography • Case report

Learning points

- Cor triatriatum sinister (CTS) is a rare cardiac congenital anomaly which may be associated with cardioembolic stroke through stagnation of blood flow in the left atrium, atrial fibrillation, and/or an accompanying atrial septal defect (ASD) or patent foramen ovale (PFO).
- The risk of CTS for cardioembolic stroke may be surreptitious, and dedicated imaging modalities including transoesophageal echocardiography and cardiac computed tomography angiography may be required to identify CTS and associated anomalies.
- Treatment strategy should be determined by a multidisciplinary team with consideration of surgical membrane resection, therapeutic anticoagulation, and/or closure of an associated ASD or PFO.

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Introduction

Cor triatriatum sinister (CTS) is a rare congenital cardiac anomaly in which a fibromuscular membrane bisects the left atrium into two chambers. The superior chamber, formed from the embryonic common pulmonary vein, receives pulmonary venous inflow. The inferior chamber, formed from the embryonic left atrium, is in contact with the mitral valve and contains the left atrial appendage and true interatrial septum.[1] The CTS membrane can vary widely in size and shape, with its configuration of fenestrations dictating its clinical presentation. With limited fenestrations CTS may present as severe left atrial flow obstruction throughout the cardiac cycle, usually diagnosed in infancy and childhood.[1] Without significant flow obstruction CTS may not be diagnosed until adulthood, found incidentally or presenting as a mitral stenosis-like picture, atrial fibrillation (AF), or rarely as a cardioembolic stroke.[2–15] There are currently no established guidelines for management of stroke in the setting of CTS, though options include resection of the CTS membrane, closure of any associated atrial septal defect (ASD) or patent foramen ovale (PFO), and/or anticoagulation. Here, we describe a case of a young male without prior medical history presenting with a first-time embolic stroke, found to have CTS.

Timeline

Initial presentation	Presented with acute onset of aphasia and weakness, found to have embolic stroke.
Day 1	Administration of tissue plasminogen activator, followed by mechanical thrombectomy.
Day 2	Transthoracic echocardiogram showed a membrane within the left atrium and a small right-to-left shunt.
Day 5	Transoesophageal echocardiogram and cardiac computed tomography angiography confirmed cor triatriatum sinister and identified an atrial septal defect.
Day 6	Started on apixaban 5 mg twice daily.
Day 7	Discharged from the hospital.
Day 36	Hypercoagulability workup showed potential protein C deficiency.
Day 108	Re-evaluated in clinic, decision made to continue anticoagulation indefinitely.

Case presentation

A 35-year-old man with no prior medical history presented with a chief complaint of acute onset weakness and aphasia. His vital signs were normal and cardiovascular and pulmonary examinations were unremarkable, though neurological examination revealed significant deficits of right hemiplegia, facial weakness, partial hemianopia, and global aphasia, with a National Institutes of Health Stroke Scale (NIHSS) score of 24. Brain computed tomography angiography (CTA) showed left M1 and A1 occlusions in a pattern consistent with embolic stroke. He received intravenous tissue plasminogen activator with improvement of his NIHSS score to 9, though repeat brain CTA revealed persistent distal left M1 occlusion. Subsequently, he was taken for mechanical thrombectomy, with successful recanalization. Post-procedural brain magnetic resonance (MR) images showed scattered acute infarcts within the left middle cerebral artery territory (*Figure 1A*), and brain MR angiogram showed M1 narrowing with distal reconstitution of flow (*Figure 1B*).

Ensuing imaging workup revealed no intra- or extra-cranial atherosclerosis. Acute phase labwork for stroke risk factors was unremarkable. Transthoracic echocardiography with agitated saline showed evidence of a small right-to-left intracardiac shunt, and a hyperechoic membrane within the left atrium (*Figure 2A*). Subsequent transoesophageal echocardiography (TOE) showed said membrane bisecting the left atrium into superior and inferior chambers (*Figure 2B*). The superior chamber received venous return from all four pulmonary veins (*Figure 2C*) and the inferior chamber contained the left atrial appendage (*Figure 2D*), confirming CTS. There was no significant flow obstruction across the membrane by Doppler (*Figure 2E*). Three-dimensional TOE images further characterized the membrane as a band of tissue with large openings on either side (*Figure 2F*). An agitated saline study confirmed a small right-to-left intracardiac shunt, though an ASD or PFO was not clearly appreciated. The remainder of the study was without abnormality, revealing normal chamber sizes, normal biventricular function, and a left atrial appendage free of thrombus with normal appendageal flow velocities.

Given the TOE findings, cardiac CTA was performed. This again demonstrated the CTS membrane within the left atrium and allowed for visualization of a small ASD (*Figure 3*). No other abnormalities were identified. Magnetic resonance angiography of the abdomen/pelvis and venous duplexes of all extremities were negative for deep venous thrombosis. Telemetry monitoring throughout the hospitalization did not reveal AF or any other arrhythmias.

The patient was started on apixaban 5 mg twice daily given the findings. On discharge, he already had significant improvement in all neurologic deficits. Five weeks post-hospitalization, thorough hypercoagulability workup revealed a low protein C activity level. Family history disclosed no thrombotic events, so it was not clear that this represented a truly prothrombotic genetic profile. In addition, it is not clear that hereditary protein C deficiency alone raises risk for stroke. However, given the constellation of a potential coagulopathy with CTS and an ASD, anticoagulation was continued. At 3-month follow-up, there were no adverse effects from anticoagulation and no additional thrombotic events. Neurologically, the patient had markedly improved with only mild residual right-sided hemiparesis. Apixaban was continued indefinitely.

Discussion

Several potential mechanisms may explain the association between CTS and cardioembolic stroke. One is an increased prevalence of AF in patients with CTS. This is due to distortion of left atrial muscle fibre architecture leading to mechanical and electrical remodelling, predisposing to arrhythmia and subsequently left atrial/appendageal clot

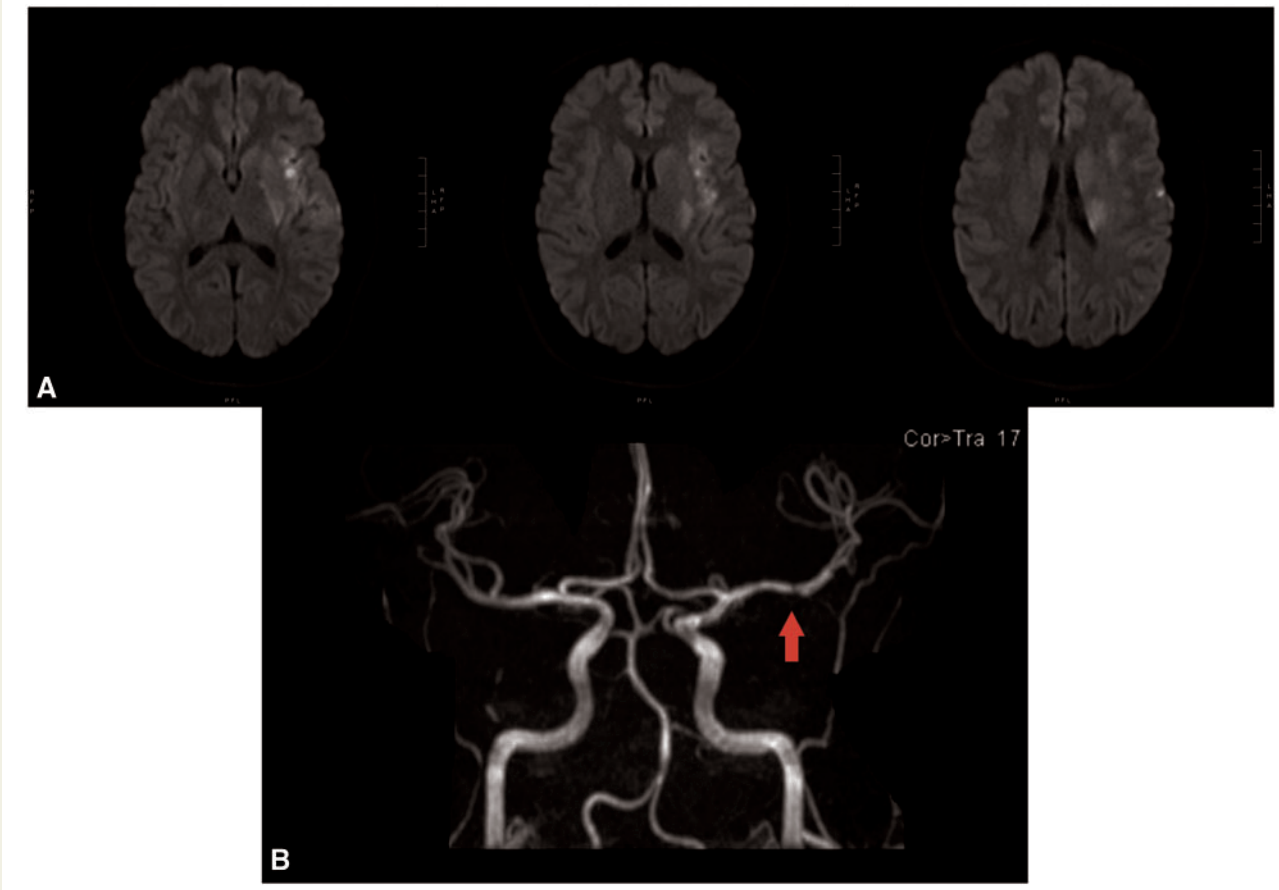

Figure 1 Post-thrombectomy brain imaging. (A) Brain magnetic resonance showing acute infarcts in the left middle cerebral artery territory. (*B*) Brain magnetic resonance angiography showing recanalization of distal M1 flow with some residual narrowing (arrow).

formation.[3] In addition, the CTS membrane itself may cause blood flow disruption, stagnation, and thrombus formation even in the absence of haemodynamically significant flow obstruction.[4] Finally, secundum ASD and PFO are common defects associated with CTS, known risk factors for paradoxical embolism.[1] Pertinent to our patient, his underlying possible coagulopathy (protein C deficiency) may have compounded his stroke risk given these multiple potential mechanisms for thromboembolism.

Our patient represents the 13th reported case of CTS associated with stroke. Cor triatriatum sinister was identified via echocardiography in all cases.[4–15] Of the 12 of 13 cases (including ours) with reported TOE findings, frank thrombus within the left atrium was noted in 3—of these, one noted thrombus within the appendage, one noted thrombus on the anterior leaflet of the mitral valve and the left atrial wall, and one noted multiple thrombi within the body of the left atrium.[4–6] Of the remaining nine cases, five demonstrated spontaneous echo contrast in one or both left atrial chambers, an indicator of impending thrombus.[7–11] A haemodynamically significant flow gradient across the CTS membrane was reported in two cases, both of which demonstrated left atrial spontaneous echo contrast.[7,11] Our case and one other identified an ASD.[12] Concomitant AF was reported in five cases.[4–6,10,11] Importantly, our patient had no evidence of transmembrane flow obstruction, blood stasis, thrombus, or evident AF, particularly highlighting the surreptitious risk that CTS may play in embolic stroke.

There are no currently established guidelines for the management of CTS in the setting of embolic stroke. Options include surgical membrane resection, therapeutic anticoagulation, and/or closure of an associated ASD or PFO. In cases with haemodynamically significant transmembrane flow obstruction and associated heart failure, membrane resection is clearly appropriate.[1,2] If there is no haemodynamically significant flow obstruction but there is membrane-associated blood stasis and/or thrombus, resection should be strongly considered, with anticoagulation as a potentially reasonable alternative.[1] In cases with neither flow obstruction nor evidence of membrane-associated blood stasis and/or thrombus, anticoagulation may be appropriate, with membrane resection considered in the right patient. Importantly, the potential for added thromboembolic risk from occult AF must be recognized in all cases. Thus, even if membrane resection is carried out, telemetry monitoring for AF should be considered, with anticoagulation instituted if AF is detected.

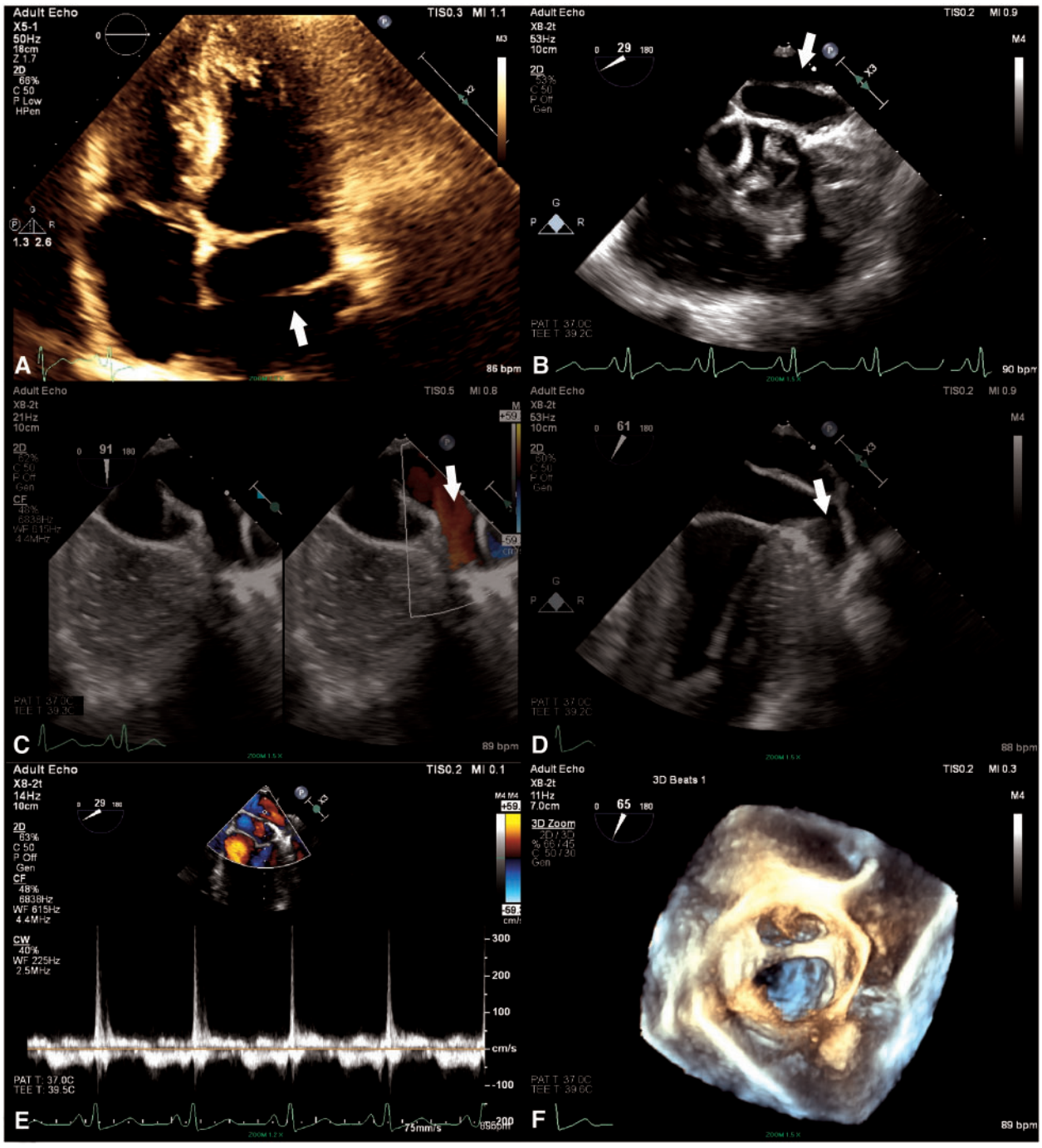

Figure 2 Transthoracic echocardiography and transoesophageal echocardiography. (*A*) Transthoracic echocardiography in apical four-chamber view showing the cor triatriatum sinister membrane (arrow). (*B*) Transoesophageal echocardiography in a short-axis aortic valve level view showing the cor triatriatum sinister membrane (arrow). (*C*) Transoesophageal echocardiography highlighting left-sided pulmonary venous inflow superior to the cor triatriatum sinister membrane (arrow). (*D*) Transoesophageal echocardiography showing the left atrial appendage inferior to the cor triatriatum sinister membrane (arrow). (*E*) Continuous wave Doppler without flow obstruction across the cor triatriatum sinister membrane. (*F*) Three-dimensional transoesophageal echocardiography visualizing the cor triatriatum sinister membrane from a superior viewpoint.

An associated ASD or PFO should be assessed for with dedicated imaging. If identified, closure is an option. Of note, data are limited on the efficacy of ASD closure and are largely extrapolated from that of PFO closure. Recent literature has shown benefit in prevention of recurrent ischaemic stroke in selected patients with a PFO.[16–18] These patients must be aged ≤60 years and have an embolic-appearing

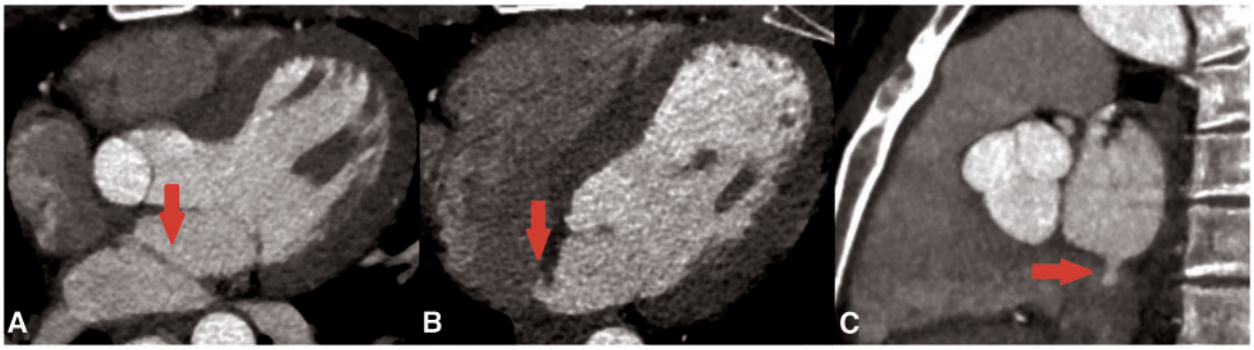

Figure 3 Cardiac computed tomography angiography. (*A*) The cor triatriatum sinister membrane (arrow). (*B* and *C*) Small atrial septal defect in axial and sagittal views (arrows).

ischaemic stroke. A multidisciplinary evaluation should determine paradoxical embolism via the PFO to be the most likely stroke mechanism, which may be supported by a concomitant deep venous thrombosis or pulmonary embolism. Patients most likely to benefit from closure are those with a large right-to-left shunt and/or an associated atrial septal aneurysm. It is important to recognize that the patients in these studies did not have CTS, and caution must be taken when extrapolating recommendations as CTS carries additional embolic risk beyond that of an ASD or PFO alone. With this in mind, ASD/PFO closure can be considered in the right candidate.

In the 12 of 13 reported cases (including ours) where anticoagulation was discussed, it was ultimately recommended.[4–14] Four cases were treated with operative resection of the CTS membrane.[5–7,12] In the previous case where an ASD was identified, it was operatively closed.[12] Closure of the ASD ± resection of the CTS membrane was strongly considered in our case; however, given the potential protein C deficiency, small ASD size with minimal right-to-left shunting, lack of an atrial septal aneurysm, and lack of significant trans-CTS membrane flow obstruction on TOE, indefinite anticoagulation with apixaban was chosen as the preferred management strategy after multidisciplinary discussions involving haematology, neurology, cardiology, and cardiac surgery, as well as shared decision-making with the patient.

In conclusion, CTS is a rare congenital anomaly which may be associated with cardioembolic stroke through mechanisms including membrane-associated stagnation of blood flow, AF, and/or paradoxical embolism via an ASD or PFO. The presence of CTS, and consequently its risk, may not be easily identified—thus, a low threshold to use dedicated imaging modalities including TOE and cardiac CTA may be appropriate, particularly in young patients without prior embolic risk factors. There are no current guidelines for the management of CTS in the setting of embolic stroke. A strategy should involve a multidisciplinary approach with thought given to membrane resection, therapeutic anticoagulation, and/or closure of an associated ASD or PFO.

Lead author biography

Richard S. Amara is a cardiology fellow in training based in Baltimore, MD, USA. He acquired his medical degree (MD) at Drexel University College of Medicine in 2014, completed his internal medicine residency training at The Mount Sinai Hospital in 2017 and is currently completing his cardiology fellowship at the University of Maryland Medical Center. His interests include cardiac imaging and electrophysiology, and he plans to pursue a career in cardiac electrophysiology.

Supplementary material

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

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

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

Conflict of interest: none declared.

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