Venous Baffle Thrombosis and Pulmonary Haemorrhage following Atrial Septal Defect Repair Diagnosed Utilising A Novel Imaging Technique of Dynamic Pulmonary Perfusion Computed Tomography

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We write to report a case of pulmonary haemorrhage and baffle thrombosis post sinus venosus atrial septal defect (SV-ASD) repair diagnosed utilising a novel imaging protocol of contrast enhanced dynamic Pulmonary Computed Tomography Perfusion (PCT-P) scan.

A 56 year-old male with past history of hypertension underwent surgical ASD repair. Pre-operative transthoracic echocardiogram revealed normal left ventricular size and function with mild concentric hypertrophy and septal wall flattening consistent with increased right-sided pressure. There was no significant valvular pathology. Subsequent transoesophageal echocardiogram (TOE) confirmed SV-ASD (superior type) with partial anomalous pulmonary drainage. The coronary sinus was enlarged, with bubble study consistent with persistent left superior vena cava.

Surgical repair was undertaken under cardiopulmonary bypass. Operative findings revealed a SV-ASD of 2.5cm high in the atrial septum with anomalous drainage of the right upper and middle pulmonary veins into the lowermost portion of the superior vena cava. A Gortex patch repair (baffle) was used to shunt the anomalous pulmonary vein into the left atrium. The superior vena cava and uppermost portion of the free wall of the right atrium were enlarged by applying a patch of bovine pericardium. The right atrium was then closed.

Day two post repair the patient developed streaky haemoptysis with chest x-ray showing right lower lobe consolidation. The patient’s white cell count remained normal, however was febrile at 37.6C so Piperacillin/Tazobactam was commenced. There was no coagulopathy, however over the following 24 hours the haemoglobin dropped from 114 g/L to 71 g/L, resulting in 2 units of red blood cells being transfused.

CT Pulmonary Angiogram (CTPA) was undertaken to determine whether pulmonary embolism was the cause forb the haemoptysis. It confirmed consolidation in the posterior segments of the upper and lower right lobes, and given the haemoptysis was thought to represent pulmonary haemorrhage. This was more predominant interestingly in the right lower lobe, not upper lobe, which had undergone vascular correction. There was no pulmonary embolism. The aetiology of the pulmonary haemorrhage still remained unclear.

On return to theatre the following day bronchoscopy and TOE were unable to determine the cause of haemoptysis, however confirmed haemorrhage. It was felt that the repair remained intact. Given there was still no clear cause, dynamic CTP-P was performed to assess pulmonary vein anatomy.

The scan was performed using an Aquilion One 320 detector array Vision addition CT scanner (Toshiba Medical Systems). Intermittent dynamic volume scanning technique was employed comprising 15 independent volume acquisitions over a scan time.
of 50 seconds. The first 8 volume acquisitions were 2 seconds apart while the remaining 7 were acquired every 5 seconds. The patient was instructed to breathe quietly during the scan due to long acquisition time. Regarding iodine contrast timing, a set delay of 5 seconds after the commencement of the contrast infusion was used. 75mls of Omnipaque 350™ (GEHealthCare) was injected at 5mls per second, followed by 30mls of normal saline at the same rate. Each volume acquisition utilised 320 detectors, a z-axis FOV of 16cm, 0.275 second tube rotation, a tube potential of 100kVp, and a tube current of 80 mA. Initial image data was reconstructed using a contiguous 0.5mm slice thickness, 180 degree reconstruction interpolator, and smooth kernel. Multiplanar images were generated in early, mid and late contrast phases, as well as cine movies in multiple locations through the 3 main anatomical planes.

Dynamic PCT-P showed arterial supply and venous drainage of the right lower lobe present, although slow, likely reflecting increased pressure of the right lower lobe due to paranchymal haemorrhage (Figure 1a & 1b). It was hypothesised that the pressure increase may have arisen at the time of initial operation subsequent to placement of the surgical clamp on the upper pulmonary artery, suddenly increasing the pressure and blood volume to the lower pulmonary arteries resulting in haemorrhage. A non-occlusive thrombus of the baffle conduit connecting the right upper and right middle pulmonary veins to the left atrium was seen (Figure 2). This was serendipitously detected and not suspected by the surgical team.

On return to theatre on day 6 of admission, indeed the atrial baffle was thrombosed with long extensions arising from the right superior pulmonary vein. An uncomplicated thrombectomy and repair was performed. Three days later the patient made a full recovery and was discharged on 6 months of aspirin.

Dynamic CT perfusion scanning has become the standard of care in a number of areas of medicine, including neuroimaging in stroke syndromes, [1] hepatocellular carcinoma characterization [2] and more recently cardiac perfusion scanning for assessment of acute chest pain. [3] Although pulmonary perfusion scans have been described in differentiating lung tumours and vascularity, [4] to our knowledge there has been no published data utilising dynamic pulmonary CT perfusion scanning in the setting of pulmonary venous thrombosis or haemorrhage.

The principle of perfusion CT is based on the temporal changes in tissue density following the administration of intravenous contrast. The changes over time in tissue density are dependent on contrast concentration and reflect the nature of tissue vascularity. By rapid sequential acquisition of images during the passage of contrast in tissue, perfusion CT allows quantification of tissue vascularity. [5]

Important parameters which can increase diagnostic accuracy can rapidly be attained, including; blood volume (BV) (i.e. volume of blood per unit of tissue), blood flow (BF) (ie, volume of blood flow per minute), mean transit time (MTT), defined as the difference between arterial inflow and venous outflow; and time to peak enhancement, which represents the time from contrast injection to maximal contrast concentration in

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**Figure 1a.** Arrow demonstrating early phase of arterial dynamic computer tomography pulmonary perfusion scan showing delayed right lower lobe arterial enhancement thought due to increased resistance from haemorrhagic consolidation.

**Figure 1b.** Arrow indicating an irregular contour pulmonary vein with a small amount of persistent arterial enhancement in keeping with delayed perfusion.

**Figure 2.** Arrow demonstrating tubular low density structure located between the superior vena cava and pulmonary artery, in the expected position of the baffle, and therefore most likely representing the thrombosed baffle.
the anatomical area of interest. [6] As an example, accurate diagnosis of acute strokes have significantly increased from the quantitative and qualitative evaluation of BF, BV and MTT that perfusion imaging provides. The hypothesis being infarcted tissue shows severely decreased cerebral BF, decreased BV and increased MTT. [7]

Our case demonstrates a first reported novel CT perfusion scan protocol of the pulmonary vasculature to assess pulmonary venous blood flow, aiding the diagnosis of surgical baffle thrombosis and pulmonary haemorrhage. Abnormalities of blood flow, volume or mean transit time in pulmonary perfusion with our protocol can give clinicians further tools to help differentiate vascular pathologies, whether it be infarction, thrombus or congenital anomalies to better target therapies.

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Conflict of Interest
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