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Case Reports

Biventricular Pacing in Conjunction with Epicardial Atrial Pacing Adversely Affects Timing of Intra-Aortic Balloon Pump

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Abstract: A case of accidental triggering of an intra-aortic balloon pump during systole is presented. The patient had a cardiac resynchronization therapy device in place preoperatively for heart failure. A temporary epicardial atrial pacing wire was used during separation from cardiopulmonary bypass for rate control. An intra-aortic balloon pump was necessary for separation from bypass. Although the pacemaker functioned properly, the intra-aortic balloon triggered from the atrial pacing spike and was inflated during systole. Pacemaker and intra-aortic balloon electronics and timing settings that caused this are discussed in detail. Suggestions for prevention are presented. **Keywords:** biventricular pacing, intra-aortic balloon pump timing, temporary atrial pacing. *JECT. 2010;42:150–152*

As the prevalence of cardiac resynchronization therapy—defibrillator (CRT-D) devices increases, so does the probability that a cardiac surgery patient will present to the operating room having one of these devices in place (1,2). Since most patients who undergo open heart surgery receive temporary sequential epicardial atrial and ventricular pacing (3), there is the potential for competition between internal and external pacing systems as well as the patient's intrinsic conduction system. We describe a problem encountered with intra-aortic balloon pump (IABP) timing and function during weaning from cardiopulmonary bypass (CPB) in a heart failure patient with biventricular pacing and an epicardial atrial lead for temporary rate pacing.

DESCRIPTION

A 74-year-old male with coronary artery disease, ischemic cardiomyopathy, and mitral regurgitation presented for 3-vessel redo coronary artery bypass grafting (CABG) and mitral valvuloplasty or repair. A CRT-D device, consisting of a dual-chamber paced, dual-chamber sensed, dual-response rate modulated, biventricular pacemaker (DDDRV) and internal cardiac defibrillator (ICD) was placed 6 months prior to surgery because of worsening systolic heart failure symptoms. Preoperative transesophageal echocardiogram (TEE) revealed left atrial enlargement with a dilated left atrial annulus of 4.9 cm, severe central mitral regurgitation, 25% left ventricular ejection fraction, and global hypokinesis.

Interrogation of the patient's pacemaker immediately preoperatively showed a St. Jude Promote® RF 3207–36 CRT-D device with rate adjustment limits from 60–130 beats/min. The patient was biventricularly paced by triggering from the sensed sinoatrial node at 65 beats/minute. The patient's underlying rhythm was sinus, but with a first-degree atrioventricular (A-V) block with a P-R interval of 240 milliseconds. The sensed A-V interval on the pacemaker was set to 110 millisecond, causing the biventricular pacemaker, instead of his A-V node, to pace his ventricles. It was felt that the patient most likely would have better biventricular synchronization if his biventricular pacemaker were allowed to pace his ventricles during separation from CPB. Because the patient had an adequate underlying rate and rhythm if the pacemaker were inhibited briefly by electrocautery during surgery, it was decided not to reprogram the pacemaker to a dual-paced, non-sensed mode, which could

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cause adverse competition with the patient's underlying rhythm. Instead, the pacemaker was reprogrammed to dual-chamber paced, dual-chamber sensed, dual-response mode, which preserved the pacemaker's sensing and biventricular pacing, but disabled the rate-response feature. The tachytherapy detection (ICD) was disabled for the surgery. It was suggested to the surgeon that only an atrial pacing wire be placed before separating from CPB to allow rate adjustment.

Following induction of general anesthesia, a pulmonary artery catheter was placed via the right internal jugular vein and a 3D TEE probe was inserted. Initial TEE exam confirmed the previous findings. There was no left atrial thrombus seen. Initial thermodilution cardiac output measurement was 5.1 L per minute.

Following completion of the CABG and mitral annuloplasty, weaning from CPB was attempted using external atrial pacing at 90 beats/minute with 14 milliamp (mA) output. The retrograde perfusion catheter in the coronary sinus had not disturbed the left ventricular pacing lead, allowing the biventricular portion of the patient's pacemaker to function properly, sensing from the temporary atrial epicardial pacemaker (Medtronic A-V sequential temporary pacemaker, Model 5388, Medtronic Corporation, Minneapolis, MN).

However, despite increasing dosages of epinephrine, norepinephrine, dobutamine, and vasopressin, the cardiac output measurements ranged between 1.9–2.9 L per minute with inconsistent systolic pressures of 80–100 mmHg. Transesophageal echocardiography showed severe global hypokinesis with an estimated ejection fraction of 10–15%. An Arrow 40-ml non-fiberoptic IABP (NarrowFlex IAB, Model Number IAB-05840-U, Arrow, Inc., Reading, PA) was inserted through the right femoral artery into the descending aorta. The IABP was set to the autopilot mode, causing the timing for inflation to be automatically set by the IABP electronics based on the electrocardiogram with temporary epicardial atrial pacing at 90 beats per minute.

The patient's hemodynamics worsened significantly when the balloon pump was activated. It was noted on the arterial waveform that inflation was occurring during systole rather than during diastole indicating that the IABP was triggering off the atrial pacing spike. The patient's blood pressure was insufficient for timing off the aortic pressure wave. Appropriate balloon inflation and deflation intervals could only be maintained if the IABP was in "Operator" mode. The IABP was then set to sense from the "Maximum Peak" setting, and the inflation time was manually adjusted based to synchronize with the aortic pulse waveform. Hemodynamics improved significantly. The patient was successfully weaned from CPB and transported to the intensive care unit.

The next day, tachytherapy sensing was enabled (ICD), the pacemaker was reset to the original DDDRV mode at a low rate setting of 75 beats/min, and the temporary pacemaker was discontinued. The IABP continued to function properly with self-adjusting settings for the patient's heart rate. The patient was weaned from vasopressors and IABP over the following 4 days, extubated on postoperative day 8, and discharged from the hospital at day 15 postoperatively.

COMMENT

While pacing with the temporary atrial pacing lead using his internal biventricular pacemaker, the IABP was not able to achieve proper capture and function in its autotiming mode. Problems associated with inappropriate IABP inflation timing using automated settings triggering from the arterial pressure waveform have been reported (4), and inappropriate timing of IABP with older style pacemakers also has been reported (5), but further investigation of the literature did not reveal any current references pertaining to this problem with newer pacemakers. In determining why this IABP triggered off the atrial pacemaker spike, numerous sources were consulted. The operations manual for the Arrow AutoCAT® 2 IABP (6) states that when the autopilot mode is used, the console selects the available trigger modes based on patient condition and signal availability. Under its description of various trigger modes under electrocardiogram pattern, the manual states that the width of the R wave must be between 25–135 milliseconds. Widened QRS complexes may not be recognized, such as bundle branch blocks. The technical manual for the Medtronic 5388 Temporary Pacemaker used to pace this patient states that within the rate adjustments and between the impedances of 200–1000 ohms, the set mA is constant and the pulse width is also constant at 1 millisecond (7). The setting of 14 mA used to pace the atrium calculates to 2.8–14 volts, depending on impedance. The preoperative interrogation of the patient's pacemaker showed a right ventricular lead output at 2.5 volts at 350 ohms and a left ventricular lead output at 1.0 volt at 600 ohms. The higher output in the right ventricular lead was calculated to be 7.14 mA. Therefore, the amplitude of the epicardial atrial lead was approximately twice that of the internal right ventricular lead.

The Arrow AutoCAT® 2 IABP detects a pacing spike when the pulse width is 0.1–0.5 millisecond and the pulse amplitude is ≥ +5 to +700 mV (6). At the 14 mA amplitude, the Medtronic 5388 atrial pacing spike is a constant 1 millisecond duration with an amplitude between 2.8–14V (7), putting the spike outside both the duration and amplitude detection limits of the IABP.

Conversations with the IABP engineering department (personal communication, Teleflex Medical Engineering, Research Triangle Park, Durham, NC) revealed additional

factors, which contributed to the IABP's failure to recognize the spike as an atrial spike. When the IABP detects such a large spike, it reduces its internal scaling. Most likely the IABP electronics were tricked into recognizing the atrial spike as an R wave. Moreover, when the IABP electronics see what it thinks is an R wave, it causes a 300 millisecond blanking period to prevent inaccurate triggering from artifacts, adding to the failure to recognize the ventricular spike.

In summary, maintenance of biventricular synchrony during separation from CPB, although controversial (3), may be necessary, requiring the use of existing biventricular pacemakers in patients who present for surgery with these devices. Because of the nature of their disease, these patients are also likely to require an IABP in separating from CPB. If a temporary atrial pacemaker is desired for rate adjustment of an internal biventricular pacemaker, it should be set just above the minimal capture amplitude. Even at that mA, it is unclear whether the duration may cause the epicardial atrial pacing spike to be detected as an R wave by the IABP electronics. The surgical team should be aware that, regardless of the atrial output required, it may be necessary to manually set the IABP timing to prevent accidental inflation of the balloon during systole should the IABP erroneously key off of the atrial pacing spike. Alternatives include presetting the intrinsic pacemaker at a greater low rate setting without manual rate adjustment capability, overriding the biventricular pacemaker totally using temporary epicardial A-V sequential pacing as needed, sensing off the arterial pressure tracing if adequate, or using the newer intravascular fiberoptic blood flow sensing mechanisms available on some IABP brands.

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