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Chronic catherization of a hepatic vein, the portal vein and a mesenteric vein in cattle using totally implantable catheter system

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Introduction

Physiological investigations of bovine hepatic functions *in vivo* are often limited due to the relatively difficult task of obtaining access to the portal and hepatic vessels and at the same time maintain a metabolically normal and unstressed animal. Several methods have been described for placing and maintaining catheters in hepatic, mesenteric and portal vessels in ruminants (*Katz & Bergman* 1969, *Symonds & Baird* 1973). The portal vein may be approached directly or through a mesenteric vein. The hepatic vein may be approached by a blind technique, via intraoperative ultra-sound guidance or by a direct approach (*Olesen et al.* 1986), which has not previously been used in cattle. All these methods include a traditional exteriorization of the catheter to the skin, and therefore meticulous care has to be taken to avoid catheter infection. The maintenance protocols often involve use of topic antibiotics or other drugs. The animals have to be kept individually or restrained in order to prevent damage of the percutaneous prosthesis or accidental implant removal. These factors may induce a stress response in the experimental animal, which is unacceptable, always for the welfare of the animal, and often for the protocol involved. As a further development of the principles of the existing methods, we therefore investigated the possibility of using a totally implantable human catheter system in experimental cattle models.

Materials and methods

Animals

Six jersey steers weighing between 450 and 620 kg, age 1.5 to 2 years, were used. The steers were designated A to F.

Catheters and modifications

The catheter set (Port-A-Cath®, Venous System, Pharmacia Nu Tech, Walpole, U.S.A.) consisted of a soft radio-opaque silicone rubber catheter (outer diameter 2.8 mm, inner diameter 1.0 mm, length 760 mm), a titanium portal with a self-sealing silicone septum, accessible by percutaneous needle puncture, and a device to ensure connection of the catheter to the portal housing (Figure 1). In advance of surgery, 3 sterile silicone cuffs were made from 1 cm long pieces of silicone tubing (Silastic®, inner diameter 3.0 mm, outer diameter 3.8 mm). A nonabsorbable purse string suture was preplaced close to the end of each cuff and the needle was left on. The cuffs were glued onto two of the catheters (the hepatic and the mesenteric catheter) 20 cm from the tip with the purse string suture towards to the tip. The last cuff was placed intraoperatively onto the portal vein catheter.

Preoperative considerations

5 days prior to surgery, the animals were fed on barley straw and 1–2 kg of concentrate per day, in order to induce a dry ruminal content. Twelve hours prior to surgery, water and food were withheld and 400 grams of sodium proprionate and 50 ml of a vitamin B preparation were administered orally.

Surgery

General anaesthesia was induced by sodium thiopentone and maintained with halothane

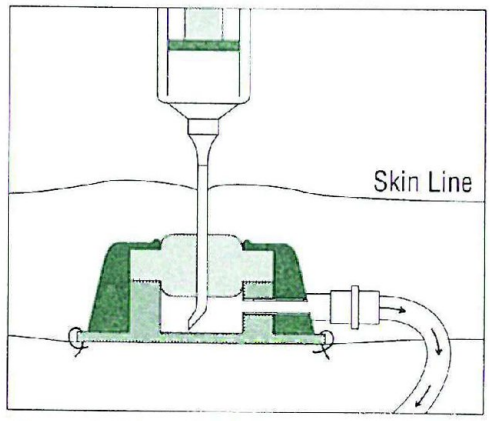

Figure 1. Schematic drawing of Port-a-Cath® implantable device.

administered in oxygen, using a semiclosed circuit system with a ventilator.

An area from the ventral to the dorsal midline, extending cranially to the 10th rib and caudally to the tuber coxae was clipped and prepared and draped *lege artis* for surgery. Sodium ampicillin (Anhypen®) as well as isotonic saline at a rate of approximately 5 mL/kg body weight/hour was infused i. v.

A paracostal incision starting above the mammary vein and extending dorsally for about 40 cm around the costal arch was made and the internal oblique and rectus muscles were exposed and divided by their fibers. A segmental nerve is cut by this procedure.

Hepatic vein catheterization

The surgery table was tilted in the anti-Trendelenburg position and the costal arch raised by an assistant. The ventral part of the left lobe was then covered by a layer of gauze and pulled gently towards the incision. The caudal vena cava was located by palpation of the liver in the region of the oesophageal notch and the distance to the exposed edge of the liver was measured, using a guide wire. The length of the intravenous part of the hepatic catheter should be at least 5 cm shorter than this distance, to avoid contamination with blood from the caudal vena cava (*Symonds & Baird* 1973). The hepatic catheter was then cut in the proper distance from the cuff.

In one case, this lobe could not be exposed satisfactorily in the laparotomy. In this animal, the inspiration was stopped at its maximum for several periods of 2 minutes followed by 2 minutes of normal ventilation. This facilitated the catheterization, which was performed according to the method of *Olesen et al.* (1989). A triangular piece of liver (approximately 4×2 cm) was cut from the edge of the liver. The two cut surfaces of the liver presented branches of hepatic veins (thin-walled, dark bleeding veins) as well as small hepatic arteries of the Glisson triads. A teflon coated guide wire, length 120 cm, diameter 0.71 mm, with a 3 cm soft tip was passed approximately 30 cm directly into one of the hepatic veins. The guide wire should not be forced into the liver. A vessel screw dilator (9 French, 25 cm) was then introduced 5 cm into the liver tissue. Haemorrhage was controlled by compression. After removal of the vessel dilator, the hepatic catheter was threaded over the guide wire until the cuff was firmly against the liver tissue. The patency filled with heparinized saline (100 units/ml) and plugged with the cap from the catheter set. The cuff was anchored into the tissue using the free ends of the purse string suture. A small piece of monofilament net (2×2 cm) was inserted between the cuff and liver in order to avoid pulling through of the sutures (Figure 2). The cut surfaces of the liver were closed with Dexon® 0, which stopped haemorrhage. The liver lobe was repositioned cranially. A subcutaneous pocket was created on the 13th rib. The pocket should be as close to the exit of the catheter as possible. The catheter was now brought subcutaneously with a large suture needle, model Bühner. The portal housing was filled with saline as described by the manufacturer and attached to the catheter, leaving adequate slack to enable body movement (approxima-

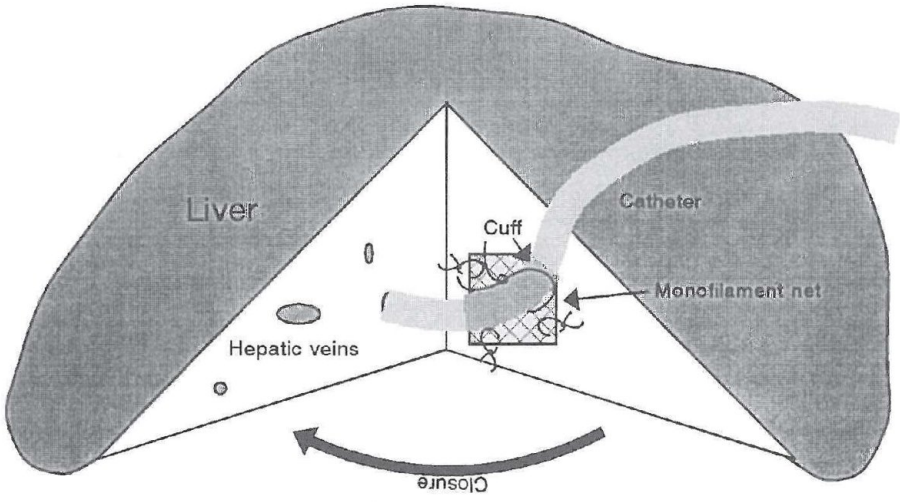

Figure 2. Schematic drawing of catheter in an hepatic vein before closure of the liver incision.

tely 10 cm extra catheter) in the abdomen. The portal was placed on the 13th rib and sutured in place. The patency of the catheter was checked and the portal chamber was flushed with heparinized saline. Ampicillin was administered topically in the subcutaneous pocket.

Portal vein and mesenteric vein catherization

A 10 cm long incision was made through both layers of the omental sac starting one hand below the descending duodenum. The borders of the superficial and profound layer were stitched together by a few holding sutures. The portal vein was catheterized according to *Symonds & Baird* (1973), through a jejunal vein. The position of the tip of the catheter was determined by palpation of the portal vein in the region of the epiploic foramen. The remaining silicone cuff was attached to the portal catheter and the jejunal vein at the inlet in the jejunal vein.

The mesenteric truncus was catheterized in a similar manner, using a jejunal vein approximately 5 cm from the vein used for portal catheterization. The mesenteric catheter should be 20 cm shorter than the portal catheter. Three non-absorbable sutures (Surgilon® no. 2) were then placed *en masse* around the inlet site of both catheters, one preferably including a mesenteric lymph node, leaving 30 cm long ends. These ends were brought through the rectus and internal abdominal muscles with a large suture needle, and knotted until the catheters and the jejunal segment were firmly against the abdominal wall (Figure 3). Attention was given to avoid strangulation of the jejunal segment. The patency of the catheters was checked before they were brought to the subcutaneous pocket and attached to portals, as described for the hepatic vein catheter. The portal of the portal vein catheter was placed on the abdominal wall because of lack of length of the catheter. The mesenteric vein catheter was placed on the 13th rib. Finally, the incision in the omental sac was closed. The laparotomy was closed in a standard manner in three layers.

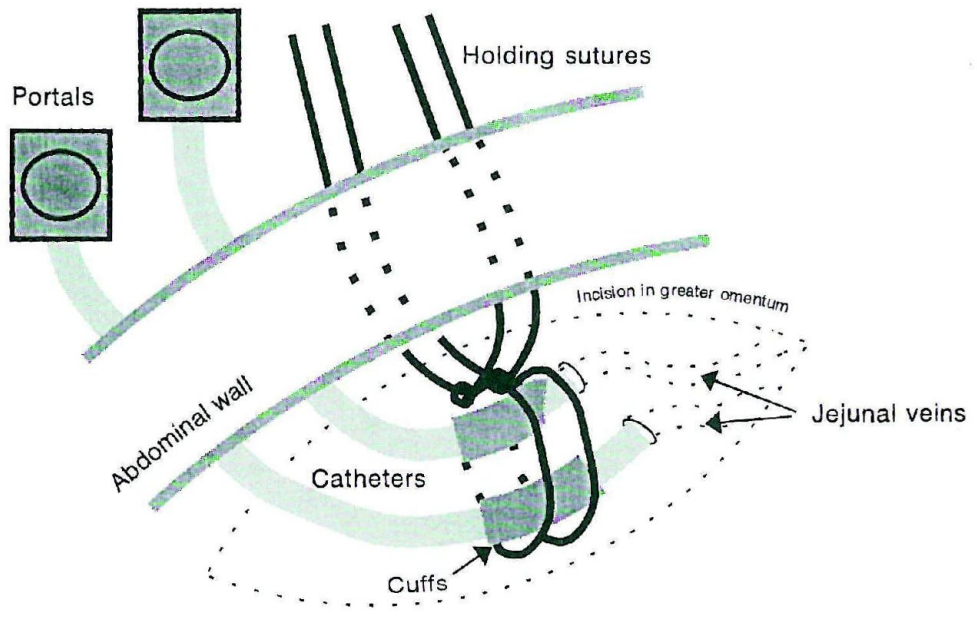

Figure 3. Schematic drawing of portal and mesenteric catheters at the site of exteriosation from the abdomen.

Post-operative care

After return of the swallowing reflex, flunixin meglumine (Finadyne®) 2 mg/kg b.w. was administered i.v. Pethidine was administered every 6th hour during the first 24 hours and later if the animal showed any sign of pain. All animals passed feces during the first post-operative day and were eating normally within 48 hours after the operation. Sodium ampicillin was administered intravenously for 6 days. The skin sutures were removed 12 days after surgery.

The catheters were flushed according to the directions of the manufacturer day 1, 2, 4 and 6 after surgery. After that flushing was performed with 2–3 weeks interval with saline containing 100 units of heparin. The blood sampling procedure involved proper antiseptic cleansing of the shaved skin over the portal and percutaneous puncture of the silicone septum with a sterile 20 Gauge needle. The first 5 ml of blood was discarded. At the end of the blood sampling procedure, 20 mL saline, followed by 5 mL heparinized saline was infused into the portal to establish a heparin lock.

Results

The animals recovered satisfactorily and ileus was not observed. Some swelling and accumulation of serous fluid occurred around the subcutaneous portals during the first days. In two cases, the fluid was aspirated aseptically with a 20 G needle and a syringe. After recovery, the animals lived without taking notice of the catheters. They were almost undisturbed by the blood sampling procedure (Figure 4) and were kept together in loose housing between the metabolic experiments. Infection of the subcutaneous portals did not occur. The placement of the portal vein portals on the abdominal wall instead of bone, did not turn out to be a problem for the blood sampling procedure. One animal developed a small hernia, that was left untreated.

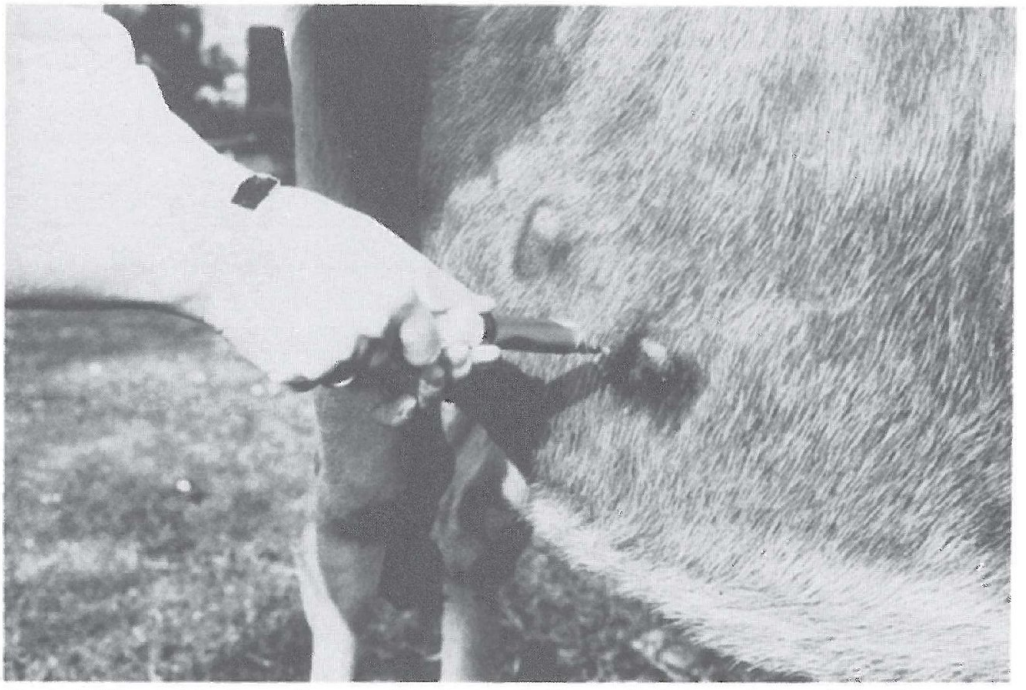

Figure 4. Hepatic blood sampling procedure in steer E. The needle is inserted through the skin and into the chamber of the subcutaneously located portal.

The mean function times of the catheters are given i Table 1. In all cases, the first indication of a decreasing function was a period of intermittent patency for withdrawal. It was possible to perform infusions in all catheters for the lives of the animals, except in the mesenteric vein catheters of animal C and D, which blocked completely after 32 and 30 weeks, respectively.

The animals showed normal condition and weight gain during the study period. The main reason for killing the animals was termination of the study, except for animal D, whose portal vein catheter was patent only very shortly.

Autopsy was performed in five of the six animals. The tip of the catheters was always located at the correct position. Kinking of the catheter was the reason for failure of the portal vein catheters in animals C and D. Formation of a firm fibrous sheath was the main cause for the bad patency for blood sampling via the mesenteric vein catheters. Damage of the vein wall of the portal and hepatic veins was not observed. The subcutaneous portals were found to be embedded in a 1 mm thick layer of fibrous tissue and fat (Figure 5). No signs of rejection of the implanted housing or catheter was observed. Histological examination revealed a thin layer of fibroblasts.

Discussion

The surgical procedure was extensive, but yielded a reliable and constant animal model without the use of ultra-sonography. The direct approach for hepatic vein catheterization was simpler to perform than the blind method described by *Symonds et al.* 1973. We did not observe complications as purulent inflammation, implant rejection, sepsis or erosions of the implant through the skin,

Table 1. Duration of catheter patency, in weeks.

	Hepatic vein		Portal vein		Mesenteric vein	
Animal	Sampling	Infusion	Sampling	Infusion	Sampling	Infusion
A	45	49	49	49	3	49
B	39	47	47	47	4	47
C	43	43	16	43	2	32
D	32	32	6	32	2	30
E	46	46	46	46	3	46
F	21	21	21	21	6	21
Mean + S.D.	37 +10	40 + 11	31 + 19	40 + 11	3 + 2	38 + 11

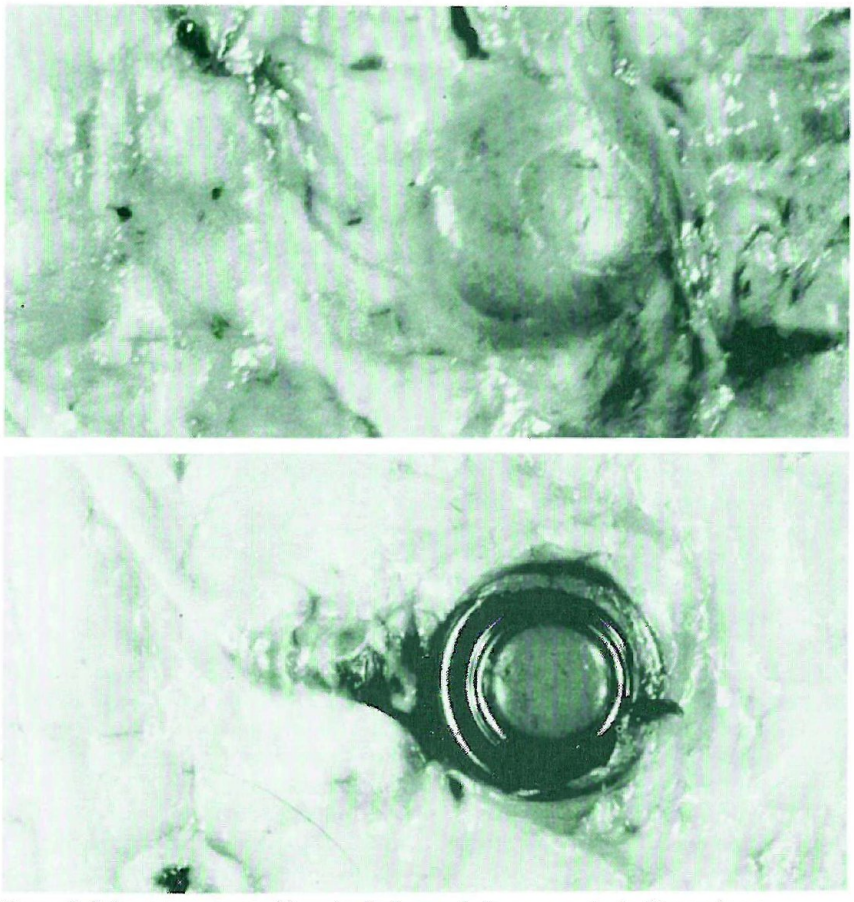

Figure 5. Subcutaneous portal housing before and after removal of a fibrous layer.

which are common when catheters are exteriorized through skin. The total implantable access system was useful in cattle and improved the welfare of the animals involved. However, the catheters of the commercial kit we used, were too short for a proper position of the catheter portal of the portal vein. The position ventral and caudal on the abdominal wall is not ideal for handling and blood sampling. The portal and hepatic vein catheters were generally patent for very long time, when compared to other reports (*Katz & Bergman* 1969, *Symonds & Baird* 1973, *Slepetis et al.* 1987, *Olesen et al.* 1989). The markedly reduced time of patency of the mesenteric vein catheters could be ascribed to the position of the tip of the catheter in this relatively small vessel. Kinks were not common and the catheter was never damaged, which is ascribed to the very thick-walled and soft silicone catheter used. The most common reason for failure was overgrowth to the catheter tip with a fibrin sheath and subsequently, fibrous tissue. Inadvertent catheter withdrawal owing to the snagging or failure of sutures is a common cause of catheter failure (*April et al.* 1983, *Spurlock et al.* 1990), which was not observed in this study, because of the subcutaneous position of the catheter. The main advantages of the totally implantable system seemed to be improved animal wellfare combined with a minimal risk of infection and long duration of the catheters.

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Summary
Surgical techniques for implanting chronic catheters in a hepatic vein, the portal vein and a mesenteric vein in adult cattle are described. A totally implantable access system permitting repeated access to the vascular system is used and evaluated. The average function time for withdrawal of blood of this system for hepatic, portal and mesenteric catheters were 37 + 10, 31 + 19, and 3 + 2 weeks (mean + S.D.), respectively. Infusions were possible for much longer time. Advantages of this method were first of all a better quality of life for the experimental animal involved, since no restrain or confinement was needed during housing and handling. The experimental animals could safely graze pastures while equipped with catheters in portal, hepatic and mesenteric veins. Catheter infections were not observed, the maintenance protocol was faster and safer than for conventional catheters. Tissue reactions were limited to a thin layer of fibrous tissue. A disadvantage of this technique was a relatively high cost of the catheter system, when compared to traditional systems.

Sammendrag
Artiklen beskriver en kirurgisk teknik, som kan anvendes ved implantation af kroniske katetre i en v. hepatica, portalvenen og en mesenterial vene. Der er beskrevet og evalueret et totalt implanterbart katetersystem, som, via en subkutant implanteret portal, giver adgang til de beskrevne blodkar over en længere periode. Der kunne i gennemsnit udtages blodprøver fra hhv. v. hepatica, v. portae og v. mesenterialis i 37 + 10, 31 + 10 og 3 + 2 uger (gennemsnit + S.D.). Det var muligt at infundere væske gennem katetrene yderligere flere uger. Den primære fordel ved den beskrevne metode er en forbedret livskvalitet for forsøgsdyret, fordi dyret kan gå frit omkring (også på græs) og være sammen med andre forsøgskøer i perioden. Ydermere undgås stress under blodprøvetagning. Infektioner blev ikke observeret og vedligeholdelsen var mindre tidskrævende end for konventionelle katetre. Vævsreaktionen omkring de subkutant implanterede portaler begrænsede sig til et tyndt lag fibrotisk væv. Ulempen ved systemet kan være relativt høje anskaffelsespriser på systemet.

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Figure 6. Hepatic blood sampling procedure in steer E. The procedure is performed in the standing, unrestrained animal without discomfort.