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Donor heart quality control. Analysis of echocardiographic (EC) findings and patient outcome

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Abstract In a retrospective analysis, 149 echocardiographic (EC) evaluations were compared with conventional clinical parameters for donor heart selection. Of these cases, 12 % were found with severe impairment of ventricular wall motion or with morphological abnormalities. Nearly half of the echocardiographically diagnosed pathological findings in donor hearts were not detected by conventional standards for heart screening. Analysis of EC-screened donor heart outcome showed a primary graft nonfunction rate of 3.1 %. We suggest EC as an additional screening instrument for further dynamic and morphological information about donor heart condition. Potential donors can be saved for transplantation and severe complications can be avoided by detecting occult cardiac dysfunction. Early detection of cardiac dysfunction may have an impact on donor therapy and can avoid unnecessary and expensive transportation of the surgical team to the harvest site.

Key words Echocardiography · Donor heart Selection · Occult donor heart diseases

Introduction

Selection of donor hearts (DH) is one of the most important and difficult parts of heart transplantation and must be carried out with care to minimize the risk of primary graft nonfunction (PGNF) and to preserve high standards of outcome. Optimal donor management includes comprehensive hemodynamic monitoring, such as can be provided in highly specialized intensive care units only. However, a part of donor management takes place in regional hospitals. Usually, the results of conventional procedures such as chest X-radiograph, electrocardiogram (ECG), arterial and central venous blood pressure, and blood chemistry are available at the time of decision for DH harvesting. Dynamic parameters such as electrocardiographic (EC) evaluation, are generally not available. Additional to the problems of DH selection using classical criteria, the DH shortage has urged some centers to extend the classical donor criteria with respect to age, trauma history, inotropic support needs, donor size matching, resuscitation and hemodynamic status [6, 8].

In our donor procurement program, EC is used as a screening method for dynamic function and morphological status of DH for each donor scheduled for multiorgan harvesting at the time of the onset of specific donor therapy. Our data, from $7^1/_2$ years experience, were analyzed to find out whether EC can give additional information on the DH in comparison with conventional parameters. All DH used for transplantation were investigated in follow-up to find out the primary function result.

Material and methods

Between January 1987 and August 1994, 182 organ donors were registered at the University Hospital of Graz, Austria. In a retrospective analysis, donors scheduled for or excluded from heart transplantation (HTX) were analyzed with respect to EC results and conventional DH criteria. Donor-specific therapy consisted of the usual management [1, 4]. Conventional parameters for the evaluation of DH quality were evaluated. Standard ECG was analyzed by the same cardiologist who performed the EC. Standard

Table 1 Criteria for acceptance of donor hearts for transplantation

1. Age below 55 years
2. No drug abuse (including alcohol)
3. No history of systemic disease
4. Circulation maintenance without high doses of catecholamines
5. No episodes of sustained resuscitation or hypotension
6. Chest X-radiograph normal
7. ECG without specific changes
8. Echocardiography indicates normal function and morphology

Table 2 Causes of exclusion from multiorgan and/or heart donation

Reason of exclusion	Number of donors
Age exceeded 55 years	8
Severe polytrauma with unstable circulation	12
Unstable circulation without trauma	16
Systemic disease	4
Pathological findings on echocardiography	18

Table 3 Early graft function analysis

	Patients
Normal EC (total)	130
No response from Tx center	20
Good primary function	87
Donor age exceeded	8
Not transplanted	12
Primary graft nonfunction	3 (3.1 %)

chest X-radiographic (anterior–posterior) results were reported by the radiologist on duty. Levels of creatinine phosphokinase (CPK) and its isoenzyme MB, indicated as units per liter (U/l), were obtained. We considered the normal range of CPK to be 0–80 U/l and of MB to be 0–10 U/l.

According to the donor's circulation status, the inotropic support needs were categorized into a low-dose group (dopamine < 6 μg/kg per min) and a high-dose group (dopamine in combination with one or more additional inotropics). Hypotensive episodes were defined as a drop of systolic blood pressure to 80 mm Hg or less lasting for more than 15 min. Spontaneous or traumatic cerebral affection or any trauma as the cause of death was also included in the analysis.

EC examinations were carried out in all donors judged suitable for transplantation, performed on the occasion of the first O-EEG. At this time, specific brain edema therapy was usually replaced by donor-specific therapy (i.e. excessive volume and electrolytes replacement). In a left elevated position, standard EC parameters were taken parasternally, apically, subcostally, and optionally suprasternally (longitudinally and crossectionally). In cases of doubtful results, transesophageal EC was also performed. In the M-mode, the ventricles and atria were measured. The global and regional left ventricular (LV) function was estimated by B-pictures in two dimensions. The LV was measured across the short axes at the end of diastole (LVED) and of systole (LVES). Using the formula of Teichholz, the fractional shortening (FS) and the ejection fraction (EF) were calculated. The width of the right ventricle (RV) and the left atrium (LA), as well as the myocardial wall thickness of the septum (IVS) and of the posterior wall (LVPW) were determined. The two- and fourchamber views were examined from the apical cross point and from the longitudinal section. All valves were examined with continuous wave, pulsed wave, and the color Doppler technique Examinations were carried out with a Hewlett Packart Sonos 1000 3.5 MHz sectorsonde by a small number of experienced investigators.

DH were offered for HTX according to the criteria listed in Table 1. Outcome analysis was performed for DHs transplanted in our center and for exported DHs (a questionnaire was sent to each transplant center). PGNF was defined as loss of cardiac function within 3 days of HTX. Excluded were cases of RV failure due to pulmonary hypertension, acute rejection and death from other noncardiac causes.

Results

The mean age of the 183 donors was 33 years (range 2–66), 122 were males and 142 (77.6 %) were multiorgan donors (explantation of two or more different organs). Reasons for exclusion from multiorgan and/or heart donation are listed in Table 2.

EC findings were obtained from 149 donors, of which 130 had normal global and regional LV contractility, normal valve functions and normal morphology. LVED mean score was 46.1 ± 3.2 mm, LVES mean score 28.4 ± 2.1 mm and the FS mean score 37.8 ± 4.2 %. Of the DHs with normal EC transplanted in our institution, 48 had good primary graft function, and there was one case of PGNF. The remaining 81 DHs with normal EC were offered to heart transplant centers linked to the Eurotransplant network. Results from 90 transplanted DHs were analyzed; PGNF was 3.1 %, and 12 with normal parameters and function were not transplanted because of virus infection, drug abuse, risk group or were not able to coordinate with a recipient (Table 3).

Pathological EC results were obtained in 19 donors (12.7 %). The detailed results are listed in Tables 4 and 5. Of these hearts, 18 were excluded from transplantation and the detailed description of the relationship between EC and conventional parameters are described below.

Pathological ECs with normal conventional findings

Nine DHs (6 % of all potential DHs) were diagnosed normal according to conventional parameters. However, using EC, significant pathologies were detected (Table 4). Hypokinesis and akinesis of the LV were the main pathological findings by EC. Occult heart diseases were found in three cases. Case no. 6, a 9-year-old female donor with a spontaneous ICH, suffered from bivalve insufficiency (mitral, tricuspidal). In case no. 8 (48-year-old female) an unknown HOCM was diagnosed, and in case no. 9 an atrial septal defect was diagnosed. All hearts except case no. 9 were excluded from

Table 4 Pathological EC findings listed with conventional parameters for donor heart screening. Conventional parameters are not considered to be a contraindication for transplantation (*Hypokin* Hypokinesis, *Akin* Akinesis, *MINS* Mitral valve insufficiency, *TRINS* Tricuspital valve insufficiency, *LV* left ventricle, *RV* right ventricle, *HOCM* hypertrophic obstructive CMP, *PV* pulmonary vein, *Pneumoth* pneumothorax, *ASD 2* septum secundum defect of the atrium)

No.	Age (years)	Echocardiography	ECG	Chest X-ray	CPK	MB	Hypo-tension	Resus-citation	Inotropic support	Trauma
1	21	Akin anterior wall	Nonspecific	0 pathol	82	5	No	No	Low	Yes
2	27	Akin diffuse, LV EF = 30 %	Nonspecific	0 pathol	119	17	No	No	Low	No
3	16	Hypokin diffuse, LV	Nonspecific	0 pathol	279	21	No	No	0	Yes
4	24	Hypokin LV EF = 76 %	Nonspecific	0 pathol	333	4	Yes	Yes	Low	Yes
5	34	Hypokin diffuse, LV, RV EF = 30 %	Nonspecific	0 pathol	112	15	Yes	Yes (10 min)	Low	No
6	9	Hypokin LV MINS TRINS EF = 33 %	Nonspecific	0 pathol	110	13	No	No	0	No
7	22	Hypokin LV, RV	Sinus tachycardia	Pneumoth unilateral	218	4	No	No	Low	No
8	48	HOCM	Nonspecific	0 pathol	341	8	No	No	Low	No
9	42	ASD 2	Nonspecific	0 pathol						

Table 5 Pathological EC findings listed with pathological findings of the conventional parameters for donor heart screening (*Hypokin* hypokinesis, *Akin* akinesis, *Dyskin* dyskinesis, *CMP* cardiomyopathy, *LA* left atrium, *RV* right ventricle)

No.	Age (years)	Echocardiography	ECG	Chest X-ray	CPK	MB	Hypo-tension	Resus-citation	Inotropic support	Trauma
10	54	Hypokin LV Hypertrophy LV LA dilatation Sclerosis aortae EF = 50 %	Pathological findings	Hypertrophy LV	62	11	Yes	Yes (10 min)	Low	No
11	47	Hypokin global EF = 45 %	Tachycardia Repolarization changes	0 pathology	74	67	No	No	Low	Yes
12	17	Hypokin posterior wall, LV	Nonspecific	Lung contusion	89	902	Yes	No	High	Yes, severe
13	24	Dyskin septum EF = 56 %, Dilatation	Nonspecific	Cardiac dilatation	146	54	Yes	No	High	Gun shot
14	21	Hypokin LV LVEDP elevated	Nonspecific	PV congestion	109	8	No	No	High	Yes
15	36	Hypokin LV Hypertrophy LV	T-wave elevated	Hypertrophy LV	69	16	No	No	High	No
16	33	Hypokin LV Hypertrophy LV EF = 45 %	Nonspecific	Hypertrophy LV	465	11	No	No	Low	No
17	13	Dilat LV Hypokin LV Dilatative CMP	Sinus tachycardia	Heart dilatation	133	95	No	No	High	Gun shot
18	17	Hypokin LV LVEDP elevated Dilatative CMP	Pathological findings	Heart dilatation	631	29	No	No	High	Yes
19	46	Hypokin diffuse	Arrhythmia	0 pathology	73	14	Yes	Yes	High	No

HTX; case no. 9 was used. The ASD 2 was closed by a running suture before implantation without complications.

In case no. 7 ECG indicated a sinus tachycardia and chest X-radiograph indicated a unilateral pneumothorax (due to central venous catheterization). Discreet elevation of the CPK/MB value was observed in two cases. One was associated with a 10-min resuscitation (case no. 5) and the other with trauma (case no. 3). Neither needed inotropics. Trauma was the cause of death in four cases. None of these conventional findings was a definite cause for exclusion of DHs from HTX.

Pathological ECs and pathological conventional findings

In ten cases (6.7 % of the potential DHs) pathological ECs were associated with significant pathological findings of conventional parameters. In five of these ten donors pathological ECG signals were observed. Chest X-radiographs were free from pathological findings of the heart in two cases only (no. 11 and no. 19). CPK/MB values were elevated in seven cases. Mechanical resuscitation had occurred in two and hypotension in four cases. A high inotropic drug support was required in seven cases. Trauma was the cause of death in six cases, two of them gun shots (to the head).

EC findings were mainly hypo- and akinesis. Hypertension was found in the history of one case out of three LV hypertrophies detected by EG and chest X-radiograph. Two cases of dilatative CMP, 13 and 17 years of age, were not reported in the patients' history.

Discussion

To select a DH for HTX can be a very delicate decision. As reported by the International Society of Heart and Lung Transplantation [5], approximately 26 % of deaths in HTX are accounted for by early donor heart failure, affirming the need for careful selection. In our analysis, nearly one-half of the hearts rejected on the basis of pathological findings by EC, such as LV dysfunction, valve insufficiency and occult heart disease, would been accepted by conventional standards and, if transplanted, would have led to deleterious complications. A recent report suggests a 22 % probability of death after HTX if diffuse wall-motion abnormalities are detected with EC [10]. In relation to a rate of 67 % acceptance of DHs previously reported [8], our data suggest a high rate (71 %) of acceptance of DHs using conventional screening parameters combined with EC screening. However, the overall Eurotransplant acceptance, rate is 38.3 % [6]. Potential DHs which have been rejected by conventional criteria, for example a history of chest trauma, short episodes of resuscitation and hypotension and age over 50 years, could be considered for HTX when EC indicates normal function and none of the clinical findings not related to the heart provides a contraindication. Consistent with our own findings, a recent study suggests a 32 % increase in DHs for HTX when screened with EC despite exclusion by the usual clinical criteria [2]. Nevertheless, at least 12 of our donors found to have impaired ventricular function were previously healthy young people.

Experimental studies of brain death in baboons [7] have shown that severe myocardial cell damage is directly related to extreme autonomic nervous system activity which occurs during the agonal period. Additionally, significant reduction in the circulating levels of triiodothyronine, cortisol and insulin lead to increased anaerobic metabolism and depletion of myocardial high energy stores. Replacement of these hormones is accompanied by an improvement in myocardial function. A clinical investigation suggested the potential for increasing the donor pool by up to 30 % and for significantly improving the function of initially unsuitable DHs by hormone replacement and optimal donor management [9]. Early detection by EC may have an impact on therapy [3], which can avoid the exclusion of potentially usable organs.

Trauma had occurred in approximately 40 % of our EC-screened donors with impaired cardiac function. In all cases circulation was maintained by volume replacement or with additional inotropic support. Organs of donors who died from trauma can be affected by different impacts such as volume loss, hypoxemia and the previously described agonal trauma. These factors can cloud the real cause of heart damage. A unique case has been studied in our department recently. An ice-hockey professional, 31 years of age, experienced an isolated cardiac contusion in a high speed collision with a another player. Cardiac dilatation was primarily diagnosed on the following day from a chest X-radiograph. EC parameters were characterized by diffuse LV hypokinesis with a drop of the EF to 35 % and LV dilatation. All parameters recovered to normal within 7 days with strict rest and cardiac protective therapy. This case teaches us that traumatically impaired donor hearts could possibly be saved for transplantation by prolonging the special care period on condition that dynamic function and morphology of the heart is investigated repeatedly.

Hearts from donors over 50 years of age with normal EC were transplanted without complications in eight cases. These results are in accordance with those of studies with donors aged up to 54 years [8] and up to 49 years [6]. Two donors over 55 years were not used for HTX only because of their age, despite all cardiac parameters including EC being normal. In selected cases, this part of the donor pool can probably be considered for transplantation with optimal donor manage-

ment and careful EC screening. EC can be considered a standard method used in nearly all hospitals that treat cardiac diseases in the Eurotransplant-associated countries. As HTX is a highly specialized treatment, good results can only be obtained with careful monitoring after HTX, but the same careful screening should also be applied in the selection of the donor organ.

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