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ORIGINAL ARTICLE

Characterisation and Comparison of Acute Haemodynamic, Cardiac Biochemical and Hormonal Response to Different Ventricular Pacing Sites in the Normal Heart

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Background Acute cardiac response to right ventricular pacing is unknown. We aimed to assess the acute haemodynamic, biochemical and hormonal response to asynchronous right ventricular pacing and investigate whether there is a difference between an apical and outflow tract site.

Methods In 21 patients with normal cardiac function, haemodynamics, brain natriuretic peptide and high sensitive troponin T were measured in response to 10 minutes of pacing at each site in a randomised crossover fashion and compared.

Results Pacing both sites there were significant increases in pulmonary capillary wedge pressures ($p < 0.001$) and QRS width ($p< 0.01$). In comparison to baseline, apical pacing demonstrated significant ($p < 0.05$) increases in arterial peptide and troponin levels and venous peptide levels. Outflow tract pacing compared to baseline demonstrated significant ($p < 0.05$) increases in arterial peptide and venous, arterial and coronary sinus troponin. There were no significant differences in responses between sites.

Conclusion Asynchronous right ventricular pacing demonstrated significant increases in filling pressures, cardiac hormonal and biochemical response above baseline with very short durations of pacing (10 minutes). There was no difference in response between sites. These findings imply that even very short periods of right ventricular based pacing are potentially deleterious.

Keywords Pacing • Hormonal response • Biochemical response • Haemodynamic response • Alternative right ventricular pacing sites

Introduction

Right ventricular apical (RVA) pacing has been the mainstay of ventricular pacing largely due to the ease of lead positioning and the reliable outcomes. The acute effect of right ventricular pacing on cardiac performance as assessed by acute hormonal, biochemical and haemodynamic response is unknown. Previous studies have suggested detrimental

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chronic effects with right ventricular pacing in the normal heart [1] and this would appear more pronounced in the failing heart [2]. It is also independent of atrio-ventricular synchrony [3]. In addition, increasing percentage burden of RVA pacing has been associated with worsening outcome [2,4] however the exact duration of RVA pacing required is unknown. In addition, alternative pacing sites, such as the right ventricular outflow tract (RVOT) [5,6] have also been investigated with mixed results.

In this study we sought to measure and compare the acute haemodynamic, biochemical and hormonal response of asynchronous ventricular pacing at the RVA and RVOT in patients with preserved biventricular function. This was to determine if even brief periods of asynchronous ventricular pacing are associated with measurable changes in haemodynamic, hormonal and biochemical profiles and as such infer a potential detrimental effect of this type of pacing.

Patients and Methods

Twenty-one patients with normal bi-ventricular, renal function and QRS duration, prior to an electrophysiological study for supra-ventricular tachycardia, were consecutively enrolled in the study. The study was approved by the locally appointed ethics committee. Baseline demographics of the study group are presented in Table 1. In a fasted, non-sedated state with anti-arrhythmic medications discontinued five half-lives, patients underwent right femoral venous access and placement of a luminal coronary sinus catheter (St Jude Medical). A femoral venous sheath and femoral arterial sheath were also placed for blood sampling and haemodynamic measurements. A Swan-Ganz catheter was placed in the pulmonary artery via the femoral vein for pulmonary capillary wedge pressure (PCWP) measurements. A quadripolar electrophysiological pacing catheter (St Jude Medical) was used for the pacing protocol via the pacing stimulator (Micro Pace EPS-320 cardiac stimulator 3.21). The catheter was positioned in an RVOT septal position and a RVA position and was confirmed with orthogonal x-ray views and electrocardiographically as has previously been described [7]. Pacing capture threshold was subsequently determined and the myocardium paced at twice the diastolic capture threshold similar to programming for permanent cardiac devices (typically 3 Volts and 0.5 milliseconds). Representative pacing lead positions during the study are demonstrated in Figure 1.

Table 1 **Patient Demographics.**

Characteristic	Patients n=21
LVEF (%)	61 +/- 5
Male	6/21 (29%)
Age (years)	48 +/-19
Beta-Blocker	9/21 (43%)
Verapamil/Diltiazem	5/21 (24%)
Anti-arrhythmic drugs	0/21 (0%)
BMI, kg/m2	27 +/- 6
Hypertension	3/21 (14%)
Diabetes	1/21 (5%)
Serum Creatinine µmol/L	70 +/- 17

Protocol for Pacing

The pacing protocol is presented in Figure 2. Prior to their electrophysiological study in sinus rhythm, patients were randomly assigned to commence with 10 minutes of either RVA or RVOT asynchronous pacing at 10 beats above baseline heart rate and subsequently crossed over to the alternate pacing site for a further 10 minutes of pacing at 10 beats above baseline. Patients were in stable sinus rhythm during pacing which ensured constant ventricular pacing. There was a 20-minute washout period between each pacing period to re-establish a steady state and a second baseline. Blood sampling and haemodynamic measurements occurred at each baseline and completed pacing period. Each pacing response was compared to its own baseline. The period of pacing and intervening period between pacing site protocols were chosen because similar timing in measuring acute cardiac response such as in this study has previously been employed [8–11]. In addition the authors were interested in determining how quickly hormonal and biochemical parameters change occurred with ventricular pacing. The duration of the paced QRS and sinus QRS in lead II were also recorded. In addition, the time to peak systolic blood pressure in the femoral artery was also recorded from the onset of the QRS or paced QRS in lead II.

Haemodynamic Measurements

Haemodynamic data were collected at baseline and the end of each time interval (see Figure 2); heart rate (HR) in beats per minute, mean arterial blood pressure (MAP), pulmonary capillary wedge pressure (PCWP), all in mm/Hg.

Blood Collection and Analysis of Brain Natriuretic Peptides and Troponin

Blood samples were collected into blood collection tubes: EDTA for the brain natriuretic peptide (BNP) assay, serum for the N-Terminal pro-brain natriuretic peptide (NT pro-BNP) and high sensitive troponin T (hs-TnT) assays (serum #456071, EDTA # 454023, Greiner Bio-One Gratz, Austria) at baseline and the end of each time interval (Figure 2). Blood samples were obtained from the femoral artery, the femoral vein and the coronary sinus at each time interval. Analysis of BNP was performed on the Beckman Access 2 system (Beckman Coulter Brea, CA, USA). Analysis of the NT Pro-BNP and the hs-TnT was performed on the Roche Elecsys e170 system (Roche Diagnostic, Sydney, Australia).