

The mechanical complications of acute myocardial infarction: echocardiographic visualizations

Akut miyokardiyal infarktın mekanik komplikasyonları: Ekokardiyografik görüntülemeler

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Background: Majority of the clinical experiences, especially by echocardiographic evaluations, was merely limited to sporadic cases as reported in the literature.

Methods: Between January 2004 and July 2008, 19 patients (9 males, 10 females; mean age 71.7±8.2 years; range 56 to 91 years) were referred to our clinic for surgical treatment of the mechanical complications of acute myocardial infarction. Eight (42.1%) patients had free wall rupture (FWR). One of them developed FWR after completion of anesthesia before being scrubbed on the operating table for a scheduled coronary artery bypass grafting surgery. Five (26.3%) had papillary muscle rupture, five (26.3%) had ventricular septal rupture (VSR), and one (5.3%) had double structure rupture (VSR + FWR).

Results: Seven of the eight FWR patients had their echocardiographic information archived. At the onset of these mechanical complications, six (85.7%) patients presented with pericardial tamponade on echocardiography, and one (14.3%) with moderate pericardial effusion. Posterior mitral leaflet flail was noted in all four patients with a posteromedial papillary muscle rupture on echocardiography. The flow across the flail mitral valve was mosaic but not eccentric in two patients, and neither mosaic nor eccentric in two patients. Large erratic movement of the ruptured papillary muscle and the swirling papillary muscle head could be observed in the left atrium in the patient with a complete ruptured papillary muscle. Anterior mitral leaflet flail with eccentric mosaic flow was noted on echocardiography in the only patient with an anterolateral papillary muscle rupture. Four (80%) of the five ventricular septal ruptures were located in the anterior wall, and one (20%) was anterolateral. The defect and the shunt flow were observed in all five (100%) patients on echocardiography. Two of them (40%) had moderate pericardial effusion.

Conclusion: Echocardiography is a reliable diagnostic tool for diagnosing the mechanical complications of acute myocardial infarction in terms of the location and dimension, and is essential for the decision-making on the treatment strategy and postoperative follow-up.

Key words: Acute myocardial infarction; echocardiography; mechanical complications.

Amaç: Özellikle ekokardiyografik değerlendirmelerle elde edilenler olmak üzere, literatürde bildirilen klinik deneyimlerin çoğunluğu sporadik olgularla sınırlıdır.

Çalışma planı: Ocak 2004 ile Temmuz 2008 arasında 19 hasta (9 erkek, 10 kadın; ort. yaş 71.7±8.2 yıl; dağılım 56-91 yıl) akut miyokard infarktüsünün mekanik komplikasyonlarının cerrahi tedavisi için kliniğimize sevk edildi. Sekiz hastada (%42.1) serbest duvar rüptürü (SDR) var idi. Bu hastalardan birinde SDR, planlanmış bir koroner arter bypass greftleme ameliyatında anestezinin ardından ameliyat masasında boyama işlemi gerçekleştirilmeden önce gelişti. Hastaların beşinde (%26.3) papiller kas rüptürü, beşinde (%26.3) ventriküler septal rüptür (VSR) ve birinde (%5.3) çift yapı rüptürü (VSR + SDR) var idi.

Bulgular: Sekiz SDR hastasının yedisinin ekokardiyografik verileri toplandı. Bu mekanik komplikasyonların başlangıcında, ekokardiyografide altı hastada (%85.7) perikardiyal tamponad, bir hastada (%14.3) ise orta dereceli perikardiyal efüzyon görüldü. Ekokardiyografide posteromediyal papiller kas rüptürü olan dört hastanın tümünde posteriyor mitral yaprakçık sallanması tespit edildi. Sallanan mitral kapaktan geçen kan akışı iki hastada mozaik nitelikte idi ancak eksantrik değildi, iki hastada ise ne mozaik ne de eksantrik nitelikte idi. Tam papiller kas rüptürü olan hastanın sol atriyumunda rüptüre olmuş papiller kasın büyük ve düzensiz, papiller kas başının ise helezonik hareketler sergilediği görülebilmekte idi. Yalnızca bir anterolateral papiller kas rüptürü olan tek hastanın ekokardiyografisinde, eksantrik mozaik akışla birlikte anterior mitral yaprakçık sallanması tespit edildi. Beş ventriküler septal rüptürün dördü (%80) anterior duvarda idi, biri (%20) ise anterolateralde idi. Defekt ve şant akımı ekokardiyografide beş hastanın tümünde (%100) gözlemlendi. Bu hastaların ikisinde (%40) orta dereceli perikardiyal efüzyon vardı.

Sonuç: Ekokardiyografi, akut miyokard infarktüsünün mekanik komplikasyonlarının konum ve boyut açısından tanınabilmesi için güvenilir bir tanı aracıdır tedavi stratejisinin belirlenmesinde ve ameliyat sonrası takip konusunda çok büyük öneme sahiptir.

Anahtar sözcükler: Akut miyokardiyal infarkt; ekokardiyografi; mekanik komplikasyon.

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Mechanical complications of acute myocardial infarction are infrequent but lethal. They mainly involve the ventricular free wall, interventricular septum, papillary muscle, or combinations thereof,^[1] representing 2.3% of acute myocardial infarction, and 15.7% of hospital mortality.^[2] The patient's survival depends on preoperative hemodynamic status and 77% of the patients presenting preoperative cardiogenic shock died.^[3] The mechanical complications of acute myocardial infarction are such a less frequent pathology that the majority of clinical experiences, especially by echocardiographic evaluation, were merely limited to sporadic cases as reported in the literature.

PATIENTS AND METHODS

Between January 2004 and July 2008, 19 patients (9 males, 10 females; mean age 71.7±8.2 years; range 56 to 91 years) were referred to our clinic for surgical treatment of the mechanical complications of acute myocardial infarction. Eight (42.1%) patients had free wall rupture (FWR). One of them developed FWR after completion of anesthesia before being scrubbed on the operating table for a scheduled coronary artery bypass grafting (CABG) surgery. Five (26.3%) had papillary muscle rupture, five (26.3%) had ventricular septal rupture (VSR), and one (5.3%) had double structure rupture (VSR + FWR). Their demographic data were listed in table 1. The echocardiography films archived in the "Horizon Cardiology Web" and relevant information recorded in the "Doctor's Record" database of our clinic constitute the basis of the present study.

RESULTS

Seven of the eight FWR patients had their echocardiographic information archived. At the onset of mechanical complications of acute myocardial infarction, six (85.7%) patients presented with pericardial tamponade on echocardiography (Fig. 1), and one (14.3%) with moderate pericardial effusion. A swirling flow disturbance was noted in one of the patients with pericardial tamponade (Fig. 2). At operation, FWR was identified as a blow-out type in four (50%) patients with a tear ranging from 1-5 cm in diameter, and an oozing type in four (50%) patients. The FWR was a multiple blow-out type in one patient. The locations of the FWR were posterior in four (50%), anterior in two (25%), posterolateral in one (12.5%), and inferoposterior in one (12.5%), respectively. Four (50%) patients died of cardiogenic shock during the perioperative period (Table 2).

Five patients developed papillary muscle rupture after myocardial infarction. The rupture was partial

Table 1. Clinical features of 19 patients with mechanical complications of acute myocardial infarction

Variable	Result		
	n	%	Range Mean±SD
Age			56-91 71.7±8.2
Gender			
Male	9		
Female	10		
Infarct region			
Anterior	7	36.8	
Inferoposterior	5	26.3	
Apical	1	5.3	
Posterolateral	1	5.3	
Inferior	1	5.3	
Lateral	1	5.3	
Not available	3	15.8	
Culprit coronary artery			
LAD artery	8	42.1	
LAD artery + RCA	3	15.8	
LAD artery + Cx artery	2	10.5	
Circumflex artery	2	10.5	
Posterolateral artery	1	5.3	
Not available	3	15.8	
Myocardial rupture			
FWR	8	42.1	
PMR	5	26.3	
VSR	5	26.3	
Double structure VSR + FWR	1	5.3	
Duration of diseased course before referral			
<1 day	13	68.4	
1 day	3	15.8	
3-8 days	3	15.8	
Clinical manifestation			
Pulmonary edema	1	5.3	
Cardiogenic shock	4	21.1	
Cardiac tamponade	6	31.6	
Hypertension	10	52.6	
Hyperlipidemia	9	47.4	
Diabetes	4	21.1	
Obesity	4	21.1	
Inotropic support	19	100	
Intraaortic balloon pumping	5	26.3	
Mechanical ventilation	2	10.5	
Operation			
FWR patch repair	3	15.8	
FWR patch + glue	6	31.6	
Mitral valve replacement	2	10.5	
MVR + CABG	3	15.8	
VSR patch repair	3	15.8	
VSR patch repair + CABG	2	10.5	
VSR patch repair + PCI	1	5.3	
Complication			
Post-pericardiectomy syndrome	2	10.5	
Residual shunt after VSR repair	1	5.3	
Clinical outcome			
Survival	11	57.9	
Early mortality	7	36.8	
Intermediate mortality	1	5.3	

LAD: Left anterior descending; RCA: Right coronary artery; Cx: Circumflex; FWR: Free wall rupture; PMR: Papillary muscle rupture; VSR: Ventricular septal rupture; MVR: Mitral valve replacement; CABG: Coronary artery bypass grafting; PCI: Percutaneous coronary intervention.

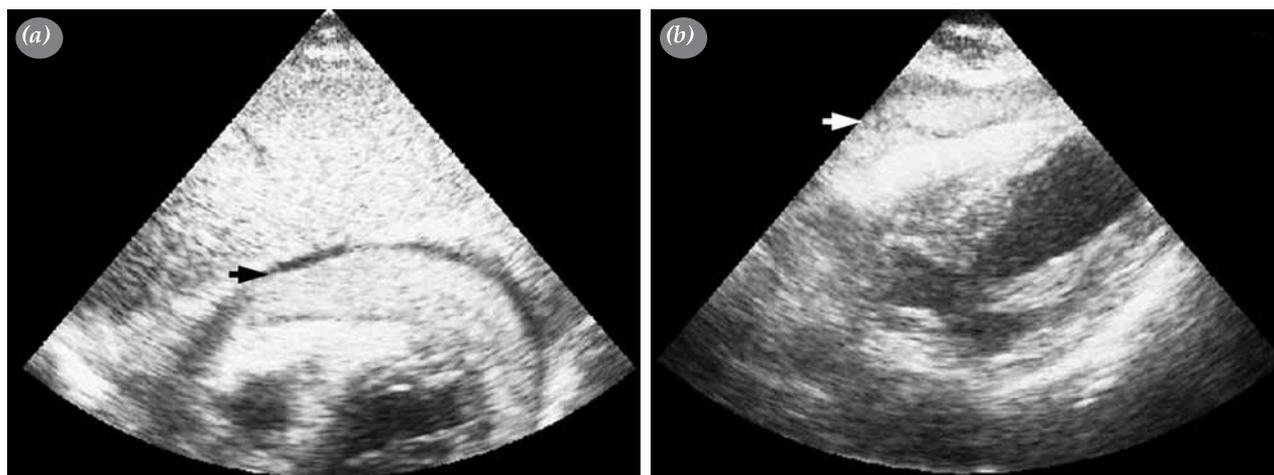


Fig. 1. Transthoracic echocardiography showing pericardial tamponade (arrow), in (a) oozing type; and (b) 3 cm blow-out type of free wall rupture.

in four (one of them had sub-total rupture) (80%), and was complete in one (20%) patient. The posteromedial papillary muscle was involved in four (80%), and the anterolateral in one (20%) patient, respectively. Posterior mitral leaflet flail was noted on echocardiography in all four patients with one posteromedial papillary muscle rupture (Fig. 3). The flow across the flail mitral valve was mosaic but not eccentric in two patients, and neither mosaic nor eccentric in two patients. Large erratic movement of the ruptured papillary muscle and the swirling papillary muscle head could be observed in the left atrium in the patient with a complete ruptured papillary muscle (Fig. 4). Anterior mitral leaflet flail with eccentric mosaic flow was noted on echocardiography in the only patient with an anterolateral papillary muscle rupture (Fig. 5). All five patients had a mitral valve replacement, as the ruptured papillary muscle was not amenable to repair.

Three of them had simultaneous CABG to the culprit coronary arteries. All five patients survived the operation (Table 2).

Five patients had ventricular septal rupture. Four (80%) were located in the anterior wall, and one (20%) was anterolateral. The defect and the shunt flow were observed in all five (100%) patients echocardiographically (Fig. 6). Two of them (40%) had moderate pericardial effusion. The diagnoses were identified by operation, illustrating the defect ranging from 0.6 to 1.9 cm in diameter. Patch repair was conducted in all five patients. One patient had successful percutaneous coronary intervention prior to surgical repair, and simultaneous CABG was performed in two patients. Two patients survived the operation, one of them was doing well and one developed residual shunt measuring 0.8 cm, in whom the intact patch and



Fig. 2. A swirling flow disturbance was noted in the left ventricle in a patient with pericardial tamponade. LV: Left ventricle.



Fig. 3. Posterior mitral leaflet flail was noted in the patient with a posteromedial papillary muscle rupture.

Table 2. Mechanical complications of acute myocardial infarction and their prognoses

Case	Age/ gender	Site of rupture	Echocardiographic finding	Operative finding	Operation	Result
<i>Free wall rupture</i>						
1	79/F	Posterior		Blow-out, multiple	Patch repair	Died
2	62/M	Posterior	Pericardial effusion	Blow-out, 4-5 cm	Pach glue repair	Survived
3	71/M	Posterior	Tamponade	Oozing	Patch glue repair	Survived
4	78/F	Anterior	Tamponade	Blow-out, 3 cm	Patch glue repair	Died
5	63/F	Anterior	Tamponade	Oozing	Patch glue repair	Post-pericardiectomy, survived
6	65/F	Posterolateral	Tamponade	Oozing	Patch glue repair	Survived
7	73/F	Posterior	Tamponade	Oozing	Patch repair	Died
8	71/F	Inferoosterior	Tamponade	Blow-out, 1 cm	Patch repair	Died
<i>Papillary muscle rupture</i>						
1	78/M		PML flail	Posteromedial	MVR	Survived
2	66/F		PML flail	Posteromedial, sub-total	MVR	Survived
3	76/M	Apical	PML flail	Posteromedial	MVR + CABG	Survived
4	56/M	Posteroinferior	AML flail, eccentric mosaic jet	Anterolateral	MVR + CABG	Survived
5	70/M		PML flail	posteromedial	MVR + CABG	Survived
<i>Ventricular septal rupture</i>						
1	56/M	Anterior	Defect + shunt	Posteroinferior, 1.9 cm	Patch repair + CABG	Post-pericardiectomy, residual shunt, survived
2	83/F	Anterolateral	Defect + shunt + pericardial effusion	Apical, 1.5x0.5 cm	Patch + stripe repair + CABG	Survived
3	91/M	Anterior	Defect + shunt + pericardial effusion	Apical, small	PCI + patch repair	Died
4	73/F	Anterior	Defect + shunt	Anterior, 1cm	Patch repair	Died
5	71/F	Anterior	Defect + shunt	Anterior, 0.6 cm	Patch repair	Died
<i>Double structural rupture</i>						
1	71/F	Lateral		Apical ventricular septal rupture, lateral free wall rupture	Ventricular septal rupture patch repair, free wall rupture patch + glue repair	Died

PML: Posterior mitral leaflet; MVR: Mitral valve replacement; CABG: Coronary artery bypass grafting; AML: Anterior mitral leaflet; PCI: Percutaneous coronary intervention;

residual shunt were visualized by echocardiography postoperatively in two survivors of VSR patients. The remaining three patients died early postoperatively (Table 2).

The only patient with double structural rupture (apical VSR + lateral FWR) who underwent a VSR patch repair and a FWR patch glue repair died of cardiogenic shock on the first postoperative day.

Seven survivors had postoperative echocardiography follow-up at 12.8±16.7 (range 1-48) months. Their left ventricular ejection fraction was 44.7±22.3% (range 20-83%), left ventricular diastolic dimension 4.80±0.73 cm (range 4.2-6.39 cm), systolic dimension 3.40±1.17 cm (range 2.45-5.83 cm), and left ventricular posterior wall dimension 1.01 ± 0.12 cm (range 0.9-1.18 cm), respectively.

DISCUSSION

The mechanical complications of acute myocardial infarction include four types of pathological conditions: FWR, papillary muscle rupture, VSR, and double structural rupture.^[4]

Free wall rupture may involve the anteroseptal, anteroseptal, inferolateral, and inferior left ventricular walls, respectively.^[5] Iemura et al.^[6] reported 13/17 (76.5%) patients with FWR were diagnosed by echocardiography, and the diagnoses were established by pericardial puncture, catheterization and operation in the remaining patients. The main echocardiographic findings in patients with FWR are pericardial effusion^[7] tamponade^[8] or periepicardial hematoma.^[9] Cardiac compression and tears of the ventricular wall may be visualized by echocardiography except for hypokinesis.^[10,11]

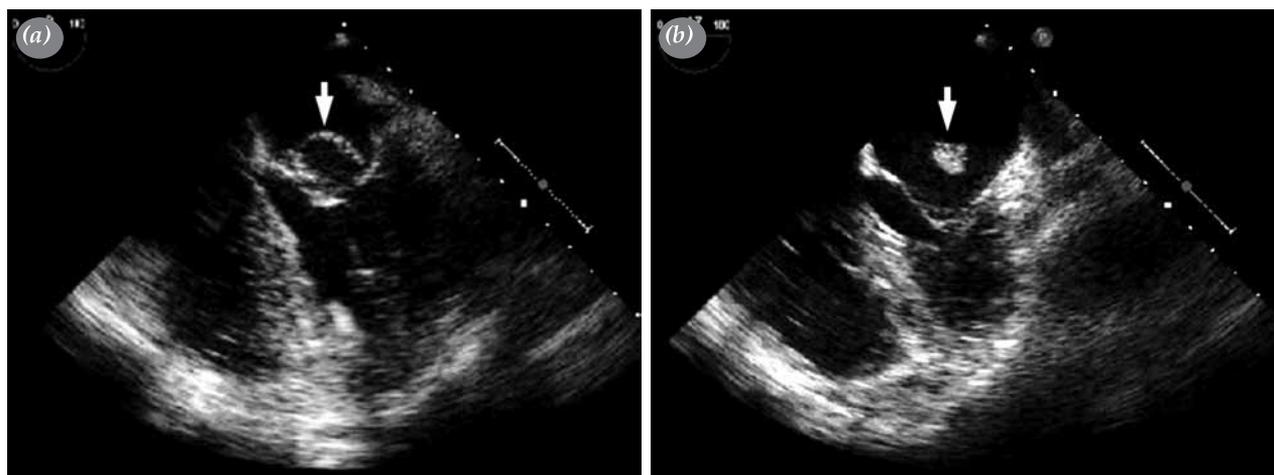


Fig. 4. (a) Large erratic movement of the ruptured papillary muscle and systolic leaflet buckling (arrow), and (b) the swirling papillary muscle head (arrow) could be observed in the left atrium in the patient with a complete ruptured papillary muscle.

Cardiogenic shock and pulmonary edema in patients with first-onset acute myocardial infarction is usually suggestive of papillary muscle rupture. In such cases, mitral leaflet flail with massive mitral regurgitant flow or swinging papillary muscle with large-amplitude erratic motion could be noted.^[12,13] The papillary muscle head and mitral chordae may get tangled shortly after development of the rupture. However, in 35% of the patients, a sign of left atrial prolapsing papillary muscle was absent.^[14]

In patients with VSR, visualization of the septal defect may be sometimes difficult, and a severe hypokinesis in the middle and distal portion septum may be visible instead.^[15] Color Doppler echocardiography may initially show a small ventricular septal defect as shunt flow in turbulent nature across the ventricular septum. The size of the rupture may increase with time.^[16]

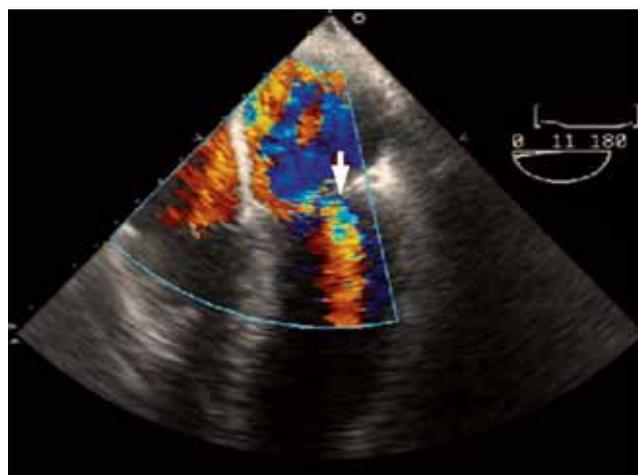


Fig. 5. Anterior mitral leaflet flail and eccentric mosaic flow jet could be observed on echocardiography in the patient with an anterolateral papillary muscle rupture.

Combined FWR and VSR is the most common type of double structural rupture with an incidence of about 0.3% of patients with an acute myocardial infarction.^[4] Mann and Roberts^[17] classified double structural rupture as two types: true and junctional. In the true type, the tears were present separately in the ventricular septum and free wall; while in the junctional, tears of both structures incorporated together. Rentoukas et al.^[18] reported a case of double structural rupture diagnosed by echocardiography where VSR and apical FWR with pseudoaneurysm formation were demonstrated. Our patient with double structural rupture was typically a true type according Mann's classification.

In this report, we note that 85.7% of patients with FWR presented with tamponade, and 14.3% had pericardial effusion on echocardiography. Occasionally, flow disturbances in the left ventricular cavity caused by FWR could be visible. All the patients with papillary muscle rupture showed flail mitral leaflet with absence of eccentric jet flow behind the mitral valve in four of them. The defect and shunt flow across the ventricular septum could be visible in all patients with VSR. In a word, direct signs of rupture can only be seen occasionally, as the myocardial tear is often irregular and tortuous, and may be covered by thrombi or blood clot.^[7] The indirect echocardiographic signs, including tamponade, pericardial effusion, intrapericardial echoes, or ventricular wall compression, may be helpful for the diagnosis of the mechanical complications in patients with acute myocardial infarction.^[7] Although magnetic resonance imaging, catheterization and computed tomographic scan may also contribute to the diagnosis of an impending myocardial rupture, they are more likely to be applicable when the patients with a rupture are hemodynamically stable.^[19] However, such patients



Fig. 6. (a) The ventricular septal defect, and (b) the shunt flow, were observed in the patient with ventricular septal rupture on four-chamber view of transesophageal echocardiography.

are usually circulatory-collapsed presenting with cardiogenic shock or pulmonary edema, and thus echocardiography could not be overlooked in such occasions.

In conclusion, mechanical complications of acute myocardial infarction are infrequent but lethal. Early surgery may rescue some critically ill patients. Echocardiography is a reliable diagnostic tool for diagnosing these mechanical complications in terms of the location and dimension, and is essential for decision-making on the treatment strategy and postoperative follow-up.

Declaration of conflicting interests

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REFERENCES

1. Rachko M, Safi AM, Chadow HL, Lyon AF, Gunsburg D, Rafii SE. Ventricular septal defect and left ventricular aneurysm: late occurrence as complications of an acute myocardial infarction. *Jpn Heart J* 2000;41:773-9.
2. Shapira I, Isakov A, Burke M, Almog C. Cardiac rupture in patients with acute myocardial infarction. *Chest* 1987; 92:219-23.
3. Feneley MP, Chang VP, O'Rourke MF. Myocardial rupture after acute myocardial infarction. Ten year review. *Br Heart J* 1983;49:550-6.
4. Tanaka K, Sato N, Yasutake M, Takeda S, Takano T, Ochi M, et al. Clinicopathological characteristics of 10 patients with rupture of both ventricular free wall and septum (double rupture) after acute myocardial infarction. *J Nippon Med Sch* 2003;70:21-7.

5. Vlodayer Z, Edwards JE. Rupture of ventricular septum or papillary muscle complicating myocardial infarction. *Circulation* 1977;55:815-22.
6. Iemura J, Oku H, Otaki M, Kitayama H, Inoue T, Kaneda T. Surgical strategy for left ventricular free wall rupture after acute myocardial infarction. *Ann Thorac Surg* 2001;71:201-4.
7. Raposo L, Andrade MJ, Ferreira J, Aguiar C, Couto R, Abecasis M, et al. Subacute left ventricle free wall rupture after acute myocardial infarction: awareness of the clinical signs and early use of echocardiography may be life-saving. *Cardiovasc Ultrasound* 2006;4:46.
8. Canovas SJ, Lim E, Dalmau MJ, Bueno M, Buendía J, Hornero F, et al. Midterm clinical and echocardiographic results with patch glue repair of left ventricular free wall rupture. *Circulation* 2003;108 Suppl 1:II237-40.
9. Kudo M, Misumi T, Koizumi K, Shin H. A surgical case of ventricular septal perforation after repairing left ventricular free wall rupture. *Ann Thorac Cardiovasc Surg* 2005; 11:121-4.
10. Hahn PS, Donohue T, Ghantous A. Early left ventricular free wall rupture complicating successful reperfusion of acute myocardial infarction. *Tex Heart Inst J* 2006;33:264-5.
11. Nishizaki K, Seki T, Fujii A, Nishida Y, Funabiki M, Morikawa Y. Sutureless patch repair for small blowout rupture of the left ventricle after myocardial infarction. *Jpn J Thorac Cardiovasc Surg* 2004;52:268-71.
12. Nishimura RA, Gersh BJ, Schaff HV. The case for an aggressive surgical approach to papillary muscle rupture following myocardial infarction: "From paradise lost to paradise regained". *Heart* 2000;83:611-3.
13. Wada H, Yasu T, Murata S, Ohta M, Kubo N, Fujii M, et al. Rupture of the anterolateral papillary muscle caused by a single diagonal branch obstruction. *Circ J* 2002;66:872-3.
14. Whiting PC, Morgan-Hughes NJ. Transesophageal echocardiographic findings in papillary muscle rupture. *Anesth Analg* 2005;101:1292-3.
15. Bindea D, Olariu C, Papp S, Oprita S, Mot S, Scridon T. Surgical treatment of post infarction ventricular septal rupture and left ventricular aneurysm without aortic cross

- clamping. *Timisoara Med J* 2009;59:91-2.
16. Kannan D. Ventricular septal rupture - three year follow-up. *E-chocardiography Journal*. Available from: <http://rwjms1.umdj.edu/shindler/vsr3yr.html>
 17. Mann JM, Roberts WC. Fatal rupture of both left ventricular free wall and ventricular septum (double rupture) during acute myocardial infarction: analysis of seven patients studied at necropsy. *Am J Cardiol* 1987;60:722-4.
 18. Rentoukas EI, Lazaros GA, Kaoukis AP, Matsakas EP. Double rupture of interventricular septum and free wall of the left ventricle, as a mechanical complication of acute myocardial infarction: a case report. *J Med Case Reports* 2008;2:85.
 19. Vogel-Claussen J, Skrok J, Fishman EK, Lima JA, Shah AS, Bluemke DA. Cardiac CT and MRI guide surgery in impending left ventricular rupture after acute myocardial infarction. *J Cardiothorac Surg* 2009;4:42.