Cryoballoon ablation has been demonstrated to allow safe and effective isolation of pulmonary veins (PV) for the treatment of paroxysmal atrial fibrillation. Recently, the second-generation cryoballoon device has been developed (Arctic Front Advance, Medtronic CryoCath LP) with improved cooling capabilities by increasing the number of refrigerant injectors, resulting in homogeneous cooling of the balloon surface. In contrast, the first-generation balloon is characterized by.

Remainig Ice Cap on Second-Generation Cryoballoon After Deflation

Stefano Bordignon, MD; Alexander Fürnkranz, MD; Boris Schmidt, MD; KR Julian Chun, MD

Cryoballoon ablation has been demonstrated to allow safe and effective isolation of pulmonary veins (PV) for the treatment of paroxysmal atrial fibrillation. Recently, the second-generation cryoballoon device has been developed (Arctic Front Advance, Medtronic CryoCath LP) with improved cooling capabilities by increasing the number of refrigerant injectors, resulting in homogeneous cooling of the balloon surface. In contrast, the first-generation balloon is characterized by

**Figure.** A, Cryoballoon at right superior pulmonary vein (RSPV). The angiography reveals a perfect occlusion. The **dotted white line** highlights the balloon. **B**, Ice cap (**dotted blue line**) persists after balloon deflation. **C**, Reproduction in vitro of the ice cap. **D**, Ice cap persistence on the left superior pulmonary vein (LSPV) of patient 2. **E**, Real-time visualization (**arrow**) of sustained PVI at the RSPV in patient 1. CB indicates cryoballoon catheter; CS, coronary sinus; SVC, superior vena cava; ESO, esophageal probe.
a cooling zone concentrated on the equator of the balloon with less cooling around the frontal nose. This limitation is hypothesized to result in incomplete lesion formation in the myocardium contacting this area, specifically the inferior circumference of the inferior PVs.1 The nonhomogeneous cooling of the first-generation device may also explain a relative long time to left atrium-PV block recorded by an endoluminal spiral mapping catheter.2 However, the influence of these technical changes on ice formation around the balloon in the clinical setting is unknown.

Case Report
Two patients with paroxysmal atrial fibrillation (patient 1: male, 59 years; patient 2: female, 70 years) underwent PV isolation in our center with the second-generation 28-mm cryoballoon. After single transseptal puncture and PV angiographies, the cryoballoon was sequentially maneuvered to each PV ostium, and circumferential contact was demonstrated by injecting contrast medium through the catheter tip before freezing initiation. Complete PV isolation demonstrated by an endoluminal spiral mapping catheter (Achieve, 15 mm, Medtronic CryoCath LP) was achieved in both patients. During the freezing phase on the right superior PV in patient 1, ice formation opacified by contrast medium at the tip of the inflated balloon could be demonstrated (Figure). Intriguingly, the ice cap was stable throughout the entire thawing phase of the balloon and resolved 10 seconds after balloon deflation, which automatically occurs at a temperature of +20°C measured by a thermocouple in the proximal part of the balloon (Figure B). Real-time right superior PV isolation recorded after 23 seconds of freezing at a balloon temperature of −32°C is shown in Figure E. During freezing at the left superior PV in patient 2, similar ice cap formation could be demonstrated. Again, the ice cap was stable after deflation of the balloon (Figure D, online-only Data Supplement Movie I) and slowly dissolved 15 seconds after balloon deflation (online-only Data Supplement Movie II). The phenomenon of ice cap formation on the nose of the catheter could be reproduced in vitro as displayed in Figure C.

Discussion
The ice cap in the PV stable throughout the thawing phase observed in the present cases with the second-generation 28-mm cryoballoon is a novel phenomenon resulting from improved cooling capability. This may have several clinical implications. First, enhanced ice formation may contribute to PV occlusion during freezing, facilitating effective lesion formation even if complete occlusion was not achieved before freezing. On the other hand, automated balloon deflation before dissolution of the ice cap may enhance the risk of embolization of large ice crystals in the systemic circulation. Whether ice embolization bears a clinical risk is currently unknown. Further studies are needed to clarify whether prolongation of the thawing phase may be beneficial.

Disclosures
Drs Chun, Schmidt, and Fürnkranz received speaking honoraria from Medtronic, and Drs Chun and Schmidt received speaking honoraria from Cardiofocus.

References
Remaining Ice Cap on Second-Generation Cryoballoon After Deflation
Stefano Bordignon, Alexander Fürnkranz, Boris Schmidt and KR Julian Chun

Circ Arrhythm Electrophysiol. 2012;5:e98-e99
doi: 10.1161/CIRCEP.112.975516

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://circep.ahajournals.org/content/5/5/e98

Data Supplement (unedited) at:
http://circep.ahajournals.org/content/suppl/2012/10/22/5.5.e98.DC1
SUPPLEMENTAL MATERIAL

Remaining ice cap on second-generation cryoballoon after deflation

Stefano Bordignon MD, Alexander Fünkranz MD, Boris Schmidt MD, KR Julian Chun MD

Cardioangiologisches Centrum Bethanien, Frankfurt am Main, Germany

Corresponding author

Dr. KR Julian Chun
Cardioangiologisches Centrum Bethanien – CCB
Medizinische Klinik III
Markus Krankenhaus
Wilhelm-Epstein-Str. 4
D-60431 Frankfurt a.M.
Phon: +49 69-945028-110
Fax: +49 69-945028-119
j.chun@ccb.de

MOVIE LEGEND

Movie 1: Balloon deflation with persistence of the ice cap.

Movie 2: Ice cap gradually disappears after 15 seconds from balloon deflation.