Journal of the American College of Cardiology
© 2012 by the American College of Cardiology Foundation
Published by Elsevier Inc.

Vol. 59, No. 9, 2012
ISSN 0735-1097/$36.00
doi:10.1016/j.jacc.2011.11.023

Misleading Long Post-Pacing Interval After Entrainment of Typical Atrial Flutter From the Cavotricuspid Isthmus

Dirk Vollmann, MD,*† William G. Stevenson, MD,† Lars Lüthje, MD,* Christian Sohns, MD,* Roy M. John, MD, PhD,† Markus Zabel, MD,* Gregory F. Michaud, MD†

Göttingen, Germany; and Boston, Massachusetts

Objectives The purpose of this study was to evaluate the prevalence and mechanism of a misleading long post-pacing interval (PPI) upon entrainment of typical atrial flutter (AFL) from the cavotricuspid isthmus (CTI).

Background In typical AFL, the PPI from entrainment at the CTI is expected to closely match the tachycardia cycle-length (TCL).

Methods Sixty patients with confirmed CTI-dependent AFL were retrospectively analyzed and grouped into short (≤30 ms) or long (>30 ms) PPI-TCL. Thereafter, we prospectively studied 16 patients to acquire the PPI-TCL at 4 CTI sites with entrainment at pacing cycle-lengths (PCLs) 10 to 40 ms shorter than the TCL. Conduction times during AFL and entrainment were compared in 5 segments of the AFL circuit.

Results Eleven patients (18%) in the retrospective analysis had a long PPI-TCL after entrainment from the CTI. Subjects with long PPI-TCL had similar baseline characteristics but greater beat-to-beat TCL variability. In the prospective cohort, PPI-TCL was influenced by the difference between PCL and TCL and site of entrainment. Conduction delays associated with a long PPI-TCL were located predominantly in the segment activated first by the paced orthodromic wave front, and were mainly due to local pacing latency, as confirmed by the use of monophasic action potential catheters.

Conclusions A long PPI upon entrainment of typical AFL from the CTI is common and due to delayed conduction with entrainment. Whether these findings apply to other macro–re-entrant tachycardias warrants further investigation.
(J Am Coll Cardiol 2012;59:819–24) © 2012 by the American College of Cardiology Foundation

A pacing site is considered to be part of the macro–re-entrant circuit if the first post-pacing interval (PPI) after entrainment is ≤30 ms of the tachycardia cycle-length (TCL) (1–3). It has been noted earlier, however, that the PPI-TCL may be misleadingly long if the pacing cycle-length (PCL) is ≥40 ms below the TCL (2–4).

Typical atrial flutter (AFL) is due to right atrial macro–re-entry, and the cavotricuspid isthmus (CTI) is a critical component of the circuit and the primary target for ablation (1). We aimed to evaluate the prevalence and mechanism of a misleading long PPI-TCL in patients presenting with typical AFL for CTI ablation.

Methods

This study was conducted in patients presenting with typical AFL for ablation therapy. A retrospective analysis addressed the prevalence of a misleading long PPI-TCL (>30 ms) upon entrainment from the CTI. Thereafter, we conducted a prospective study to systematically evaluate the PPI at different PCLs from pre-specified CTI sites.

Study population. Institutional ethics committees approved the study protocol, and subjects gave written informed consent. For the retrospective analysis, we reviewed data from 243 consecutive subjects referred for AFL ablation to the Brigham and Women's Hospital. A total of 60 patients met the following pre-defined criteria: 1) sustained AFL during the electrophysiological (EP) procedure; 2) atrial activation from the proximal to the distal coronary sinus; 3) documented entrainment with concealed fusion from the CTI; and 4) AFL termination during CTI ablation.

The prospective study was conducted at the University Medical Center in Göttingen. Patients with persistent AFL were eligible if the 12-lead electrocardiogram was suggestive of typical AFL. Prior atrial ablation or surgery were exclusion criteria.

EP study and catheter ablation. All catheters were introduced through femoral veins. Bipolar intracardiac electrograms were filtered between 30 and 500 Hz and recorded at a sampling rate of 1,000 Hz (Prucka CardioLab EP system, GE Healthcare, Waukesha, Wisconsin).

From the *Department of Cardiology and Pneumology, University Medical Center Göttingen, Germany; and the †Cardiovascular Division, Department of Medicine, Brigham and Women's Hospital, Harvard Medical School, Boston, Massachusetts. Dr. John has received modest speaker honoraria from St. Jude Medical. All other authors have reported that they have no relationships relevant to the contents of this paper to disclose.

Manuscript received August 16, 2011; revised manuscript received November 9, 2011, accepted November 17, 2011.

Abbreviations and Acronyms

AFL = atrial flutter
CTI = cavotricuspid isthmus
EP = electrophysiological
MAP = monophasic action potential
PCL = pacing cycle-length
PPI = post-pacing interval
TCL = tachycardia cycle-length

Diagnostic catheters were positioned as shown in Figure 1. An open-irrigated 3.5-mm-tip catheter (Celsius Thermocool, Biosense Webster, Diamond Bar, California) was utilized for pacing and ablation. In the retrospective analysis, an 8-mm-tip catheter was also used.

Entrainment from the CTI was performed with ≥15 bipolar stimuli (pulse strength: 10 mA at 2 ms). In the retrospective analysis, stimuli were delivered with a PCL 10 to 40 (21 ± 9) ms below the TCL. In the prospective study, entrainment was performed from 4 pre-specified CTI locations (Fig. 1) with a PCL 10 ms, 20 ms, 30 ms, and 40 ms below the TCL. Reproducibility of repeated PPI measurements was evaluated by determining the standard deviation (SD) of 3 consecutive measurements from 1 pre-specified site at a constant PCL. In 2 patients, we utilized a monophasic action potential (MAP) recording and pacing catheter (EasyMap MAP, MedFact, Lörrach, Germany). Details on MAP catheter design and application have been described elsewhere (5). Conventional CTI ablation was performed as described earlier (6).

Definitions and data analysis. Local atrial activation was defined as the first sharp peak in the corresponding bipolar electrogram or as sharpest deflection of the local MAP upstroke. TCL was the mean value of 5 consecutive atrial cycles during AFL immediately before entrainment. TCL

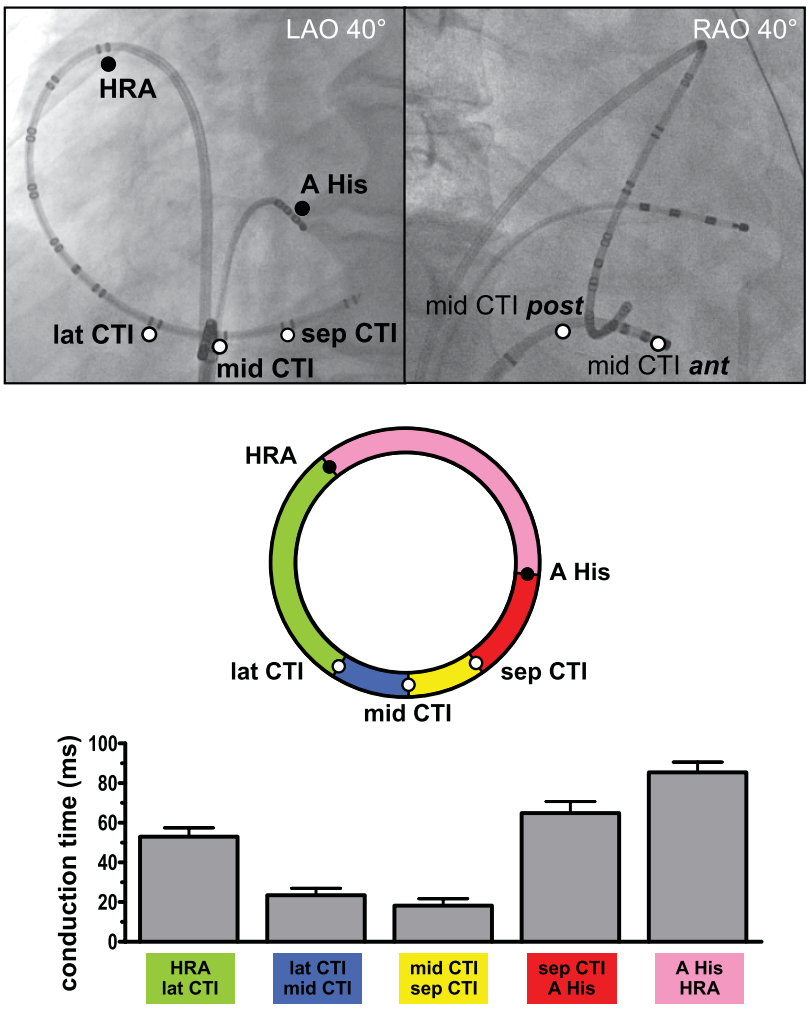

Figure 1 **Instrumentation for Entrainment and Measurement of Segmental Conduction Times**

The **white dots** indicate entrainment pacing sites at the cavotricuspid isthmus. **(Top)** Catheter position on fluoroscopy. **(Middle)** Schematic illustrating the 5 segments of the atrial flutter circuit (LAO view). **(Bottom)** Baseline segmental atrial conduction times during atrial flutter (mean values with standard error, data from the prospective study). A His = atrial signal at the His position; HRA = high right atrium; LAO = left anterior oblique; lat CTI = lateral cavotricuspid isthmus; mid CTI ant = anterior mid cavotricuspid isthmus (close to the tricuspid valve); mid CTI post = posterior mid cavotricuspid isthmus (close to the inferior vena cava); RAO = right anterior oblique view; sep CTI = septal cavotricuspid isthmus.