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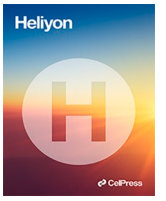

Case report

Identification and treatment of midaortic syndrome in an adult patient with orthostatic tachycardia and hypertension: A case report

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ABSTRACT

Anatomical cardiovascular etiologies are less frequently investigated and identified in cases of orthostatic intolerance, which can have a profound impact on a patient's functional status. Here, we present a 26-year-old female with a recent diagnosis of hyperadrenergic postural orthostatic tachycardia and hypertension who was found to have diminished pedal pulses. Workup revealed an underlying midaortic syndrome that was then surgically corrected with resolution of symptoms. We discuss the epidemiology, presentation, and management of this rare condition, as well as its role in our patient's symptomatology.

1. Introduction

Upon standing, pooling of blood in the lower extremities triggers a complex physiologic response that maintains stable blood pressure and cerebral blood flow [1,2]. Orthostatic disturbances to this homeostasis commonly occur with aging due to declining structure and function of the cardiovascular and nervous systems [3], compromising cerebral perfusion and placing patients at risk for syncope. In younger patients, inappropriate postural hemodynamics are frequently attributed to hypovolemia and dysautonomic states such as postural orthostatic tachycardia syndrome (POTS) [4]. However, anatomical cardiovascular etiologies are less frequently investigated and identified in cases of orthostatic intolerance, though they can have a profound impact on circulatory physiology [5,6]. Here, we report a patient with a solitary right kidney and recent diagnosis of hyperadrenergic postural orthostatic tachycardia and hypertension who was found to have an underlying coarctation of the abdominal aorta, also known as midaortic syndrome.

2. Case presentation

A 26-year-old female presented to the vascular medicine clinic for evaluation of absent pedal pulses and abnormal ankle-brachial index (ABI). The patient denied exertional claudication. Examination revealed absent bilateral dorsalis pedis pulses, decreased bilateral femoral and posterior tibial pulses, and mid-abdominal bruit accentuated by expiration. Relevant cardiac, carotid, and upper extremity vascular exams were unremarkable. Resting ABIs were 0.93 (right) and 0.94 (left) with bilateral reduction of upper thigh blood pressures (BP) compared to brachial pressures (Table 1).

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Abbreviations

MAS	midaortic syndrome
MCAS	mast cell activation syndrome
POTS	postural orthostatic tachycardia syndrome
RA	renal artery
CT	celiac trunk
SMA	superior mesenteric artery
IMA	inferior mesenteric artery

2.1. History

The patient has a history of congenitally absent left kidney, atopic dermatitis, reflux esophagitis, allergic rhinitis, and asthma. She has no family history of vascular, connective tissue, or autonomic problems. For the past three years, she experienced orthostatic hypertension and tachycardia with accompanying dizziness, shakiness, anxiety, presyncope, and hypervigilance. 24-hour BP and Holter monitoring revealed daytime hypertension (average 132/82 mmHg; standing 164/95 mmHg) and nighttime hypotension (average 99/53 mmHg; nadir 82/50 mmHg) with sinus bradycardia averaging 50 bpm. She also experienced occasional flushing, hive-like lesions, and gastrointestinal symptoms (pain, nausea, and constipation) unrelated to eating. Workup for pheochromocytoma was unremarkable, though episodic increases in plasma free metanephrines were detected (most recently 0.62 nmol/L, reference $<$0.49 nmol/L). Partial symptom relief was achieved with cetirizine and diltiazem. Autonomic workup revealed abnormal heart rate (HR) acceleration (increased by 68 bpm; sustained $>$120 bpm; maximum 160 bpm) and postural hypertension (172/123 mmHg) upon 10-min head up tilt, as well as exacerbated BP responses during Valsalva late phase 2 and phase 4. The patient was diagnosed with POTS, and the hyperadrenergic subtype was suspected given both orthostatic tachycardia and hypertension, though confirmatory postural catecholamine measurements were unavailable. Additionally, mast cell activation syndrome (MCAS) was suspected given relief with cetirizine. In addition to supportive measures, diltiazem was transitioned to propranolol (20 mg TID) with improved effect. Differential diagnosis at the time included renal artery stenosis, aortoiliac occlusive disease, Takayasu arteritis, and median arcuate ligament syndrome.

2.2. Investigations

Renal arterial doppler of the solitary right kidney revealed normal blood flow, and renin and aldosterone levels were within normal limits. Echocardiogram and carotid artery dopplers were normal. Aortoiliac duplex demonstrated an increase in peak velocity from 175 to 551 cm/sec between the mid-to-distal abdominal aorta with associated luminal narrowing, suggesting significant flow restriction. Additionally, celiac artery velocity increased from inspiration (131 cm/sec) to expiration (202 cm/sec). No abnormal aortic aneurysmal dilatation was noted. Contrast-enhanced computed tomography angiography (CTA) of the abdomen revealed a stenotic segment within the mid-abdominal aorta from below the superior mesenteric artery origin to below the right renal artery origin. The stenotic segment measured 6.0 $\times$ 6.7 mm and contained a dissection flap, with the portion superior measuring 13.3 $\times$ 13.3 mm (Fig. 1A–C). CTA of the chest was unremarkable, with the ascending and descending thoracic aorta measuring 22.6 $\times$ 24.0 mm and 16.0 $\times$ 16.0 mm, respectively, (Fig. 1D). Three-dimensional rendering of the stenotic segment was performed (Fig. 1E). These findings are consistent with coarctation of the abdominal aorta, also known as midaortic syndrome (MAS).

2.3. Management

Given the patient's narrow aorta, age, and evidence of mild dissection, vascular surgery recommended non-emergent surgical repair due to potential difficulties with endovascular stenting, in accord with recent guidelines [7]. The patient elected to have surgery and potential interventions were discussed, including patch angioplasty or bypass from the thoracic aorta to the infrarenal aorta with incorporation of the right renal artery. Intraoperatively, aortic coarctation was observed from the visceral bearing segment of the aorta below the right renal artery and extending down to the mid infrarenal aorta, with several synechia causing complete obliteration of the aorta. Distal perfusion was present via collaterals from the superior mesenteric and lumbar arteries. Successful surgical repair was

Table 1
Ankle-brachial index (ABI) values.

Blood Pressure	Right (mmHg)/ABI	Left (mmHg)/ABI
Brachial	126	130
Upper Thigh	124/0.95	121/0.93
Lower Thigh	114/0.88	121/0.93
Calf	119/0.92	114/0.88
Dorsalis Pedis	117/0.90	122/0.94
Posterior Tibial	121/0.93	113/0.87

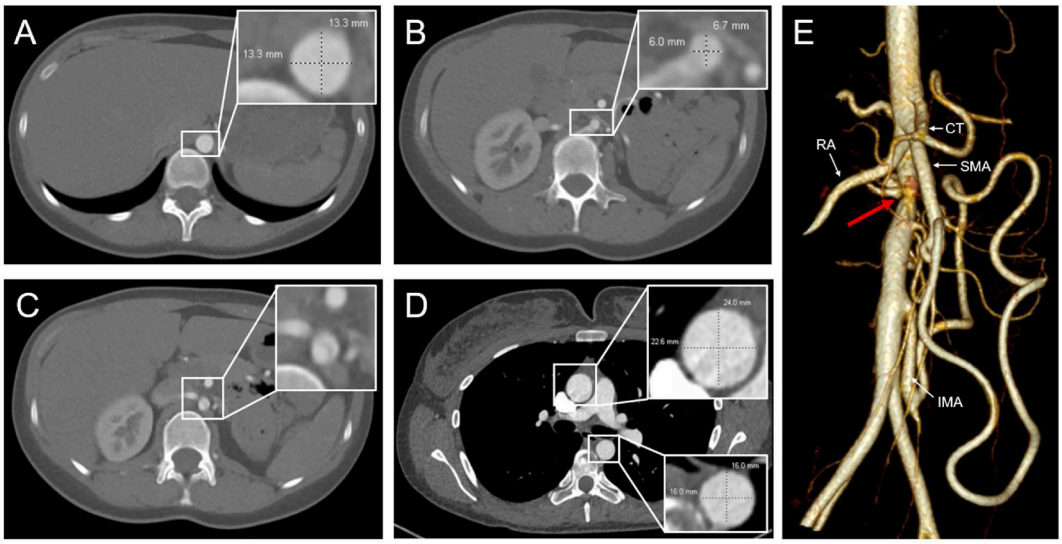

Fig. 1. Abdominal coarctation identified with CTA. (A) Maximal diameter of the abdominal aorta superior to the coarctation (13.3 × 13.3 mm) and **(B)** at the abdominal coarctation (6.0 × 6.7 mm). **(C)** Dissection flap within the coarctation. **(D)** Thoracic aorta demonstrated no coarctation. **(E)** Three-dimensional arterial reconstruction to visualize the segmental narrowing of the abdominal aorta (red arrow) and major vessels (white arrows). CT, celiac trunk; RA renal artery; SMA, superior mesenteric artery; IMA, inferior mesenteric artery. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

accomplished via resection of the entire aortic coarctation, which was sent for pathology assessment, followed by end-to-end anastomosis with an interposition polytetrafluoroethylene (PTFE) graft to reconstruct the aorta. Doppler interrogation demonstrated appropriate augmentation and flow throughout, and the patient left the operating room in stable condition with excellent pedal pulses.

2.4. Follow-up

The patient's immediate post-operative course was uncomplicated apart from temporary urinary retention that required catheterization and shortly resolved. The pathology report for the resected aortic coarctation demonstrated fibrin deposition, intimal hyperplasia, and mural fibrosis. One week following surgery, the patient reported resolution of her previous symptoms of orthostatic hypertension and tachycardia. Vitals were BP 110/60 and HR 110 bpm. Her propranolol was reduced to 10 mg TID, and she was advised to periodically measure her sitting and standing vitals at home. Seven weeks following surgery, the patient was asymptomatic with normal vitals and her propranolol was discontinued. Eight months following surgery, office vitals were as follows: sitting BP 118/70 with HR 68 and standing BP 118/72 with HR 70.

3. Discussion

MAS is a rare condition that represents 0.5–2.0 % of aortic coarctation cases [8]. It is characterized by segmental narrowing of the abdominal aorta and typically manifests in early adulthood with proximal hypertension and distal hypotension, producing diminished distal pulses, renin-angiotensin activation, exertional claudication, headache, palpitations, and gastrointestinal symptoms [9]. MAS is a highly underrecognized entity due to variability of presentation and other more common etiologies for these symptoms. MAS should be on the differential diagnosis for any young patient with difficult to control blood pressure and signs and symptoms of distal hypoperfusion (claudication, abdominal bruit, absent or diminished pedal pulses, decreased femoral pulses, and discordant upper and lower blood pressures). Diagnosis of MAS is commonly accomplished with non-invasive imaging of the vasculature, such as CT angiography or magnetic resonance angiography. While the mechanism underlying MAS is not well understood, it is thought to be due to congenital malformation, which is possible in our patient given her congenitally absent left kidney. Other cases have been reported to be associated with conditions including Williams syndrome, Takayasu arteritis, Neurofibromatosis-1, Alagille syndrome, and Moya-Moya [10]. Familial exome sequencing has detected possible causal mutations in >40 % MAS cases [11]. Additionally, the presence of a dissection flap in our patient may be explained by severe episodic hypertension, though compromised vascular integrity cannot be excluded given the presence of congenital malformation and potential vasculitis. Another consideration is Ehlers-Danlos Syndrome (EDS), as approximately one-third of POTS patients have EDS and vascular complications are common in EDS, particularly the vascular subtype [12–14]; however, our patient does not meet diagnostic criteria for EDS [15].

A major question for MAS patients is whether surgical repair is indicated. If left untreated, nearly 50 % of MAS patients develop hypertensive encephalopathy, congestive heart failure, or stroke in the third to fourth decade of life, and survival is <20 % after age 40 [10]. Given that medical management does not adequately control BP [16], surgical and endovascular repair are typically employed,

though surgical approaches have shown to be superior with regard to acute complications and long-term outcomes [10]. Indications for surgery have included uncontrolled hypertension, palpitations, lower extremity claudication or diminished pulses, and abdominal pain [10,17,18], all of which were present to some degree in our patient. While more commonly identified and treated in children, adults have good surgical outcomes [17]. Additionally, recent guidelines recommend open surgical repair in young patients with non-atherosclerotic lesions, such as those with MAS [7]. However, our patient's presentation was complicated by her suspected diagnosis of hyperadrenergic POTS, which has not been previously described in cases of MAS, creating a complex combination of anatomic, autonomic, and neuroendocrine physiology [19]. Given the presence of MAS and solitary kidney, right renal artery perfusion may have been decreased when our patient was standing pre-operatively, potentially leading to inappropriate postural renin–angiotensin activation and catecholamine surge, suggesting POTS presentation was secondary to MAS. Resolution of our patient's symptoms following surgical correction of MAS supports this etiology, as persistent symptoms would alternatively support hyperadrenergic POTS as either an independent etiology or stable compensatory mechanism. Given the patient's persistent symptoms despite medical management, surgical intervention was pursued with subsequent resolution of symptoms and hemodynamic abnormalities. From a broader perspective, better evaluation and management of POTS could have important socio-economic implications, as long-standing POTS has been shown to reduce quality of life and limit work abilities [20,21].

4. Conclusion

MAS is a rare condition typically managed by surgical intervention instead of percutaneous or medical therapy. In our patient with a solitary right kidney and hyperadrenergic POTS, identification and surgical correction of MAS yielded full resolution of her symptoms and supported MAS as the etiology of her severe postural tachycardia and orthostatic hypertension.

Patient perspective

The patient reports improvement in her symptoms after surgery, with resolution of gastrointestinal symptoms and flushing, as well as less frequent headache and sensation of tachycardia. She hopes this report helps clinicians better identify and manage patients with MAS.

Ethics statement

Written informed consent was obtained from the patient to publish this report and the anonymised images and clinical data.

CRediT authorship contribution statement

Anthony M. Pettinato: Writing – review & editing, Writing – original draft, Investigation, Formal analysis, Data curation. **Manish Kumar:** Writing – review & editing. **Agnes S. Kim:** Writing – review & editing, Supervision, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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