Technical Note: Development of a Duodenal Cannula for Sheep


*Faculty of Agriculture and 1School of Medicine, Tohoku University, Sendai 981, Japan

ABSTRACT: A single T-shaped duodenal cannula of silicone rubber with a gutter-type small inner flange was developed for sheep. The barrel of the cannula was 24 mm long with an internal diameter of 12 mm. A polyester surgical mesh (100 mm × 100 mm) was connected to the barrel of the cannula as an anchor. Fibrous tissues grew on the polyester mesh anchor and adhered firmly to the serosa of the intestine, thus leaving no gap and, hence, preventing any leakage of intestinal contents from the side of the fistula. The small (24 mm in diameter) and thin (3 mm in thickness) outer flange of the cannula became buried in the wool and prevented any mechanical disturbance of the cannula by the activity of the animal. The elasticity of the silicone rubber prevented distortion of the duodenum around the barrel of the cannula. No erosion of the tissue between the inner flange of the cannula and the mesh was seen in postmortem observations.

Key Words: Sheep, Ruminants, Duodenum, Cannula, Fistula

Introduction

Cannulation of the duodenum has been widely used for the study of the digestive process in ruminant nutrition (Brown et al., 1968; Hecker, 1974; Ivan and Johnston, 1981; Komarek 1981; Aliyev, 1982; Robinson et al., 1985; Streeter et al., 1991). Total digesta cannot be collected by other methods. However, cannulas that frequently are used are mostly prepared from hard materials. They often suffer from mechanical disturbance to both the cannula and the tissues surrounding it. Also, due to pressure necrosis, continuous bleeding and leakage of intestinal contents may occur. Most of the reported cannulas have a large internal flange or large tubing. It was observed that the intestine bends at the edge of the flange or tubing, thus causing blockage of the flow of digesta and also intestinal deterioration. To overcome these problems, a silicone rubber cannula was developed. This note describes the preparation of the cannula and its application to sheep.

Materials and Methods

Chemicals. Silicone rubber compounds (KE 1600) and curing agents (CAT 1600) were products of Shin-Etsu Chemical (Tokyo, Japan). The cannula was made with a hardness score (JIS A) of 45, tensile strength of 441 N/cm, and tear strength of 147 N/cm.

Surgical Mesh. A polyester knitted surgical mesh (20 mesh/cm², .43 mm in thickness) was the product of Nakao Filter Media (Osaka, Japan). The mesh was woven from 48 filaments (100 denier) of fine polyethylene fibers.

Molds. The mold for the cannula, constructed locally (Koito Jyushi, Sendai, Japan), was made with pieces of MC-Nylon (Nippon Polypenco).
pieces of the mold coated with Teflon spray were joined together with bolts.

**Design.** Figure 1 is a diagram of the mold for the cannula and the inner plug. The barrel of the cannula is 24 mm long. The outside and inside diameters of the barrel are 16 and 12 mm, respectively. The tip diameter of the outer flange and the fringes of the barrel are 24 and 20 mm, respectively. The thickness of the outer flange and the fringes of the barrel are 3 and 2 mm, respectively. The depth of the outer and inner grooves are 2 and .5 mm, respectively. The gutter-type inner flange is 35 mm x 25 mm in width. The barrel of the cannula is closed with a small polyacetal resin plug that is 18 mm long with a diameter of 12 mm. The tip diameter of the fringe is 13 mm. Two holes for the large forceps are 4 mm in diameter and 12 mm in depth.

**Processing.** A 9:1 (vol/vol) mixture of the silicone rubber compound (KE 16001 and the curing agent (CAT-1600) was degassed in a vacuum desiccator for approximately 5 min until large air bubbles disappeared. The silicone rubber (approximately 15 g) was poured into the assembled mold and degassed for 5 min more. The cylindrical part of the mold was then inserted slowly. The assembled mold was pressed with a vice, then cured at 50°C in an oven for 2 h. After curing, the mold was cooled and disassembled, and the cylindrical part of the mold was pulled out from the cannula. Then, the outer opening of the barrel was sealed with a thin film of silicone rubber and cured.

A piece of knitted, polyester surgical mesh (100 mm x 100 mm) was cut in the middle approximately 5 mm smaller in diameter than the cannula barrel to ensure a fit. The cut edges of the center hole of the mesh were sutured with a purse string suture of silk thread (No. 11, forced over the barrel of the cannula, and placed into the bottom groove (Figure 2). The groove and the internal edge of the mesh were then filled with the silicone rubber and cured at 50°C for 30 min.

**Surgery.** Sheep weighing from 23 to 69 kg were fasted and water was withdrawn for 24 h before surgery. The sheep, secured on a surgical table, were anesthetized with a slow intravenous administration of Ravonal (2 mg/kg BW). Then, < 10 mL of Procaine-HCl (2%, wt/vol) was used to induce local anesthesia according to the physical condition of each sheep. Surgery was performed as per standard surgical procedures using an electric surgical knife (Model ESU-103, Aloka, Tokyo, Japan). A 5-cm vertical incision was made approximately 5 cm behind the last rib. The muscles were separated by blunt dissection to expose the duodenum. The incision on the duodenal wall was approximately 1.5 cm to allow insertion of the tucked inner flange in the lumen of the cylindrical part, leaving only a small lip outside, as shown elsewhere (Horigane et al., 1989). After insertion into the incision, the flange expanded in the lumen of the duodenum (Figure 3). The surgical mesh was wrapped around the duodenum and the two sides were tied using interrupted suture of silk thread (No. 2) without pulling each end of the mesh, reducing the disturbance of intestinal movements after surgery. A small circular second incision with a diameter of 1.5 cm was made in the middle between the last rib and the first incision. The outer flange and the barrel of the cannula were pulled through the hole with heavy forceps. The
Results and Discussion

The cannula reported herein has several advantages over the conventional hard ones. The simple design can be made easily from molds in the laboratory, and the cannulation can be accomplished within 1 h with a small amount of anesthetic. Immediately after surgery, sheep can stand, and they can be returned to their cages. The cannula is flexible, so the incision required is small, and the moderate elasticity of the outer flange prevents pressure necrosis of the abdominal wall. The top opening of the barrel closed with the film of silicone rubber prevents leakage of intestinal contents during the operation. Obvious postoperative swelling of the tissue around the outer flange was not observed. Recovery from surgery was rapid, and normal dietary consumption was resumed within 5 to 7 d. No exudate was observed from the epithelial tissue of the fistula (Figure 4). The knitted, polyester surgical mesh that had been fitted loosely over the duodenum prevented the occlusion of the blood supply to the intestine, and no necrosis of the tissue, which is often observed when an artificial graft is used, was observed around the duodenum. Care of animals with hard cannulas is difficult, because the leakage of digesta usually starts within 1 mo after surgery, but the introduction of surgical mesh as an anchor for the cannula worked well. It was observed 3 to 7 d after surgery that the fibrous tissue surrounding the mesh connected the serosa of the duodenum and the peritoneum at the bottom of the barrel. After removing the internal plug with large forceps, samples can easily be withdrawn. The collection of the whole digesta can be achieved with the aid of a balloon catheter (Number 8) expanded in the lumen of the duodenum surrounded by the surgical mesh. The inner plug is positioned loosely in the groove of the barrel. However, the fringe of the plug is posi-
tioned inside the body of the sheep approximately 3 mm lower than the outer skin and is pressed by the skin and the muscle, thus assuring the placement.

Seven types of cannulas made of different silicone rubber with different hardness scores and molds with different barrel sizes or internal flanges were evaluated in 13 sheep over a period of 6 yr. With a cannula similar to that described here, animals grew normally and no abnormalities of the sheep or deterioration of the cannulas were observed for 1 yr. Four months after the operation, the outer flange of the cannula, buried in the wool, fitted snugly. The animals with large ruminal cannulas on the left flank (Horigane et al., 1989) could rest with their duodenal cannulas on the wooden hurdle-floor of the cage without difficulty, thus improving their welfare.

Implications

Use of these surgical techniques to prepare sheep with duodenal cannulas solves many problems associated with research applications. The techniques have the advantages of rapid surgeries, quick recuperation, and long use in healthy sheep.

Literature Cited