*G Chir Vol. 32 - n. 11/12 - pp. 464-466*
*November-December 2011*

# Transmyocardial laser revascularization. Personal experience

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SUMMARY: **Transmyocardial laser revascularization. Personal experience .**

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Background. *Indirect revascularization is a therapeutic approach in case of severe angina not suitable for percutaneous or surgical revascularization. Transmyocardial revascularization (TMR) is one of the techniques used for indirect revascularization and it allows to create transmyocardial channels by a laser energy bundle delivered on left ventricular epicardial surface. Benefits of the procedure are related mainly to the angiogenesis caused by inflammation and secondly to the destruction of the nervous fibers of the heart.*

Patients and method. *From September 1996 up to July 1997, 14 patients (9 males – 66.7%, mean age 64.8±7.9 years) underwent TMR. All patients referred angina at rest; Canadian Angina Class was IV in 7 patients (58.3%), III in 5 (41.7%). Before the enrollment, coronarography was routinely performed to find out the feasibility of Coronary Artery Bypass Graft (CABG): 13 patients (91,6%) had coronary arteries lesions not suitable for direct revascularization; this condition was limited only to postero-lateral area in one patient submitted to combined TMR + CABG procedures.*

Results. *Mean discharge time was 3,2±1,3 days after surgery. All patients were discharged in good clinical conditions. Perfusion thallium scintigraphy was performed in 7 patients at a mean follow-up of 4±2 months, showing in all but one an improvement of perfusion defects. Moreover an exercise treadmill improvement was observed in the same patients and all of them are in good clinical conditions, with significantly reduced use of active drugs.*

Conclusion. *Our experience confirms that TMR is a safe and feasible procedure and it offers a therapeutic solution in case of untreatable angina. Moreover, it could be a hybrid approach for patients undergoing CABGs in case of absence of vessels suitable for surgical approach in limited areas of the heart.*

RIASSUNTO: **Rivascolarizzazione miocardica con laser. Esperienza personale.**

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Background. *La rivascolarizzazione miocardica indiretta è un approccio terapeutico in caso di angina severa non idonea alla rivascolarizzazione diretta percutanea o chirurgica. La rivascolarizzazione miocardica mediante laser (TMR) è una delle tecniche utilizzate per la rivascolarizzazione indiretta e permette di creare canali transmiocardici attraverso un fascio di energia laser irradiato sulla superficie epicardica del ventricolo sinistro. I meccanismi attraverso cui la TMR può determinare una riduzione dell'angina sono correlati principalmente all'angiogenesi indotta dalla infiammazione e in secondo luogo alla distruzione delle fibre nervose.*

Pazienti e metodi. *Da settembre 1996 fino a luglio 1997, 14 pazienti (9 maschi - 66,7%, età media 64,8 ± 7,9 anni) sono stati sottoposti a TMR. Tutti i pazienti erano sintomatici per angina, 7 (58,3%) con Canadian Angina Class IV e 5 (41,7%) con classe III. Tutti i pazienti sono stati valutati pre-operatoriamente mediante studio coronarografico. Tredici pazienti (91,6%) avevano lesioni coronariche non idonee alla rivascolarizzazione diretta. In un paziente è stato confezionato un by-pass sulla parete postero-laterale oltre alla TMR.*

Risultati. *Il tempo medio di degenza postoperatoria è stato di 3,2 ± 1,3 giorni. Tutti i pazienti sono stati dimessi in buone condizioni cliniche. La scintigrafia al tallio è stata eseguita in 7 pazienti dopo un follow-up medio di 4,0 ± 2,0 mesi: in tutti i casi, tranne uno, è stato evidenziato un miglioramento della perfusione miocardica con netto miglioramento allo sforzo sul tapis roulant e netta riduzione della necessità di assunzione di farmaci vasoattivi.*

Conclusioni. *La nostra esperienza conferma che laTMR è una procedura sicura e fattibile e offre una soluzione terapeutica in caso di angina intrattabile. Inoltre, potrebbe essere un approccio ibrido per i pazienti sottoposti a CABG qualora in aree limitate del cuore non vi siano coronarie adatte alla rivascolarizzazione chirurgica.*

KEY WORDS: Ischemic cardiomyopathy - Transmyocardial laser revascularization.
Cardiopatia ischemica - Rivascolarizzazione miocardica con laser.

## Introduction

Coronary artery bypass grafting (CABG) represents the most common surgical procedure in the treatment of ischemic heart disease offering good results in terms of survival and quality of life. After the standardization

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of the technique by Effler and Favaloro in 1968, many patients received CABG procedure with progressive reduction of the operative risk due to improvement of surgical treatment.

The discussion about the management of patients with angina and coronary artery lesions not suitable for percutaneous or surgical treatment, is still ongoing and many strategies of indirect myocardial revascularization have been proposed with variable results. On the basis of the old techniques, many authors have been interested in the debate regarding indirect revascularization. Large experiences of indirect revascularization have been conducted using transmyocardial revascularization (TMR) that allows to create transmyocardial channels by a laser energy bundle delivered on left ventricular epicardial surface. According to the original hypothesis, benefits of the procedure are related mainly to the angiogenesis caused by inflammation and secondly to the destruction of the nervous fibers of the heart.

## Patients and methods

We present our previous experience carried out more than ten years ago at our institution. From September 1996 up to July 1997, 14 patients (9 males – 66.7%, mean age 64.8±7.9 years) underwent TMR. All patients referred angina at rest; Canadian Angina Class was IV in 7 patients (58.3%), III in 5 (41.7%). All the patients enrolled were under treatment with 3 to 4 vasoactive drugs (nitrates, B-blockers, calcium antagonist, Ace inibitors). Heparin and iv nitroglycerin were administered in 9 patients because of their highly unstable conditions.

All the patients had previous acute myocardial infarction (AMI). Six patients (50%) had previously been submitted to direct myocardial revascularization: CABGs (4 patients.) or PTCA (2 patients.), performed about 5.8±4.5 years before. 2 of the 4 patients already submitted to CABG, underwent stenotic graft PTCA after 3.9±3.2 years. Preoperative mean ejection fraction was 51±9%.

Risk factors were smoke (7/12), hypertension (9/12), dislypidemia (5/12), diabetes (4/12), familiarity (5/12), obesity (3/12), renal failure (3/12), peripheral arteriopathy involving carotid arteries. Before the enrollment, coronarography was routinely performed to find out the feasibility of CABG. In 13 patients (91,6%) had coronary arteries lesions not suitable for direct revascularization; this condition was limited only to postero-lateral area in 1 patient submitted to combined TMR + CABG procedures. All the patients were evaluated with preoperative scintigraphy: decision for surgical treatment depended on the evidence of ischemia in the areas not suitable for conventional revascularization in patient with intractable angina.

Before to start the laser procedure, Intra Aortic Balloon Pump (IABP) was implanted in 6 patients because of their unstable hemodynamic conditions. The device was removed 36 hours later; no complication due to IABP were reported. The mean duration of the surgical procedure was 3.17±0.7 hours with a "lasing" time of 34.5±12.8 minutes. The mean number of channels performed were 38.6±9.5 per patient. During the procedure, autotransfusion was never needed. Some runs of ventricular tachiarrhythmia were evident in the most unstable cases; 3 patients experienced ventricular fibrillation during the surgery requiring a 30 Joules cardiac shock. In 2 cases an adjunctive defibrillation was done in the ICU in the early post-operative period. The mean bleeding was 325±150 cc during the first 24 hours and 2 units of autologous blood were necessary in two cases.

*Surgical technique*

The patient position on the operative table is supine but with a gentle right rotation of the trunk and the left arm suspended over the head. A general anesthesia and a standard intubation is then performed. In highly risk patients, an IABP is positioned through the femoral artery before starting the laser procedure. Through a small skin incision (6-7 cm) at the IV or V intercostal space, antero-lateral wall of the left ventricle was exposed. The IV space is the best way to treat the basal areas of the heart but the V is preferable for the inferior and apical areas.

After heart exposure a xylocaine infusion is started to reduce the risks of ventricular arrhythmia. A number of channels are then performed through the left ventricular wall treating the areas preoperatively mapped by scintigraphy. The system used is a Holmium source Laser whose energy bundle is administered by a flexible fiberoptic, 1 mm diameter. The laser energy is delivered in short pulses of 250 μsec. that progressively achieve a complete transmyocardial channel using an average power of 6 watts. The blood suffusion, that generally appears after the myocardial perforation, is easily controlled by a sponge and a gentle digit compression for few minutes. By transesophageal echo steam-like bubbles are visualized as a result of tissue ablation at endocardial surface, assessing the completeness of the channel. A temporary pacemaker wire is positioned before the thoracic closure in the usual manner. The intercostal nerve alcoholization or a catheter positioning for analgesic infusion can be also easily done to reduce the pain that generally can appear after a thoracotomy.

## Results

No inotropic drugs were administered during the Intensive Care Unit (ICU) stay, except for 1 patient who needed 5 micrograms/kg/min of dobutamine in the first period. All patients received a corticosteroid treatment for at least 38 hours. CPK maximum level was 1200±230 but CPK-MB was 81±40, resulting statistically significant in pts with IABP implanted ($p<0.05$). ECG alteration have not been observed, except 1 patient who experienced perioperative acute AMI. We had one death in a 80-years-old male, after 10 days from the operation because of pulmonary failure who required a tracheostomy and resulting in a fatal complication.

Mean discharge time was 3,2±1,3 days after surgery. All patients were discharged in good clinical conditions.

Perfusion thallium scintigraphy was performed in 7 patients at a mean follow-up of 24,0±2,0 months, showing in all but one an improvement of perfusion defects. Moreover an exercise treadmill improvement was observed in the same patients and all of them had significantly reduced use of active drugs.

## Discussion

Patients with severe diffuse coronary artery disease and refractory angina that cannot be treated with conventional coronary artery bypass graft surgery or angioplasty

may be candidates for transmyocardial laser revascularization therapy. Recent randomized studies on TMR have demonstrated relief of angina (1-3) but the cause of these beneficial effects is unclear. It has been proposed that TMR may increase myocardial perfusion by promoting angiogenesis (4). Other studies have shown that TMR causes myocardial denervation (5).

Many experiences suggest that TMR is an effective short-term therapy for the relief of angina and the improvement of the quality of life of patients with diffuse coronary artery disease who cannot receive angioplasty or bypass graft surgery. Unfortunately, its efficacy is discussed because most patients remain with some degree of angina. Major limitation of TMR is that the clinical benefit is partly lost in the long term follow up suggesting that the improvement may be transient, although recent studies have reported the effectiveness of TMR up to five years (6). An important question is whether the effectiveness of TMR can be increased and maintained by a better understanding and exploitation of its mechanism of action. Our experience is very limited but the case report presented supports the hypothesis of benefits in long term follow up: patient had not longer angina altought in the recent period had mild dispnea. Moreover, the images show that TMR could induce in long term follow up a reguardable angiogenesis that may explain its benefits (7-11).

The main advantages of TMR compared to CABG surgery are:

- mini-invasive surgery using skin incision less than 10 cm or even thoracoscopic;
- does not need extracorporeal circulation and cardiac arrest;
- early extubation and hospital stay limited to a few days;
- possibility of implementing the procedure in cases of severe carotid artery disease, or malignancy with less risk to the patient;
- recovery of the patient faster.

We learned something about TMR procedure during our experience: first of all, the risk of malignat arrhythmias is considerable so that a continuous intravenous infusion with Xilocaina is mandatory. It is recommended to prevent excessive body cooling during the procedure using a heating system. In case of severe impairment of left ventricular function or for instable patients, could be useful preoperative IABP implantation in order to reduce left ventricular afterload improving coronary perfusion. Moreover, channels creation should be responsible of myocardial edema: so that we recommended the use of steroids for the 24-36 hour after procedure in order to prevent edema and the risk of myocardial dysfunction.

## Conclusion

Our experience confirms that TMR is a safe and feasible procedure and it offers a therapeutic solution in case of untreatable angina. Moreover, it could be a hybrid approach for patients undergoing CABGs in case of absence of vessels suitable for surgical approach in limited areas of the heart. Finally, the costs for surgical approach and patients management are limited and this makes TMR an interesting approach for patients with untreatable angina.

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