A new cryoprobe for intraoperative ablation of atrial fibrillation

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A New Cryoprobe for Intraoperative Ablation of Atrial Fibrillation

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We describe the use of a new argon cryoprobe (SurgiFrost) for isolated endocardial surgical ablation. A right lateral minithoracotomy and femoro-femoral cardiopulmonary bypass were applied. The basic mechanism of cryoablation is to remove heat from the targeted arrhythmogenic tissue followed by electrical isolation. In this first case of isolated treatment of atrial fibrillation using the new flexible SurgiFrost cryocatheter, we were able to perform pulmonary vein isolation reaching temperatures as low as −144°C. The patient was discharged in sinus rhythm. This new argon cryoprobe represents an encouraging technology for the isolated endocardial as well as concomitant treatment of atrial fibrillation.

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In 1987, the Cox-Maze procedure was introduced for the surgical treatment of atrial fibrillation. After several modifications, this operation has become the gold standard for the treatment of atrial fibrillation. To simplify this complex operation, several tools with different energy sources have been developed for surgical ablation therapy. The aim of this treatment is to create transmural lesions in a patient-depending lesion pattern. Since the early 1970's, cryotherapy was applied to degenerate tissue. This case report demonstrates the feasibility of left atrial cryoablation with a new argon catheter through a minimally invasive surgical approach.

A 62-year-old male patient with a long history of atrial fibrillation causing severe restrictions in his activities of daily living and quality of life was admitted for surgical treatment of atrial fibrillation. The patient was treated using a lateral minithoracotomy and femoro-femoral cardiopulmonary bypass to perform surgical left atrial endocardial cryoablation. The aim was to eliminate left atrial reentrant circuits [1].

A new argon cryoprobe, SurgiFrost, was used for creating linear and contiguous lesion lines. This tool was evaluated before in acute and chronic animal models, in which safety and effectiveness was shown. It is CE certified and available on the market. The basic mechanism of cryoablation has been described before [2]. Electrical isolation is induced by means of different factors of immediate and delayed tissue response. During the treatment, collagen structures or elastic fibers within the myocardial tissue are not affected [3–4].

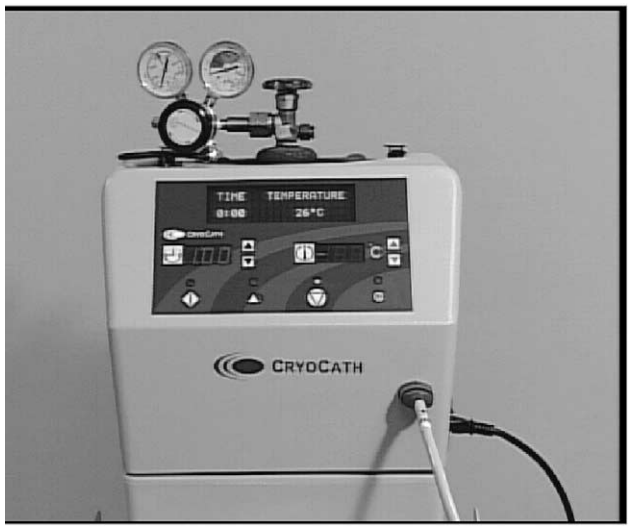

Fig 1. SurgiFrost CryoSurgical console. Cryoablation can be controlled by presetting temperature and duration of the system. Argon gas is used as a refrigerant.

The SurgiFrost system (Fig 1) (CryoCath Technologies Inc, Québec, Canada) is a cryoablative device especially designed for thoracic surgery procedures. Ablation is performed by removing heat from the targeted arrhythmogenic tissue.

The hand-held probe (Fig 2) operates on the Joule-Thomson effect, providing a 60-mm-long malleable freezing segment (Ø = 3.9 mm) attached to a 170-mm malleable shaft.

An adjustable isolation sleeve allows the ablation zone to be varied between 10 and 60 mm. Temperature monitoring is done by using a thermocouple, which is located in the tip of the probe. Inert argon gas is used as refrigerant.

The SurgiFrost cryosurgical system is based on the Joule-Thomson effect. Probe cooling is achieved by the expansion of compressed gas after passing through the restricted orifices (Joule-Thomson ports) in the freezing segment of the probe. When the argon gas reaches the Joule-Thomson ports through a flexible insulated transfer line, a pressure drop from $p_{initial}$ = 19.000 kPa (220 bar or 3.200 psi) down to p_{final} = 1,000 kPa (10 bar or 145 psi) is observed. For this dramatic (isenthalpic) expansion of the gas and the increase in gas volume (potential), energy

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Fig 2. SurgiFrost CryoSurgical probe. Hand-held probe with 60-mm-long flexible freezing segment and 170-mm-long malleable shaft. Ablation zone can be adjusted by insulation sleeve. (Reprinted from Ann Thorac Surg, 76, Doll N, et al, Intraoperative left atrial ablation [for atrial fibrillation]: using a new argon cryo catheter: early clinical experience, 1711–5, Copyright 2003, with permission from The Society of Thoracic Surgeons.)

is needed and taken from the kinetic energy of the gas. A decrease in kinetic energy is synonymous with a decrease in temperature and results in freezing temperatures at the ablation segment of the probe. Freezing performance is enhanced by precooling the argon gas. A homogenous temperature distribution along the freezing segment is achieved by implementing multiple Joule-Thomson ports into the probe's design.

At the probe-tissue interface, the cooling rate is enormous, and freezing (phase change) extends into the tissue volume by thermal conduction, creating a well-defined freezing front [5].

The gas is returned back through the transfer line and is vented at the console. Using inert argon gas, there is no need for scavenging in the operating room.

The probe temperature is controlled by the flow and pressure of the argon gas within the console and can be adjusted by the surgeon.

In October 2002, a male patient received isolated cryoablation through a lateral minithoracotomy. Left ventricular ejection fraction was 55%, left atrial diameter was 55 mm, and the patient was New York Heart Association functional class 2. Indications for surgery were palpitations and repeat cerebral embolization.

Cardiopulmonary bypass was established by femorofemoral cannulation; continuous CO_2 insufflation was applied.

Aortic cross-clamp was accomplished with a direct clamp (Chitwood Clamp, Scanlan International, Minnesota, MN) inserted percutaneously through the second intercostal space. Myocardial protection was achieved by antegrade cold crystalloid cardioplegia in the ascending aorta.

Based on previous experimental studies, the preselected temperature of the catheter tip was set to −160°C. Ablation time was set to 45 seconds. A continuous lesion line was created extending from the left inferior aspect of the posterior mitral valve leaflet (P3) to the left inferior pulmonary vein, then to all other pulmonary veins, and finally to the atriotomy (Fig 3).

The entire procedure took 5 minutes. The effect of cryoadhesion could be used for retracting the myocardial tissue from collateral structures.

Temperatures down to −144°C could be reached, measured at the tip of the probe. The cardiopulmonary bypass time was 82 minutes and the total operating room time was 112 minutes. Postoperatively, 12-lead electrocardiograms were performed daily within the first 5 days. The patient also underwent two additional 24-hour holters. After 2 days in the intensive care unit, and a total hospital stay of 7 days, the patient left the hospital in sinus rhythm. Anticoagulation was given for 3 months until the first follow-up. He remained in stable synus rhythm.

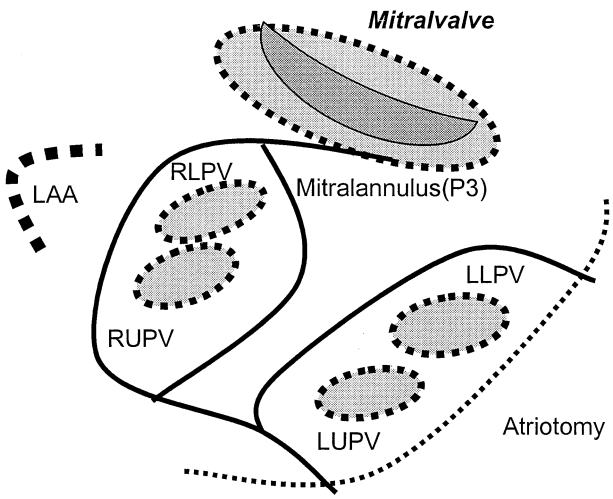

Fig 3. Cryolesions performed in the left atrium. LAA = *left atrial appendage;* LLPV = *left lower pulmonary vein;* LUPV = *left upper pulmonary vein;* RLPV = *right lower pulmonary vein;* RUPV = *right upper pulmonary vein. (Reprinted from Ann Thorac Surg, 76, Doll N, et al, Intraoperative left atrial ablation [for atrial fibrillation]: using a new argon cryo catheter: early clinical experience, 1711–5, Copyright 2003, with permission from The Society of Thoracic Surgeons.)*

Comment

This is the first case reported on isolated treatment of atrial fibrillation using a new flexible SurgiFrost cryocatheter. We were able to safely perform successful intraoperative ablation by inducing the creation of contiguous lesion lines, as described previously [6].

The target was the elimination of anatomically determined left atrial reentrant circuits responsible for the perpetuation of atrial fibrilation and the restoration of sinus rhythm. The flexibility and malleability of the

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SurgiFrost catheter enabled the procedure to be easily performed and minimally invasive through a right anterolateral minithoracotomy. In combination with the effectiveness and safety [7, 8] of cryotherapy, this new argon cryoprobe represents an encouraging technology for the isolated and concomitant treatment of atrial fibrillation, and further investigations should be performed.

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