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How to define setup channels for an electrophysiological recording system in left bundle branch pacing

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INTRODUCTION

An electrophysiological recording system was used to record an intracardiac electrogram (EGM) and an electrocardiogram (ECG) in left bundle branch pacing (LBBP) in the present study. The process utilized clipping, high pass, and low pass settings. ECG morphology changes were evaluated using different signal trace setup conditions. Recently, our group reported on a novel LBBP lead implantation technique assisted by John Jiang's connecting cable [1] to record an isoelectric interval in the pacing lead as an endpoint for lead implantation with continuous monitoring of paced EGM [2]. An isoelectric interval was used as criteria to confirm selective the left bundle branch (LBB) capture [3]. This study discusses how to define setup channels for an intracardiac electrogram for observing isoelectric interval to determine the depth of the lead for fear of perforation.

METHODS

All patients underwent a novel LBBP procedure guided by recording an isoelectric interval as an endpoint for lead implantation using the continuous pacing and recording technique which had been described in detail elsewhere [2] at Hwa Mei Hospital, University of Chinese Academy of Sciences from May 2021 to January 2022. All procedures involving human participants were in accordance with the ethical standards of the institutional research committee and the Helsinki Declaration (as revised in 2013). Written informed consent for publication of this study and any accompanying images was obtained from the patient.

We consider LBB capture present when the isoelectric interval was observed and the shortest and constant V6 R-wave peak time (V6 RWPT) was measured [2]. If this criteria were not met we diagnosed left ventricular septal pacing (LVSP).

Isoelectric interval was defined as the segment from the pacing stimulus to discrete ventricular deflection in EGM. An isoelectric interval was categorized into two EGM morphologies as follows: (1) superior oblique or downsloping and has no notch after the pacing spike (Generally in the initial time after implantation because of current of injury); (2) a horizontal segment after the pacing spike (Generally a period of time after implantation because of recovery of injury). All EGM morphologies were analyzed independently by two physicians, and in the absence of consistency between the two observers, a third physician adjudicated the results. ECGs and EGMs of adjacent beats were monitored and recorded during the transseptal placement of the pacing lead in real time. The differences in morphologies were retrospectively compared and analyzed under different high pass filters (30 Hz, 60 Hz, 100 Hz, 200 Hz) and low pass filters (300 Hz, 500 Hz) to identify the most favorable setup criteria for LBB capture with an electrophysiological recording system (EP-WorkmateV4.3.2, St. Jude Medical, St. Paul, MN, US). For each patient, the sweep speed was 150 mm/s. The clipping was set at 3 cm, and the amplitude was set at 0.5 mV/cm (Figure 1).

Statistical analysis: Continuous variables were reported as mean (standard deviation [SD]). Categorical variables were expressed as percentages. Chi-square test was used to compare proportions between two or more groups. To evaluate the diagnostic accuracy of detecting discrete EGM, we calculated the sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of different filter settings. Cohen's kappa coefficient was measured inter-rater agreement for categorical items. A P-value of <0.05 was considered significant. Statistical analysis was performed using IBM SPSS Statistics for Macintosh (version 26.0, IBM Corp, Armonk, NY, US).

RESULTS

77 patients with average age of 71.1 (9.1) years were consecutively collected in the study from May 2021 to January 2022, and 39 (50.6%) were females. Evidence captured by the LBB systems was successfully obtained in 70 patients (90.9%). In seven patients, LVSP was

presented due to the inability to capture LBB. Pacing indications include sick sinus syndrome in 35 patients, atrioventricular block in 40 patients, and CRT indication in 2 patients. Among the 77 subjects, 20 had heart failure, 45 had atrial fibrillation, 3 had dilated cardiomyopathy, and 1 had hypertrophic cardiomyopathy.

A total of 77 patients, the occurrence rates of discrete EGM were 15 (19.5%), 15 (19.5%), 33 (42.8%), 33 (42.8%), 57 (74%), 57 (74%), 64 (83.1%), and 64 (83.1%) for the corresponding filter settings of 30–300 Hz, 30–500 Hz, 60–300 Hz, 60–500 Hz, 100–300 Hz, 100–500 Hz, 200–300 Hz, and 200–500 Hz. The analysis of discrete EGM detection showed significant differences between the different filter settings ($X^2 = 79.652$; $P < 0.05$). Using LBB capture as the gold standard, the results of EGMs showed that the sensitivity was 23.4% and the specificity was 100% for the filter settings of 30–300 Hz, 30–500 Hz. The PPV was 100% and the NPV was 20.96%, respectively. The filters of 60–300 Hz, 60–500 Hz, selective LBB capture was a sensitivity of 51.56%, a specificity of 100%, with a PPV of 100% and an NPV of 29.55%. The filters of 100–300 Hz and 100–500 Hz had a sensitivity of 89.06%, a specificity of 100%, with a PPV of 100% and an NPV of 65%. The filter of 200–300 Hz and 200–500 Hz had a sensitivity of 100%, a specificity of 100%, with a PPV of 100% and an NPV of 100%. Cohen's kappa coefficient was 1 ($P < 0.05$) at filters of 200–300 Hz, 200–500 Hz, while it was 0.733 ($P < 0.05$) at filters of 100–300 Hz, 100–500 Hz.

DISCUSSION AND CONCLUSION

Typical EGM filter settings are 30 Hz for a high pass channel and 500 Hz for a low pass channel for bipolar intracardiac signal [4]. The high pass filter (HPF) removes lower frequencies by allowing frequencies higher than the filter setting to pass. The higher the frequency, the less baseline drift and the more biphasic the waveforms become. The low pass filter (LPF) removes frequencies by passing frequencies lower than the filter setting. The lower the frequency, the fewer the high frequency signals and the lower the baseline noise. Due to the clipping level limit, it does not allow the user to view the EGMs signal apparently at a high amplitude. Usually, the pacing spike and the current of injury of the potential were high amplitude. Therefore, in the same conditions of clipping level limit, it can improve the legibility of isoelectric discrete interval in EGMs with a higher HPF. In general, different LPF mainly affect the baseline noise. It has less impact for the discrete interval because isoelectric interval was defined as the segment from the pacing stimulus to discrete ventricular deflection without notch.

The best parameters for an electrophysiological recording system are low pass filter set at 300–500 Hz and high pass filter set at 200 Hz. These settings help to obviously observe the isoelectric interval for confirming LBB capture during lead deployment.

Article information

Conflict of interest: The corresponding author owns the patent for John Jiang's connecting cable, the other author declares no conflict of interest.

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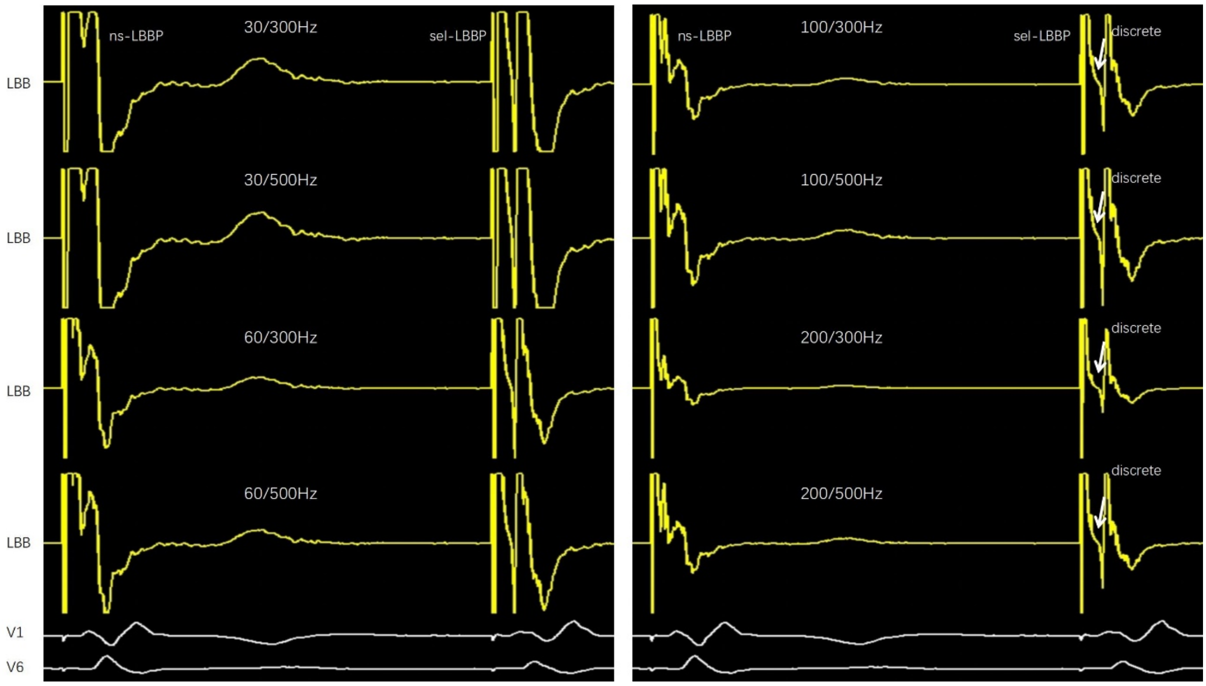

Figure 1. The paced electrocardiogram morphology changed from a "rSR'" to an "M" pattern in the V1 lead and the V6 RWPT were constant 80 ms between two adjacent beats. The isoelectric interval was apparent when the high pass filters were 100 Hz and 200 Hz, the low pass filters were 300 Hz and 500 Hz