



# Management of post-pancreatectomy haemorrhage using resuscitative endovascular balloon occlusion of the aorta

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Received: 28 December 2018 / Accepted: 4 February 2019 / Published online: 13 February 2019  
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## Abstract

**Background** Delayed massive post-pancreatectomy haemorrhage (PPH) is a highly lethal complication after pancreatectomy. Angiographic procedures have led to improved outcomes in the management of these patients. In the setting of an acute haemorrhage, laparotomy and packing are often required to help stabilise the patient. However, re-operative surgery in the post-pancreatectomy setting is technically challenging.

**Methods** A novel strategy of incorporating the resuscitative endovascular balloon occlusion of the aorta (REBOA) is described.

**Results** Two patients where the specific application of this technique uses the REBOA were described.

**Conclusion** The REBOA serves as a useful adjunct in haemorrhage control and haemodynamic stabilisation to allow successful management of delayed massive PPH.

**Keywords** Pancreatectomy · Bleeding · Complication · Mortality · Fistula

## Introduction

Pancreatic resection is associated with significant morbidity and major complications such as post-pancreatectomy haemorrhage (PPH), which occur in up to 6% of patients [1]. The failure to rescue of PPH is lethal and delayed massive PPH (Grade C) carries a mortality rate in excess of 35% [2]. Delayed massive PPH is often extraluminal and culprit vessels

include the gastroduodenal, splenic, and/or superior mesenteric artery or veins [3]. Its occurrence is thought to be a vasculopathy developing in the setting of a concomitant intra-abdominal inflammatory or infective process that results in vessel wall erosion and subsequent rupture [4].

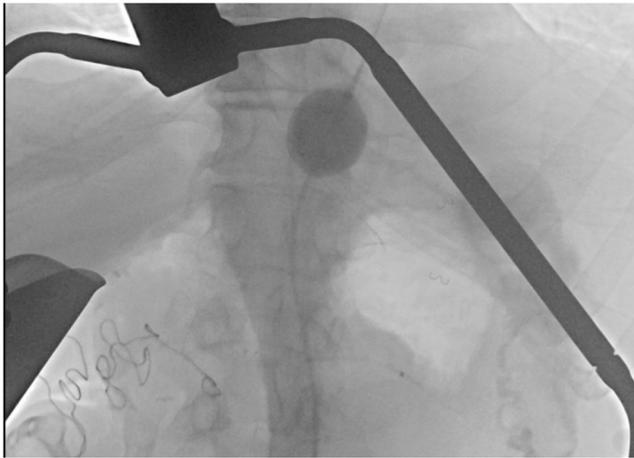
The role of interventional angiography is increasingly recognised in the management of PPH [5] especially in the setting of a sentinel bleed. However, with acute haemorrhage, angiography is often required in combination with laparotomy to achieve haemostasis and evacuation of intra-abdominal haematoma [6]. A critical determinant of survival after PPH is the ability to obtain timely control of the haemorrhage. We describe a novel strategy using resuscitative endovascular balloon occlusion of the aorta (REBOA) to achieve rapid control of haemorrhage and haemodynamic stability to allow successful management of delayed massive PPH.

## Technique

In our institution, massive post-pancreatectomy haemorrhage is managed in a hybrid operating theatre where angiography is available. Under general anaesthesia, a 12Fr sheath is inserted into the right common femoral artery (CFA), through which a Reliant balloon (Medtronic Vascular, Santa Clara, CA, USA)

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**Fig. 1** Intraoperative fluoroscopic image of REBOA. Reliant™ Balloon has been inflated within the supra-celiac aorta

is placed and inflated in the supra-coeliac aorta (Fig. 1). This allows temporary control of the intra-abdominal haemorrhage and resuscitative blood transfusion. Following acute haemorrhage control and stabilisation of the patient, intermittent partial deflation of the balloon allows the identification of the bleeding vessel. Following this, haemostasis of the culprit vessel may be achieved by endovascular techniques including coiling or stenting depending on the vessel pathology. Alternatively, a laparotomy can be performed to suture ligate the bleeding vessel. Laparotomy also allows the evacuation of intra-abdominal haematoma.

## Outcomes

Two patients underwent management of massive PPH using the above strategy and their clinical course is summarised. The first patient was a 71-year-old male who was day 10 post combined pancreatoduodenectomy, liver metastasectomy, and right hemicolectomy for pancreatic neuroendocrine tumour with liver metastases. He developed massive PPH and underwent deployment of REBOA. At angiography, a bleeding gastroduodenal artery (GDA) stump was identified, and laparotomy was performed to suture ligate the vessel and wash out the abdominal cavity. The patient subsequently made a complete recovery. The second patient was a 76-year-old male with a 2.5-cm pancreatic adenocarcinoma who underwent neoadjuvant chemotherapy followed by pancreatoduodenectomy. Postoperatively, he recovered well and was discharged on day 8, but represented on day 33 with frank haematemesis and per rectal bleeding associated with marked hypotension leading to activation of the massive transfusion protocol (MTP). CT mesenteric angiogram demonstrated an arterioenteric fistula between the superior mesenteric artery (SMA) pseudoaneurysm and a loop of jejunum (Fig. 2). As he was haemodynamically unstable, resuscitative measures were undertaken by the



**Fig. 2** Angiogram revealing dorsal false aneurysm of the SMA with extravasation of contrast into small bowel

deployment of the REBOA, the SMA was accessed by a C1 catheter (Cook Medical, Bloomington IN, USA), and a 7 × 38-mm Atrium stent (Maquet, Rastatt, Germany) was deployed over the false aneurysm. An 8 × 50-mm Viabhan stent (Gore Medical, Newark DE, USA) was then placed over the remainder of the dilated SMA. Upon completion, no false aneurysmal flow was visualised. The patient recovered from the event, however, after a prolonged hospital stay succumbed to pneumonia.

## Discussion

The use of REBOA was first described in two moribund Korean war casualties to control torrential haemorrhage [7]. In the present report, we described the effective use of REBOA to achieve rapid haemorrhage control in the setting of massive post-pancreatectomy haemorrhage. In the first case, REBOA was used as an adjunct to facilitate suture ligation of a bleeding GDA stump. In the second case, REBOA was used to achieve haemostasis to facilitate totally endovascular management of SMA-enteric fistula. Traditional surgical principles of rapid control of sub-diaphragmatic haemorrhage require the application of a supra-coeliac clamp. Accessing the supra-coeliac aorta requires retraction of the left lobe of the liver, incising the lesser omentum, lateral retraction of the oesophagus, and digital palpation of the crus of the diaphragm on the spine to create a landing site for the aortic clamp. This procedure is often not easy to perform in the re-operative setting due to the presence of dense intra-abdominal adhesions and the presence of pancreatobiliary reconstruction. In addition, decompression of the abdominal cavity may result in further haemorrhage and exacerbation of ongoing hypotension that may precipitate a cardiovascular arrest. The REBOA approach allows endovascular access to the supra-coeliac aorta in an expedient and safe manner without decompressing the abdominal cavity

haematoma. Intermittent deflation of the balloon facilitates identification (either at open surgery or on angiography) of the site of haemorrhage to allow for definitive control of haemorrhage under controlled conditions.

In the current literature on PPH, interventional angiography is increasingly recognised as an effective strategy to deal with a bleeding vessel by insertion of a covered stent or embolization by coiling [8]. Despite this improved technique to manage the vascular pathology, the mortality rate remains high. This relates to the fact that there are a significant proportion of patients who die from exsanguination and failure to resuscitate. Adding REBOA to the angiographic armamentarium for the management of PPH in the unstable PPH patient may improve the rate of success of endovascular management of this complication.

Our understanding of the complications of the use of REBOA arises from the trauma literature [9]; however, many of these may be minimised in a hospital setting. Puncture-related pseudoaneurysm formation, thrombosis, and limb ischaemia associated with the larger sheaths needed for occlusion balloon inflation are minimised by ultrasound-guided vessel puncture and the use of a pre-close closure device technique. Malposition of the balloon into the aortic arch in the trauma setting, with the complications of myocardial or cerebrovascular complications, is minimised by direct visualisation of the balloon inflation in the hybrid operating room, limiting it to a zone in the descending aorta just proximal to the coeliac axis.

In summary, we describe a novel approach of incorporating the use of the REBOA in an unstable patient with massive post-pancreatectomy haemorrhage facilitating resuscitation and definitive management of the bleeding vessel via open surgery or endovascular treatment.

### Compliance with ethical standards

**Conflict of interest** The authors declare that they have no conflict of interest.

**Human and animal rights** All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964

Helsinki declaration and its later amendments or comparable ethical standards; informed consent was obtained from all individual participants included in the study.

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