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Original Research Paper

Cardiology

ELECTIVE MECHANICAL SUB PULMONARY SUPPORT - THE FINAL FRONTIER OF SINGLE VENTRICLE PALLIATION

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KEYWORDS : Sai Spandan, TAH- Total Artificial Heart, MCA -Mechanical circulatory assist, Failing Fontan, TERM - Tissue and Regenerative Medicine, TCPC -Total Cavopulmonary Connection, SMV-Skeletal muscle ventricle connection

INTRODUCTION

Sophisticated technology advances are fast taking taking shape to provide long term destination therapy mechanical circulatory assistance. Sai Spandan total artificial heart with hybrid BSRM core with dual motor and controls, virtual fit technology is one such over the horizon. The promise is of better quality of life and longevity. Transcutaneous charging of fully implantable models would very soon revolutionize cardiac surgical treatment modalities. The final frontier in a failing Fontan is sub pulmonary mechanical assistance. We take a short look into the issues and possibilities. The research gap exists for the innovator in this field.

DISCUSSION

Over 65,000 Fontan operations are performed annually (1). This is expected to double over the next decade (2). This surgery essentially relies on the pulmonary atrial pressure gradient to drive the venous circulation with its attendant disadvantages of augmented central venous pressure, venous congestion and reduced cardiac output, but provides the advantage of increased oxygen saturation. A failing Fontan which is time dependent deterioration of the altered physiology has a high mortality (3).2/3rd of deaths are associated with preserved ventricular function (4).A valve in the Fontan circuit which was in the original conceived idea of Fondan and Baudet, was for obvious reasons associated with increased risk of thrombosis(5). The atrial geometry typically would produce loss of energy in linear flow dynamics which lead cardiac surgeons to fashion out the extracardiac total cavopulmonary connection or extracardiac TCPC.This surgery is known also as the lateral tunnel operation(6). Various methods of sub pulmonary assist can broadly be categorized as mechanical or biological. Mechanical can then be subcategorized as intra and extra vascular.

Paced autologous skeletal muscle flaps, neoventricles or warp around was one of the biological methods attempted. The Rastelli SMV modification was then suggested to overcome disadvantages like a hampered preload, with better survival pattern (7).Another method that emerged was atrial cardiomyoplasty which looked into ventricularisation of right atrium (8). For these patterns to be effective a valve regulation at IVC opening, avoiding overstimulation of muscle flap, a conduit augmented by skeletal muscle wrap from RA to distal PA, and closure of tricuspid valve was needed. Effectivess of these ideas being translated into clinical success was not impressive with production of its own share of attendant problems.

Mechanical assistance was another alternative that emerged. Temporary support can be achieved by catheter based VADs.Suction devices in total cavopulmonary circulation emerged as an interesting option, but suction induced caval collapse avoiding recirculation and retrograde flows with separators would need careful attention to as suggested by flow hemodynamic properties of T junctions. Axial flow devices could be tested on mock circulatory loop with Fontan physiology. Jarvik 2000 and Heart Mate II have found applications in this set up (9).Use of systemic pressure to drive the Fontan circulation was attempted by Pekkan and Colleagues (10).Caval Collpase, hemolysis and venous obstruction needs preventive strategies. Von Karman principle finds interesting application in this set up. Extra vascular assist devices include C cuff (12) and sequential compression devices over compressible tubes (13). In the latter memory alloy tubes over e PTFE conduits contract on stimulation provided by electrical current. From view point of computational fluid dynamics it is important to provide unidirectional flow without suction and compression effect for such mechanisms to be clinically successful.

It is here that biventricular support or total artificial heart emerges in the management options. Berlin Exocor, SynCardia or the pipe line project of hybrid BSRM based Sai Spandan being developed in India are useful considerations in this respect(15). One of the options is creating a pesudobiventricular support. One being placed traditionally and another from atrial to PA after closure of atrial communication. Fully implantable, drive line free mechanical circulatory assist devices with textured lining and reliable TET

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charging methods would soon be available. Bioengineered pulsatile tube grafts would be another interesting development in this area (14).

CONCLUSIONS

Failing Fontan has opened up the avenue for mechanical circulatory devices as the final frontier in elective sub pulmonary assist purposes. Open and percutaneous methods of placement provide interesting avenues of research completion. Fast emerging technological options in the multidisciplinary domain is providing interesting clues which would reshape even the implantation techniques of total artificial hearts in near future.

Figure 1 Saispandan 12/14 Hybrid BSRM Total Artificial Heart for Destination Therapy- on *Bench work* Design Phase (reproduced with special permission of cardiothoracic surgery depart of Gitam University Research Division)

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