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HOW TO DO IT

Application of cryoenergy to improve septal exposure during transaortic septal myectomy in hypertrophic obstructive cardiomyopathy

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Abstract For the past few decades, the transaortic septal myectomy (Morrow's procedure) has been the gold standard for treating severe left ventricular outflow tract obstruction in hypertrophic obstructive cardiomyopathy (HOCM) patients. 30-day mortality has been reported at less than 1% in dedicated centers. However, in a subgroup of patients, the interventricular septal obstruction is localized very distally, below the aortic valve plane, and the transaortic approach can be very challenging. A subset of these patients can present with residual obstruction after surgery, due to inadequate length of septal excision, leading to reoperation. The aim of this work is to illustrate an original application of cryoenergy to improve the transaortic exposure of the interventricular septum and thus enable surgeons to perform very distal myectomies in HOCM patients.

Keywords Hypertrophic cardiomyopathy · Cryoenergy · Transaortic myectomy · Residual left ventricular outflow tract obstruction

Introduction

Current treatments for hypertrophic obstructive cardiomyopathy (HOCM) focus on the prevention of sudden cardiac death and the relief of left ventricular outflow obstruction by surgical septal myectomy [1]. However, a subset of patients with obstructions extending distally, below the aortic valve plane (Fig. 1), can have residual obstruction after surgery, leading to reoperation [2].

Here, we illustrate an original technique involving the application of cryoenergy to improve the transaortic exposure of the interventricular septum and enable performance of more extended myectomies towards the apex.

Clinical vignette (video 1: clinical case presentation)

Since 2015, seven patients underwent operation with this technique at our institution. Mean age was 57.4 ± 12 years and most patients were in NYHA functional class III–IV. Mean peak LVOT gradient at rest was 75.1 ± 34.1 mmHg and interventricular septum thickness was 21.1 ± 4.3 mm.

Surgical technique (video 2: surgical technique; video 3: final result)

The patients were operated on through a median sternotomy with standard cardiopulmonary bypass. After cardioplegic arrest, the aorta was incised transversally a few millimeters above the right coronary ostium. The right and left aortic cusps were gently elevated with a little surgical manual retractor.

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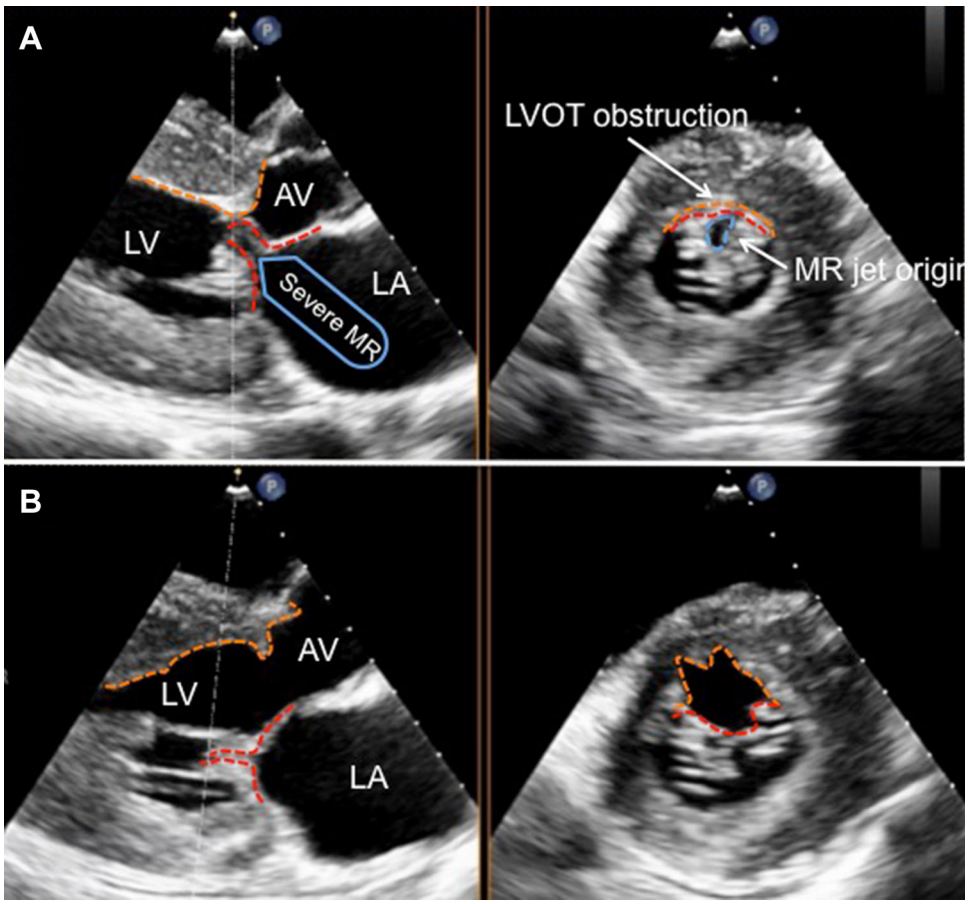

Fig. 1 **a** Echocardiographic views of a huge septal hypertrophy. **b** Final echocardiographic result of the extended myectomy

The standard myectomy started slightly rightward to the nadir of the right aortic cusp, 3–4 mm below the aortic ring, and was extended to the proximity of the mitral anterior commissure. At this stage a linear nitrous oxide cryoenergy probe (AtriCure, Inc.) was inserted into the LVOT through the opened aorta and attached to the septum. The septal tissue is brittle and easily falls apart. By freezing the portion to be removed with the cryo probe (5–10 s at minus 50–80 °C) the excision with a knife can be more exact (Fig. 2) and by pulling the probe with the frozen tissue attached it can be extended deeper into the LV (additional 1–2 cm), according to the particular anatomy of the hypertrophy. Half of the tip was protected by a rigid plastic tube to prevent freezing of and injuries to the surrounding structures (e.g., the aortic cusps; see Fig. 3).

This maneuver was accomplished by pulling the septum downward, thanks to the linear application of the cryoprobe, and to expose the residual more apical 1–2 cm of the obstructing muscle, in comparison to a standard myectomy. Intraoperative epicardial 2D echo was performed to evaluate LVOT gradients and the efficacy of the myectomy (see video). At discharge, mean peak LVOT gradient measured was 15 ± 7 mmHg. Trivial mitral regurgitation was present in five patients and mild

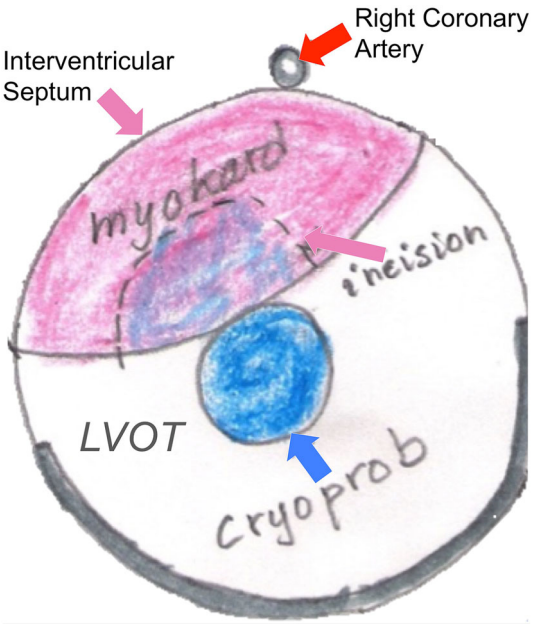

Fig. 2 Sketch depicting the cryo technique, with focus on the contact between the myocardium and the cryo probe. By freezing the portion to be removed with a cryo probe (*blue*) the excision with a knife can be more exact and by pulling the probe with the frozen tissue (*blue* and *pink area*) attached it can be extended deeper into the LV. LVOT

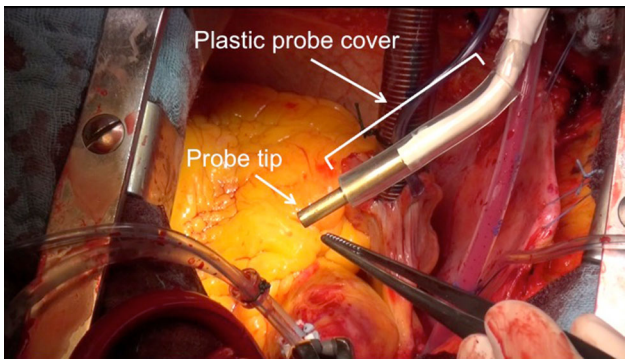

Fig. 3 Protection of the probe tip to prevent injury to surrounding structures

regurgitation in 2. No post-operative complications were detected (i.e., no interventricular septal defect, atrio-ventricular block, or aortic cusp ruptures). We did not register any signs of relapse of HOCM, after that all the patients completed the first year follow-up. No one of them presented gradients >25 mmHg at transthoracic echo control (mean peak LVOT gradient was 19 ± 5 mmHg) or has been reoperated.

Comments

Transaortic septal myectomy (Morrow's procedure) has long been the standard treatment for LVOT obstruction in HOCM patients. However, in patients where the septal obstruction is localized very distally, a few centimeters below the aortic valve plane, the standard transaortic myectomy can be very challenging. In a very thorough paper from the Mayo Clinic, Cho et al. reported residual LVOT obstructions in 52 patients after the Morrow's procedure. The principal mechanisms were inadequate length of septal excision, insufficient depth of resection, and the presence of mid-ventricular obstruction at the level of the papillary muscles [2]. Moreover, at reoperation, a left ventriculotomy was needed in 15% of patients to achieve a complete septal resection.

In this regard, our technique of using the cryoprobe with nitrous oxide represents a valid solution for achieving distal septal exposures without changing the approach. It increases the length (1–2 additional cm) and the depth of the resection and therefore is useful in all the anatomies characterized by septal hypertrophy. This technique was devised to freeze the septum exclusively with the nitrous oxide probe.

Our approach could find an application also as additional technique in patients with anomalies of the mitral apparatus. Wang et al. have reported on the importance of removing all intraventricular abnormalities and extending the septal resection as far as possible below the aortic valve plane (to the base of the papillary muscles) to improve outcomes [3]. If these anomalies are not treated during surgery, incomplete relief of LVOT obstruction may occur.

We did not have any complications in our small series, and adopting the plastic protection on the tip of the probe effectively prevented damage to surrounding tissues. The gradient outcomes at discharge were confirmed at 1-year transthoracic echo follow-up. Although many surgeons would favor extensive approaches (e.g., anterior mitral leaflet detachment for septal exposure followed by repair or a modified Konno's procedure), no evidence of their additional benefits is available in the literature.

In conclusion, this simple technique could represent an effective tool in the armamentarium of HOCM surgical therapy, improving septal exposure and therefore allowing more extensive resections.

Compliance with ethical standards

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Conflict of interest Alberto Pozzoli reports no conflict of interest; Luca Vicentini reports no conflict of interest; Stefan Thelin reports no conflict of interest; Elisabetta Lapenna reports no conflict of interest; Leif Nilsson reports no conflict of interest; Ottavio Alfieri reports no conflict of interest.

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