RUMEN AND ABOMASAL CANNULATION OF SHEEP WITH SPECIALLY DESIGNED CANNULAS AND A CANNULA INSERTION INSTRUMENT

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Summary

Rumen and abomasal cannulas for sheep and an instrument that facilitates rapid insertion of the cannulas were developed. The cannulas were made from epoxy-filled polyurethane and were supported by outer support rings held in place by nuts screwed onto the threaded tops of the cannula barrels. The insertion device was used to pull the cannula through a separately made incision in the abdominal wall and to stretch the skin and other tissues over a cone and onto the barrel of the cannula, thus ensuring a tight fit and the formation of a ring of scar tissue that virtually eliminated digesta leakage. Expansion plugs, used to seal the cannulas, were designed to eliminate a twisting force that could be transferred to the cannula when the plugs were secured or released. The plugs were also designed to protrude minimally from the side of the animal. More than 75 sheep were cannulated, and the preparations proved to be relatively maintenance free and resistant to mechanical disturbance by the animal. The cannulas had a long functional life and permitted convenient sampling of digesta and introduction of liquid and solid materials, including digestion bags.

(Key Words: Sheep, Rumen Cannula, Abomasal Cannula, Cannulation.)

Introduction

Our knowledge of the function of the rumen and abomasum has been greatly enhanced through the use of surgically constructed fistulas. Cannulation is needed to maintain an open fistula and to minimize its interference with normal digestive function. A variety of rumen and abomasal cannulas have been used and many have been described in reviews and texts (Dougherty, 1955; Markowitz *et al.*, 1964; Johnson, 1966; Willes, 1972; Hecker, 1974). The cannulas have varied from rigid forms made from metal or plastic (Phillipson and Innes, 1939; Hill and Gregory, 1951; Komarek and Leffel, 1961; Markowitz *et al.*, 1964; Hecker, 1974) to pliable forms made from poly(vinylchloride)plastisols, vinyl tubing and silicone elastomer tubing (Yarns and Putnam, 1962; Stewart and Nicolai, 1964; Stewart, 1967; Driedger *et al.*, 1970; Alonso *et al.*, 1973; Thyfault *et al.*, 1975).

Cannulas made of flexible materials are generally easy to fabricate and to insert into the animal. Rigid cannulas, however, can be inserted tightly into the abdominal wall, because the skin and other tissues are sufficiently elastic to stretch over the rigid cannula. Although a tight fit is difficult to accomplish consistently, when it is achieved, the resultant formation of a tight ring of scar tissue seals the cannula in the abdominal wall and produces an essentially maintenance-free preparation (Komarek*et al.*, 1960; Komarek and Leffel, 1961; Markowitz *et al.*, 1964).

Ideally, a cannulated preparation should seal the fistula and eliminate leakage. It should not protrude from the side of the animal or be vulnerable to mechanical disturbances, and it should be easily opened and sealed and avoid any twisting action that may disturb the cannula. Rigid cannulas designed to satisfy these criteria were prepared for the rumen and abomasum of sheep, along with a device for inserting the cannulas and a cannula closure or plug. The cannulas described in this report

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were relatively leak-free, did not protrude from the side of the animal and were easily sealed with a low profile expansion plug.

Materials and Methods

Animals. Surgery was performed on lambs that weighed between 27 and 40 kilograms. Some rumen cannulas were inserted into larger sheep. The sheep were crossbreds, with Dorset and Hampshire blood predominating.

Cannulas. The cannulas were designed with a bottom flange, a barrel or tubular portion and a threaded top with matched nuts that secured the outer rings to the top of cannulas (figure 1). The rumen and abomasal cannulas were of the same design, but they were different in size and proportion (figure 1). The internal diameter of the barrel of the abomasal cannula was 12 mm, and that of the rumen cannula was 33 millimeters. The cannulas were made from a rigid, epoxy-filled polyurethane[3], and the tissue contact areas were coated with a medical-grade silicone elastomer[4]. The cannulas were sealed with expandable neoprene plugs, or closures (figure 1), operated by cam action levers from commercial closures[5]. An inner peritoneal support ring, made from a foamed poly(fluoroformal) material, was used with the abomasal cannula (figure 1d).

Insertion Instrument. The cannula insertion instrument was designed to utilize the drawing action of a Tyding tonsil snare[6]. The instrument consisted of a stainless steel cone, which was attached to the top of the cannula; a rod, which was attached to the cone and drew the cone into the instrument, and two floating foot pads that slid over the cone when the operator squeezed the handle of the instrument (figures 2 and 3). A special pair of calipers was used during this procedure to bridge the gap between the two foot pads (figure 6d).

Surgery. The animals were clipped, washed the day before surgery and fasted for 24 hours. Surgery was performed under general

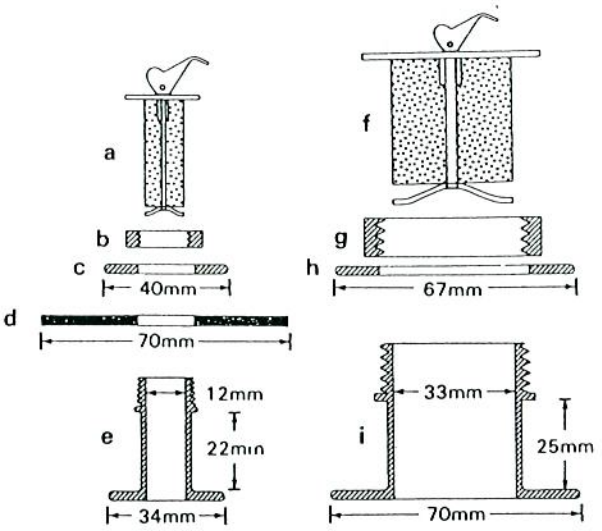


Figure 1. Abomasal and rumen cannulas made from epoxy-filled polyurethane, along with respective closures or plugs: (a) cam-activated expansion plug for the abomasal cannula, (b) retaining nut, (c) outer flange, (d) inner peritoneal support ring, (e) abomasal cannula, (f) rumen cannula plug, (g) retaining nut, (h) outer flange, (i) rumen cannula.

anesthesia produced either by IV infusion of a mixture of chloral hydrate and pentobarbital sodium[7] or, preferably, with halothane[8] administered in a closed circuit inhalation anesthetic unit[9]. Atropine was given to inhibit salivation and the motility of the rumen and abomasal musculature, and to increase respiratory efficiency. With halothane, anesthesia could be induced by masking, thus eliminating the need for an IV anesthetic. After the induction of anesthesia, the trachea was intubated with a cuffed endotracheal tube and anesthesia was maintained with halothane. The animals were positioned in either a left (abomasal cannula) or a right (rumen cannula) lateral recumbency. The operating table was constructed so that the thorax was elevated in relation to the head and abdomen (Komarek *et al.*, 1960; Hecker, 1974). In this position, the saliva and digesta drained away from the trachea, preventing inhalation of these fluids, and the viscera were directed caudally to reduce the pressure on the diaphram and the operating field. Entrance to the peritoneal cavity was achieved by a paracostal laparotomy (see figures 4a and 4b). Standard aseptic surgical procedures were used (Markowitz *et al.*, 1964).

After the site of the rumen or abomasal incision was located and the surgically exposed tissues and peritoneal cavity were isolated and

[3] 850 Adiprene, E. I. Du Pont de Nemours & Co., Wilmington, DE.

[4] Silastic 382, Dow Corning, Midland, MI.

[5] Moeller Manuracturing Co., Greenville, MS.

[6] No. 683 310, Dittmar and Penn Corp., Philadelphia.

[7] Equithesin, Jensen-Salsbery Laboratories, Kansas City, MO.

[8] Fluothane, Ayerst Laboratories, Inc., New York.

[9] VML-Fraser Sweatman, Inc., Lancaster, NY.

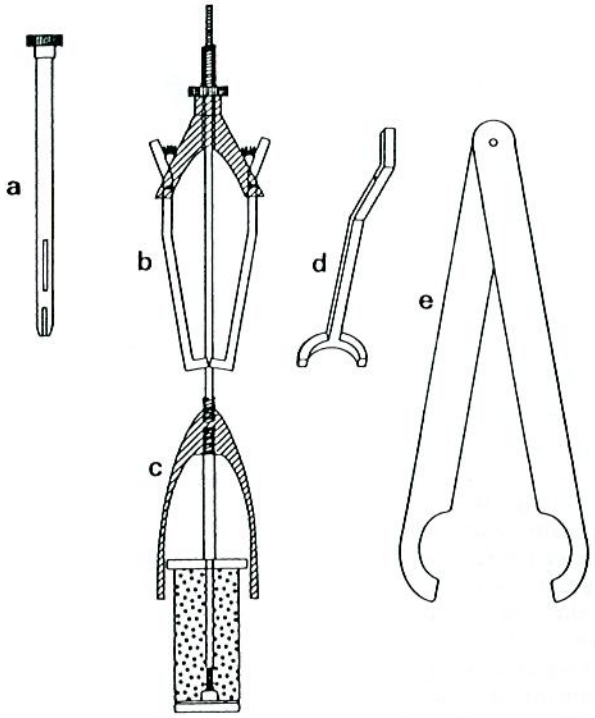


Figure 2. Parts of the cannula insertion instrument that must be fabricated to convert the Tydings tonsil snare into the insertion device: (a) upper segment of the drawing rod, (b) endpiece assembly with presser feet and the lower segment of the drawing rod, (c) cone with attaching neoprene plug, (d) presser foot, (e) support calipers.

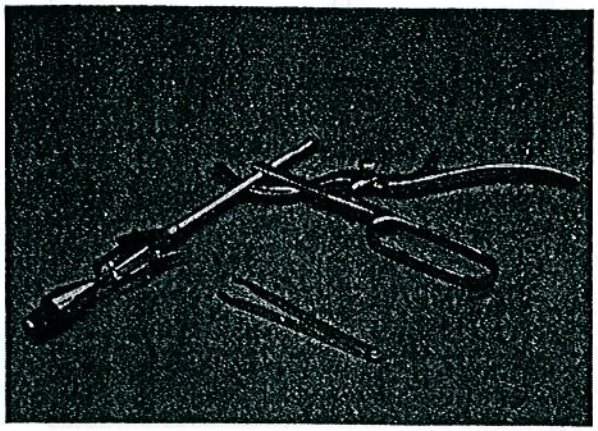


Figure 3. Insertion instrument assembled with cone and calipers for the abomasal cannula. A larger endpiece, presser feet, cone and calipers were used for the rumen cannula.

protected with sterile towels, an incision was made (preferably by electrocautery) in either the dorsal sack of the rumen between the terminal left ruminal artery and the dorsal branch of the right ruminal artery, which extends around to the left side (figure 4c), or the pyloric region of the abomasum, 10 to 12 cm from the pyloric sphincter (figure 4d). The incision was only large enough to allow introduction of the bottom flange of the cannula into the organ. It was necessary to aspirate excess rumen or abomasal fluid from the organ after the incision was made. A Murphy purse-string suture was used to close the incision around the barrel or the cannula, and, when necessary for proper inversion, this suture was oversewn with a regular purse-string suture (figure 5a). For added strength in the region of the abomasal cannula, an inner peritoneal ring (figure 5b) was slipped over the barrel.

The insertion cone was then slid over the top of the cannula and the neoprene plug slid into the barrel. The plug in the cannula was expanded by a clockwise turning of the cone (figure 5c). The cone served to seal the cannula and prevent contamination of the operating field. The cannula and cone were loosely secured with a long piece of suture before being returned to the peritoneal cavity (figure 5c), thus allowing easy retrieval after the second skin incision was made.

Either a stab incision no longer than 12 mm, for the abomasal cannula, or a circular incision 22 mm in diameter (figure 5d), for the rumen cannula, was made in the skin adjacent to the opening incision. A stab incision penetrating the muscle layers and peritoneum was then made. With the insertion instrument partially disassembled, the drawing rod from the instrument was passed down alongside the scalpel through the abdominal wall (figure 6a) and

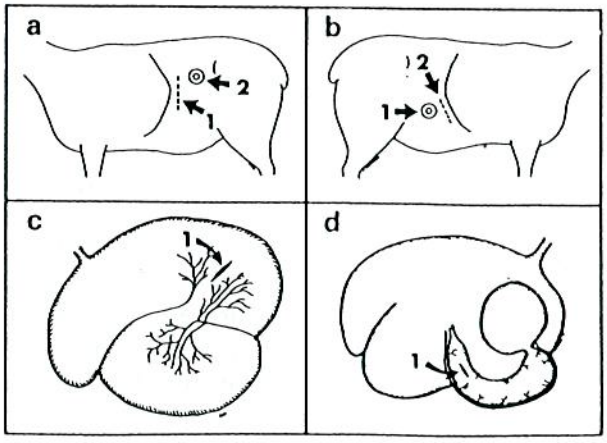


Figure 4. (a) Positions of the (1) laparotomy and (2) rumen cannula in a sheep. (b) Positions of the (1) laparotomy and (2) abomasal cannula in a sheep. (c) Position of the (1) ruminal incision. (d) Position of the (1) abomasal incision.

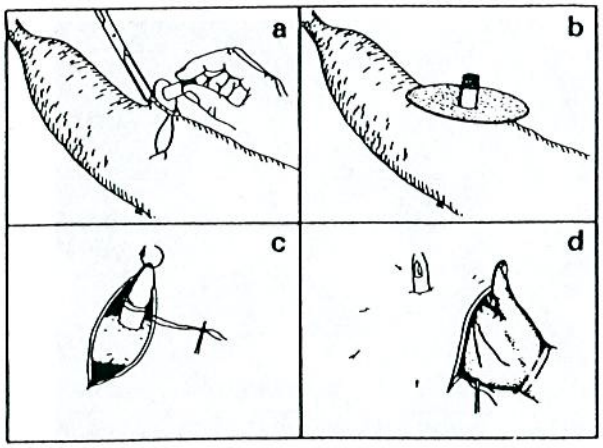


Figure 5. (a) Introduction of the abomasal cannula with an Allis forceps; drawing shows the Murphy purse-string suture in place. (b) Peritoneal ring is slipped over the barrel of the cannula and lies on the serosal surface of the abomasum. (c) Cone is attached to the cannula: plug portion is inserted into the barrel and the cone over the barrel, and plug is expanded by turning the cone. The cannula must be held firmly while the cone is attached. (d) A circular section of skin is removed with a specially designed circular scalpel before the larger rumen cannula is inserted.

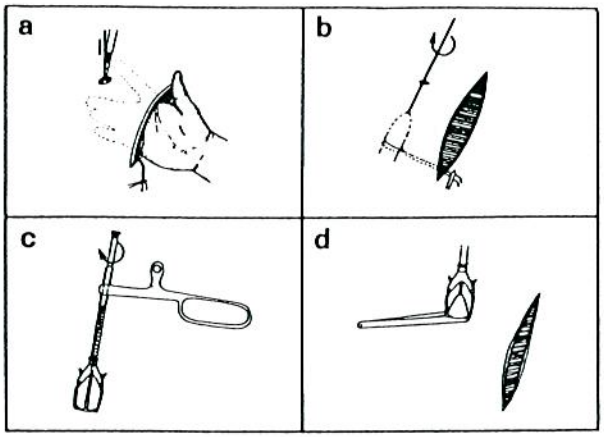


Figure 6. Insertion of the cannula in the abdominal wall. (a) Lower segment of the drawing rod is slid down alongside a small-bladed scalpel that has penetrated the muscle layers and peritoneum; (b) rod is screwed into the top of the cone; (c) body of the instrument is slid over the lower segment of the rod and the upper segment is screwed into the lower segment; (d) after movable portion of the handle is attached and calipers are set in place, handle of the instrument is squeezed, forcing the muscle layers and skin over the cone and onto the barrel.

screwed into the top of the cone (figure 6b). After the rod was attached to the instrument (figure 6c), the calipers were set in place under the foot pads (figure 6d). A steady squeezing action on the handles of the instrument was then used to pull the cone through the abdominal wall. The tissues were stretched over the cone and forced onto the barrel of the cannula (figure 6d). The cone was removed, and the outer support ring was slipped over the top and secured with the cannula nut (figure 7). After the cannula was sealed with an expandable plug, the opening incision was closed.

The use of IV anesthetic occasionally required the infusion of a plasma extender to treat surgical shock. A 5% glucose solution was used, postoperatively, to enhance detoxification of the anesthetic. IV therapy was not necessary when the animals were anesthetized with halothane. A mixture of penicillin and dehydrostreptomycin[10] was injected IM at .06 ml/kg body weight immediately after surgery and daily at .03 ml/kg for 5 days thereafter.

[10] Combiotic, Pfizer Inc., New York.

Results and Discussion

More than 60 sheep were abomasally cannulated, and 15 were ruminally cannulated. Recovery from surgery was rapid, and the animals consumed feed and water within 12 hours. Except in three lambs found to have serious respiratory lesions, all surgical attempts produced functional cannulated preparations. No excessive swelling around the cannulas or infections were encountered. The absence of swelling and the minimal protrusion of the cannula from the side of the lamb, a day after abomasal cannulation, can be seen in figure 7. All sheep resumed normal levels of feed consumption within 7 to 10 days after surgery.

The abomasal cannula was used both to introduce solid or liquid material and to sample abomosal fluid. The manipulations were easily accomplished, and, in addition, the rumen cannula was large enough to permit convenient introduction and recovery of rumen digestion bags.

The low external profile of the cannula enabled sheep to lie on the cannula or to be grouped with other sheep, without any danger of their mechanically disturbing the cannula.

The dimensional stability of the rigid cannula allowed insertion in a manner whereby the elastic recoil of the skin and other tissues was

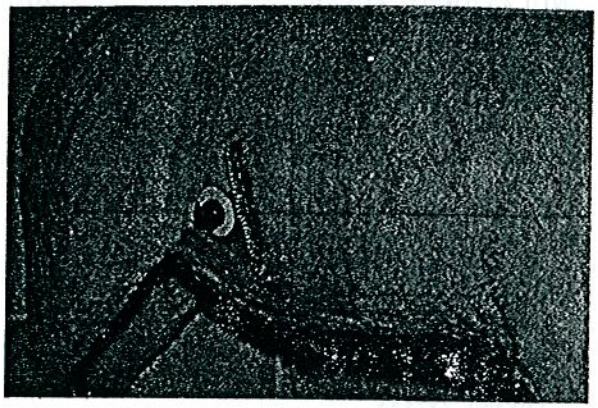


Figure 7. An abomasally cannulated sheep the day after surgery; note the lack of swelling and the minimal protrusion of the external portion of the cannula.

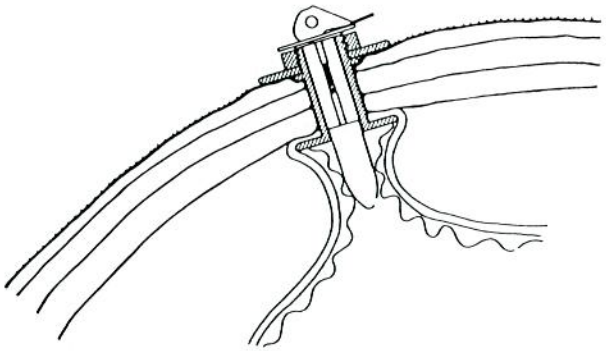


Figure 8. Function of a cannula plug with a bullet-shaped extension designed to keep the mucosal folds from closing off the end of the cannula.

used to ensure formation of a tightly sealing scar ring around the device. The difficulties associated with this type of insertion prompted the development of the insertion instrument. The instrument accomplished the insertion quickly and easily and consistently produced a tight fit. The rigid cannulas also allowed the use of effective expansion plugs for convenient sealing.

The scar ring that formed around the cannula produced a liquid-tight seal, and no digesta leakage occurred for 3 to 6 months after the operation. The scar tissue around the neck of the cannula was flexible, and eventually stretched away from the device and allowed a small amount of abomasal or rumen fluid to seep by during movements of the animal. The quantity of fluid was not sufficient to require daily care. No leakage of digesta into the peritoneal cavity was encountered.

Subsequent experimentation indicated that the leakage could be eliminated by the insertion of an inner peritoneal flange into a tightly fitting groove in the cannula just above the purse string suture (Komarek, 1981). This procedure has not yet been used for rumen or abomasal cannulation.

Collection of abomasal fluid through the abomasal cannula often became difficult 3 to 6 months after surgery. Autopsy indicated that the abomasum migrated back toward the omasum while attached to the abdominal wall by the cannulation and formed a tubular passage from the abdominal wall to the abomasal lumen (figure 8). The folded mucosa tended to act as a valve, and, although test material could be introduced, abommasal fluid samples were difficult to collect. The problem was solved by the design of a cannula plug with a bullet-shaped endpiece which kept the channel open and allowed easy collection of fluid during the life of the preparation (figure 8). Collection was facilitated by the insertion of a hollow tube through the cannula and past the mucosal folds.

Abomasal cannulas commonly remained functional for about 2 years. They were eventually rejected by a general weakening and stretching of the abdominal wall in the region of insertion. The weight of the viscera seemed to be an important factor in this hernial protrusion of the cannula. Experience indicated that positioning the cannula higher on the side of the animal increased the longevity of the preparation.

In ruminally cannulated animals, the weight of the viscera did not bear upon the cannula. Consequently, these preparations usually lasted as long as the animals were experimentally useful.

The rumen and abomasal cannulas fulfilled the original design objectives. They effectively sealed the fistula and were essentially maintenance-free. They did not protrude from the side of the animal and, consequently, were not vulnerable to mechanical disturbance by the animal. The cannulas were long lasting and were easily used for the sampling of digesta or administration of test materials.

The success of the preparation was due in large part to the use of the cannula insertion instrument, which, with relative ease, stretched the tissues and pulled the cannula through the abdominal wall, thus ensuring the formation of a tight scar ring.

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