Successful use of a military haemostatic agent in patients undergoing extracorporeal circulatory assistance and delayed sternal closure

Luigi Muzzi*, Giulio Tommasino, Enrico Tucci and Eugenio Neri*

Unità Operativa di Chirurgia del Cuore e Grossi Vasi, Azienda Ospedaliera Universitaria Senese, Policlinico ‘Santa Maria alle Scotte’, Siena, Italy

* Corresponding author. Tel: +39-577-585283; fax: +39-577-586168; e-mail: luigimuzzi@hotmail.com (L. Muzzi)/euxneri@tin.it (E. Neri).

Received 4 November 2011; received in revised form 4 January 2012; accepted 10 January 2012

Abstract

We report the successful control of bleeding in two patients who underwent post-cardiotomy extracorporeal circulatory support (ECMO) and then developed life-threatening bleeding due to severe coagulopathy. After the failure of conventional techniques, bleeding control was achieved using Celox™ Gauze (MedTrade Products Ltd, Cheshire, UK) packed on the sternal edges and pericardial cavity.

Keywords: Bleeding • Extracorporeal circulatory support • Coagulants

CASE PRESENTATION

Patient 1

In November 2010, a 59-year old man presented for the treatment of acute type A dissection with type B right coronary artery (RCA) involvement [1]. The patient presented in cardiogenic shock, with right ventricular failure, severe inferior LV wall hypokinesia and pericardial tamponade. A severe consumptive coagulopathy was already present at admission. Emergency axillary, hypothermic (target nasopharyngeal temperature of 25°C) cardiopulmonary bypass (CPB) was instituted after full heparinization (3 mg/kg) and median sternotomy. The aortic procedure consisted of an open hemiarch replacement together with patch closure of the RCA and aortic root replacement using a composite graft (mechanical valved graft; St Jude Medical, Inc., Minneapolis, MN, USA). At the end of the procedure, right ventricular failure associated with inferior LV hypokinesia made the weaning from CPB unsuccessful and thereby veno-arterial (right femoral vein–right axillary artery) extracorporeal circulatory support was established, using a totally coated closed circuit with a centrifugal pump (Jostra Rotaflow centrifugal pump, Jostra Bioline circuit and Quadrox PLS membrane oxygenator; Maquet-Cardiopulmonary, Rastatt, Germany). Despite meticulous haemostasis, diffuse bleeding was present, mostly from the mediastinal tissues, sternal edges and axillary incision. Thromboelastography and coagulation profile tests (bleeding time, prothrombin time, activated partial thromboplastin time, fibrinogen, fibrin split products, platelet count, mean platelet volume and platelet haematocrit) were profoundly altered.

Despite the use of fresh frozen plasma, platelets, desmopressin and epsilon-aminocaproic acid to correct fibrinolysis, thrombocytopenia and coagulative parameters together with prolonged surgical haemostasis, complete control of the bleeding was not attained. Any attempt at sternal re-approximation caused haemodynamic deterioration, which required the sternum to be left open.

We initially used our usual technique for delayed sternal closure: by packing the mediastinum with surgical gauze pads, stabilizing the sternum with a VAC™ sponge (KCI, Inc., San Antonio, TX, USA), covering the chest wound with a plastic membrane and connecting a cell saver to the sump chest tubes. The bleeding rate was excessive, with 1260 cc of blood processed by the cell saver during the first 15 min. We then decided to re-explore the mediastinum and to use Celox™ gauze (MedTrade Products Ltd, Cheshire, UK) to attempt haemostasis. Celox gauze was cut into strips (10–20 cm), which were used to pack the sternal edges and pericardium. A thin VAC™ sponge isolated the Celox dressing from the mediastinal drains. Dressing was completed in the usual fashion with another VAC™ sponge and a plastic membrane sutured to the wound margins and covered with VAC™ drape. Negative pressure was applied to the mediastinal tubes, thus making the VAC™ sponge rigid, and producing sternal edge stabilization, while increasing the suction surface. A cell saver was connected to the chest tubes. After Celox application, bleeding dramatically decreased: 500 cc in the first 30 min, 900 cc in the first hour and 1200 cc 2 h after re-exploration. Coagulation parameters improved significantly over the first 36 h and we could remove the mediastinal dressing and close the sternum 48 h after the procedure. The patient was weaned from ECMO 3 days later without further complications.

Patient 2

In January 2011, a 55-year old man was admitted to our department for the treatment of acute prosthetic endocarditis. The patient had been operated on four months earlier for acute type...
Aortic dissection treated with replacement of the ascending aorta and aortic valve with a mechanical valve tube graft.

At re-admission, a partial detachment of the proximal anastomosis corresponding to the right and non-coronary portion of the annulus was shown on TEE and thoracic CT scan with the evidence of a pseudoaneurysm over the left atrial roof. The surgical procedure consisted of the replacement of the composite graft with an aortic homograft. CPB was instituted via the right axillary artery and femoral vein. Preoperative treatment with intravenous heparin had created an impaired coagulation state with low plasma Antithrombin III (ATIII) activity (55%), and supplemental doses of heparin and ATIII were needed to achieve a satisfactory activated clotting time before CPB institution.

Upon inspection, the prothetic graft was found to be disconnected from the aortic annulus as a consequence of an extensive annular abscess extending from the mitro-aortic junction to the annular insertion of the right coronary cusp. The treatment of the annular abscess was complex and required a pericardial patch reconstruction of the mitro-aortic junction to facilitate the homograft implantation. At the end of the procedure, failure to wean the patient from CPB due to right ventricular failure and associated severe hypoxaemia required the institution of veno-arterial (femoral-axillary) extracorporeal circulatory support.

Extensive bleeding from the dissected mediastinal tissues and the chest wall required prolonged surgical haemostasis and transfusion with blood, platelets, fresh frozen plasma and anti-fibrinolitics. Several conventional topical haemostatic agents (fibrin glue, thrombin and collagen gels) failed to control the diffuse bleeding sites.

Thromboelastography and coagulation profile tests confirmed a severe impairment of the coagulation system which precluded surgical haemostasis. Therefore it was decided to leave the sternum open. The technique described above was employed, with strips of Celox gauze being used to pack the sternal margins and mediastinum. The chest drains were positioned as previously described and connected to a cell saver. The patient was transferred to the intensive care unit. As the coagulation improved, the bleeding progressively reduced. On the second postoperative day, the bleeding completely stopped and the patient was returned to the operating room for re-exploration.

The Celox gauze was removed and the mediastinum irrigated with saline solution to completely wash out any residual chitosan granules. Surgical haemostasis was completed and the sternum re-approximated in the usual manner. Weaning from the extracorporeal circulatory support happened a day later without complications.

DISCUSSION

Celox is a life-saving haemostat originally developed to assist military medics and is composed of chitosan, a natural linear polysaccharide very similar to cellulose. Among its properties, chitosan is capable of stopping bleeding by bonding with red blood cells and gelling with fluids to produce a pseudo-clot.

Celox simply clots the blood once it comes directly into contact with it, thus not setting off the normal clotting cascade. Since chitosan works independently from the physiological clotting mechanisms, it has also been proved to work in the presence of common anti-coagulants such as warfarin as well as in the presence of heparin (i.e. patients on extracorporeal assistance) and also in moderate hypothermia.

After a preliminary report about the use of chitosan granules (Celox) for haemostasis in cardiothoracic surgery [2], we report its life-saving use in patients supported with post-cardiotomy extracorporeal circulatory support.

Under such circumstances, Celox demonstrated a high efficacy to reduce and stop bleeding compared with other haemostatics that were ineffective. The commonly used agents for topical haemostasis (i.e. fibrin glues, fibrinogen/thrombin and collagen/thrombin gels, oxidated cellulose, gelatin sponges) and tissue sealant (polyethylene glycol hydrogels) are useful in the setting of a competent coagulation system but, since they work by interfering with the physiological pathways of coagulation cascade, they can be ineffective once a severe coagulative disease is triggered [3]. Generally, the event of untreatable postoperative bleeding is managed by packing the sternum and mediastinal tissues with swab and towels and the sternum is left open. Such manoeuvres are usually adequate to achieve a sufficient haemostasis for delayed sternal closure (intended as a ‘permissive/not excessive bleeding’ allowing the haemodynamic stability and the restoration of the coagulative balance in the meanwhile).

In patients undergoing post-cardiotomy ECMO, the clinical scenario is somehow different. This condition is known to increase dramatically the blood loss from every surgical site and dissected tissue because patients are, in adjunct, under heparin. As a result, the usual packing technique can sometimes result ineffective to achieve a haemostatic control just sufficient to attempt a delayed sternal closure.

The unique, direct, clotting mechanism of Celox favourably applied to the clinical setting of patients on post-cardiotomy ECMO where bleeding mostly derives from a mismatch of coagulation and fibrinolysis that makes it impossible to obtain a surgical control of the resulting haemorrhagic state. In this scenario, our experience demonstrated the use of Celox to be life-saving due to its capability to combine the compressive haemostatic effect (as for gauzes and swabs) with the ability to clot the blood directly and also in the presence of circulating heparin.

Because of the ability of Celox to clot heparinized blood, particular attention must be taken in the placement of chest drains when using a cell saver (because of the possibility of clotting the circuitry) [2]. For this reason, we developed a method to manage patients with delayed sternal closure that minimizes as much as possible the contact between chitosan granules and chest tubes.

Briefly, the mediastinal sumps are positioned as usual in the pericardial cavity. A large gauze swab is placed in the mediastinum to isolate the heart and drains. The Celox gauzes are then packed along the sternal edges and mediastinal tissues, apart from the suction site. When necessary, a thin VAC™ sponge can be used to further isolate the Celox gauzes from the chest tube. Sternal stabilization is then achieved by a VAC™ sponge placed over the gauze swab and between the bone margins, and a plastic membrane is sutured to the skin margins to better isolate the surgical incision and, at the same time, improve the vacuum effects.

Finally, the specifically designed drape for the VAC™ system is placed to cover the incision and the sumps connected to the vacuum system (Fig. 1).

Using this technique for delayed sternal closure we did not observe any complication with the use of cell savers, and the drained blood could be reinfused when necessary after processing and washing.

This ‘modified application’ of VAC™ system takes account of two favourable aspects. First, like the rationale of use in its original indication (treatment of wound dehiscence and infections), the
Polyurethane sponge microstructure is capable of increasing the suction surface and thus enhancing the sump effect.

Second, in patients needing delayed sternal closure (especially in cases of severe bleeding) a moderate sternal re-approximation can also result in hemodynamic impairment. Among the several methods available to prevent this effect, the interposition of a VAC™ sponge was the most effective and simple method in our experience. In fact, it is sufficient to shape the VAC™ sponge to the required width to achieve the desired degree of sternal approximation and place it between the sternal edges. Once the negative pressure is applied, the vacuum effect makes the sponge rigid, stabilizing the sternum to the desired distance (Fig. 1, Supplementary Video 1).

The combination of such favorable effects of the VAC™ sponge/system prompted us to develop this ‘closure technique’ that we now apply in all patients needing delayed sternal closure.

Figure 1: The picture shows the technique used for delayed sternal closure. The sump chest tubes are placed in the pericardial cavity as usual and connected to a cell saver. Strips of Celox gauze are packed around the sternal edges and mediastinal tissues as appropriate with a large gauze swab used to isolate the Celox dressing from mediastinal drains (upper left). A VAC™ sponge is positioned between the sternal edges and the chest wound covered with a plastic membrane sutured to the skin (upper right). Dressing is completed with the specifically designed VAC™ drape (lower left). Negative pressure applied to the mediastinal drains make the VAC™ sponge rigid, producing sternal stabilization and increasing the suction surface (lower right).
SUPPLEMENTARY MATERIAL

Supplementary material is available at ICVTS online.

ACKNOWLEDGEMENT

Special thanks to Russell Millner (Department of Cardiothoracic Surgery, Blackpool Victoria Hospital, Blackpool, UK) for his precious assistance.

Conflict of interest: none declared.

REFERENCES


eComment. Activated recombinant factor VII in intractable bleeding after cardiac surgery

Author: Jamil Haji-Chahine
Department of Cardio-Thoracic Surgery, University Hospital of Poitiers, Poitiers, France
doi:10.1093/icvts/ivs121
© The Author 2012. Published by Oxford University Press on behalf of the European Association for Cardio-Thoracic Surgery. All rights reserved.

I read with great interest the paper by Muzzi et al. [1] concerning the salvage use of Celox gauze (MedTrade Products Ltd, Cheshire, UK) in two patients and the postoperative course was uneventful. Celox gauze is a very effective haemostatic agent and it is capable of clotting heparinised blood [2]. However, its use is limited in controlling haemorrhage in a military trauma setting on the battlefield.

The authors stated that despite the use of fresh frozen plasma, platelets, desmopressin and epsilon-aminocaproic acid, control of the bleeding was not achieved. I would like to ask the authors why they did not make use of activated recombinant factor VII or rFVIIa (NovoSeven®, Novo Nordisk, Denmark). Bleeding is a troublesome situation and carries a dismal prognosis in postoperative extracorporeal membrane oxygenation (ECMO) implantation for post-cardiotomy cardiogenic shock. Since 1999, rFVIIa has been used after cardiac surgery as a compassionate therapy for life-threatening haemorrhage [3]. Dramatic bleeding secondary to consumptive coagulopathy post-cardiopulmonary bypass has been shown to be successfully managed by the infusion of a single dose of 60-90 µg/kg of rFVIIa. However, previous compensation with fibrinogen (>1 g/l) and platelets (>50 g/l) is mandatory to ensure an effective clotting cascade.

In a recent multicentre observational study [3] assessing the efficacy of rFVIIa in cardiac surgery, the authors concluded that a single dose of rFVIIa was sufficient to stop or decrease bleeding in 80% of their patients, of whom 34% (n = 37) were assisted by mechanical devices. Thrombotic events were the major drawback especially in patient with assist devices and occurred in 27% of them. A review of the literature published in 2006 [4] showed that rFVIIa was an effective homeostatic agent for intractable bleeding after cardiac surgery and the risk of serious, adverse thrombotic events was estimated to be under 1%.

The usage of Celox in combination with a vacuum assisted closure device seems to be lifesaving and represents an effective and safe (thrombotic event-free) tool. It should be considered in the armamentarium of every cardiac surgeon.

References