VENOUS CATHETERIZATION OF DAIRY COWS

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In studying the phosphorous metabolism of dairy cows by the use of radioactive tracers (16), it was necessary to develop a suitable injection and bleeding technique which would fulfill the following requirements: (a) It must permit complete injection of the radioactive material for hazard control; (b) it must provide for accurate and rapid injection of the material, followed immediately with the withdrawal of blood samples; (c) it must allow for the bleeding at frequent intervals over long periods (4 to 5 weeks); and (d) it must minimize the disturbance and apprehension of the cow, conditions which have been shown to affect the blood phosphorous values.

REVIEW OF LITERATURE

Forssman (9) in 1929 catheterized the right auricle on himself, after exposure of a vein of the arm by a surgeon. From 1930 to 1939 this technique (4) of catheterizing the right heart was widely used in Europe for injecting contrast substances in order to visualize the right chambers of the heart and the pulmonary vascular tree. Cournand and Ranges (2) modified the Forssman technique. They used a specially made gauge (no. 10) Lindeman type of needle; a three way stopcock with a Leur lock; a tightly fitted adapter; and a No. 8 F flexible, X-ray opaque, varnished, silk catheter with two holes, one at the rounded tip and another about 1 cm. from the tip. A saline reservoir with rubber tubing and a clamp for controlling the rate of flow was used to supply a constant flow of saline, at the rate of 15 drops per minute as an anticoagulant. The catheter was introduced into the median basilic vein of either arm. The passage of the catheter through the vein was accomplished while the patient was on a fluoroscopic table. There was no evidence of blood clotting or thrombi in the holes of the catheter.

Since the Cournand and Ranges (2) paper, venous catheterization has been employed to obtain blood samples from the coronary sinus of man (1, 12, 20), of the dog (8, 10, 11, 12, 13), the right auricle of man (2, 3, 4, 6, 12, 23, 24), of the dog (21), the hepatic vein of man (24), the portal vein of the dog (5), the jugular vein of man (18), of the dog (25), and the pulmonary artery of the dog (8, 10, 15), as well as in the measurement of cerebral blood flow in man (14), in the monkey (6, 22) and in the dog (14).

Catheters made of various materials have been used: steel or other metal cannulae (13, 14, 21), a soft ureteral catheter (9), a flexible radiopaque ureteral catheter (1, 2, 3, 4, 8, 10, 15, 24), and a modified, tapered tipped ureteral catheter with a woven, shellacked nylon core covered with a heavy X-ray-opaque...
plastic covering. This latter catheter has been modified (12) by the addition of two small side eyes, with shallow grooves on the outer surface of the catheter leading forward from the side eyes to the terminal eye. Unspecified plastic catheters (25), vinylite (18) and polyethylene (5) catheters have been used for intravenous work. Polyvinyl chloride tubing (19) was used for prolonged intramuscular injections.

Several thousand short-time catheterizations of the right auricle, to determine the cardiac output in man, have been performed in various laboratories without serious ill effects. However, it is a potentially dangerous procedure and should only be carried out with considerable care and thoughtfulness (20). Occasionally linear mural thrombosis occurred in patients near the site of incision when the catheters were left in place for 24 hours (3). Plastic intravenous catheters, used for protracted administration of various drugs to patients caused a transient phlebitis about the tube when left in the vein for several days (18). This condition may have been due to the injected fluids rather than the presence of the tube.

Dogs with the external jugular vein catheterized for 4 to 5 weeks showed that the veins were thrombosed around the tube in about half of the cases (25). In patients, the injection of materials into the median basilic vein for 12 days was satisfactory. This author felt that thrombosis of the veins occurred when concentrated or irritating substances were infused. Subendocardial fibrosis, mural thrombi and subendocardial hemorrhage were found in the right auricle after catheterization of the right heart (10). Following catheterization of the pulmonary artery, the right ventricle and the tricuspid valves showed some injury. Dogs were catheterized (11) seven times during 4 months, with only three failures out of 68 catheterizations. The catheters were left in the dogs up to 5 hours. Blood samples were obtained from the portal veins of dogs (5) for an average of 21 days and a maximum of 34 days after insertion of the catheter.

It is apparent from the foregoing summary that blood can be obtained satisfactorily by the use of catheters. Further investigations, however, are needed to improve the technique and to evaluate the effect of the infusion of various materials on long term blood sampling.

**EXPERIMENTAL PROCEDURE**

A smooth, flexible, transparent tubing made of polyvinyl chloride was used as a catheter. This tubing ("spaghetti") is used as insulation by electricians and can be obtained from electrical supply houses. Our catheters were 40 to 45 cm. in length with an inside diameter of 1.4 mm. and an outside diameter of 2.2 mm.

In our experiments catheters were placed in both external jugular veins of cows. Radioactive substances were injected into one jugular vein, while blood samples were drawn from the other. Prior to insertion of the catheter, the skin area over the jugular veins was closely clipped and local anesthetic (procaine) injected at the site of insertion. A jugular tourniquet was applied. Then a
sterile hypodermic needle of 10 to 12 gauge was thrust into the vein. A needle with a relatively short beveled point was used with the short edge of the bevel turned in the direction which the catheter was to travel. The sterile catheter was inserted through the needle into the vein, leaving 6 to 8 cm. protruding. The needle then was removed. A small clamp halted the flow of blood through the catheter and held the tube in place to prevent it from being drawn into the blood stream. Finally, the catheter was filled with a sodium heparin solution (4 mg. sodium heparin per 100 ml. of 0.9 per cent saline) to wash out the blood and prevent the formation of a clot. The catheter then was closed with a plug. A sterile, heavy silk suture was placed in the skin to form a loop close to the catheter. The catheter then was tied to the suture my making three single knots.

A syringe fitted with a 16 gauge needle was used to draw blood samples. To reduce the apprehension of the cow and to prevent her from pulling out the catheter during bleeding or injecting, the catheter was lengthened by using the tubing from a 16 gauge needle connected to an additional piece of "spaghetti" 15 to 20 cm. in length.

Prior to drawing a blood sample, the catheter was washed with heparinized saline to remove any clot which may have partially closed the tube. Occasionally considerable force was necessary to open the catheter. Often a valve-like clot formed in the catheter which permitted injection but not withdrawal. Following the bleeding, the injection of heparinized saline was repeated.

**EXPERIMENTAL RESULTS**

Nineteen catheters were used in twelve trials on five different cows. Blood was obtained through these catheters at the rate of 1 ml. per sec. Bleeding caused very little disturbance to the cows. One sample was secured while one cow was lying in a paddock chewing her cud. Numerous samples were drawn when the cows were eating or ruminating. The length of time a catheter remained opened varied from 2.1 hours to 14.5 days (table 1).

From one cow 24 samples were obtained in 14 hours. During a 38-day trial, another cow had five catheters inserted into the right jugular vein from which 135 samples of blood were taken. In the same period only one catheter was placed in the left jugular vein for repeated injections of radioactive material at 12-hour intervals.

Preliminary trials with calves as well as catheterization of the carotid artery of one dairy cow for 4 days show promise.

In two instances catheters were drawn into the blood stream, in one cow when the needle was being withdrawn and in the other cow when the tubing was being placed in the opposite vein. No deleterious physiological effects were observed during the following 66 and 48 days respectively, at which time the cows were slaughtered. At autopsy, one catheter was found in the right pulmonary artery. No gross abnormalities were observed.

Cresson and Glenn (5) report that polyethylene catheters caused a cloting
reaction in some of their dogs. Only in one out of twenty dogs did a complete
thrombosis occur and then this followed three separate catheterizations of the
portal vein at 2 and 3 week intervals, the catheter having been left in the vein

TABLE 1

Time venous catheters remained functional and number of samples obtained

<table>
<thead>
<tr>
<th>Trial no.</th>
<th>Cow no.</th>
<th>Catheter</th>
<th>Blood samples per catheter</th>
<th>Functional time</th>
<th>Condition of catheter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>798</td>
<td>a</td>
<td>4</td>
<td>3.3 hr.</td>
<td>occluded</td>
</tr>
<tr>
<td>2</td>
<td>890</td>
<td>a</td>
<td>4</td>
<td>2.1 hr.</td>
<td>occluded</td>
</tr>
<tr>
<td>3</td>
<td>798</td>
<td>a</td>
<td>9</td>
<td>15.6 hr.</td>
<td>open</td>
</tr>
<tr>
<td>4</td>
<td>890</td>
<td>a</td>
<td>6</td>
<td>1.1 d.</td>
<td>open</td>
</tr>
<tr>
<td>5</td>
<td>890</td>
<td>a</td>
<td>21</td>
<td>4.0 d.</td>
<td>open</td>
</tr>
<tr>
<td>6</td>
<td>798</td>
<td>a</td>
<td>17</td>
<td>1.0 d.</td>
<td>open</td>
</tr>
<tr>
<td>7</td>
<td>890</td>
<td>a</td>
<td>7</td>
<td>2.2 hr.</td>
<td>occluded</td>
</tr>
<tr>
<td>8</td>
<td>798</td>
<td>b</td>
<td>10</td>
<td>3.8 d.</td>
<td>occluded</td>
</tr>
<tr>
<td>9</td>
<td>890</td>
<td>a</td>
<td>13</td>
<td>1.0 d.</td>
<td>open</td>
</tr>
<tr>
<td>10</td>
<td>853</td>
<td>a</td>
<td>8</td>
<td>10 0 d.</td>
<td>occluded</td>
</tr>
<tr>
<td>11</td>
<td>834</td>
<td>a</td>
<td>8</td>
<td>3.1 d.</td>
<td>occluded</td>
</tr>
<tr>
<td>12</td>
<td>757</td>
<td>a</td>
<td>45</td>
<td>11.0 d.</td>
<td>occluded</td>
</tr>
</tbody>
</table>

for 2 months. In one of the cows, slaughtered 18 days after the catheters had
been inserted, a complete thrombus was found in both the right and left jugu-
lar veins. The occluded portion corresponded approximately to the length of
the catheters in the veins.

SUMMARY

A technique of venous catheterization has been adapted to dairy cows, which
allows numerous blood samples to be taken at short intervals and the frequent,
accurate intravenous injection of substances (particularly radioactive material)
over a long period with a minimum of disturbance to the animals.

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