Cardiology in the Young

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Internal thoracic artery as a growing conduit for pulmonary shunt

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Abstract

Studies suggest the internal thoracic artery as a shunt option due to its growth potential. However, long-term data are lacking. Here, a patient with a failing single ventricle shunt had an enlarged internal thoracic artery. We followed the patient for 12 years after converting this artery into a Blalock–Taussig shunt, analysing its growth to assess its effectiveness

Brief Report

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Case

A 13-year-old male, diagnosed with a variant of single ventricle, underwent a modified Norwood procedure at 1 month old. Severe postoperative complications, including hypoxic encephalopathy, led to tracheostomy and recurrent pneumonia. Further surgery was initially ruled out but became imperative as the patient outgrew the modified Blalock–Taussig shunt. To ensure stable pulmonary blood flow and avoidance of anticoagulants, the right internal thoracic artery was chosen as a graft at 13 months. During the 10-year follow-up, serial CT scans were performed periodically to identify potential collateral vessel proliferation associated with airway infection, which could lead to recurrent haemoptysis and hypoxaemia. Coil embolisation was performed on the culprit collaterals whenever indicated (Fig. 1). Blood vessel imaging was done with a catheter during haemoptysis, followed by coil embolisation via the femoral and right subclavian artery at the suspected responsible site (such as branches of the intercostal artery, internal thoracic artery, and bronchial artery). Serial CT angiography was utilised to monitor the diameter of the internal thoracic artery for any concerning changes in size over time. To assess whether the internal thoracic artery calibre adapts proportionally to the anticipated rise in pulmonary blood flow, a scatter plot was constructed. This analysis was based on the principles of the Hagen–Poiseuille equation. The ratio of the fourth power of the internal thoracic artery diameter to its total length was plotted against the patient`s contemporaneous body surface area. This approach aimed to evaluate the potential for adaptive growth of the internal thoracic artery in response to increasing haemodynamic demands (Fig. 2)

Discussion

The present case shows a gradual increase in the diameter of the internal thoracic artery, used for the pulmonary shunt, over time. This progression was evidenced through periodic contrast-enhanced CT scans conducted on a patient who underwent the stage 1 Norwood operation who manifested with episodes of intermittent haemoptysis. Typically, the internal thoracic artery diameter in adults is around 2 mm. While there are numerous reports[1–5] in the literature regarding the utilisation of the internal thoracic artery as a living graft to supply blood flow to the pulmonary circulation, it is noteworthy that these reports are generally limited to short-term outcomes, with no documented cases extending beyond a 10-year timeframe. Consequently, there is a lack of evidence concerning the long-term growth potential of this shunt graft. Therefore, there is insufficient corroboration for the hypothesis regarding the livelihood of the graft.

To assess the adequacy of the internal thoracic artery size in relation to body size, we rely on data related to the modified Blalock–Taussig shunt used for small infants. It has long been established that an artificial graft of size 3.5 mm optimally supplies pulmonary blood flow, ensuring optimal oxygen saturation and cardiac output for patients with parallel circulation. Considering the typical body surface area of small infants is approximately 0.2 m^2, Figure 2 suggests that the size of the internal thoracic artery adjusts to accommodate the increasing pulmonary blood flow associated with growth in accordance with the optimal shunt size for infancy. Over the course of time with the present case, there was a noticeable trend in the rapid enlargement of the internal thoracic artery diameter, followed by a gradual decrease in the growth rate. Eventually, it exhibited a convergence towards the optical point that was mentioned earlier. Interpreting these data, it suggests that the internal thoracic artery functions as a graft

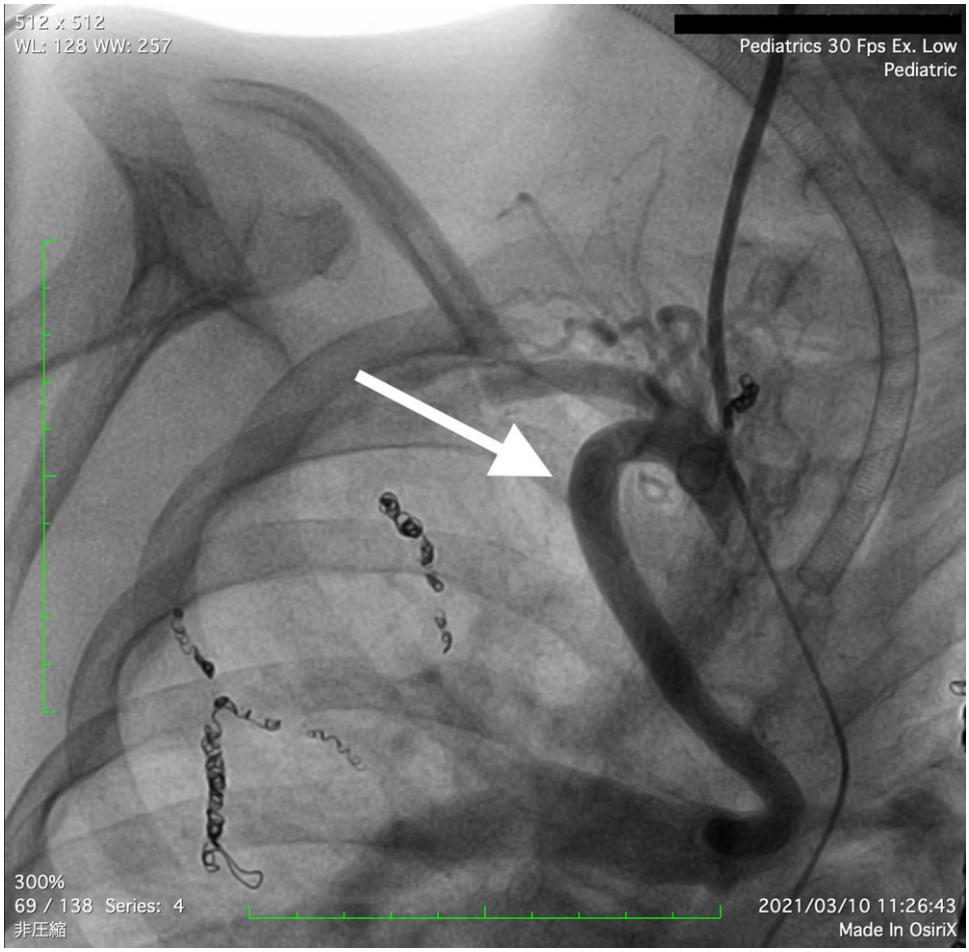

Figure 1. Angiogram of the right internal thoracic artery shunt (white arrow) at 12 years postoperative showing no stenosis,.

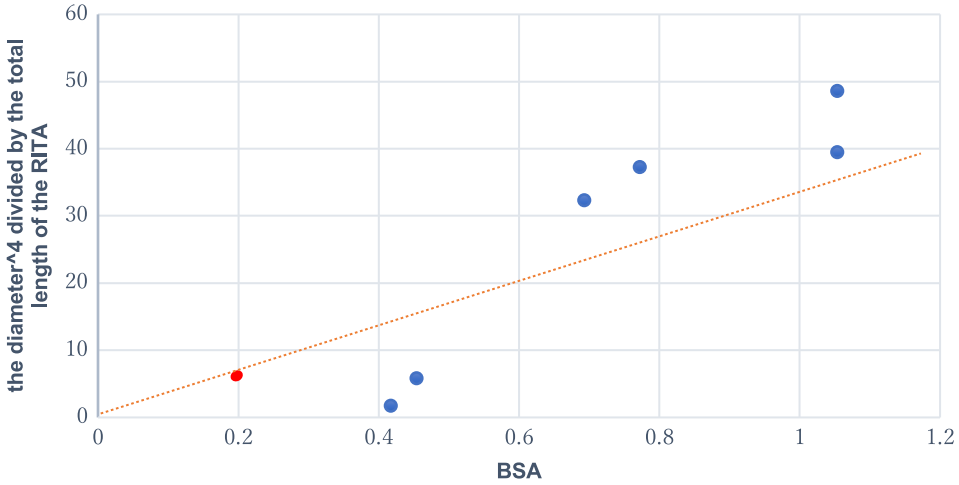

Figure 2. The scatter plot showing the relationship between internal thoracic artery diameter, length, and body surface area. Assuming constant pressure and viscosity, pulmonary blood flow is proportional to the fourth power of the diameter of the internal thoracic artery (D ^ 4) divided by its length (L). The red data point represents a young infant (body surface area (BSA) = 0.2) who received a graft considered optimal practice: 3.5 mm diameter and 2 cm long. This orange line illustrates the theoretical optimal blood flow for each BSA based on this reference point. The patient data (shown in blue) converge around the line with growth, suggesting an age-proportional growth.

capable of adjusting and growing in size in proportion to the increasing demands of the growing body over an extended period. To the best of our knowledge, this article represents the first documentation demonstrating the hypothesis outlined above.

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