Neurohumoral response and clinical effectiveness of continuous aortic flow augmentation in patients with decompensated heart failure

Abstract The increasing number of patients with progressive or exacerbated heart failure that is refractory to medical treatment necessitates the development of innovative cardiac assist devices. The aim of this study was to investigate whether a new percutaneously inserted system, which allows continuous aortic flow augmentation (CAFA), could be shown to be clinically effective with neurohumoral benefit in patients admitted with decompensated heart failure. Patients with exacerbations of chronic heart failure were recruited for the study. A percutaneous circulation assist device (Cancion system) promoting CAFA was implanted for up to 4 days in each patient. Clinical improvement was evaluated by measuring the clinical status according to the New York Heart Association (NYHA) classification and biochemical parameters including troponin and B-type natriuretic peptide (BNP) as markers of cardiac necrosis and cardiac overload; these parameters were measured before, during, and after CAFA treatment. The decrease in BNP was determined after implantation, reaching, on average, a maximum decrease of 57% at 72 h \((P = 0.04)\). The neurohumoral response remained significant \((P < 0.05)\) up to 120 h after implantation, with a decrease in BNP levels of 37%, on average, compared to baseline values. Troponin I did not show any significant change during mechanical assistance \((P > 0.2)\). All patients had improved clinical status according to the NYHA classification, and the improvement lasted for more than 1 week. Percutaneous heart-assist devices promoting CAFA offer clinical improvement and a neurohumoral response, with a significant BNP reduction in severe exacerbation of chronic heart failure that is refractory to medical treatment.

Key words Heart failure · Continuous aortic flow augmentation · B-type natriuretic peptide (BNP) · Heart-assist device

Introduction

Heart failure is a major cause of mortality and morbidity in Western societies. The growing population and the scientific improvement of medical treatments have resulted in an increase in the number of patients who require resource-intensive management with multiple admissions and high-cost therapies. However, many of these patients, unless they die or undergo a heart transplant, become refractory to inotropic, vasodilating, and diuretic drugs, reaching a clinical status with deteriorating quality of life and high rates of recurrent and long-term hospitalization.1

There is a basic understanding that the low cardiac output in heart failure triggers a variety of neurohumoral responses, which, as the disease progresses, cause adverse effects, including vasoconstriction, increased afterload, sodium and water retention, and arrhythmias.2 Thus, therapeutic attempts to support continuously the aortic flow could break this cycle between hypoperfusion and progressive neurohumoral activation.3 Percutaneously inserted devices that continuously augment aortic blood flow offer a solution to this clinical problem, providing relief from increased cardiac afterload and improving cardiac function.

In this study, patients with acute exacerbation of chronic heart failure received treatment with the Cancion system (Orqis Medical, Lake Forest, CA, USA) of continuous aortic flow augmentation (CAFA) in an attempt to support cases of disease refractory to medical treatment. Previous studies reported results relating to hemodynamic data and renal function.4 We focused on the neurohumoral response. Clinical outcomes consisting of adverse effects and discharge clinical status were also observed.
Methods

Patients

Participants were admitted to hospital with acute or exacerbation of chronic heart failure and with New York Heart Association (NYHA) class III or IV symptoms. All patients were resistant to conventional medical therapy or became symptomatic after withdrawal of inotropic support. Inclusion criteria included signs or symptoms of heart failure on physical examination despite optimal diuretic and inotropic treatment and reduced left ventricle ejection fraction (<35%) and systolic blood pressure >80 mmHg. Exclusion criteria included clinical cardiogenic shock, ST-elevation myocardial infarctions (STEMIs), severe renal impairment, a cerebrovascular event during the previous year, life-threatening arrhythmias, untreated peripheral vascular disease, and usage of other forms of mechanical support.

Study protocol

All participants in the study underwent implantation of the percutaneous Cancion System (Orqis Medical) in the catheterization laboratory. The system consists of two 12-F catheters, inserted via the femoral arteries, delivering CAFA at a flow rate of 1.0–1.5 l/min. An external, bearing-less, magnetically-spun pump draws blood from the inflow catheter, positioned in the left iliac artery, and returns blood through the 60-cm-long outflow catheter positioned through a right femoral arterial sheath, terminating in an end-hole pigtail configuration (Fig. 1). The latter is positioned under fluoroscopy to terminate just below the subclavian artery level (Fig. 2). The desired flow rates of 1.1 to 1.5 l/min were achieved by a pump speed of 3500 to 4500 rpm. Patients underwent anticoagulation with continuous intravenous infusion of unfractionated heparin (800–1400 U/h), targeting an activated partial thromboplastin time of between 65 and 85 s. The patients were under close monitoring in the intensive care unit for the treatment duration and for at least one additional day. It was anticipated that the device would be removed in the event of serious adverse events, such as bleeding, hemolysis, or infection. The medical treatment of the participants did not change, with the exception of inotropic agents, which were withdrawn. One of the five patients was given inotropic support with dopamine at the dose of 5 μg/kg per minute.

Measurements

Demographic data including age, sex, body mass index (BMI), reason for admission, etiology of heart failure, and NYHA class were collected. Detailed cardiovascular risk factors, the presence of an automatic implantable cardioverter defibrillator (AICD) or biventricular device, and the number of diseased coronary vessels were also recorded. Serum creatinine, urea nitrogen, and glomerular filtration rate (GFR) (determined by the Modification of Diet in Renal Disease algorithm) were measured before treatment, on every day of treatment, and for up to 2 weeks following treatment discontinuation. Measurements of cardiac necrosis markers (myoglobin and troponin-I) were also performed. Plasma concentrations of BNP were measured before, during, and following CAFA treatment.

Statistics

Continuous variables were tabulated with the minimum, maximum, mean, and standard deviation. Differences in continuous variables were evaluated with the nonparametric paired t test of Wilcoxon. In all tests, the null hypothesis was rejected at a confidence level of 5%. The SPSS version 12 statistical package was used (SPSS, Chicago, IL, USA).