



Rate-dependent elevation of the capture threshold after implantation of a leadless pacemaker

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2 **of a leadless pacemaker**

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20 **Keywords:** capture threshold, leadless pacemaker, phase 4 block

21 **Abbreviations**

22 ECG, electrocardiogram

23 AV, atrioventricular

24 RV, right ventricle

25 ppm, paces/min

26

27 **Abstract**

28 The procedural success in the implantation of cardiac electric devices depends on both
29 the implanted position and the electric performance. The capture threshold and the
30 pacing output affect the estimated battery longevity. In a case with a high capture
31 threshold, recapture and reimplantation of a leadless pacemaker are commonly
32 recommended. We experienced a case with the rate-dependent elevation of the capture
33 threshold following the implantation of a leadless pacemaker. The recognition of the
34 rate-dependency of the capture threshold and the acceptable programming could avoid
35 the unnecessary recapture and reimplantation of that, avoiding the increase of
36 procedural risks.

37 **Case report**

38 A 77-year-old man who had a history of hypertension, cerebral infarction, and chronic
39 renal failure on hemodialysis presented bradycardia with less than 40 beats/min and
40 hypotension with disdialysis syndrome. Twelve-lead electrocardiogram (ECG) showed
41 an advanced atrioventricular (AV) block with 6:1 AV conduction and ventricular escape
42 beats (Figure 1). Echocardiography demonstrated concentric left ventricular
43 hypertrophy with normal left ventricular systolic function without valvular diseases.
44 The patient took no medication with negative dromotropic effects and had normal

45 electrolyte metabolism on a blood examination test. The preceding ECG a month had
46 demonstrated 1:1 AV conduction with a complete right ventricular block and left
47 anterior fascicular block. Collectively, the etiology of advanced AV block was
48 suggested in the primary AV conduction block. Taking the cardiac electric devices
49 infection risk and AV synchrony into account, the implantation of a leadless pacemaker
50 of Micra AV™ (Medtronic, Minneapolis, MN) was chosen through the discussion with
51 the patient and his family. The requirement for written informed consent to the
52 institutional registry was waived by the local ethics board of the institution given the
53 retrospective nature of the registry.

54 Vascular access was obtained via the right femoral vein. The delivery sheath
55 was inserted into the right ventricle (RV). Right ventriculography visualized the RV
56 anatomy and the direction of the septum. The 1st. and 2nd. attempts of implantation in
57 the RV septum showed high capture thresholds of >2V/0.24ms only at a pacing rate of
58 60 paces/min (ppm), regardless of adequate 2-tine fixation. Then, we attempted a 3rd. re-
59 location. Finally, the Micra AV™ was implanted in the mid-septum of the RV on the 3rd
60 attempt with the 2-tine fixation (Figure 2). After the pull-and-hold test, the electric
61 performance tests were performed in VVI (single ventricular demand pacing) mode. R-
62 wave amplitude was >5 mV and the impedance was 500-600 ohms. The capture
63 threshold was rate-dependently changing, which was 1.75V/0.24ms at a pacing rate of
64 60 paces/min and 0.75V/0.24ms at 80 ppm (Figure 3A and 3B). The programming at a
65 pacing rate of 70 ppm (over 60 ppm) was acceptable since the rate of sinus rhythm was
66 over 60 beats/min. Hence, the tether was removed, avoiding unnecessary procedural
67 risks of recapture and reimplantation. The rate-dependent change of the capture
68 threshold was not changed immediately after the procedure. No loss of capture at a

69 pacing rate of 70 ppm and 2.5V/0.24ms was observed within five days after the
70 implantation. Subsequently, the interrogation tests were performed again. R-wave
71 amplitude (>5 mV) and the impedance were stable. The rate-dependent change of the
72 capture threshold disappeared; that was 0.5V/0.24ms at a pacing rate of both 50 ppm
73 and 80 ppm (Figure 3A). The final programming was set in VDD (atrial mechanical
74 sensing and ventricular pacing) mode at a rate of 50-105 ppm, which resulted in AV
75 synchronous pacing with low pacing output functioning as a capture management mode.

76 **Discussion**

77 Rate-dependent elevation of the capture threshold has been rarely reported during an
78 early phase after pacemaker implantation^{1,2}. The previous reports focused on the
79 bradycardia-dependent rise in the atrial capture threshold and the possible mechanism of
80 phase 4 block^{1,2}. The phase 4 block was caused by the loss of capture during the
81 refractory period formed by slow diastolic depolarization. The mechanisms of slow
82 diastolic depolarization remain uncertain. Micro-dislodgement of the lead or local
83 myocardial inflammation is estimated. At present, left ventricular hypertrophy
84 associated with dialysis might be associated with some mechanisms. Further, the
85 intensity of tined fixation of a leadless pacemaker might influence the instability of the
86 capture threshold. However, the leadless pacemaker was implanted, satisfied with the
87 criteria of 2-tine fixation on the pull-and-hold test. The rate-dependent change of the
88 capture threshold was not detected five days after the implantation. To our knowledge, a
89 case of the rate-dependent change of the capture threshold with a leadless pacemaker is
90 very rare. There is only one case report similar to the present one³. Recapture and
91 reimplantation are commonly recommended in a case with the high capture threshold of
92 a leadless pacemaker, but give an additional risk. The recognition of the rate-

93 dependency of the capture threshold during the procedure may give a chance of a
94 solution by the device programming, avoiding the increase of procedural risks in
95 relocation.

96 **References**

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108 **Figure legends**

109 **Figure 1. Twelve-lead electrocardiogram**

110 Twelve-lead electrocardiogram showed an advanced atrioventricular block with 6:1 AV
111 conduction (asterisk) and ventricular escape beats.

112

113 **Figure 2. Implantation of a leadless pacemaker**

114 The Micra AV™ (Medtronic, Minneapolis, MN) was implanted in the mid-septum of the
115 RV on the 3rd attempt with the 2-tine fixation (arrows) on the right anterior oblique view
116 of 30 degrees (A) and the left of 50 degrees.

117

118 **Figure 3. Rate-dependent change of the capture threshold and the ECG findings**

119 A) The capture threshold at the implantation was 1.75V/0.24ms at a pacing rate of 60
120 paces/min (ppm) and 0.75V/0.24ms at 80 ppm. That after 5 days was 0.5V/0.24ms
121 at a pacing rate of both 50 ppm and 80 ppm.

122 B) Loss of capture at a pacing rate of 60 paces/min (ppm) and 1.75V/0.24ms and stable
123 capture at 80 ppm 0.75V/0.24ms.

Figure 1.

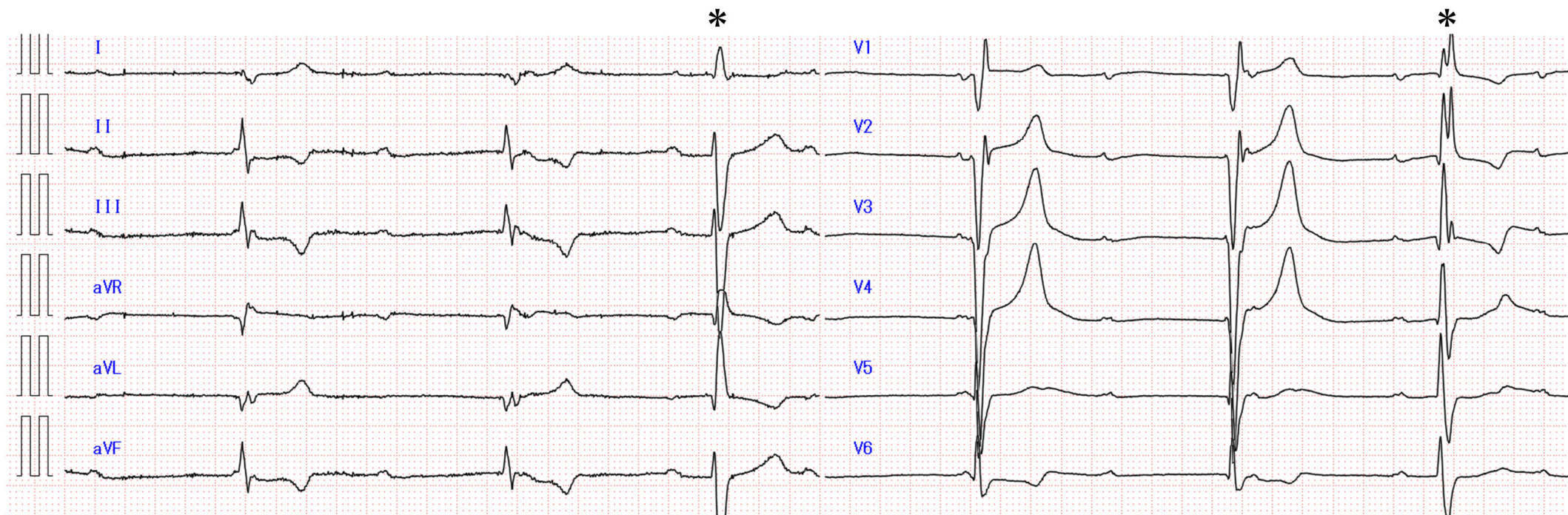
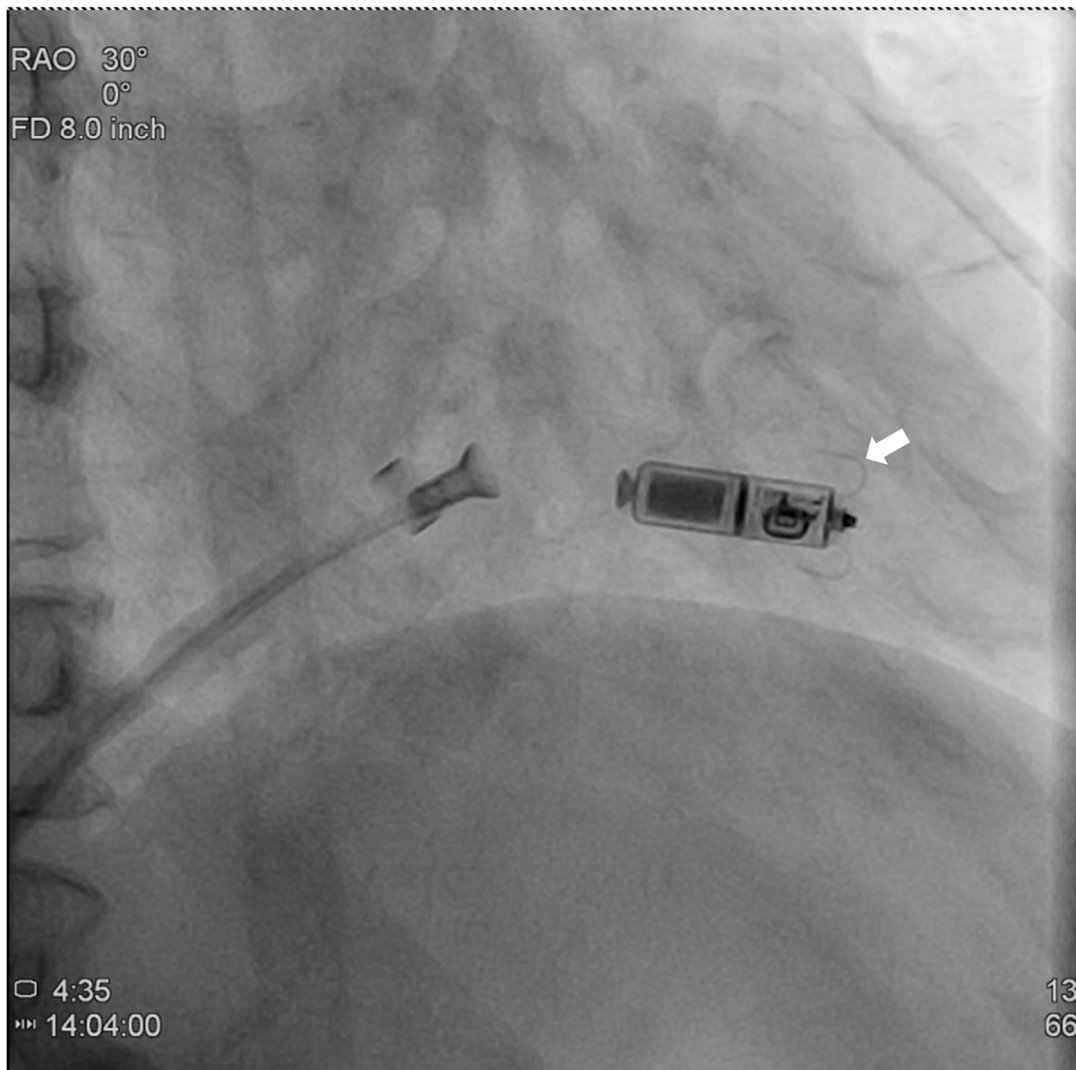


Figure 2.

A)



B)

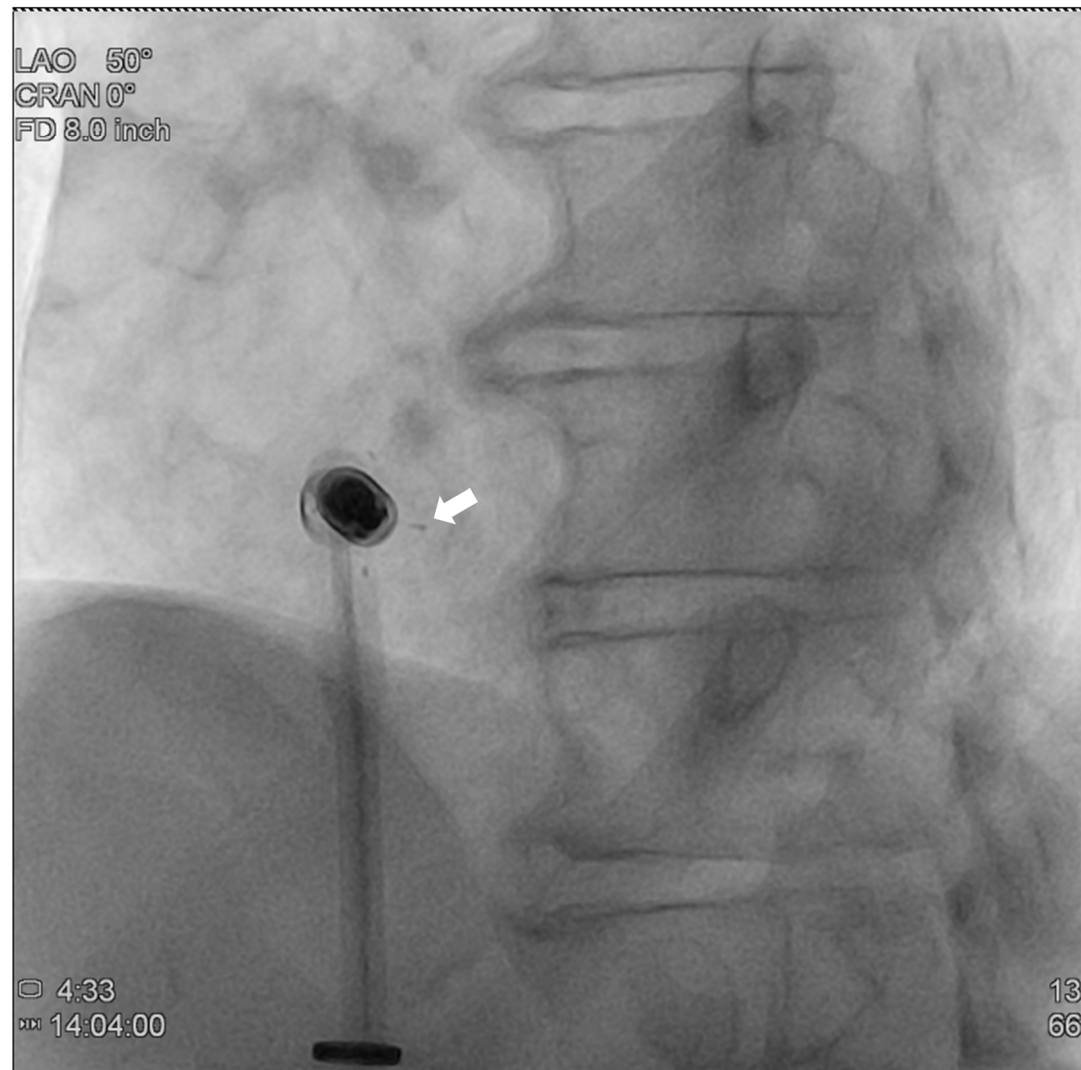


Figure 3A.

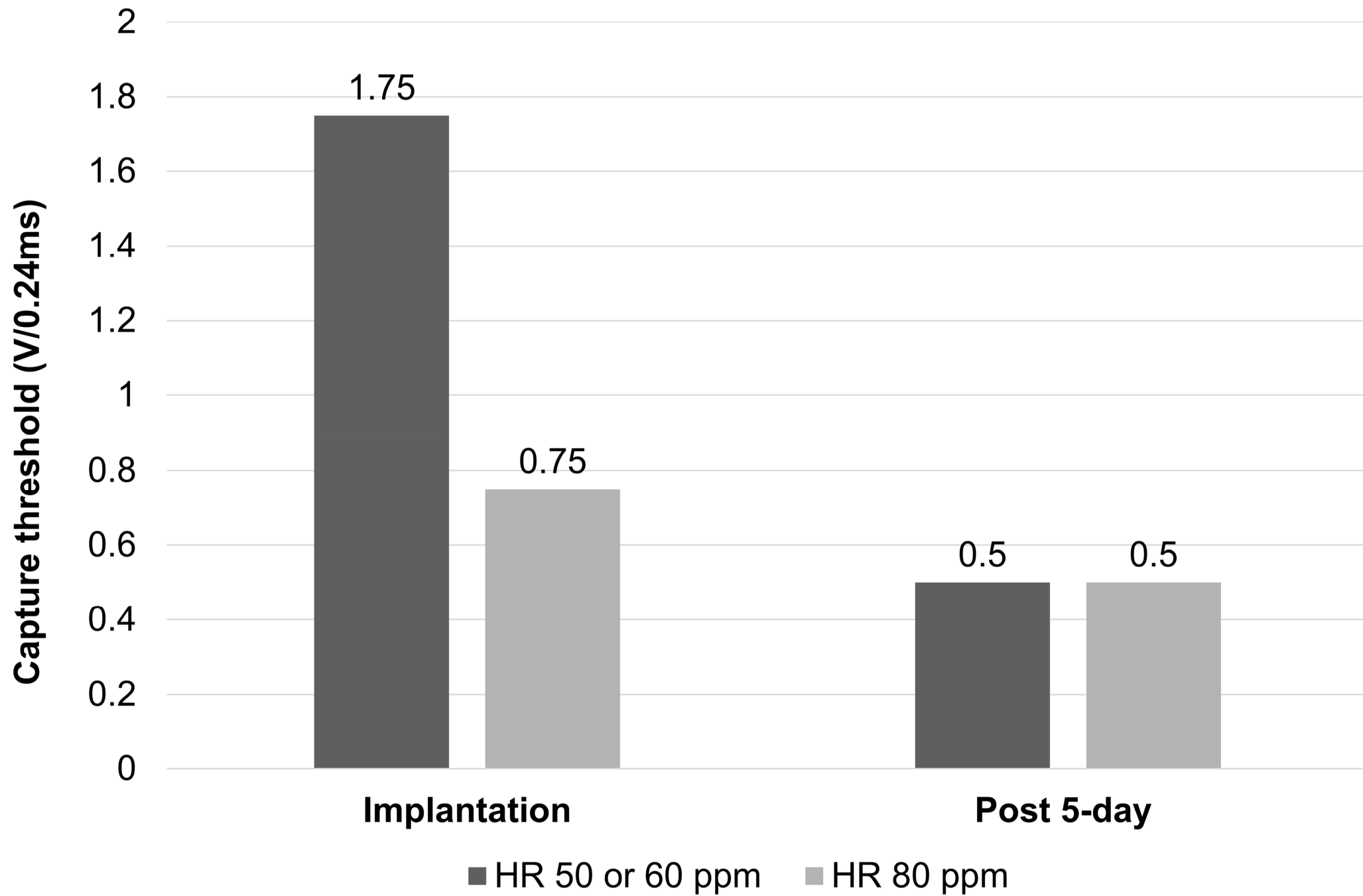


Figure 3B.

