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Penetrating Cardiac Trauma: Follow-up Study Including Electrocardiography, Echocardiography, and Functional Test

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Abstract. A prospective study was carried out to analyze the evolution of patients who survived penetrating cardiac trauma. A total of 642 patients were evaluated. A 1-year follow-up, which included physical examinations, electrocardiography, echocardiography and stress tests, was completed in 192 patients. Data processing included calculation of average and percentage values. At follow-up, 90% of patients were asymptomatic at 2 days after surgery, with normal cardiac monitoring; baseline and control ECGs showed myocardial infarction in 9.1% of patients. Baseline ECGs showed pericarditis as well in 27% of patients and repolarization changes in 35.2%. The latter became normal within 1 to 6 months after the trauma. All (100%) of the patients had a functional status I stress test, and 56% had a normal echocardiography. In conclusion, the epidemiologic behavior of penetrating cardiac trauma is identical to that of general trauma. ECG is useful during the postsurgery period for diagnosis of traumatic myocardial infarction. Likewise, the stress test is useful in patients with myocardial infarction and echocardiography in the presence of either myocardial infarction or any symptom suggesting anatomic or functional alterations of the heart.

Civil cardiac trauma is extending worldwide owing, among other factors, to overall increase of violence and automobile high-speed accidents [1, 2]. About 10% of patients with thoracic trauma present with heart lesions [3]. Mortality from this type of trauma is high; and as a matter of fact, most patients with heart injury die before assistance [1, 4, 5]. Among surviving patients taken to emergency rooms, the mortality rates have decreased to figures ranging from 5.5% to 57.6% [1, 6–13].

Concerning sequelae from penetrating cardiac trauma, numerous studies have reported residual intracardiac lesions in 4% to 56% of cases [12, 14, 15]. Functional sequelae in such patients have rarely been described. One study [16] reported an analysis of 20 patients on psychological sequelae as the cause of work disability.

The present study was carried out to determine the epidemiologic, clinical, electrocardiographic (ECG), echocardiographic and functional behavior of penetrating cardiac trauma in a group of surviving patients assisted at San Vicente de Paul University Hospital (SVPUH) in Medellín, Colombia.

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Materials and Methods

We studied 642 surviving patients after a thoracotomy caused by a penetrating cardiac wound admitted at SVPUH from July 1, 1990 to December 31, 1994. The first evaluation was done on the second or third postsurgery day at the Department of Cardiac Rehabilitation. A complete data collection form was filled out by one of the researchers, followed by a thorough physical examination, an ECG with a three-channel Hewlett Packard electrocardiograph, and cardiac rhythm monitoring for 10 minutes with a MV5-lead Honeywell-DE-420 monitor. In the presence of heart alterations, bidimensional M-mode echocardiography and Doppler testing were performed (Toshiba Echocardiograph).

The second follow-up visit was done on day 10 after surgery and included physical examination and a resting ECG. The third follow-up visit, 1 month after surgery, included an interrogatory, a physical examination, and a conventional stress test using Bruce and Bruce modified protocols, applied according to the patient's status. Echocardiography was performed in some of these patients. At 3, 6, and 12 months after the trauma, follow-up examinations were performed that included an interrogatory, physical examination, ECG, and stress testing. Echocardiography was performed in some of these patients.

The ECG interpretation had three categories.

1. *Acute myocardial infarction* if pathologic Q waves (one-fourth of the QRS complex and 40 ms or more) appeared in two or more leads of a defined coronary area, with ST elevation of 0.2 mV or more in these leads
2. *Pericarditis* if ST general elevation was observed without a Q wave, with ST depression in the aVR and V1 leads
3. Repolarization *unspecific changes* if other changes were observed (negative T wave)

Data were processed through electronic tabulation methods. Statistical analysis included calculation of average and percentage

Table 1. Distribution of patients with penetrating cardiac trauma according to patient's condition at admission.

Patient's condition	No.	%
Cardiac tamponade	296	46.1
Shock	93	14.5
Cardiac arrest	7	1.1
Stable	119	18.5
Shock and tamponade	81	12.6
Tamponade, shock, arrest	8	1.3
No data	38	5.9
Total	642	100.0

Table 2. Distribution of patients with penetrating cardiac trauma according to diagnostic method.

Diagnostic method	No.	%
Clinical	462	72.0
Pericardial window	63	9.8
Digital exploration	44	6.8
Radiologic images	13	2.0
Clinical and exploration	6	0.9
Radiologic and pericardial window	11	1.7
Clinical and pericardial window	1	0.2
Radiologic and clinical	3	0.5
No data	39	6.5
Total	642	100.0

values. No statistical significance tests were used owing to the descriptive nature of the study.

Results

During the study period, surgery was performed in 1022 patients with penetrating heart injury, of whom 132 (12.9%) died during surgery. The 642 survivors came for the first follow-up visit. Patient demographics showed that 95% of 642 survivors were male; 88.4% were under 39 years old; only 3.4% had a high school education; 75.6% were unemployed or employed part-time; and 91.9% had one or more of the following antecedents: liquor, tobacco, or psychoactive drug consumption. A cohort of 9.4% had had previous personal injuries. Most wounds were caused by knives (88.5%); gunshots were used in only 11.5% of cases.

Baseline findings included cardiac tamponade in 46.1% of cases and shock in 14.5%; 18.5% of patients were stable (Table 1). The diagnosis was made clinically in most cases (72%). In other cases, some type of diagnostic aid was used (images, pericardial window, digital exploration) (Table 2). Most lesions involved only one cardiac structure as follows: right ventricle in 47.1% of cases; left ventricle 26.8%; right atrium 8%; left atrium 2%; pericardium only 6.2%; and coronary arteries 0.6%.

At the first follow-up visit, 88% of patients were asymptomatic, and the rest presented mild to moderate dyspnea. Auscultation was normal in 57% of patients. Murmurs were found in 16.8% of cases, pericardial friction rub in 18.2%, and gallop rhythm in 9.3%. Cardiac monitoring was normal in 93% of patients. In the remaining cases, clinically insignificant supraventricular and ventricular extrasystoles were found.

Electrocardiography

At the first follow-up visit, 59 (9.1%) ECGs fulfilled criteria for acute myocardial infarction, 185 (27.0%) fulfilled criteria for stage I pericarditis, 28.7% were normal, and the other 35.2% had unspecific repolarization alterations. The following intraventricular conduction alterations were observed: complete right bundle branch block of His bundle in 7 patients (1.1%), nonadvanced right bundle branch block of the His bundle in 29 (4.6%), and left bundle branch block of the His bundle in 2 (0.3%).

Echocardiography

During the first week after thoracotomy it was possible to perform echocardiography in 139 patients; half were normal, 18% had some degree of pericardial effusion, 11% had segmentary contractility alterations, 7.9% had a small interventricular shunt, and 7.1% had a valvular lesion. One patient had an aortopulmonary artery fistula that underwent surgical treatment with an excellent outcome.

Stress Test

Stress tests were performed during the first month of follow-up in 192 patients. Altogether 164 of them (85%) reached 10 or more mets; the rest stopped because of dyspnea, but none had a performance inferior to 7 mets. A stress test was performed in 20 patients with myocardial infarction; 13 of them had a functional status inferior to 10 mets, 7 had ST segment elevation, and 5 had significant ventricular arrhythmias. There were no signs suggesting exercise-induced ischemia in patients with myocardial infarction or in the other patient subgroups.

Follow-up

It was difficult to convince patients to return for appointments at 3, 6, and 12 months. At 3 months only 29 attended, at 6 months 21, and at 12 months 14.

Discussion

The problem of violence in Colombia and especially in our city, Medellín, is serious, and it has displaced atheroesclerotic disease as the major case of morbidity and mortality. The epidemiologic analysis reveals that at most risk of a penetrating heart injury are unemployed, poorly educated youngsters who are on psychoactive drugs or drink liquor and who have antecedents of previous personal injuries. The investigations identified particular places in the city where the possibility was stronger for the occurrence of such lesions and the hours during which they occur most frequently. The police authorities were given this information so they could take some preventive measures.

During a 4.5-year period in SVPUH, Medellín, 1022 surviving patients were surgically treated (i.e., a yearly average of 227 patients—well over what has been reported) [4, 8, 10, 14, 15]. Such figures are fivefold higher than those reported by Mattox et al. (45 per year) [15].

The mortality rate in the operating theater due to penetrating heart injuries was 12.9%: A differential analysis of the mortality was not done between injuries caused by stab or gunshot wounds

because the study was conducted specifically with surviving patients after thoracotomy and cardiorrhaphy. These results show the efficiency of the SVPUH surgeons at diagnosing and operating on cardiac trauma because this mortality is one of the lowest reported in literature [1, 6–13]. The clinical presentation, diagnosis, and treatment data from the present study are in accordance with reports in the world literature [2, 3, 10, 11, 17, 18]. What is remarkable, however, is the slightly different type of diagnostic aids used in our region. In particular, digital exploration and pericardial windows are not widely used as diagnostic aids in other regions of the world, where radiology and pericardiocentesis are mostly applied [1, 2, 10, 17–20].

It is noteworthy that digital exploration as a diagnostic aid was used in 7% of these patients. We do not have a follow-up regarding its sensitivity and specificity because the analysis was done in patients in whom the wound was confirmed at surgery. We propose to design an investigation for this purpose because sometimes in underdeveloped countries such as ours we do not have all the desired technologic resources.

The ECG findings were a surprise to us because we found myocardial infarction in 9.1% in patients in whom it was not suspected during the surgery. This observation has motivated us to conduct a study aiming at diagnosing myocardial infarction during the intraoperative period and trying to find a reason for its occurrence. (It does not seem to be due to severed coronary branches in most of the cases.) We hope this study will clarify this conundrum in a short time.

We could not conduct a strict follow-up on these patients over the first postoperative year owing to personal, social, and legal problems. For those who could be followed the pericarditis evolved to stage III at 3 to 6 months (with negative deep T waves in several leads). It is important to note that the unspecific precordial ache in one of these patients could have been confused with a subepicardic ischemia, and to continue with expenditures on examination and hospitalizations was thought unnecessary. It is also important to clarify that none of the patients had postpericardiotomy syndrome, and it was not necessary to treat patients with pericarditis because they were not symptomatic.

The echocardiography correlated well with clinical findings of murmurs that made us suspect an interventricular shunt, valve lesion, or segmentary alterations of contractility with the ECG findings that shows a zone of necrosis. It is necessary to perform other examinations when the clinical or ECG evaluations suggest it.

Currently, there is an ongoing long-term follow-up in those patients with traumatic myocardial infarction to establish what happens with myocardial remodeling process. It was possible to follow up two patients with interventricular shunt. In one the shunt has closed spontaneously. The other patient progressed to heart failure that required surgical correction.

As mentioned above, most patients behaved as expected according to their ages, with normal heart rate and blood pressure. There were no changes of exercise-induced ischemia in any of them. During exercise, negative T waves tended to be positive, which further supports the nonspecificity of this finding in a stress test. In patients with myocardial infarction, ST segment showed some tendency to increase during exercise, which is indicative of dyskinesia. This finding is expected to be correlated in the future with echocardiographic results to determine its ability to predict infarction spread or remodeling [21]. Taken together, the data from stress tests suggest that the patients' functional capacity remained unaltered.

Summary and Conclusions

This prospective study was carried out in an 800-bed general hospital on 642 patients who survived a penetrating wound heart. Unemployed, drug-addicted young people with little schooling under the effects of liquor and with previous personal injuries are at highest risk of this injury. The operative mortality was 12.9%.

Postoperatively, we found ECG and echocardiographic evidence of unsuspected myocardial infarction in 9.1% of the patients. The results of echocardiography at week 1 after surgery are in good accordance with clinical findings and the ECG. Patients without myocardial infarction, interventricular shunt, or a valve lesion were in functional status I the first month after trauma, and they reached 10 mets or more during the stress test.

In regard to the epidemiologic aspects, violence is the primary cause of mortality in this city, and the results of the study provide some parameters for those who try to prevent it: (1) try to have greater education coverage; (2) find alternatives to diminish the use of liquor and psychoactive drugs; (3) set policies to increase stable employment; and (4) establish concrete surveillance police rules in specific areas of the city. We recommend that the group of people who participate in such undergo violence and incur such lesions be studied so we can prevent new accidents.

It is recommended that an ECG be obtained during the early postsurgery period and the days following to exclude myocardial infarction (MI), as the possibility of MI without warning is about 9%. The patients could then benefit from aggressive medical intervention. Echocardiography must be undertaken in patients with murmurs or signs of heart failure or when ECG changes suggest MI.

The stress test does not add anything to the follow-up of patients who survive penetrating heart injury, but it is worthwhile in MI patients in the context of evaluation or follow-up at cardiac rehabilitation. Patients who survive penetrating heart injury and who do not have sequelae recover quickly and without limitations.

Résumé

Dans cette étude descriptive et prospective, on a analysé les caractéristiques des patients ayant survécu à une plaie du cœur. 642 patients ayant une plaie du cœur ont été vus en première intention et parmi eux, on a pu réaliser un examen physique, un électrocardiographie, une echocardiographie et une épreuve à l'effort chez 192. Toutes les valeurs ont été exprimées en moyennes et en pourcentages. Au moment du suivi, 90% des patients étaient asymptomatiques deux jours après leur opération avec des constantes de monitorage cardiaque normales. L'ECG de base et de contrôle ont mis en évidence un infarctus du myocarde chez 9,1% des patients. L'ECG de base a également montré des signes de péricardite chez 27% des patients et des modifications de la repolarisation chez 35,2%. Ces modifications de repolarisation se sont normalisées 1 à 6 mois après le traumatisme. En ce qui concerne les résultats des épreuves d'effort, 100% des patients avaient un résultat fonctionnel «état-I» et 56% avaient un échocardiogramme normal. En conclusion, les données épidémiologiques des plaies du cœur sont identiques à celles des traumatismes en général. L'ECG est utile dans la

période post-chirurgicale pour le diagnostic d'infarctus post-traumatique. De même, l'épreuve d'effort est utile chez les patients ayant eu un infarctus du myocarde alors que l'échocardiographie doit être réalisée chez tout patient ayant eu un infarctus du myocarde ou tout autre symptôme suggérant une anomalie cardiaque anatomique ou fonctionnelle.

Resumen

Se realizó un estudio descriptivo y prospectivo a fin de analizar la evolución de pacientes que sobrevivieron un trauma cardíaco penetrante. Se evaluaron 642 pacientes al comienzo, y luego, al año de seguimiento, se practicaron exámenes físicos, electrocardiografía, ecocardiografía y prueba de estrés en 192 de ellos. El procesamiento de los datos incluyó el cálculo de los valores promedio y los porcentajes. En el seguimiento se observó que 90% de los pacientes aparecían asintomáticos a los dos días postoperatorios, exhibiendo monitoría cardiaca normal; en los ECG de base y de control se demostró infarto miocárdico en 9,1% de los pacientes. El ECG de base también mostró pericarditis en 27% de los pacientes y cambios de repolarización en 35,2%. Este último hallazgo se normalizó entre 1 y 6 meses luego del trauma. El 100% de los pacientes exhibió una prueba de estrés clase funcional l y 56% exhibieron un ecocardiograma normal. En conclusión, el comportamiento epidemiológico del trauma cardiaco es idéntico al del trauma general. El ECG es de utilidad en el período postoperatorio para el diagnóstico del infarto miocárdico de origen traumático. Así mismo, lo son la prueba de estrés en pacientes con infarto miocárdico y la ecocardiografía en presencia de infarto miocárdico o de cualquier síntoma que sugiera alteraciones anatómicas o funcionales del corazón.

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