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Visualization and Quantification of Acute Drug Coating Distribution on Porcine Esophagus and Common Bile Duct Surfaces After Drug Coated Balloon Treatments

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INTRODUCTION

Drug coated balloons (DCB) provide a flexible platform for non-obstructive local drug delivery to tubular organs, without requiring chronic implantation. DCBs have been approved for treatment of atherosclerotic lesions and are increasingly being explored as a novel therapy for esophageal and biliary strictures. Repurposing of existing DCB technologies could save development costs, but it is unclear to what degree device performance varies with the target anatomy.

AIM

The current preclinical study characterized the acute patterns of drug-coating on the luminal surfaces of porcine esophagi and common-bile ducts post treatment with two types of commercial DCBs.

METHOD

Following a cholangiogram (***Figure 1***), 3 Yorkshire swine (92.0 -109.3kg) each received a treatment of either a 7.0 x 40 mm DCB or a non-coated balloon in the common bile duct through direct access via laparotomy. One 19.0kg Yorkshire swine received 2 treatments of 2 different 12.0 x 40 mm DCB types in the esophagus via oral access. All balloons were inflated to nominal pressure for 3 minutes in the common bile duct and 5 minutes in the esophagus. Fluoroscopic guidance was used to confirm placement, inflation, and deflation (***Figure 1***). Used balloons were retracted and saved for future analysis. Treatment animals were sacrificed acutely for tissue collection and processing for scanning electron microscopy (SEM). SEM images of the tissue surfaces were acquired at 50x and 150x magnifications on a Hitachi S3400–NII. In each treated tissue, coating presence was morphometrically traced in the 72x125 mm^2 area exhibiting the highest coating density and a white mask overlaid on the coating (***Figure 2-3***), both using Adobe Photoshop (Version 25.1.0). Then, masked SEM images were montaged and segmented using trainable Weka segmentation and quantified for coated and uncoated tissue areas using a color counter, both implemented on ImageJ (see ref 1 for methodology).

RESULTS

SEM images of DCB treated tissue exhibited variable amounts of transferred coating, with high magnification images resolving flat coating flakes on luminal surfaces regardless of DCB type, in cases overlaid by leukocytes (***Figures 2-3***). Treatments with Type 1 DCB achieved a maximal coverage of 24.7% in bile duct surfaces and 2.2% in the esophagus. By contrast, treatments with Type 2 DCB achieved a maximal coverage of 4.7% in the bile duct surfaces and 1.5% in the esophagus.

	Bile Duct	Esophagus
DCB Type	% Coating	% Coating
Type 1	24.7%	2.2%
Type 2	4.7%	1.5%

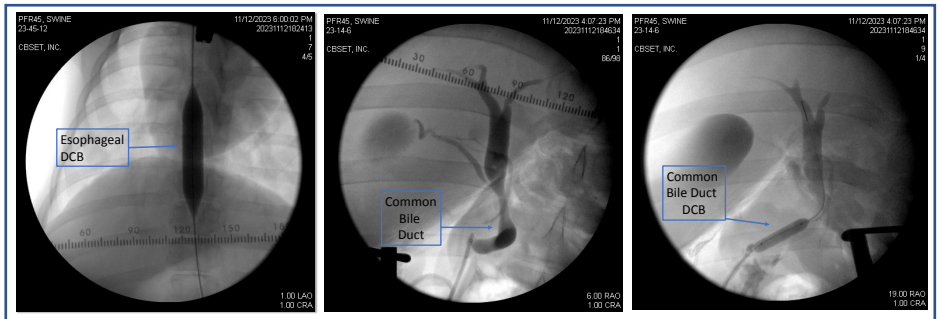

Figure 1. (A) Fluoroscopic image of DCB inflated in esophagus (B) Baseline cholangiogram (C) Fluoroscopic image of DCB inflated in common bile duct

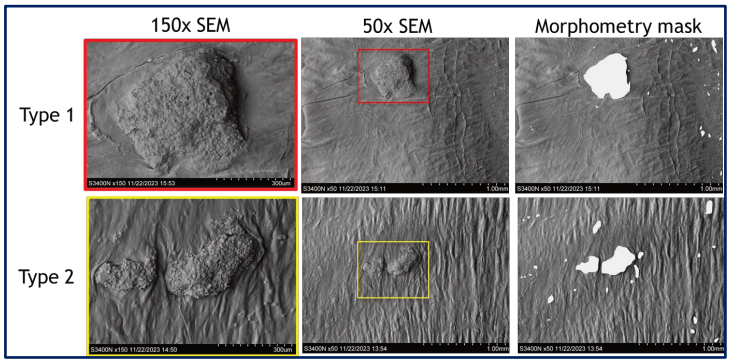

Figure 2. Enface SEM images of esophagi post treatment with Type 1 DCB (Top) or Type 2 DCB. Masked white areas (Right Panels) denote coating and used to calculate the percentage of coated tissue (See Table)

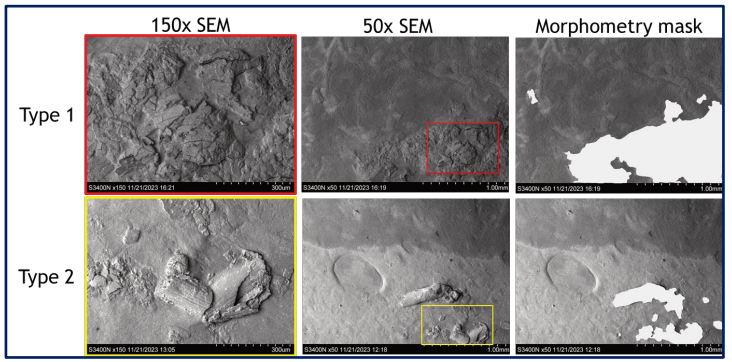

Figure 3. Enface SEM images of common bile ducts post treatment with Type 1 DCB (Top) or Type 2 DCB. Masked white areas (Right Panels) denote coating and used to calculate the percentage of coated tissue (See Table)

CONCLUSIONS

SEM imaging reveals variable patterns of coating transfer on biliary duct and esophagus surfaces after DCB treatment. The degree of coating transfer appears to depend both on the DCB technology and on the target tissue, as both DCB types achieved higher coating transfer to the common bile duct than to the esophagus. These data provide a framework for comparative evaluation of DCB technologies and may suggest that DCB design should be optimized for each target tissue.

REFERENCES

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