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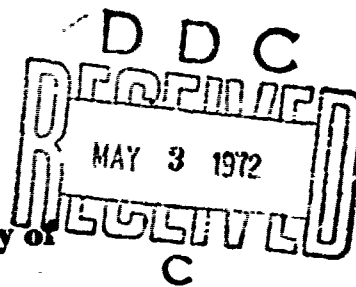
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Surgical Techniques in the Study of Canine Fetal Physiology

By RICHARD L. BERNSTINE AND ARNOLD G. CORAN

THE SURGICAL APPROACH to the intrauterine environment has developed as a useful procedure to study the fetus.

A number of investigators have utilized the fetal dog as a model in a variety of experiments.¹⁻⁴ Barnard,¹ Jackson and Egdahl,⁴ Haller,² and Hodari and Thomas³ described surgical procedures on the fetal dog. Jackson and Egdahl introduced the technique of suturing the fetal skin to the uterine wall prior to making either the uterine or fetal incision. The development of surgery on the mammalian fetus has recently been reviewed by Rosenkrantz.^{5,6}

The present report details the technical aspects of specific surgical procedures and the experience gained from more than 500 operations performed on the pregnant dog and is presented as a guide to the avoidance of pitfalls in canine fetal surgery.

GENERAL PRINCIPLES

(1) *The pregnant bitch shall be placed in the lateral position and a vertical flank incision is preferred. The muscles should be split along their fibers. This approach allows adequate exposure of one uterine horn, diminishes postoperative dehiscence (vs. a midline lower abdominal incision), and permits more direct exteriorization of the catheters (Fig. 1).*

(2) *The fetuses at or near the cervix should not be used for surgery. The manipulation of fetuses near the cervix leads to initiation of labor in over 50% of the cases.*

(3) *Expose only as much of the fetus as is necessary to complete the surgical procedure. Minimizing fetal exposure decreases heat loss; the proximity of fetal vessels to the surface and the additional surface area composed of umbilical cord and placenta lead to rapid radiative heat loss when the fetus is taken out of the uterus.⁶*

(4) *Make the uterine incision distant from the placental site. In order to protect the placental circulation and to avoid large maternal and fetal vessels,*

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The opinions or assertions contained herein are the private ones of the authors and are not to be construed as official or reflecting the views of the Navy Department or the Naval Service at large.

The experiments were conducted according to the principles enunciated in *Guide for Laboratory Animal Facilities and Care*.

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the uterine incision should be placed at a maximum distance from the placenta. Regardless of the site of the uterine incision, adequate fetal exposure can almost always be obtained (for example, exposure of fetal upper abdomen).

(5) *Make a small uterine incision; the delivery of the fetal part will enlarge it.* Compromise of uterine vessels is lessened by eliminating the need to ligate some of these vessels, which is usually necessary with a large incision.

(6) *When performing head and neck surgery, the membranes should be left intact over the mouth and nose and then incised over the chosen operative site.* This will prevent the fetus from inflating his lungs, if respiratory activity should be initiated.

(7) *Any exposed area should be covered with a warm moist sponge to decrease the significant radiative heat loss from the fetus to the room environment.*

(8) *Following exposure of the appropriate area for surgery, the fetus should be secured to the uterus with either Allis clamps or sutures.* By so doing one can prevent delivery of the fetus, contraction and retraction of the uterus, loss of amniotic fluid, and reduction of the total capacity of the uterus.

(9) *Immediate control of fetal bleeding, however small, is mandatory.* Because of the small blood volume of the fetus, hemostasis must take precedence over all other maneuvers.

(10) *The amniotic sac must be closed during uterine closure.* Continued loss of amniotic fluid postoperatively will usually lead to fetal death.

(11) *If more than one fetus is to be explored surgically, the position of all selected fetuses must be determined prior to the initiation of surgery.* The catheters of the first fetus will not be disturbed while preparing the second fetus for surgery.

(12) *All fetal incisions are closed with fine nonabsorbable interrupted sutures to prevent restricted fetal growth in the area of surgery that occurs with continuous absorbable or nonabsorbable sutures.*

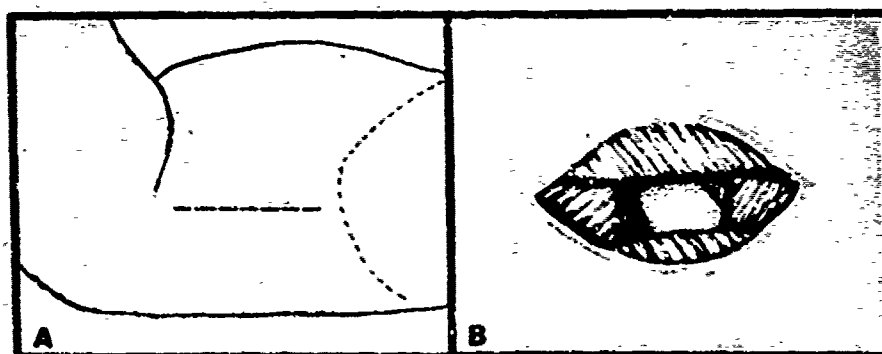


Fig. 1.—(A) The dotted line represents the extent of the flank incision in the maternal animal. (B) The muscle layers have been separated and the uterus (stippled area) is evident in the center.

(13) All fetal catheters should be exteriorized through a separate incision in the maternal abdomen to prevent dislodgement and/or kinking of the catheters during closure of the abdominal incision.

(14) Side holes should be placed in the portion of catheter to be inserted into a hollow viscus. This prevents mucosal occlusion of the opening at the end of the catheter. These holes, in addition, will prevent clogging of the small fetal catheters that may result from stasis secondary to the slow flow and small volume of excretion in fetal organs.

(15) The umbilical cord must be protected from exposure and manipulation to prevent compromise of the umbilical circulation.

(16) Great care must be exercised in suturing or ligating fetal tissue. The decreased amount of connective tissue in the fetus results in increased friability. There is less tendency for sutures to cut through tissues when larger sizes are used (i.e., No. 000 vs. No. 00000).

PREPARATION OF THE MATERNAL ANIMAL

The animal is allowed only water for 12 hr prior to surgery. No premedication is given. Anesthesia is induced with intravenous nembutal (25 mg/kg body weight). An endotracheal tube is inserted. The animal is allowed to respire spontaneously on room air. Anesthesia is supplemented as needed.

An intravenous drip of 5% dextrose in water is maintained during surgery. The flank is shaved and washed with betadine (Bard Pharmaceuticals, Yonkers, N.Y.) antiseptic solution and then painted with betadine.

SPECIFIC SURGICAL PROCEDURES

Exposure of the Fetal Urinary Bladder (Fig. 2)

The uterus is incised and, following exposure of the fetal hindquarter, a right paramedian incision is made equidistant above and below the penis. In the

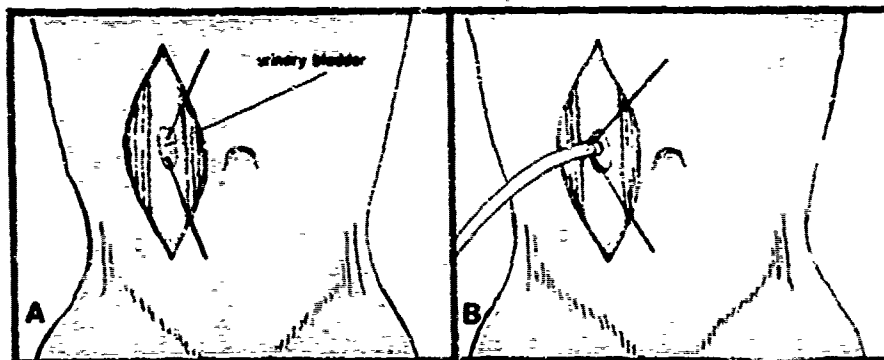


Fig. 2.—(A) The lower portion of the fetus has been delivered to a level just below the umbilicus. The right rectus incision extending above the level of the penis is outlined. (B) The muscles on the right side have been retracted and a small opening has been made in the peritoneum. The fetal bladder is presented through the incision and sutures have been placed in this organ. (C) The catheter is secured in place utilizing the sutures.

female fetus, the incision is centered on the junction of the middle and lower third of the abdomen. A small vein is frequently encountered superficial to the rectus muscle. The incision is carried down through the peritoneum. Invariably, the distended urinary bladder fills the incision. The umbilical arteries are not usually visualized but their proximity to the operative site must be borne in mind.

Two figure-of-eight sutures of No. 00000 mersilene are placed through all layers of the anterior wall of the bladder. The sutures should be placed 1-2 mm apart. An opening is made between the two sutures into the interior of the bladder. Urine always flows out through the incision. Prior to the insertion of the polyethylene catheter, PE200 (I.D. 0.55 inch, O.D. 0.075 inch), the entire thickness of the bladder (including mucosa) should be grasped with tissue forceps. This will prevent submucosal placement of the catheter.

To secure the catheter in place, one free end of each suture is looped about the catheter. These two ends are tied together. The remaining ends of the sutures are tied together to close the bladder opening.

The abdomen may be closed in layers if the tissue planes are well developed; otherwise, through and through interrupted sutures should be used. A similar closure is employed in subsequent procedures.

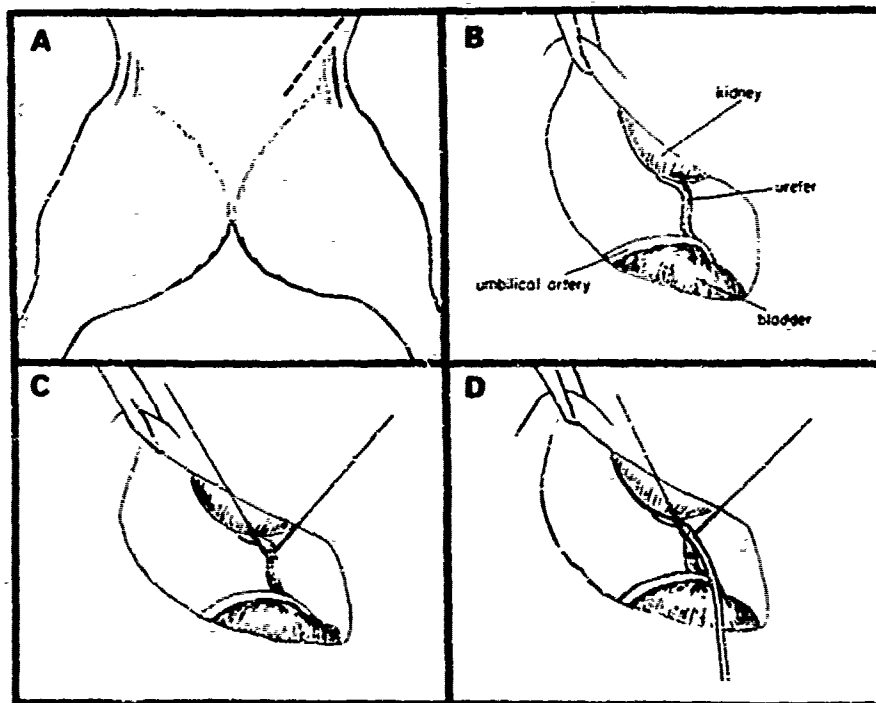


Fig. 3.—(A) The dotted line represents the incision for exposure of the fetal ureter. (B) The anatomic relationships of the ureter are depicted. (C) The ureter has been isolated. (D) A catheter has been inserted into the ureter.

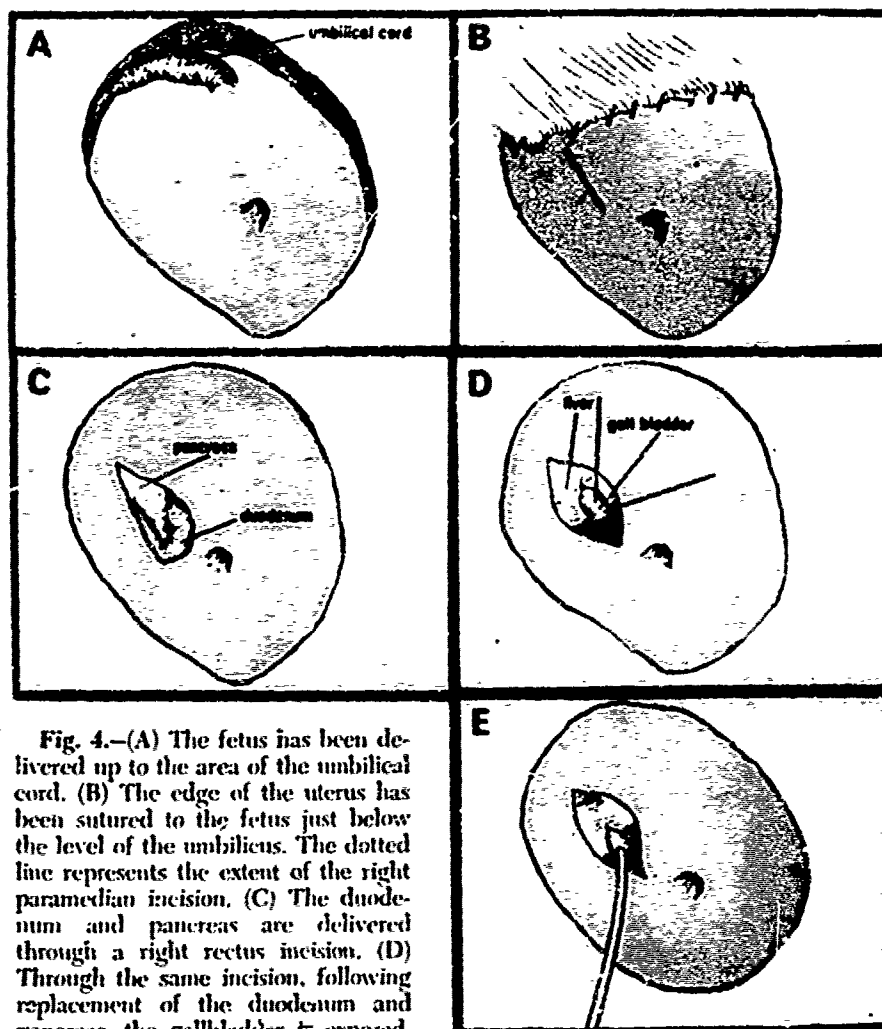


Fig. 4.—(A) The fetus has been delivered up to the area of the umbilical cord. (B) The edge of the uterus has been sutured to the fetus just below the level of the umbilicus. The dotted line represents the extent of the right paramedian incision. (C) The duodenum and pancreas are delivered through a right rectus incision. (D) Through the same incision, following replacement of the duodenum and pancreas, the gallbladder is exposed. (E) A catheter has been placed in the gallbladder.

Exposure of the Fetal Ureter (Fig. 3)

Fetal exposure is the same as for catheterization of the urinary bladder. A modified Halstead herniorrhaphy incision is made and is continued down into the peritoneal cavity. By elevating the margins of the incision and gently packing the intestines anteromedially, the ureter can be exposed as it enters the bladder.

In this area, the ureter lies posterior to the hypogastric artery and gonad. It is covered by a very thin layer of peritoneum and is relatively avascular at this site.

The ureter may be elevated with a blunt nerve hook and a small incision can be made in the anterior wall. A polyethylene catheter PE10 (I.D. 0.011 inch.

O.D. 0.024 inch) is placed into the ureter and threaded to the kidney pelvis. The catheter is secured in place.

Because of the low-lying position of the fetal kidney, the ureter is relatively short.

Exposure of the Fetal Duodenum, Pancreas, and Gallbladder (Fig. 4)

The uterine incision is made over the lower extremities of the fetus and the fetus is delivered to the umbilicus. The fetus is sutured to the uterus so that the umbilicus is covered by the uterine wall.

A right paramedian incision is made from the costal margin inferiorly for approximately 2 cm. The incision is continued into the peritoneal space. The first loop of intestines to present into the incision is generally the duodenum. This can be readily confirmed as the loop is delivered and the pancreas

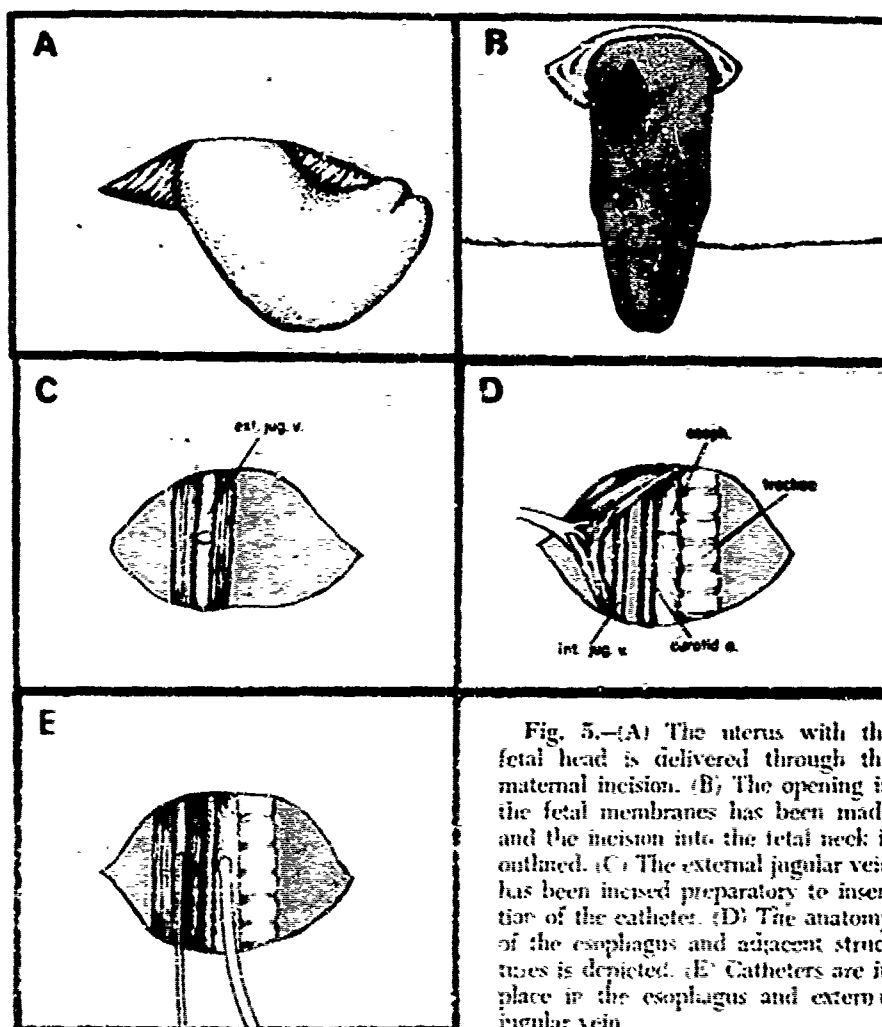


Fig. 5.—(A) The uterus with the fetal head is delivered through the maternal incision. (B) The opening in the fetal membranes has been made and the incision into the fetal neck is outlined. (C) The external jugular vein has been incised preparatory to insertion of the catheter. (D) The anatomy of the esophagus and adjacent structures is depicted. (E) Catheters are in place in the esophagus and external jugular vein.

identified. The entrance of the common bile duct into the duodenum can be visualized and the bile duct can be ligated at this site. The loop of intestines is replaced and gently packed away with a moist sponge strip.

The fetal abdominal wall is elevated and the liver displaced downward. The downward depression of the liver will expose the intrahepatic gallbladder. If the gallbladder is not readily visible by this technique, separation of the lobes of the liver will expose it.

Catheterization of the gallbladder follows the same general principles as outlined in the section for placement of a catheter in the urinary bladder. In addition, in this instance, it is important to secure the catheter to the anterior abdominal wall to prevent perforation of the viscus.

Exposure of the Fetal Esophagus and Catheterization of the Fetal Stomach (Fig. 5)

The uterus is opened over the fetal nose and the fetal head is delivered with the membranes intact. The head is covered with a warm moist sponge and the membranes are opened over the fetal neck. A transverse incision is made just below the thyroid cartilage from the midline to the left external jugular vein. The incision is between the strap muscles and the left sternocleidomastoid muscle is developed. The esophagus is identified lying between the trachea and carotid sheath. It is isolated and ligated proximally just below the inferior pole of the thyroid gland. The esophagus is opened transversely and a polyethylene catheter PE200 (I.D. 0.055 inch, O.D. 0.075 inch), is inserted into the stomach.

Insertion of Central Venous Catheter (Fig. 5)

Fetal delivery and exposure is the same as in the previous procedure (esophagus). A small transverse incision is made over either external jugular vein that can be seen through the skin. The vein is dissected free from the surrounding tissue and ligated proximally. The vein is grasped with pointed tissue forceps and tented up. Using microscissors, an incision is made into the vein by cutting against the tissue forceps. The margins of the incision are held apart. The opening in the vein may not be readily visible, but the intima of the posterior vein wall can be identified by its light reflex. A polyethylene catheter, PE50 (I.D. 0.023 inch, O.D. 0.035 inch) or PE90 (I.D. 0.034 inch, O.D. 0.50 inch) is inserted into the vein and threaded centrally. The catheter is secured in place.

POSTOPERATIVE CARE

(1) The catheter from the hollow viscus is allowed to drain into a test tube. An appropriate sized Jelco (Jelco Laboratories, Raritan, N. J.) needle is inserted through the stopper of the test tube so that the hub of the needle remains inside the tube. The fetal catheter is either attached to or passes through the plastic portion of the needle.

(2) The maternal abdomen is covered with a stockinette dressing.

(3) 600,000 U of penicillin and 5 g of streptomycin are administered daily to the mother for the first 5 postoperative days.

(4) Experimental studies are performed the day following surgery on the awake animal. If desired, repeat studies can be made for the subsequent 48-hr period in 80% of the experimental preparations.

(5) Sufficient evidence of fetal life is demonstrated by function of the organ system being studied.

(6) If signs of labor develop, the stockinette dressing should be removed to allow the newborn puppies to nurse.

(7) If survival of the newborn is desired, the mother must be observed closely at the time of delivery. Frequently, she will destroy any fetus that has undergone surgery.

SUMMARY

Surgical techniques for operating on the canine fetus together with pre- and postoperative management have been described. These principles have been developed during the course of over 500 surgical procedures performed on the pregnant dog.

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