# Heart Failure (HF)

Heart failure (HF) is a chronic condition affecting 2% of the adult population in developing countries (European Society of Cardiology, 2013). Nearly 900,000 people in the United Kingdom are affected (NICE,2014). Cardiac function can be disrupted due to structural or functional abnormalities that impairs the hearts ability to support circulation effectively. Based on this concept, HF can be classified as biventricular (BV) failure (reduced left ventricular ejection fraction) or right heart failure (preserved left ventricular ejection fraction) (NICE,2014). Patient group included in this study have biventricular failure so are manage with pharmacological therapy and cardiac resynchronisation therapy (CRT) device therapy.

Long term right ventricular pacing on its own has shown to have adverse effects on people with left ventricular dysfunction such as reduction in ejection fraction (EF) which can compromise the patient haemodynamically. For this reason, biventricular pacing is recommended in this patient cohort (Nahlawi et al, 2004). A subset of these patients may have an increased risk of sudden cardiac death (SCD). They are prone to cardiac arrhythmias, predominantly ventricular arrhythmias such as sustained ventricular tachycardia (VT) that can degenerate into ventricular fibrillation (VF) which is life threatening ; also a major cause of mortality in this group of patients (Lou et al, 1989) (Baher and Valderrabano, 2013). A CRT-D device is indicated in this patient group (image 1). A short term study demonstrated that, BV pacing improved quality of life (Qol), improved symptoms and reversed LV remodelling. ICD has been reported to have added benefits to CRT-D with an incremental survival benefit and 36% reduction in risk of death (Bristow et al. 2004).

Indications for an ICD and CRT-D are similar for patients, a study showed that patients are more likely to receive therapy if the patients have a low ejection fraction. On the contrary, they found that patients with a CRT-D had a lower incidence of therapy which they attributed to BV pacing therapy as it facilitates electrical treatment of HF. They concluded that the two treatments have synergistic benefits (Di Biase et al. 2008). BV pacing in CRTDs have been associated to a decrease in the spontaneous occurrence of ventricular arrhythmias (VA's) and need to deliver (shock/ATP) therapy (Arya et al. 2005) (Ermis et al. 2005).

A study has shown that BV may contribute to the low count of therapy delivered by the CRT-D devices (Higgins et al, 2000). The aim of a CRT-D is, to ensure cardiac resynchronisation by maximising the amount of pacing to allow cardiac remodelling. Furthermore, this is influenced by a number of factors (refer to discussion) and optimal benefit is seen at pacing percentages closer to 100% (Ruwald et al, 2014), arbitrary values are 85-98%. A study has reported that biventricular pacing has a potential antiarrhythmic function which reduces the number of ventricular arrhythmias which can be accounted to the low numbers of patients that needed therapy (Arya et al, 2005) (Ermis et al, 2005). A study has shown that an increase in percent pacing is associated with low numbers of appropriate therapy being delivered (Higgins et al.2000).

BV pacing is pacing the RV and LV simultaneously or at a slight offset to ensure cardiac resynchronisation. This can be optimised based on the patient's requirements by adjusting the V-V activation interval, may be influenced by scar tissue (find reference). Anti tachycardia

pacing (ATP) therapy works by delivering short cycle length bursts of pacing to terminate the VT circuit by blocking the re-entrant pathway. This reduces the number of unnecessary shocks and prolongs battery longevity (Qian et al.2015). For shock therapy the algorithm detects the heart rate for a number of beats for a set interval before it decides if it lies in the VT/VF therapy zone before delivering a shock (Noro et al.2015). The shock therapy delivered can range from