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Case Reports: Sinus of Valsalva Injury During Percutaneous Coronary Intervention and Perioperative Management

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Author's contribution:

DQY, NJX, HJD and GL performed the operation. BQF, YWL and TT collected the data and constructed the manuscript. DQY, NJX, HJD, GL and XBW were responsible for patients' care. All authors read and approved the final manuscript.

Keywords:

Case report; Sinus of Valsalva; Percutaneous coronary intervention; Antiplatelet therapy

Abbreviation:

SOVA: Sinus of Valsalva aneurysm; PCI: Percutaneous coronary intervention; APT: Antiplatelet therapy; LCX: Left circumflex coronary artery; CAG: Coronary angiography; RCA: Right coronary artery; DAPT: Dual antiplatelet therapy; LM: Left main branch; LAD: Left anterior descending artery; CT: Computed tomography; CCU: Coronary care unit; PRECISE-DAPT: Dual Antiplatelet Therapy; SAPT: Single antiplatelet therapy; MRI: Magnetic resonance imaging; MRA: Magnetic resonance angiography; DWI: Diffusion-weighted imaging; LMWH: Low molecular weight heparin; MCA: Middle cerebral artery; ESC: European Society of Cardiology

1. Abstract

1.1. Background: Sinus of Valsalva injury, either due to congenital defect or major traumatic events, was known to be rare.

1.2. Case presentation: A 44-year-old male and 68-year-old female underwent coronary angiography and experienced sinus of Valsalva injury at our hospital, that confirmed with computed tomography scanning of aorta with contrast and was successfully managed conservatively with continuous pericardial drainage and antiplatelet therapy. Both patients recovered well without surgery and their 2-year follow-up showed complete healing of the injuries.

1.3. Conclusions: Antiplatelet therapy should be administered on a case-by-case basis based on complete clinical assessment of ischemia and hemorrhage status determined using various scoring systems, as well as on guideline recommendations.

2. Introduction

The sinus of Valsalva is an anatomic structure of the aorta that when injured, can result in acute cardiac tamponade and perturbation of hemodynamic stability. Similar to the spontaneous perforation in sinus of Valsalva aneurysm (SOVA), injury to the sinus of Valsalva can be life-threatening without timely diagnosis and treatment [1]. However, unlike aneurysms, in the absence of a congenital defect injury to the aorta is typically only associat-

ed with major traumatic events such as blunt trauma [2]. To date there have been no reports of sinus of Valsalva injury during Percutaneous Coronary Intervention (PCI); as such, there are no evidence-based intraoperative rescue and postoperative Antiplatelet Therapy (APT) strategies for such cases. Here we describe 2 cases from 2018 and 2019 of non-aneurysm perforation of the sinus of Valsalva during PCI at Guangdong Provincial People's Hospital, with the aim of providing guidance for the management of similar cases in the future.

3. Case

3.1. Initial Presentation

3.1.1. Case #1

A 44-year-old man was admitted for elective PCI on the Left Circumflex coronary artery (LCX). A Coronary Angiography (CAG) 4 months prior had revealed chronic total occlusion of the left LCX and 80% stenosis of the right coronary artery (RCA); the latter was treated by PCI with one stent implantation. Past medical history was negative for hypertension and diabetes mellitus and results of the general examination were unremarkable. The patient had received dual (D)APT (aspirin 100 mg per day + clopidogrel 75 mg per day) for 4 months. After CAG, the decision was made to reperfuse the LCX based on the patient's complaint of chest tightness, cold sweats, dizziness and weakness. After the procedure, his blood pressure dropped to 70/50 mmHg.

3.1.2. Case #2

A 68-year-old woman presented at our hospital with recurrent chest pain after physical activity for 1 year, with acute exacerbation for 7 days. Past medical history was significant for poorly controlled primary hypertension and type II diabetes mellitus (hemoglobin A1C=7.1%). She was hypertensive with a blood pressure of 171/77 mmHg and heart rate of 98 bpm. Cardiac and pulmonary examinations were unremarkable. Coronary angiography showed 40% stenosis of left main branch (LM), 80%–90% stenosis at the opening, 90% stenosis at the middle segment of the left anterior descending artery (LAD), and 80%–90% stenosis of the LCX. PCI was eventually performed on the LM-LAD (2 stents) and LCX (1 stent). After the procedure, the patient complained of thirst and cold sweats and the cardiac monitor showed a blood pressure drop to 80/50 mmHg.

3.2. Diagnostic Assessment

3.2.1. Case #1

Angiography of the ascending aorta showed leakage of contrast in the outer layer of the sinus of Valsalva and acute cardiac tamponade. Differential diagnoses included dissection of the aorta root and perforation of the aortic sinus. Given the instability of the patient's vital signs, pericardiocentesis was performed with cardiac surgeons on standby. After slowly draining 50 ml of bloody fluid, the blood pressure recovered to 96/63 mmHg and symptoms of chest tightness, chest pain, and dizziness were relieved. Emergency computed tomography (CT) of the aorta with contrast showed a 2-mm laceration and leakage of contrast in the posterior wall of the noncoronary sinus at the level of the aortic valves (Figure 1a). Perforation of the noncoronary sinus was eventually confirmed.

Figure 1: CT images demonstrating non-coronary sinus perforation, readmission and 2-year follow-up results.

3.2.2. Case #2

CAG images did not show any injury of the coronary artery. Because of our previous experience with noncoronary sinus perforation, we again immediately performed pericardiocentesis with cardiac surgeons on standby; 280 ml bloody fluid was slowly drained. Emergency CT of the aorta showed leakage of contrast on the left superior posterior side of the left coronary sinus, and the formation of a minor fistula (around 3mm) between the left coronary sinus and aortic adventitia (Figure 2a). The patient was therefore diagnosed with fistula formation from the left coronary sinus to the aortic adventitia. Because of the patient's history of poorly controlled hypertension along with the intraoperative blood pressure fluctuation, we also performed head CT, which excluded intracranial hemorrhage.

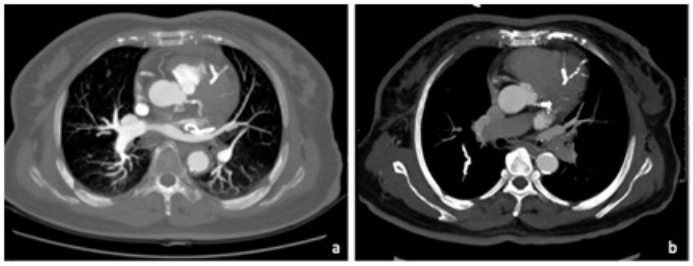

Figure 2: CT images demonstrating left-coronary sinus perforation and 2-year follow-up results.

3.3. Treatment

3.3.1. Case #1

APT was suspended given the recent PCI (4 months prior) and because of the patient's current life-threatening bleeding condition, with CHA2DS2-VASc (Congestive Heart Failure; Hypertension; Age ≥75 Years; Diabetes Mellitus, Stroke, or Transient Ischemic Attack; Vascular Disease; Age 65–74 years; Sex Category) score=1'; HAS-BLED (Hypertension; Abnormal Liver/Renal Function; Stroke History; Bleeding History or Predisposition; Labile International Normalized Ratio; Elderly; Drug/Alcohol Usage) score=2; CRUSADE (Can Rapid Risk Stratification of Unstable Angina Patients Suppress Adverse Outcomes With Early Implementation of the ACC/AHA Guidelines) score=28'; and PRECISE-DAPT (Predicting Bleeding. Complication in Patients Undergoing Stent Implantation and Subsequent Dual Antiplatelet Therapy) score=32'. Continuous bedside heart ultrasound was performed and hemoglobin level was measured to assess active bleeding status, and the drainage tube was removed on day 5 when the abovementioned variables were stable. Single (S)APT with clopidogrel (75 mg daily) was initiated on day 8 after CAG. The patient recovered well and as no other in-hospital complication occurred, he was discharged on day 11 after CAG with continuation of SAPT (clopidogrel 75 mg daily).

3.3.2. Case #2

Given that 3 stents were already implanted—of which 2 were in the LM-LAD where acute occlusion could have a fatal outcome—and the fact that the patient was at a higher risk of ischemic events (CHA2DS2-VASc score=6', HAS-BLED score=3', and CRUSADE score=66'), we maintained SAPT with clopidogrel (75 mg daily) through blood transfusion. The effusion in the pericardium gradually decreased, and the drainage tube was removed on day 4.

On day 3 in the CCU, the patient presented with sudden onset of hallucinations and anxiety. Neurologic examination revealed no changes in muscle tone or strength. Physiologic reflexes were brisk and normal. The company of family after the patient was transferred back to the regular ward relieved the psychological symptoms, but her daughters reported that her speech was incomprehensible. Her neurologic signs remained negative. A neurologic consultation suggested global aphasia and a comprehensive examination was recommended. The patient underwent head magnetic resonance imaging (MRI), head magnetic resonance angiography (MRA), and diffusion-weighted imaging (DWI), which revealed a massive ischemic stroke involving the left frontal, temporal, and occipital lobes. A week had passed since the diagnosis, and therefore no interventional or thrombolytic therapy was administered. We added neurotropic medicines to the treatment regimen and contacted the rehabilitation department to design a neurologic training program for the patient. Aspirin was added at discharge on day 10 because of the high risk of in-stent thrombosis and for secondary prevention of stroke.

3.4. Follow-up

The male patient was readmitted 10 days after discharge with chest tightness that progressively worsened along with dyspnea, dizziness, and transient amaurosis. His vital signs were stable and physical examination was unremarkable except for the left deviation of apical impulse. Bedside heart ultrasound confirmed pericardial effusion and pericardiocentesis drained 250 ml of dark red fluid. An emergency CT revealed complete absorption of blood around the previous left coronary sinus perforation site and no current active bleeding (Figure 1b), but we speculated that an incompletely healed wound and subtle hemorrhage could account for the recurrent cardiac tamponade. Because of the patient's recent experience of sinus of Valsalva perforation, surgical repair was indicated as a possible treatment in the event that conservative medical management failed. Clopidogrel monotherapy was switched to low molecular weight heparin (LMWH) injection (0.4 ml every 12 h) for the first 3 days. The patient responded well to conservative medical management, with the heart ultrasound showing decreasing daily pericardial effusion. LMWH was discontinued as surgery was no longer indicated, and the overall cessation period of clopidogrel was 5 days. The patient is still receiving SAPT and there have been no other episodes of pericardial effusion.

The female patient was regularly followed up at the rehabilitation department. There has been partial recovery of language function although she is still unable to formulate a complete sentence. Her mood is stable and she can perform simple activities of daily living such as brushing her teeth and getting dressed. Treatment with DAPT along with aspirin and clopidogrel is ongoing. There has been no recurrence of pericardial effusion or ischemic events.

We performed CT on both patients at the 2-year follow-up at the outpatient clinic to assess the healing of the sinus of Valsalva injury. Neither the previous coronary sinus changes nor further pericardial effusion was detected in either patient (Figures 1c and 2b). The timeline of both cases regarding clinical presentation, diagnostic assessment, treatment and 2-year follow-up were summarized in (Figure 3).

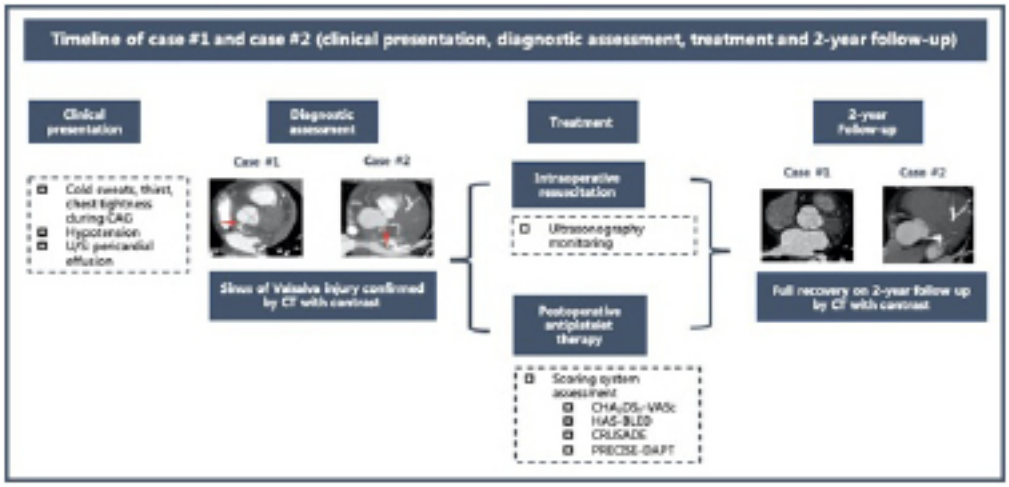

Figure 3: Timeline of case #1 and #2 (clinical presentation, diagnostic assessment, treatment and 2-year follow-up)

4. Discussion

The sinus of Valsalva shares similar histologic characteristics with the aorta—namely, the thick elastic lamellae in the tunica media of the vascular wall that withstands systolic pressure generated by left ventricle contraction [1, 3]. Because of its natural flexibility, injury to a congenitally normal aortic sinus is rare. Apart from cases of major trauma, sinus of Valsalva injury during PCI has not been previously reported. On the other hand, many cases of SOVA have been described in the literature in which the underlying pathophysiologic mechanism is congenital or acquired weakening of the aortic wall. Curative treatment usually involves open surgery regardless of whether there is rupture [1]. In our patients, since there was no preoperative imaging evidence indicating pathologic changes to the aorta, the only possible cause of injury was manual trauma. It is unclear whether different etiologies require different management strategies. Another treatment dilemma was APT with an active bleeding status; although guidelines recommend ceasing APT when life-threatening bleeding occurs [4], the dosing regimen needs to be individualized for each patient.

4.1. Intraoperative Resuscitation

In our patients, intraoperative investigation by CAG and heart ultrasound only revealed leakage of contrast outside the aortic wall, which could be aortic dissection or perforation. Perforation and pericardiocentesis would aid the patient whereas a Stanford type A dissection where pericardiocentesis was contraindicated as a method of pericardial blood evacuation could aggravate intimal tearing, which would necessitate emergency cardiac surgery [5]. Acute cardiac tamponade is a life-threatening condition that manifests as sudden pooling of a large amount of fluid around heart, which could compromise hemodynamic status. Early decompression and fluid resuscitation are essential to avoid death [6]. Given the unstable hemodynamic status of the patients and based on the fact that pericardiocentesis is the fastest treatment, we made the decision to perform pericardiocentesis and careful drainage with cardiac surgeons on standby. The rapid recovery of both patients ultimately validated our decision and emphasized the important role of pericardial decompression and stable hemodynamic status in the resuscitation of acute cardiac tamponade. Nonetheless, there were some other differential diagnoses such as ascending aortic dissection where conservative medical treatments could fail; thus, cardiac surgeons should stand by to perform instant emergent procedure such as Bentall surgery.

4.2. Post-PCI ischemic stroke

The incidence of post-PCI ischemic stroke was 0.56% according to data from the National Inpatient Sample. Risk factors include female sex, significant comorbidities, and cardiogenic shock [7]. Pathologically, postischemic stroke is considered to result from a thromboembolic event. During interventional therapy, catherization may impinge on atherosclerotic plaques in arteries proximal to the cerebral circulation, resulting in the sloughing off of debris that can eventually block cerebral arteries [8]. The risk increases with higher complexity of the vasculature and longer duration of the procedure [7]. Additionally, cerebral autoregulation is thought to be perturbed in patients with prolonged hypertension. Physiologically, cerebral arterial pressure remains constant over a broad range (50–170 mmHg) to assure stable nutrient delivery [9]. However, in hypertensive patients, a compensatory mechanism shifts the autoregulation range to a higher threshold, which weakens the brain's natural resistance to hypoperfusion during hypotensive events [10]. If the stroke was due a thromboembolic event during PCI therapy, incomplete reperfusion of the MCA would be expected rather than the complete occlusion observed in our patients [13]. Additionally, the watershed zone is anatomically vulnerable to hypoperfusion, which usually results from a sudden drop in peripheral blood pressure [14]. Our patient lacked a preoperative MRA that could identify any pathology of the MCA, but the medical history of poorly controlled hypertension and diabetes mellitus was highly suggestive of potential underlying cerebro-

vascular diseases [15]. Immediately after PCI therapy, the patient experienced a period of hypotension that could compromise cerebral perfusion. In the CCU, in order to reduce cardiac effort the patient's blood pressure was controlled within a relatively lower range (100–110/60–70 mmHg) compared to the preoperative record (150–160/70–80 mmHg) [14]. Thus, the patient was at risk of prolonged cerebral hypoperfusion not only during cardiogenic shock but also during intensive care in the CCU. We hypothesized that the MCA was acutely occluded through chronic narrowing resulting from cerebral hypoperfusion followed by local inflammation and oxidative stress that disrupted endothelial function [16]. As preoperative head images were unavailable, it is not possible to draw a definitive conclusion.

4.3. Post-PCI APT

The updated 2017 European Society of Cardiology (ESC) guidelines on APT define acute hemorrhage resulting in unstable hemodynamic status as a life-threatening bleeding condition and recommend discontinuation of all antithrombotic medicines [4]. Both of our cases had acute cardiac tamponade with unstable hemodynamics (hypotension) following perforation of the sinus of Valsalva; therefore, in theory both should have immediately discontinued APT. The 2017 ESC guidelines also recommend reevaluating the need for APT once bleeding is controlled, but a straightforward and comprehensive scoring system is currently lacking. The 2011 American College of Cardiology Foundation and American Heart Association recommend ceasing APT for at least 5 days before coronary artery bypass grafting [17] by weighing platelet count rebound (or ischemic risk) vs effective antiplatelet drug coverage (or hemorrhagic risk).

Apart from guideline recommendations, a scoring system that evaluates the risk of ischemia and hemorrhage could be used as a reference in clinically complex situations. In patients with coronary artery disease who underwent PCI, HAS-BLED score had a higher predictive value for in-hospital hemorrhagic events compared to CRUSADE score (AUC=0.722 vs 0.520) [18]. As for ischemic risk assessment, CHA2DS2-VASc score has been used in patients in addition to atrial fibrillation because it includes several common cardioembolic risk factors such as hypertension, diabetes mellitus, and age [19].

For our male patient, the first PCI was 4 months prior with adequate DAPT. The PRECISE-DAPT score was 32', indicating that a shortened period of DAPT (3–6 months) was acceptable [4]. DAPT for 1–3 months followed by treatment with the P2Y12 inhibitor SAPT was shown to be noninferior to 12 months of DAPT in terms of adverse events [20, 21]. After experiencing cardiogenic shock following sinus of Valsalva injury, the patient was determined to be at an absolute higher risk of bleeding according to the 2017 ESC guidelines [4]. Although his HAS-BLED and CRUSADE scores were in the low-risk category, the clinical picture should be prioritized since these two score do not take "active bleeding status" into consideration thus were incapable of giving full assessment of our male patient. Considering that the DAPT had been sufficient, we discontinued this treatment. The recurrence of pericardial effusion 10 days after discharge could have easily been misinterpreted as a consequence of early administration of clopidogrel. The dark red drainage as well as the normal platelet counts and function on admission excluded this possibility; the most likely reason was subtle hemorrhage of an unhealed wound. Simply ceasing SAPT and draining the pericardium led to complete recovery. SAPT was added to the treatment regimen when there was no pericardial effusion observed by repeated ultrasonography.

Our female patient was at extremely high risk of ischemia. Her CHA2DS2-VASc and HAS-BLED scores were 6 and 3, respectively, which could be interpreted as a strong indication for anticoagulation [19]. Additionally, she had just been implanted with 3 stents, of which 2 were placed at junction of the LM and LAD where thrombus formation or vasospasm could lead to cardiogenic shock or even sudden death [22, 23]. Therefore, despite being in the extremely high-risk group for bleeding based on CRUSADE score, we followed the guidelines for CHA2DS2-VASc score and administered P2Y12 inhibitor.

5. Conclusion

In summary, sinus of Valsalva injury is a potential PCI-related complication-specifically caused by an intraoperative trauma in our cases-that could result in a life-threatening condition. Unlike perforation of SOVA, conservative medical therapy with adjustment of APT, continuous pericardial drainage and repeated heart ultrasound monitoring can lead to recovery. Intraoperative manipulation during PCI inevitably leads to fluctuations in blood pressure, especially when handling complicated vasculature. Thus, effective preoperative antihypertensive management is critical to avoid drastic intraoperative changes in blood pressure and cerebral hypoperfusion. APT should always be individualized based on the risk of ischemia and hemorrhage determined using various scoring systems.

6. Acknowledgement

The authors appreciate all the medical staff that have been involved in delivering medical care to these patients as well as the two generous patients in giving their consents to this case report.

7. Declarations

Consent for publication: Chinese written informed consents were obtained from our male patient and the daughter of our female patient for publication of their medical records and CT images.

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