Percutaneous aortic valve replacement: computed tomography scan after valved stent implantation in human cadaver hearts

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Abstract

Computed tomography scans were performed before and after aortic valve resection with consecutive implantation of a valved stent in human hearts with highly calcified aortic valves in situ (n = 2). This demonstrates that the valved stent shows better fitting in the annulus after removal of the native valve.

Keywords: Resection; Percutaneous; Human; Aortic valve; CT; In situ

1. Introduction

The promising trans-catheter — percutaneous or trans-apical — implantations of artificial heart valves suggest better outcomes in the last year due to a learning curve, optimised devices and sufficient preoperative screening of the patients [1]. However, not much is known about the behaviour of the valved stent in a highly calcified annulus. The aim of this study was to analyse the alignment of a nitinol stent in a severely calcified annulus in human cadaver hearts.

2. Material and methods

2.1. Human preparations

Before death, these people had given written consent to the Institute of Anatomy of the Christian-Albrechts University of Kiel (n = 2). The study has been approved by the Ethics Committee of the University of Kiel from 24 November 2004 (D 434/04).

2.2. Experimental set-up

The human hearts (n = 2) were immersed in water and the water heated up to a temperature of approximately 37 °C. Self-expandable nitinol valved stents (Ø 26 mm) with insuftered porcine aortic valves were implanted into the calcified aortic annulus of the hearts after valvuloplasty (balloon: Thyshak II). Computed tomography (CT) scans were performed. Following this, the stents were re-dilated by the balloon. Nitinol stents were then removed and the calcified aortic leaflets conventionally excised using surgical scissors. Implantation and dilatation of the valved stents was performed into the pre-treated aortic annuli. A second CT scan confirmed the results of the implantation. For CT scans, the hearts were briefly removed from the water.

2.3. Analysed parameters

The stent diameters in the ascending aorta and in the ventricle were analysed before and after removal of the valve.

2.4. Valvuloplasty device

For all valvuloplasties, a commercially available valvuloplasty balloon — a Thyshak II® (NuMED Inc., New York, USA) with an outer diameter of 20 mm and a maximum pressure of 1.5 atm — was used.

3. Results

The alignment of the valved stent was imperfect in the highly calcified aortic valve. A CT scan of the aortic valve area after maximal balloon re-dilatation of one deployed valved
stent is shown in Fig. 1. The insufficient alignment of the stent was due to the presence of the highly calcified valve. The arrow indicates a paravalvular leakage spot. The part of the stent in the ascending aorta had a diameter of 21.7 mm (second stent: 20.0 mm) and the ventricular part of the stent, a diameter of 8.7 mm (second stent: 10.6 mm). The latter diameter increased after resection from 8.7 mm to 19.2 mm (second stent: 10.6–13.7 mm).

4. Discussion

It is known that the implantation of a valved stent into a severely calcified annulus causes different problems [2]. Pretreatment of the annulus to remove the bulky calcified areas is not yet mentioned in the current trans-catheter implantation guidelines [3]. Unfortunately, the anatomical structure of a highly calcified aortic valve does not ideally lend itself to the implantation of a circular valved stent. In this image, an implanted self-expandable nitinol valved stent into a highly calcified aortic annulus from a human cadaver is shown before and after removal of the valve. Better alignment of the stent and better expandability were observed in the CT scan after resection of the severely calcified valve. There are only two investigated cadaver hearts due to the rareness of human cadavers with such an extensive aortic valve disease. Limitations of this study are the in vitro set-up and only a self-expanding valved stent. The balloon-expandable steel stents are missing; however, here, the alignment of the stent should be demonstrated without using excessive deployment force.

There is little known about the acute and the long-term behaviour of the aortic valve apparatus after implantation. Only a few publications report autopsy results after failed implantation or postprocedural death of the patient [4,5]. However, this especially provides important information for the physician — for the cardiac surgeon and the cardiologists. The potential outcome for the patient cannot be realistically discussed before implantation when the impact of the treatment might be unclear.

Additionally, nearly all implantation results published by the leading groups demonstrated paravalvular leakage in a mild to severely calcified annulus [4,6]. Although likely to be less relevant, aortic regurgitation and, especially, the accompanying haemolysis in decompensated heart failure are an additional risk [7].

The clinical relevance of these studies is to learn from human cadavers.

These findings are not intended to find fault with actual clinical results of our colleagues. On the contrary, they should be a stimulus to share results at an earlier phase and further the team approach among users of this new technology. The ultimate goal is to find the best solution for the patient.
The future of this promising technology will, of course, not be restricted to octogenarian or multimorbid patients. It will certainly be a challenge for the treating physicians to resolve the issues associated with paravalvular leakage and a small aortic valve area in younger patients.

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References


