Introduction

The important role of left ventricular (LV) function as a prognostic indicator in patients with CAD has been illustrated in a number of studies (1,3,5,7,15,25,26). Results of large registries and randomized trials comparing CABG surgery and medical therapy have suggested improved survival in patients with reduced LVEF and multivessel CAD treated with surgery (2,6). However, especially these patients have shown increased surgical risk and lower operative and long-term survival rates than those with normal LVEF (20).

In patients with poor LV function, medical treatment carries a bleak long-term prognosis despite recent advances in pharmacological therapy (15,26,32). An estimated 2-year survival rate in this group of patients is about 30% (34). Although HTX is an attractive option for end-stage ischemic cardiomyopathy, limited donor availability, strict indication criteria and high mortality rate among patients on waiting lists make HTX a very limited option (8,20,21,23).

Over the past decade it has become clear that chronic LVD is not necessarily an irreversible process (1,5). As a result, the concept of myocardial hibernation was introduced by Rahimtoola to describe "a state of significantly impaired LV function at rest due to persistent reduction of coronary blood flow which can be partially or completely restored to normal by improving blood flow or by reducing oxygen demand" (29). In his theory, based on clinical observations, hibernation was described as down-regulation of myocardial function which represented an attempt by myocytes to balance oxygen supply and demand by reducing oxygen consumption, thus preventing myocardial necrosis and ischemic symptoms at rest (30,31). According to various authors, recovery of dysfunctional myocardium in areas of hibernation after revascularization can take several days, weeks or even months to occur following blood flow restoration (16,22,31).

The current clinical challenge is to identify those high-risk patients with multivessel CAD, severe LVD and preoperatively demonstrated HM who are likely to derive greatest functional and prognostic benefit from CABG surgery (11,12,13,28). Moreover, minimizing perioperative and postoperative complications associated with high-risk surgery seems to be another reasonable endpoint to assess myocardial viability in patients with severe LVD prior to CABG (19,31). In patients with preoperatively identified HM, even coronary EAE could be fully justified in order to revascularize reversibly dysfunctional myocardium (14).

Furthermore, MIDCAB procedure could be an attractive surgical option, especially when dealing with a very selective group of high-risk patients who suffer from severe is-
chemic but reversible LVD and various comorbidities (e.g. chronic renal dysfunction, lung dysfunction, liver dysfunction, peripheral vascular disease, previous stroke, severe aortic atherosclerotic disease) where standard CABG surgery in extracorporeal circulation (ECC) may be contraindicated (3,24,33).

Patients and methods

Study objective

The objective of the present pilot study was to evaluate early and medium - term results of CABG surgery in patients with multivessel CAD, severe LVD and selectively documented HM.

Design

Prospective evaluation (early and medium postoperatively) of all patients with severe LVD and preoperatively documented HM who underwent CABG procedure from April 1996 to April 1998 and were referred to the Follow - up Clinic for regular postoperative check - up.

Preoperative data

Seventeen patients (16 men, 1 woman, mean age 61.9 ± 6.9) with multivessel CAD and preoperative mean LVEF of 28 ± 5.7 % (range 16 to 38 %) were studied and HM as a reversible cause of LVD was demonstrated. Preoperatively all patients had a history of myocardial infarction (100%). Preoperatively the mean NYHA functional class was 3 ± 1 and the mean left ventricular end - diastolic pressure (LVEDP) was 20 ± 7. Signs of congestive heart failure, especially dyspnea were present in 16 patients (94.2%); II of our patients (64.7%) did not have any valvular morphological changes (Table 1). All patients with multivessel CAD, severe LVD and preoperatively documented HM who underwent CABG surgery. The selection of therapy was made not on randomised basis, but on clinical criteria. One conclusion that might help in providing more specific data to prove these assumptions and to assist in clinical decision making (28).

Follow - up

All patients were followed up (100% follow - up) for 2.9 to 24.5 months (the mean follow - up 17.1 months). The follow - up included assessment of survival, clinical status (NYHA classification) using a routine clinical check - up and LVEF from a standard thoracic echocardiography scan.

Results

Postoperative data

In 16 patients (94.2%) we used dopamine infusion for preoperative and early postoperative inotropic support. Intravenous balloon pumping (IABP) was used peri - and postoperatively in one patient (5.8%).

Mortality

None patient died within 30 days postoperatively. One patient could be weaned from ECC only with inotropic and IABP support, on the 6th postoperative day respiratory distress syndrome (ARDS) and needed longer ventilatory support. Except of that there were no other significant non - lethal complications present during early postoperative period.

Late mortality

During the follow - up period ranged from 2.9 to 24.5 (the mean 17.1 months) there was no death in the studied group. Thus, survival rate was 100%. The mean LVEF increased postoperatively from 28 ± 5.7 % to 44 ± 8.7 % (p<0.001). The mean NYHA functional class improved from 3.1 ± 0.4 preoperatively to 1.6 ± 0.7 postoperatively (p<0.001). None patient needed any interventional procedure, redo CABG nor HTX during follow - up period. The summarised postoperative data are tabulated in Table 2.

Discussion

Advanced CAB and ischemic cardiomyopathy are criteria of a severe illness (18). However, in selected cases surgical revascularization has proved beneficial in terms of survival, reduction of morbidity and lowering the frequency of angina in numerous studies over past two decades (17,19,20,27,28). Despite increased surgical risk and higher long - term mortality rates than patients with normal LVEF, patients with LVD and multivessel CAD undergoing CABG surgery have shown improved outcome compared with those treated medically (1,28).

Late mortality

During the follow - up period ranged from 2.9 to 24.5 (the mean 17.1 months) there was no death in the studied group. Thus, survival rate was 100%. The mean LVEF increased postoperatively from 28 ± 5.7 % to 44 ± 8.7 % (p<0.001). The mean NYHA functional class improved from 3.1 ± 0.4 preoperatively to 1.6 ± 0.7 postoperatively (p<0.001). None patient needed any interventional procedure, redo CABG nor HTX during follow - up period. The summarised postoperative data are tabulated in Table 2.

Operative management:

Fourteen patients (82.4%) underwent isolated CABG using a standard operative technique without any other open heart procedure. Routine ECC was commenced with aortic and two - stage venous cannulas. Myocardial preservation was performed by moderate systemic hypothermia (28 - 30 °C), antegrade cold crystalloid, and more recently in 5 patients, blood cardioplegia were administered into ascending aorta after aortic cross - clamping. Topical pericardial cooling with ice was used as an adjunct. Three patients (17.6%) underwent a minimally invasive bypass grafting on beating heart: through median sternotomy approach in one case and through left anterior small thoracotomy /LAST/ approach in two cases, without using heart - lung machine. The number of distal anastomoses detected by any diagnostic tool the greater the probability of improvement in LVEF following CABG surgery and thus better short - and long - term outcome after CABG than in similar patients with lesser amounts of viability (13.28). On the other hand, patients with a depressed LV function and extensive myocardial viability treated mediately have a high cardiac event rate. Similarly, patients with poor viability who still undergo CABG procedure have a high rate of early and late cardiac deaths or need for HTX compared with patients with greater viability (13.28).

Furthermore, some studies have also clearly shown that patients with non - viable myocardium have a poorer longer - term outcome following CABG (28). Rejecting such patients from surgery should result in a reduction in costs as a result of avoiding surgical interventions that are unlikely to be of major short - term or longer term benefit. Thus, these patients are the ultimate candidates only for HTX (8). Future prospective studies might help in providing more specific data to prove these assumptions and to assist in clinical decision making (28).

Medical management of HM does not result in improvement in symptoms and LV performance deteriorates over time without revascularization (13).

Study limitations

The present pilot study evaluated early and medium - term postoperative results in symptom profile and LVEF changes in a highly selected group of patients with multivessel CAD, severe LVD and preoperatively demonstrated HM who underwent CABG surgery. The selection of therapy was made not on randomised basis, but on clinical criteria. One conclusion that might help in providing more specific data to prove these assumptions and to assist in clinical decision making (28).

Table 1:

| Preoperative data | n=17 |
|-------------------|------|
| Age (years)       | 61.9 ± 5.9 |
| Sex               | male/ female |
| NYHA functional class | I (17.1%) |
| LVEDP (mm Hg)     | 20 ± 7.9 |
| Multivessel CAD   | 17/17 (100%) |
| Ischemic mitral regurgitation | 9/17 (52.9%) |

Table 2:

| Postoperative data | n=17 |
|--------------------|------|
| LVEF (%)           | 7.1 (range 16 to 38%) |
| NYHA functional class | I (17/17 (100%)) |
| IABP               | 1/17 (5.8%) |
| Number of distal anastomoses | 2.7 (1 - 4) |
| LIMA                | 11/17 (64.7%) |
| LVEF (%)           | 7.1 (range 16 to 38%) |
| Mortality           | 1. Early (30 - day mortality) | 0/17 (0%) |
| II                  | 2/17 (11.8%) |
| Mean follow - up (months) | 17/17 (100%) |
| NYHA classification | 1.6 ± 0.7 (p < 0.001) |
| I                  | 9/17 (52.9%) |
| II                  | 6/17 (35.3%) |
| III                 | 2/17 (11.8%) |
| PCI + redo CABG     | 0/17 (0%) |
| HTX                 | 0/17 (0%) |

Conclusions

CABG surgery may be offered even to patients with severe chronic left ventricular dysfunction LV function if the presence of HM as a reversible cause of LVD has been identified by any of diagnostic tools. Viability assessment in patients with multivessel CAD and severe LVD prior to CABG surgery seems to be crucial because it does not leave the patient with multivessel CAD and LVD a candidate only for HTX. In the presence of HM, more aggressive surgical approach
chemic but reversible LVD and various comorbidities (e.g., chronic renal dysfunction, lung dysfunction, liver dysfunction, peripheral vascular disease, previous stroke, severe aortic atherosclerotic disease) where standard CABG surgery in extracorporal circulation (ECC) may be contraindicated (3,24,33).

Patients and methods

Study objective

The objective of the present pilot study was to evaluate early and medium - term results of CABG surgery in patients with multivessel CAD, severe LVD and preoperatively documented HM.

Design

Prospective evaluation (early and medium postoperatively documented) of all patients with severe LVD and preoperatively documented HM who underwent CABG procedure from April 1996 to April 1998 and were referred to the Follow - up Clinic for regular postoperative check - up.

Preoperative data

Seventeen patients (16 men, 1 woman, mean age 61.9± 6.9) with multivessel CAD and preoperative mean LVEF of 28.5±7.1 (range 16 to 38%) were studied and HM as a reversible cause of LVD was demonstrated. Preoperatively all patients had a history of myocardial infarction (100%). Preoperatively the mean NYHA functional class was 3.1±0.4 and the mean left ventricular end - diastolic pressure (LVEDP) was 20±7.9. Signs of congestive heart failure, especially dyspnea were present in 16 patients (94.2%); 11 of our patients (64.7%) had no signs on echocardiographic assessment. Nine patients (52.9%) had mild to moderate degree of mitral re- gurgitation preoperatively classified as ischemic without any valvular morphological changes (Table 1). All patients were preoperatively screened for the presence of HM using a stress echocardiography scan with low - dose dobutamine (5 - 10 µg/kg/min) and „parietoseptography” assessment from coronary angiogram.

Table 1:

| Preoperative data | n=17 |
|-------------------|------|
| Age (years)       | 61.9±6.9 |
| Sex               | male 16/17 (94.2%) female 1/17 (5.8%) |
| Prior myocardial infarction | 17/17 (100%) |
| NYHA functional class | 3.1±0.4 |
| LVEDP (mmHg)      | 20±7.9 |
| Multivessel CAD   | 17/17 (100%) |
| Ischemic mitral regurgitation | 9/17 (52.9%) |

Operative management:

Fourteen patients (82.4%) underwent isolated CABG using a standard operative technique without any other open heart procedure. Routine ECC was commenced with aortic and two - stage venous cannulas. Myocardial preserva- tion was performed by moderate systemic hypothermia (28 - 30°C); antegrade cold crystalloid, and more recently in 5 patients, blood cardioplegia were administered into as- cending aorta after aortic cross - clamping. Topical pericar- dial cooling with ice was used as an adjunct. Three patients (17.6%) underwent a minimally invasive bypass grafting on beating heart; through median sternotomy approach in one case and through left anterior small thoracotomy (LAST/ approach in two cases, without using heart - lung machine. The number of distal anastomoses carried out per patient was 2.7 (range 1 - 4) always aiming at complete revasculari- zation. The left IMA (LIMA) was used in 11 patients (64.7%). Coronary EAE was performed in 2 patients (11.8%).

Follow - up

All patients were followed up (100% follow - up) for 2.9 to 24.5 months (the mean follow - up 17.1 months). The follow - up included assessment of survival, clinical status (NYHA classification) using a routine clinical check - up and LVEF from a standard transthoracic echocardiography scan.

Results

Postoperative data

In 16 patients (94.2%) we used dopamine infusion for perioperative and early postoperative support. Intraaortic baloon pumping (IABP) was used peri - and postoperatively only in one patient (5.8%).

Mortality

None patient died within 30 days postoperatively. One patient could be weaned from ECC only with inotropic and LIMA support. A small number of patients and also on a very selected pop- ulation. The left IMA (LIMA) was used in 11 patients (64.7%). Coronary EAE was performed in 2 patients (11.8%).

Late mortality

During the follow - up period ranged from 2.9 to 24.5 (the mean follow - up 17.1 months) there was no death in the studied group. Thus, survival rate was 100%. The mean LVEF increased postoperatively from 28.5±7.1 to 44±8.7 (p<0.001). The mean NYHA functional class improved from 3.1±0.4 preoperatively to 1.6±0.7 postoperatively (p<0.001). None patient needed any interventional pro- cedure, redo CABG nor HTX during follow - up period. The summarised postoperative data are tabulated in Table 2.

Table 2:

| Postoperative data | n=17 |
|--------------------|------|
| LVEF (%)           | 44±8.7 (p<0.001) |
| NYHA functional class | 1.6±0.7 (p<0.001) |
| I                  | 9/17 (52.9%) |
| II                 | 6/17 (35.3%) |
| III                | 2/17 (11.8%) |
| PITA or redo CABG | 0/17 (0%) |
| HTX                | 0/17 (0%) |

Discussion

Advanced CAD and ischemic cardiomyopathy are cri- teria of a severe illness (18). However, in selected cases sur- gical revascularization has proved beneficial in terms of survival. Reduction of morbidity and lowering the frequency of angina in numerous studies over past two decades (17,19,20,27,28). Despite increased surgical risk and higher long - term mortality rates than patients with normal LVEF, patients with LVD and multivessel CAD undergoing CABG surgery have shown improved outcome compared with those treated medically (1,28,33). Severe LVD can be resulted of myocardial necrosis or myocardial hibernation (16,31). The noninvasive assess- ment of myocardial viability has been clinically use- ful for demonstrating residual myocardial viability and predicting improvement in global and regional LVEF after CABG surgery in patients with significant LVD (2,3,4,6,33). The most frequently used techniques include stress echocardiography during stepwise infusion of dobutamine (DSE) (6,9,10,33). The re- sults obtained from these techniques are more - less com- parable in preoperative identification of viable myocardium (2,3,4).

Only if viability can be demonstrated, are revasculariza- tion procedures fully justified (2,3). Few recent studies have shown that the greater the number of viable myocardial segments detected by any diagnostic tool the greater the probability of improvement in LVEF following CABG and thus, better short - and long - term outcome after CABG than in similar patients with lesser amounts of viability (13,28). On the other hand, patients with a depressed LV function and extensive myocardial viability treated medi- cally have a high cardiac event rate. Similarly, patients with poor viability who still underwent CABG procedure have a high rate of early and late cardiac deaths or need for HTX compared with patients with greater viability (13,28).

Furthermore, some studies have also clearly shown that patients with severe CAD in the presence of extensive zones of viable (hibernating) myocardium have a signifi- cantly better outcome following CABG surgery than do those treated medically, as reflected by enhanced survival, improvement in symptoms of heart failure and increased exercise capacity (12,17,18,28). Another conclusion that can be drawn is that patients with predominantly nonviable myocardium have a rather poorer long-term outcome fol- lowing CABG (28). Rejecting such patients from surgery should result in a reduction in costs as a result of avoiding surgical interventions that are unlikely to be of major short- term or long-term benefit. Thus, these patients are the ulti- mate candidates only for HTX (8). Future prospective studies might help in providing more specific data to prove these assumptions and to assist in clinical decision making (28).

Medical management of HM does not result in improv- ement in symptoms and LV performance deteriorates over time without revascularization (13).

Study limitations

The present pilot study evaluated early and medium - term postoperative results in symptom profile and LVEF changes in a highly selected group of patients with multivessel CAD, severe LVD and preoperatively demonstrat- ed HM who underwent CABG surgery. The selection of therapy was made not only on the basis of extent of disease but also on the presence of nonviable myocardium in the left ventricular free wall. The present study is not intended as a recommendation for such high - risk patients either for CABG surgery or medical therapy. Another limitation of the study is that we did not use of scintigraphic imaging scans in addition to DSE to increase the probability of tissue viability detection.

Conclusions

CABG surgery may be offered even to patients with se- vere CAD and severe LVD prior to CABG surgery seems to be crucial because it does not leave the patient with multivessel CAD and LVD a candidate only for HTX. In the presence of HM, more aggressive surgical approach

176

177
could be recommended to salvage chronically jeopardised but viable myocardium using not only routine revascularization surgical techniques in ECC but also alternative approach of coronary EADE or MIDCAB grafting on beating heart, without any adverse impact on operative mortality. We are encouraged by our preliminary results to continue in the direction of preoperative viability assessment in this highly selected group of patients. If HM is preoperatively identified, routine surgical revascularization could be employed and the results in terms of low mortality as well as excellent outcome may be expected. On the other hand, in patients with reversible ischemic LVD who have significant comorbidities that significantly increase the risk of a standard surgical intervention, MIDCAB procedure without using heart-lung machine can be considered as an alternative treatment to revascularize viable myocardium.

References
1. Alderman EL, Fisher LD, Litwin P et al. Results of coronary artery surgery in patients with poor left ventricular function (CASS). Circulation 1983;68:783-95.
2. Bass JJ, van Eck-Smit BLF, van der Wall EE. Assessment of tissue viability: clinical demand and problems. Eur Heart J 1998;19:847-58.
3. Beller GA. Assessment of myocardial viability. Current Opinion in Cardiol 1997;12:459-67.
4. Bonow RO: Identification of viable myocardium. Circulation 1996;94:2674-80.
5. Braunwald E, Rutherford JD. Reversible ischemic left ventricular dysfunction: Evidence for the “hibernating myocardium”. J Am Coll Cardiol 1986;5:4462-70.
6. Cigarroa CG, deFilippi CR, Bruckner ME, Alvarez LG, Wait MA, Grayburn PA. Dobutamine stress echocardiography identifies hibernating myocardium and predicts recovery of left ventricular function after revascularization. Circulation 1993;88:430-36.
7. Cohn PF, Gorlin R, Cohn LH, Collins JJ Jr. Left ventricular ejection fraction as a prognostic guide in the surgical treatment of coronary and valvular heart disease. Am J Cardiol 1974;34:136-41.
8. DeNofrio D, Loh E. Myocardial viability in patients with coronary artery disease and left ventricular dysfunction: transplantation or revascularization? Current Opinion in Cardiology 1996;11:394-402.
9. Di Carli MF, Davidson M, Little R et al. Value of metabolic imaging with positron emission tomography for evalua-
ting prognosis in patients with coronary artery disease and left ventricular dysfunction. Am J Cardiol 1994;73:527-33.
10. Di Salvo V, Bonow RO. Current diagnostıc techniques of assessing myocardial viability in hibernating and stunned myocardium. Circulation 1993;87:1-20.
11. Dreyfus GD, Duboc D, Blasco A et al. Myocardial vi-
ability assessment in ischemic cardiomyopathy: benefits of coronary revascularization. Ann Thorac Surg 1994;57:1402-8.
12. Eitzman D, Al-Aouar Z, Kanter HL. Clinical outcome of patients with advanced coronary artery disease after vi-
ability studies with positron emission tomography. J Am Coll Cardiol 1992;20:559-65.
13. Gunning MG, Chua TP, Harrington D et al. Hibernating myocardium: clinical and functional response to revascular-
ization. Eur J Cardiothorac Surg 1997;11:1105-12.
14. Harrer J. Chirurgická léčba difuzního postižení koronár-
ního řečiště. Střed Průmyslového a Lekářského Ústavu Karlovy Hradec Králové 1992;25:367-74.
15. Harris PJ, Harrel FE, Lee KL, Beker VS, Rosati RA. Survival in medically treated coronary artery disease. Circulation 1979;59:421-30.
16. Hare D. Myocardial ischemia: Can we agree on a de-
definition for the 21st Century? Editorial. Cardiovase Res 1994;28:1737-44.
17. Christenson JT, Maurice J, Simonet F et al. Effect of low ventricular ejection fractions on the outcome of primary co-
ronary bypass grafting in end-stage coronary artery disease. J Cardiovasc Surg 1995;36:45-51.
18. Klekamp G, Posival H, Minami K, El-Banayou A, Körfer R. Ischemic cardiomyopathy-revascularization vs. transplan-
tation. Eur J Cardiothorac Surg 1997;11(Suppl 1):S1-8.
19. Lee KS, Marwick TH, Cook SA et al: Prognosis of pa-
tients with left ventricular dysfunction, with and without vi-
able myocardium after myocardial infarction: relative efficacy of medical therapy and revascularization. Circulation 1995;90:2678-94.
20. Louise H, Laks H, Milgarter E et al. Ischemic cardiomy-
opathy: criteria for coronary revascularization and cardiac transplantation. Circulation 1991;94(Suppl 3):290-95.
21. Liu M, Stevenson L, Brunken R, Drinkwater D, Schelbert H, Tilsch J. Delayed recovery of revascularized myocardium after referral to cardiac transplantation. Am Heart J 1990;119:668-70.
22. Marban E. Myocardial stunning and hibernation. Circulation 1991;83:681-8.
23. Mickleborough L, Maruyama H, Takagi Y, Mohamed S, Wait MA, Grayburn PA. Dobutamine stress echocardio-
graphy identifies hibernating myocardium and predicts re-
covery of left ventricular function after revascularization. Circulation 1993;88:430-36.
24. Moshkovitz Y, Sternik L, Paz Y et al. Primary coronary bypass grafting without cardiopulmonary bypass in impai-
red left ventricular function. Ann Thorac Surg 1997;63(Suppl 6):S44-7.
25. Murray JA, Chinn N, Peterson DR. Influence of left ventricular function on early prognosis in atherosclerotic heart disease (abstract). Am J Cardiol 1974;33:159.
26. Nielson GR, Cohn PF, Gorlin R. Prognosis in medically 
treated coronary artery disease: the value of ejection fraci-
on compared with other measurements. Circulation 1972;52:408-12.
27. Nollert G, Schmoeckel A, Markwitz A et al. Surgical 
therapy of coronary artery disease in patients with a left ventricular ejection fraction of 25% or less. J Cardiovase 
Surg 1997;38:389-95.
28. Pagley PR, Beller GA, Watson DD, Gimpel LW, Ragosta M. Improved outcome after coronary bypass sur-
egery in patients with ischemic cardiomyopathy and residu-
al myocardial viability. Circulation 1997;96:793-800.
29. Rahimtoola SH. A perspective on three large multicenter randomized clinical trials of coronary bypass surgery for 
chronic stable angina. Circulation 1985;72(Suppl V):123-35.
30. Rahimtoola SH. From coronary artery disease to heart 
failure: role of the hibernating myocardium. Am J Cardiol 
1995;75:16E-22E.
31. Rahimtoola SH. The hibernating myocardium. Am 
Heart J 1989;117:211-21.
32. Shapera J, Isakov A, Yakirevich V, Toplyski M. Long-
term results of coronary artery bypass surgery in patients 
with severely depressed left ventricular function. Chest 
1995;108(6):1546-50.
33. Schelbert H. Metabolic imaging to assess myocardial vi-
ability. J Nucl Med 1994;35(Suppl 4):S8-14S.
34. Winkel E, Pecione W. Coronary artery bypass surgery 
in patients with left ventricular dysfunction: candidate se-
lection and perioperative care. J Heart Lung Transplant 
1997;16(6):S19-24.

Submitted August 1998. Accepted September 1998.

MU Dr. Jan Knapp, Hradec Králové 1124, 500 02 Hradec Králové, Czech Republic.
could be recommended to salvage chronically jeopardised but viable myocardium using not only routine revascularization surgical techniques in ECC but also alternative approach of coronary EAE or MIDCAB grafting on beating heart, without any adverse impact on operative mortality. We are encouraged by our preliminary results to continue in the direction of preoperative viability assessment in this highly selected group of patients. If HM is preoperatively identified, routine surgical revascularisation could be employed and the results in terms of low mortality as well as excellent outcome may be expected. On the other hand, in patients with reversible ischaemic LVD who have significant comorbidities that significantly increase the risk of a standard surgical intervention, MIDCAB procedure without using heart-lung machine can be considered as an alternative treatment to revascularize viable myocardium.

References

1. Alderman EL, Fisher LD, Litwin P et al. Results of coronary artery surgery in patients with poor left ventricular function (CASS). Circulation 1983;68:783-95.
2. Baas JF, van Eck-Smit BLF, van der Wall EE. Assessment of tissue viability: clinical demand and problems. Eur Heart J 1998;19:847-58.
3. Beller GA. Assessment of myocardial viability. Current Opinion in Cardiol 1997;12:459-67.
4. Bonow RO. Identification of viable myocardium. Circulation 1996;94:2674-80.
5. Braunwald E, Rutherford JD. Reversible ischaemic left ventricular dysfunction: Evidence for the „hibernating myocardium“. J Am Coll Cardiol 1986;6:1467-70.
6. Cigarroa CG, deFilippi CR, Brickner ME, Alvarez LG, Wait MA, Grayburn PA. Dobutamine stress echocardiography identifies hibernating myocardium and predicts recovery of left ventricular function after revascularization. Circulation 1993;88:430-36.
7. Cohn PF, Gorlin R, Cohn LH, Collins JJ Jr. Left ventricular ejection fraction as a prognostic guide in the surgical treatment of coronary and valvular heart disease. Am J Cardiol 1974;34:136-41.
8. DeNofrio D, Loh E. Myocardial viability in patients with coronary artery disease and left ventricular dysfunction: transplantation or revascularization? Current Opinion in Cardiology 1996;11:394-20.
9. Di Carli MF, Davidson M, Little R et al. Value of metabolic imaging with positron emission tomography for evaluat ing prognosis in patients with coronary artery disease and left ventricular dysfunction. Am J Cardiol 1994;73:527-33.
10. Dilisizan V, Bonow RO. Current diagnostic techniques of assessing myocardial viability in hibernating and stunned myocardium. Circulation 1993;87:1-20.
11. Dreyfus GD, Duboc D, Blasco A et al. Myocardial viability assessment in ischemic cardiomyopathy: benefits of coronary revascularization. Ann Thorac Surg 1994;57:1402-8.
12. Eitzman D, Al-Anour Z, Kanter HL. Clinical outcome of patients with advanced coronary artery disease after viability studies with positron emission tomography. J Am Coll Cardiol 1992;20:559-65.
13. Gunnings MG, Chua TP, Harrington D et al. Hibernating myocardium: clinical and functional response to revascularization. Eur J Cardiothorac Surg 1997;11:105-12.
14. Harrer J. Chirurgická léčba difuzního postižení koronár ního tečití. Stu Ved Pr (Suppl) Lek Fak Univerzity Karlovy Hradec Králové 1992;35:367-74.
15. Harris PJ, Harrell FE, Lee KL, Bekar VS, Rosati RA. Survival in medically treated coronary artery disease. Circulation 1979;59:421-30.
16. Heare D. Myocardial ischemia: Can we agree on a definition for the 21st Century? Editorial. Cardiovasc Res 1994;28:1737-44.
17. Christenson JT, Maurice J, Simonet F et al. Effect of low ventricular ejection fractions on the outcome of primary coronary bypass grafting in end-stage coronary artery disease. J Cardiovasc Surg 1995;36:45-51.
18. Kleikamp G, Posival H, Minami K, El-Banayosy A, Köfer R. Ischemic cardiomyopathy-revascularization vs. transplantation. Eur J Cardiothorac Surg 1997;11(Suppl):1-8.
19. Lee KS, Marwick TH, Cook SA et al. Prognosis of patients with left ventricular dysfunction, with and without viable myocardium after myocardial infarction: relative efficacy of medical therapy and revascularization. Circulation 1995;90:2678-94.
20. Louise H, Laks H, Milgalter E et al. Ischemic cardiomyopathy-criteria for coronary revascularization and cardiac transplantation. Circulation 1991;84(Suppl 3):290-95.
21. Liu M, Stevenson L, Brunken R, Drinkwater D, Schelbert H, Tisch J. Delayed recovery of revascularized myocardium after referral to cardiac transplantation. Am Heart J 1990;119:668-70.
22. Marban E. Myocardial stunning and hibernation. Circulation 1991;83:681-8.
23. Mickleborough L, Maruyama H, Takagi Y, Mohamed S, Wait MA, Grayburn PA. Dobutamine stress echocardiography identifies hibernating myocardium and predicts recovery of left ventricular function after revascularization. Circulation 1997;96(Suppl 6):S44-7.
24. Moskowitz Y, Sternik L, Paz Y et al. Primary coronary bypass grafting without cardiopulmonary bypass in impaire d left ventricular function. Thorac Surg 1995;63(Suppl 6):S44-7.
25. Murrey JA, Chinn N, Peterson DR. Influence of left ventricular function on early prognosis in anoxic/ischaemic heart disease (abstract). Am J Cardiol 1974;33:159.
26. Nelson GR, Cohn PF, Gorlin R. Prognosis in medically treated coronary artery disease: the value of ejection fraction compared with other measurements. Circulation 1972;52:408-12.
27. Nollert G, Schmoeckel A, Markewitz A et al. Surgical therapy of coronary artery disease in patients with a left ventricular ejection fraction of 25% or less. J Cardiovasc Surg 1997;38:389-93.
28. Pagley PR, Beller GA, Watson DD, Gimble LW, Ragosta M. Improved outcome after coronary bypass surgery in patients with ischemic cardiomyopathy and residual coronary myocardial viability. Circulation 1997;96:793-800.
29. Rahimtoola SH. A perspective on three large multicenter randomized clinical trials of coronary bypass surgery for chronic stable angina. Circulation 1985;72(Suppl V):123-35.
30. Rahimtoola SH. From coronary artery disease to heart failure: role of the hibernating myocardium. Am J Cardiol 1995;75:16E-22E.
31. Rahimtoola SH. The hibernating myocardium. Am Heart J 1989;117:211-21.
32. Shapera J, Isakov A, Yakirevich V, Toplisky M. Long-term results of coronary artery bypass surgery in patients with severely depressed left ventricular function. Chest 1995;108(6):1546-50.