Balloon Occlusion of the Celiac Artery: A Test for Evaluation of Collateral Circulation Prior Endovascular Coverage

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Abstract
Introduction: Visceral ischemia is a possible complication after endovascular coverage of the celiac artery (CA). A selective mesenteric angiography during simultaneous balloon occlusion of the CA imitates endovascular coverage and might therefore be suited for evaluation of collateral circulation. We report the feasibility of a balloon occlusion test (BOT) of the CA for this purpose.

Report: We performed a BOT in 5 patients selected for endovascular surgery with intended coverage of the CA. The BOT could demonstrate sufficient collateral circulation in all cases, which was not evident without occlusion of the CA. The most important collateral vessels were the pancreaticoduodenal arcades and the dorsal pancreatic artery. All patients tolerated the BOT well without abdominal symptoms or pathological laboratory findings.

Discussion: Our report suggests that a BOT of the CA is a feasible and safe procedure. It can demonstrate collateral pathways before definite coverage is performed. This test might be useful for selection of patients prior intended coverage of the CA.

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Introduction

Endovascular repair of thoracic aortic and thoraco-abdominal aneurysms (TAA/A) has become an alternative to open repair in selected patients. Occasionally, coverage of the celiac artery (CA) is necessary which has been performed without ischemic complications.1
However, early reports from animal experiments observed an insufficient blood flow after clamping the celiac artery (CA) resulting in ischemia and necrosis of the liver and stomach. Additionally, bowel ischemia and hepatic dysfunction are known complications after open surgery of TAAA. Angiographic evaluation of collateral blood supply is therefore warranted prior graft placement. A reliable approach for evaluation of collateral pathways is a temporary balloon occlusion, which has become a standardized procedure for the internal carotid artery.

We adopted the concept of temporary balloon occlusion and developed a suitable test for evaluation of collateral pathways of the CA. With this study we wanted to demonstrate the feasibility and safety of such an occlusion test.

**Report**

In five patients (f:m = 2:3; 60±63–68 yrs) a balloon occlusion test (BOT) of the CA was performed during preoperative angiography. Patients were selected for endovascular aneurysm repair with intended coverage of the CA.

**Balloon Occlusion Test**

A 5-French (F) pigtail catheter was placed in the abdominal aorta and an angiography in lateral view was performed for evaluation of ostial stenosis of the CA or superior mesenteric artery (SMA). Next, a selective angiography of the CA and SMA was performed with a diagnostic catheter (Side-winder-S2 or Cobra-C2 configuration, as appropriate). Our standard protocol includes a flow of 6 ml/sec of 24 ml iodinated contrast medium. Angiography series were taken in breath hold until visualisation of the portal vein. Finally, the catheter tip was positioned in the ostium of the CA.

For insertion of the second catheter we preferred a bilateral femoral approach. The second catheter was placed in the ostium of the SMA. A hydrophylic guide wire was navigated in the splenic or hepatic artery and the catheter was advanced over it. A balloon dilatation catheter was than advanced over an exchange wire and placed in the CA. The length of the balloon was 2 cm whereas the diameter varied between 5–6 mm. Dilatation was performed with a “road map-like” modus that superimposes the previous angiography during fluoroscopy on the same monitor. This allows exact comparison of the vessel lumen and the balloon diameter during dilatation. A BOT was only performed if the CA was at least 2 cm in length and without stenosis. We applied 3000 E Heparin intravenously before balloon inflation. Dilatation lasted not longer than 5 minutes with a maximum pressure of 5 bar (500 kPa). We did not administer vasodilatative agents. During balloon occlusion a selective angiography of the SMA with identical parameters of the previous angiography was performed.

As a result, angiographies without a BOT did not show collateral flow between the CA and the SMA (Fig. 1 a, b). Collateral circulation was only visible during the BOT of the CA (Fig. 1 c). The most important collateral vessels were the pancreaticoduodenal arcs and the dorsal pancreatic artery (Figs. 1 and 2). The pancreaticoduodenal collaterals showed a retrograde flow to the gastroduodenal artery and a normal antegrade filling of the proper hepatic artery (Figs. 1 c, and 2). The collaterals via the dorsal pancreatic artery were mainly responsible for filling of the splenic artery but showed also feeding vessels to the hepatic circulation (Figs. 1c, and 2). No arterial spasms were noticed before, during or after the balloon occlusion.

**Discussion**

With this report we wanted to introduce a BOT of the CA for evaluation of collateral blood supply. We described the technical details and want to encourage other working groups to become familiar with the procedural steps.

Our preliminary results demonstrate the feasibility and safety of this test in a small group of patients prior endovascular surgery. Coverage of the CA might be necessary in selected cases of endovascular repair of thoracoabdominal aneurysms or hybrid procedures. Vaddineni et al. recommend a selective angiography but without BOT for evaluation of collateral circulation. But the anatomy of collateral supply is very variable and

![Figure 1](image-url) (a) Angiography of the CA and (b) SMA show normal anatomy without collateral flow. (c) Collateral pathways are evident during balloon occlusion of the CA (arrowheads) and mesenteric angiography (asterisk). The gastroduodenal artery (GDA) feeds the propriate hepatic artery whereas the dorsal pancreatic artery (white arrow) demonstrates flow to the splenic artery.
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Figure 2 Selective mesenteric angiography during balloon occlusion (arrowheads) of the CA. The pancreaticoduodenal arcades (PDA) and the dorsal pancreatic artery (white arrow) demonstrate numerous collateral vessels to the hepatic and splenic artery.

sometimes even missing. Therefore, our preliminary results suggest that only a BOT is suited for accurate evaluation of the individual anatomical situation.

Modern imaging techniques like CT-angiography can be used to describe the anatomical pathways in patients with visceral pathology like chronic CA-stenosis. However, evaluation of collateral circulation remains a demanding task and angiography appears the only valid method. Moreover, a temporary occlusion of the CA can demonstrate collateral pathways before a definite coverage is performed. Because of the possible anatomical variations and the individual consequences for each patient angiographic evaluation with a BOT should be considered prior endovascular closure of the CA.

So far, we did not include a patient with inadequate collateral circulation, anatomical variations or after visceral surgery. If a BOT would demonstrate inadequate collateral vessels we would reconsider the intended endovascular procedure. In such a case an additional bypass to the CA would be necessary. Evaluation of intrahepatic collaterals might also be useful for excluding patients who might be prone to liver failure in case of a CA closure.

We therefore believe that this test can help as an adjunct to choose the appropriate endovascular approach. A BOT of the CA might be helpful for patient selection as compared to a BOT of the internal carotid artery. The procedural steps might be changed in cases of anatomic variations or the use of an occlusion balloon instead of a dilatation balloon.

In conclusion, our initial results demonstrated that a BOT of the CA is a feasible and safe procedure for evaluation of collateral circulation prior intended coverage of the CA. More experience in larger study populations is necessary to assess a possible benefit for patients.

References