Keynote Lecture Series

Sutureless repair of subacute left ventricular free wall rupture

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Left ventricular free wall rupture (LVFWR) is one of the most lethal heart conditions where mortality rates reach 40% intraoperatively and 80% in hospital. A few days after the acute event, the rupture becomes subacute, and surgery is indicated to repair the frail myocardium. Despite the lack of strong evidence to support the efficacy of sutureless repair of subacute LVFWR in the literature, this technique has recently been gaining popularity with acceptable success rates. In this article, we present two techniques to repair the subacute LVFWR without using sutures: the direct glued-hemostatic patch technique and the glued pericardial patch technique. In both techniques, the healthy myocardium surrounding the infarcted zone is recruited, together with hemostatic materials, to seal the rupture. Moreover, we describe the clinical presentation of the acute and subacute LVFWR, peri-operative management, together with intra-operative tips and the advantages and disadvantages of each material used in these operations.

Keywords: Left ventricular free wall rupture (LVFWR); sutureless repair; free wall rupture; myocardial infarction

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Introduction

Subacute cardiac rupture is a fatal complication of myocardial infarction (MI). Despite increasing knowledge about this entity, there are no clear guidelines regarding its optimal management. The current practice is based on cases, case series reports, reviews and experts' opinions.

Left ventricular free wall rupture (LVFWR) is one of the three main complications of MI where mortality rate reaches 40% intraoperatively (1) and 80% in-hospital (2). The mortality rate is correlated with the clinical presentation, where abrupt rupture and bleeding are associated with higher mortality while the oozing type rupture is less fatal.

Two main operative techniques are described when operation is indicated: sutured and sutureless techniques. In subacute LVFWR, sutureless repair has been described as a reliable treatment option in several reports (3,4), where the lateral wall rupture is sealed with a patch and glue. There are controversies regarding when the sutureless repair technique is appropriate, and it seems that milder types of rupture without active bleeding may benefit from this approach (5).

In this paper, we summarize the sutureless repair of LVFWR including sub-types of the technique according to our experience.

Subacute LVFWR

The term subacute LVFWR is poorly defined since it is not clearly distinguished from the acute condition. After the trigger event, some patients will quickly decompensate and die, some will survive the acute event and will make it to surgery, and some will be treated conservatively and may present later with ventricular pseudoaneurysms.

A subacute presentation of LVFWR should include both (I) survival of the initial rupture (the acute phase) and (II) the later onset, or continuity of symptoms after the acute phase. The acute phase starts when the rupture occurs, usually within a few hours or days of the acute coronary syndrome

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(ACS). Some patients, however, do not survive the initial rupture. The presentation of LVFWR may indicate the type of rupture; acute presentation with rapid hemodynamic deterioration may indicate true total myocardial rupture, whereas subacute presentation with milder symptoms may indicate partial myocardial thickness rupture or dissection of layers within the ventricle with the oozing type of rupture.

Regardless of the LVFWR type and presentation, if the patient maintains vital signs 48 hours after the rupture, it is considered subacute.

Technical aspects—pre-operative considerations

Clinical presentation

Clinical presentation may vary between the different types of LVFWR. In the acute type, rapidly progression into cardiogenic shock, due to tamponade, is the most common presentation. It is often associated with electromechanical dissociation and sudden death. During the acute phase, chest pain, electrocardiogram (ECG) changes and hypertension may be noted, and may resemble a second ACS.

The subacute phase occurs two to five days after the initial rupture and is usually associated with continuous clinical presentation similar to the acute type, including chest pain and possible ECG changes. Hypotension may be noticed at this phase due to evolving tamponade.

Pre-operative treatment

The myocardium is usually very fragile during the subacute phase, secondary to necrotic tissue with clot formation that is not fully organized, and soft adhesions. Hence, the possibility of full rupture, blood extravasation and eventually rapid tamponade is high. Reducing afterload and blood pressure are the main goals at this stage.

To achieve this goal, medical treatment with angiotensin II receptor blockers, angiotensin-converting enzyme inhibitors (ACEIs), calcium channel blockers, and diuretics are widely used, together with beta-blockers to stabilize dp/dt (derivative of pressure over time) and left ventricular wall stress.

According to our experience, benzodiazepines are also recommended to relieve high blood pressure associated with stress.

Operative techniques

Perioperative LVFWR mortality is high. The myocardium is frail and there is tissue necrosis surrounding the infarcted zone. As a result, sutures tend to cut through the tissue, become loose, and increase the damage. With this negative experience, and with the aim to reduce intraoperative mortality, the sutureless approach was attempted and was proved to be successful in appropriate patients. Patches, surgical glue and sealants facilitated this approach (6).

In the past 20 years, several study groups have published their experience in treating LVFWR using glue material and patches while avoiding the classic surgical treatment. However, the published data are mostly retrospective, single center experiences and lack proper long-term follow-up.

The aim of sutureless repair is to achieve maximum left ventricular free wall strength using the healthy myocardium surrounding the infarcted zone as a support. By doing so, the use of sutures that may damage the frail tissue becomes unnecessary.

Direct glued-hemostatic patch technique

This is the most commonly used technique. It is usually feasible in a relatively small, uncomplicated rupture. After opening the pericardium, the surgeon estimates the size of the infarcted lesion and the bleeding rate. It is crucial to achieve a dry working surface to obtain maximal efficacy of the glue during the procedure.

After achieving a dry surface, glue is spread over the infarcted zone including one to two circumferential centimeters of healthy myocardium. A large hemostatic patch is immediately attached to the glued area, covering the infarcted zone and the healthy myocardium surrounding it, before the glue dries out. It is also possible to apply the glue directly on the hemostatic patch before attaching it to the myocardium. Gentle pressure should be applied on the whole area for approximately one minute for the glued-patch complex to stabilize. The process may be repeated to get wider margins or to strengthen the complex. Since it is a subacute condition, it is important to notice that in some cases, there is no active bleeding. Instead, we might observe the scar on the infarcted myocardial zone, or an intra-mural organized hematoma.

Glued pericardial patch technique

This technique is attempted in more complex LVFWR where a glued hemostatic patch will not be effective due to a curvy infarcted zone or relatively wet area. The bleeding rate in these situations is higher and continuous pressure

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on the myocardium is usually needed during the procedure to minimize bleeding. To obtain continuous pressure, the left pleural space is opened and pressure is applied from the pleural side of the pericardium on the heart. After achieving satisfactory bleeding control, hemostatic material is injected between the infarcted zone of the heart and the pericardium. Again, the glued pericardial patch should cover a wider area than the infarcted zone to achieve enough strength. In some cases where oozing persists, the injection process should be repeated to obtain a dry and stable glued pericardial patch.

Materials used

Hemostatic patches

There are several hemostatic patches used in order to seal and strengthen the myocardial damaged area during the sutureless repair of LVFWR.

The most commonly used patch is TachoSil (Baxter, Illinois, USA). TachoSil is a medium size (5 cm × 10 cm) sealant matrix that is coated with active human fibrinogen and thrombin. The active side should be wettened, before attaching it to the myocardium with gentle pressure applied on it for two minutes using a wet gauze. It is relatively cheap, feasible, and ready to use. Several pieces may be required to achieve the desired effect. According to our experience, it is advised to use other types of patches, for example, Teflon felt, in combination with Tachosil to achieve maximal strength of the hemostatic complex.

Pericardial patch is also in widespread use. It covers a large myocardial area due to its larger size and it is ready to use. It is more expensive, and its smooth surface may be slippery and potentially more challenging to apply.

Dacron patch is not in routine use during sutureless repair in our practice. However, it is used by others and its rough surface may be an advantage. Dacron patch is expensive and not ready to use. It is usually tubular and needs to be adjusted and shaped before its application.

Teflon patch is another type of patch that can be used. It is not in routine use in cardiovascular surgery. Teflon felt is a strong material, pliable, and has a "hairy" surface that may better hold the glue.

Hemostatic glues

Bioglue is the most commonly used hemostatic glue during sutureless repair of LVFWR. It is a strong sealant, easy to apply, and includes distal tip extenders to reach the distal operating zones efficiently. The surgical team should be prepared to use the hemostatic patch immediately after applying the Bioglue because of its fast activation time (3–5 seconds).

Depending on the surgeon's preference, Tisseel, Coseal, Surgiseal and other similar products can also be used during these procedures. They are easy to use, immediately available and include distal tip extenders for accurate spreading. They are not as strong as Bioglue and are usually more expensive.

Cyanoacrylate glues (Dermabond, Histoacryl) are topical skin adhesives that are used primarily for superficial skin wound repair. In our experience, we have used it successfully in a very complicated LVFWR case where all other agents failed. Several ampules are needed for one case since it is contained in small ampules (less than 1 mL), which makes it harder to apply. It takes three minutes to completely dry out. In this specific case, we applied more than ten ampules of Dermabond simultaneously on the hemostatic patch before attaching it to the myocardium.

Cardio-pulmonary bypass (CPB)

The use of CPB usually depends on the patient's hemodynamic stability and the surgeon's experience in subacute LVFWR operations. According to our experience, it is advised to prepare the femoral vessels for rapid connection to CPB even in stable cases, to be able to respond quickly to rapid deterioration during pericardial opening. It is clear that operating on an unloaded heart is easier and safer, however anticoagulation during CPB may increase bleeding and be counter-effective. It is our belief that CPB should not be used routinely, rather, it should be spared for cases where the surgeon believes it is necessary and advantageous. This approach is supported by others (5,7).

Post-operative management

The immediate post-operative management is crucial to prevent re-rupture and death. This is true to all types of repairs since the myocardium is frail. The sutureless type requires extra attention due to the simplicity of the glued-patch complex and the fact that it is not enforced with sutures. This repair is very sensitive to high pressures, and rapid pressure changes may induce re-rupture.

Afterload reduction is the main goal of treatment for

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several days after the operation. Relatively low blood pressure is recommended with the aim to maintain the lowest mean arterial pressure that ensures proper organ perfusion. We rely on urine output as a measure of appropriate perfusion, as long as the kidneys are functioning appropriately. We continue to reduce blood pressure as long as urine output is within the normal range. When urine output is not a reliable measure of perfusion, mean arterial pressure of 60 mmHg is our target with clinical assessment of the patient's perfusion status (warm periphery, lactate levels, etc.).

Afterload reduction can be achieved with bed rest, medication, and intra-aortic balloon pump (IABP).

Perioperative prolonged bed rest is recommended after LVFWR to reduce effort and metabolic needs that otherwise may lead to elevated blood pressure. Some prospective evidence, although not randomized, suggests increased survival in patients with prolonged bed rest after LVFWR post-MI (8).

Medical therapy is a major component in controlling blood pressure and preventing re-rupture (9). As already mentioned, reducing blood pressure and afterload is crucial after sutureless repair of LVFWR. Beta-blockers are widely used to reduce cardiac contractility, free wall stress and oxygen consumption. They are usually prescribed as soon as the patient stabilizes hemodynamically after the MI and are continued for life in most cases. In fact, some authors have demonstrated that beta-blockers were associated with lower incidence of death during the first 48 hours after rupture (10). Nitrates and ACEIs are also important agents to reduce vascular resistance and decrease afterload. Although there are no randomized clinical trials that demonstrate the positive effect of these drugs after LVFWR, they are widely used after rupture to reduce blood pressure. Anti-aggregants and anti-coagulants are usually indicated in patients with underlying coronary disease, previous MI and arrhythmia, but in patients with fresh LVFWR repair, these medications increase the risk of bleeding. The use of these agents should be individualized after careful risk-benefit assessment.

Intra-aortic ballon pump is used in cases of LVFWR to improve hemodynamics and coronary perfusion after MI. It is also indicated in other cases where afterload reduction is needed, such as other types of cardiac rupture and/or acute mitral regurgitation after MI. Its use in LVFWR has not been investigated in depth, and as such opinions are divided on whether it should be used (8,11).

Conclusions

The mortality rate in subacute LVFWR mortality rate remains high although several techniques have been invented to repair the subacute rupture. The sutureless repair technique has been gaining popularity. Using the right materials during sutureless repair, together with close perioperative monitoring and management, may prevent complications. Further clinical investigations in the form of randomized trials are needed to demonstrate the efficiency of the sutureless repair of LVFWR.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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