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Mucosectomy impairs ileal microcirculation and results in flap contraction after experimental ileocystoplasty

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Summary

Introduction
Bladder augmentation with demucosalized ileal flap is a promising alternative approach for mucus free bladder augmentation; however, the contraction of the flap is still a major concern. It has been hypothesized that mucosectomy causes ischemic damage, but no direct histological evidence has been found and attention is now focused on the urothelium cover to prevent the exposure of the denuded surface to urine or the use of balloons to keep the flaps distended.

Objective
Our aim was to study the effect of mucosectomy on the microcirculation of ileal flaps during reverse clam ileocystoplasty using direct intraoperative imaging of the ileum. Since the omentum is successfully used to revascularize ischemic tissue, we also examined whether omentopexy can prevent contraction.

Study design
Clam ileocystoplasty was performed in anesthetized minipigs with seromuscular ($n = 3$), seromusculo-submucosal ($n = 3$) reverse demucosalized ileal flaps. The velocity of the circulating red blood cells (RBCV) and the perfusion rate (PR) was measured with intravital videomicroscopy (Cytoscan A/R, Cytometrics, Philadelphia, PA, USA) before and after mucosectomy and the denuded surface of the ileum was covered with omentum after the reverse augmentation was complete (Figure). Animals were sacrificed after 8 weeks and the ileal flap dimensions were measured.

Results
Significant reduction in RBCV and PR was detected after mucosectomy in both groups; however, no sign of acute flap necrosis or bladder perforation was seen. The omentum was found firmly attached to the ileal flaps, but contraction of the flaps was significant in both groups.

Conclusion
The disturbance in the microcirculation observed after mucosectomy may be responsible for flap contraction in ileocystoplasty with demucosalized ileum. Omentopexy did not help to prevent contraction.

Discussion
Contraction of demucosalized intestinal flaps used for bladder augmentation has been frequently reported. This study provides direct evidence the first time for severely compromised microcirculation of the ileal flaps after mucosectomy. Limitation of the study is the relative low number of animals sacrificed.

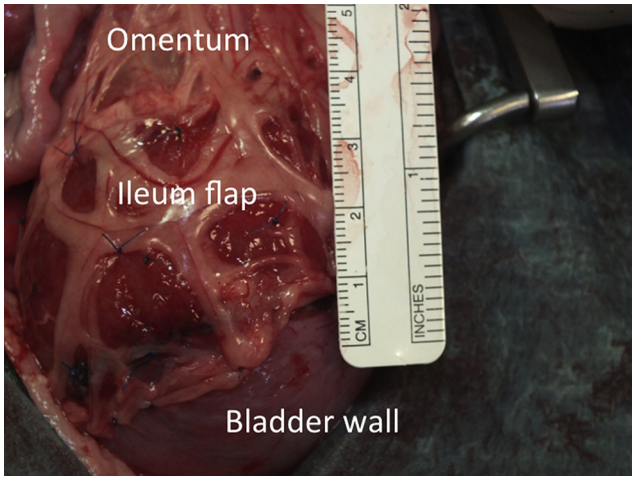

Figure Augmented bladder with reverse sero-musculo-submucosal ileal flap covered with the omentum.

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Introduction

The presence of intestinal mucosa within the augmented bladder is associated with significant complication risks such as increased infection rate due to mucus production, associated stone formation, absorption of electrolytes from the urine, and potential adenocarcinoma development [1].

William Shoemaker and his colleagues were awarded with the first prize on the essay competition of the American Urological Association in 1955 for the idea of using mucosectomized reversed ileal flaps for bladder augmentation in dogs following subtotal cystectomy [2,3]. It seemed that the intestinal mucosa-related complications would no longer be a concern after mucosectomized reversed flap bladder augmentation. The technique was then applied in four patients; however contraction of the flaps occurred and the technique was abandoned [4]. Thirty years later Oesch [5] revised this procedure and reported no contraction and full epithelization of the caecal segment in rats after mucosectomy. Salle et al. [6] were, however, not able to reproduce these good results in dogs with clam ileo- or colocystoplasty. Reverse flap augmentation was abandoned believing that vascular compromise of the flaps during the procedure may have led to contraction, however no direct evidence was found to support this theory.

Research was focused on non-reversed flaps, but contraction of the flap remained a major concern. Motley et al. [7] performing seromuscular cup shape sigmoid cystoplasty paid special attention to vascular histology, and did not find evidence of vascular thrombosis. Salle et al. [8] concluded that vascular compromise may not play a role in flap contraction after observing in rabbits that seromuscular segments of gastric fundus fixed to the anterior abdominal wall did not contract. The idea of vascular compromise has been refuted.

It has been hypothesized that the tissue contraction may be due to the exposure of the denuded intestinal surface to urine and/or prolonged postoperative decompression of the augmented bladder; therefore, research has been focused on the role of urothelium coverage of the denuded surface and the use of splints to prevent the effect of long-term drainage leading to collapse of the augmented bladder [9–11]. To some extent these varying approaches have led to acceptable results; nevertheless, the contraction of the intestinal flaps still remains a major concern.

We found it interesting that Cheng et al. [12] reported no contraction of a full thickness (intact mucosa) ileal flap used for reverse flap augmentation in a dog. This gave us the idea to review the experience with reverse flap augmentation to find out if mucosectomy has significant effect on the microcirculation of the ileal flaps during reverse clam ileocystoplasty. Since the omentum has been used clinically to promote revascularization and healing of ischemic tissues [13–16] we also examined whether omentopexy prevents the contraction.

Material and methods

The experiments were performed according to EU Directive 2010/63/EU on the protection of animals used for experimental and other scientific purposes and carried out in strict adherence to the NIH guidelines for the use of experimental animals. The study was approved by the National Scientific Ethical Committee on Animal Experimentation, with the license number V./1637/2013.

The study was performed on anaesthetized female Vietnamese mini pigs ($n = 6$; weight, 25–30 kg). The animals were kept under conventional circumstances, in standard cages, were fed with commercially available mixed food, were fasted 24 h before surgery and always had free access to water. Anaesthesia was induced with an intramuscular injection of a mixture of ketamine (20 mg/kg) and xylazine (2 mg/kg) and maintained with a continuous infusion of propofol (2%; 50 μL/kg/min i.v.) via a cannulated ear vein. An endotracheal tube was inserted and the animals were ventilated mechanically with a volume-controlled ventilator. The tidal volume was set at 8–9 mL/kg, and the respiratory rate was adjusted to maintain the end tidal carbon dioxide pressure ($EtCO_2$) between 35 and 45 mmHg. Norocarp S (carprofen; 4 mg/kg) and normal saline infusion were administered via an ear vein catheter. Hearth rate, O_2 saturation (pulseoxymetry), $EtCO_2$ (capnometry) and body temperature were continuously monitored perioperatively.

Clam ileocystoplasty was performed using 15-cm-long ileum segments in two groups. First the ileal segment was isolated and detubularized along the paramesenteric line. The bowel was kept warm with 0.9% saline solution. The detubularized bowel strips were placed on wet gauze and the width was measured with a linear ruler under no tension and the microcirculation was recorded on the serosal surface.

Then mucosectomy was applied. In the seromuscular group the mucosa and the submucosa were peeled from the seromuscular layer in one piece. It was easy to separate the submucosa from the muscular layers at one corner of the flap with fine forceps. Injection of saline into the submucosa was not necessary. In the seromusculo-submucosal group only the mucosa was scraped from the bowel with the back of forceps at the level of the mucosa propria. Surgical loops with 2.5× magnification was used to make sure no mucosa islands left behind. The microcirculation was rerecorded in each group after the mucosectomy procedure on the serosal surface. Clam ileocystoplasty was performed in each group with the serosa facing inside (reverse fashion), with non-absorbable 4/0 Prolene sutures. The denuded surface of the ileal flap facing the abdominal cavity was covered with the omentum in both groups, and anchored by 4/0 polysorb sutures. Malecot catheters (12F) were left in the urethra, the tip of the catheters being fixed with 5/0 Polysorb to the bladder mucosa. The end of the catheters needed to be cut at the level of the external urethral meatus since the animals do not tolerate catheters hanging out of their body; they were sutured to the labia minora with 5/0 Polysorb to keep them in situ for 5–7 days.

The intravital orthogonal polarization spectral imaging technique (Cytoscan A/R, Cytometrics, Philadelphia, PA, USA) was used for visualization of the microcirculation of the intestinal serosa. This technique utilizes reflected polarized light at the wavelength of the isobestic point of oxy- and deoxyhaemoglobin (548 nm). As polarization is preserved in reflection, only photons scattered from a depth of 2–300 μm contribute to image formation. A 10×