Percutaneous Ultrasound-Guided Over-the-Wire Catheterization of the Portal and Hepatic Vessels in Cattle

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ABSTRACT. A new method for catheterization of the portal and hepatic veins in cattle by means of the over-the-wire system was investigated to maintain more reliable long-term patency of catheters. Four cattle were used to evaluate the success rate, patency and safety of the procedure. The catheters, coated by urokinase were patent as long as they were in situ. In addition, the introducer was useful to prevent the catheter from being broken. No complications developed during the 10 days after the procedure. Two cows were then euthanized. Post mortem findings were minimal. The results of the study reported here are promising, the benefits are significant and there is no apparent disadvantage to its use.

KEY WORDS: bovine, over-the-wire catheterization, portal and hepatic vein.


The portal circulation allows nutrients that have been absorbed from the gastrointestinal tract to be extracted and processed prior to reaching the general circulation so that access to the portal and hepatic veins could provide a valuable method for monitoring abnormalities in the hepatic metabolism. Specifically, reliable catheterization of these veins in cattle could be an important tool for quantifying liver and intestinal function by biochemically evaluating blood prior to and after metabolism in the liver.

In the past, procedures to access the portal and hepatic veins in cattle were initially performed surgically [3, 4, 9]. These procedures are time-consuming and have inherent postsurgical complications, including peritonitis, adhesions, and failure of catheters to maintain patency. With the advent of ultrasonography, it became evident that direct access to the portal and hepatic veins in cattle was obtainable percutaneously with the ultrasound-guided catheter placement technique [5]. Until the first half of 2000, there were no reports in the literature concerning the application of this technique, but during the last three years, there have been four published reports emphasizing the need for the technique for frequent sampling of portal and hepatic blood [2, 6–8]. With some modifications, we have previously used the through-the-needle technique for placement of catheters in the portal and hepatic vessels and we concluded that the procedure is safe as long as it is performed carefully [6–8]. The method was highly effective in measuring hepatic metabolism, but some drawbacks were experienced during sampling with the catheters. The longer the procedure was conducted, the lower the patency rate was. That is to say the patency rate was less than 50% if the catheter was left in the animal for more than 5 days. Extravasation of the catheter was likely to be the most adverse finding, especially in nervous cows. Thrombus formation was a likely occurrence after the procedure. The most frequent sites of thrombus formation were (a) within the lumen of the catheter, (b) on the vessel wall at the position where the tip of the catheter caused intimal damage and (c) on the vessel wall at the point of catheter penetration, especially if this process was traumatic. Due to respiration and animal movement, bending of the catheter was also an additional drawback. In the present experiment, to solve these problems an introducer was used to strengthen the catheter and to prevent its being broken. Thrombus formation was examined in this experiment by using commercial catheters coated on the inside and outside with urokinase, a thrombolytic agent.

The authors believe that the most desirable technique for catheterization of the portal and hepatic veins should be (1) relatively simple and easy to perform, (2) safe, (3) provide a high success rate and (4) should remain functional as long as the catheter is in situ. This paper describes a technique for catheterization of the portal and hepatic veins in cattle by means of the over-the-wire catheterization set that fulfills these criteria.

Two nonpregnant, nonlactating Holstein cows weighing 536 and 674 kg, and two steers weighing 287 and 394 kg were used for the study. The cattle were proved healthy by clinical examination and blood inspection as previously reported [6, 7]. The diet has been described [6, 7]. Animal related procedures were approved by the Animal Welfare Regulation Committee of Rakuno Gakuen University. The regulations are in conformity with the Guide for the Care and Use of Laboratory Animals of the National Institutes of Health in the U.S.A. (NIH publication No. 86–23, revised 1985).

Similar to the situation in humans and dogs, as we
reported before, the portal vein in cattle is more echogenic than the hepatic vein. The accuracy of the access to the vessel was also confirmed in the present experiment by determination of total bile acids as recently investigated [7]. The decision to catheterize the portal and hepatic veins in the cows was carefully made after reviewing the coagulation data and ultrasonographic findings [6–8]. To obtain adequate restraint, the cows were slightly sedated with xylazine (0.07 mg/kg body weight, intravenously) and the region was infiltrated with 10 mL of 2% procaine hydrochloride.

The right abdominal wall was first surgically prepared from the 7th to the 12th intercostal spaces. The liver was scanned as described by Braun et al. [1]. The experiment was performed with an ultrasound scanner equipped with a 3.5 MHz linear transducer (Model RT 2600, Yokogawa Medical Systems, Tokyo, Japan). A pre-experimental study extended from December 2001 to August 2002 in which we applied different types of catheters. The over-the-wire catheterization system finally chosen for the procedure was the MU catheter kit and super sheath introducer from Medikit Co., Tokyo, Japan (Fig. 1). The set produced the best results during the pre-experimental period in comparison with other kinds of catheterization sets. After an entry site was chosen, the skin was incised with the tip of a No. 20 scalpel blade. A 14G × 150 mm spinal needle with a stylet (Kurita Co., Tokyo, Japan) was advanced through the skin into the hepatic parenchyma toward the portal vein, by the ultrasound-guided free-hand technique (Fig. 2A). The needle was advanced until visualized in the lumen of the vein. The stylet was removed and a guide wire (0.035-inch in diameter) was then passed through the needle and advanced into the vein (Fig. 2B). Once the wire was well advanced, the needle was removed, leaving the wire within the lumen (Fig. 2C). A catheter introducer (5F × 25 cm) was then passed over-the-wire and advanced into the vein to dilate the opening (Fig. 2D). This allowed easy passage of the more pliable catheter. Through the introducer, a silicon catheter (16G × 70 cm) coated on both sides with urokinase, a thrombolytic agent, was threaded into the lumen of the portal vein (Fig. 2E). The catheter could be easily seen on the screen (Fig. 2F). Moreover, the air tightness of the catheter system (the introducer and the inside catheter) was optimal. Once successful catheterization of the portal vein had been accomplished, the system was fixed in place with adhesive paste, and a sterile adhesive dressing was used to cover the site of insertion to minimize local contamination. Catheterization of the hepatic vein was then attempted as for the portal vein. Both catheters were secured to the abdominal wall with bandage tape. All of the catheter ports were capped. The catheters placed in the two cows were flushed twice a day with 10 mL of 3.8% sodium citrate. To evaluate the effect of urokinase, catheters placed in the steers were not flushed until the last day of the experiment. The animals were then monitored for ten days after the procedure. In accordance with our school regulations, and to minimize stress or possible discomfort, the experimental period was limited to ten days. The two cows were then necropsied for confirmation of procedure-associated pathologic changes.

Daily evaluation included assessment of general appearance, activity, appetite, determination of rectal temperature, pulse rate, respiratory rate, intestinal and ruminal motility and auscultation of the thorax and heart. Laboratory parameters included CBC, and the serum aspartate aminotransferase (AST) and γ-glutamyltransferase (GGT) and the concentration of total bile acids were analyzed with clinical chemistry kits (Wako Pure Chemicals, Osaka, Japan).

Fig. 1. Example of a commercially available over-the-wire catheterization set. A. The catheter introducer (top) has a side-arm that can be used to flush the system. B. The guide wire. C. The silicon catheter.
Fig. 2. Placement of the over-the-wire catheter in the portal and hepatic vessels in cattle. A. With the ultrasound-guided free-hand technique, the needle is passed through the stab incision and advanced through the skin into the hepatic parenchyma toward the portal vein. B. The guide wire is passed through the needle and advanced into the vein. C. Once the wire is well advanced into the vein, the needle can be removed, leaving the wire within the lumen. D. A catheter introducer is passed over the wire and into the vein to dilate the opening. This should allow easy passage of the more pliable catheter. E. Through the introducer, the catheter is threaded into the lumen of the portal vein. F. Ultrasonogram of normal hepatic echotexture. Notice the catheter (arrow) within the portal vein. The image was taken in the 11th intercostal space. L; liver, C; catheter, PV; portal vein, HV; hepatic vein.
In this report we used the over-the-wire system to locate a silicon catheter in the portal and hepatic vessels and we found that it provided the most satisfactory results. We did not encounter any difficulties during placement of catheters in the portal and hepatic veins by this technique. Extravasation of the catheters or thrombus formation was not recorded in any of the animals for ten days. The greatest advantage of this system is that it allows any size or type of catheter to be placed into either the portal or hepatic venous system, making it the most versatile of the placement systems. Although catheters placed in the steers were not daily flushed with the anticoagulant solution, the catheters maintained patency throughout the whole experiment period. This result indicated the usefulness of using catheter coated with urokinase as an anticoagulant for the procedure. Reduction in the flushing times, except at sampling, might reduce stress and further reduce changes that may occur in some metabolites.

Catheter introducers are designed to allow large-bore catheters to be introduced, removed and then re-introduced without having to continually re-establish vascular access. The introducer used had a hemostatic valve to prevent blood reflux and air emboli sm. It also had a side-arm tube that could be used to flush the system. To ensure the free passage of the introduced catheter through the introducer sheath, it is essential that the maximum diameter of the device be determined prior to insertion and, subsequent to this, an appropriately sized introducer is chosen. The introducer played a very effective role in protecting the catheter from impairment by respiration and movement of the animal.

The overall success rate (100%) appeared to be operator dependent, and there was a definite learning curve associated with successful catheter placement, but once mastered, the technique was relatively straightforward for the operator. As we became more proficient with the procedure, placement of the catheter could be performed in 10 to 15 min.

The free-hand technique was utilized in all cows. It enabled good visualization of the needle because the needle could be positioned more perpendicular to the ultrasound beam and the needle entered at an oblique angle to the long axis of the transducer. The technique requires more experience in the user with respect not only to ultrasound anatomy, but also in hand-eye coordination and confidence that the needle will not only pass at an appropriate angle, but also remain within the plane parallel to the ultrasound beam.

No abnormalities were apparent either during daily physical examination or in the analysis of CBC, and biochemical items such as AST and GGT activities and the total bile acid concentration. Moreover, necropsy findings were negligible. These data indicated that the procedure in the present study was safe as in the previous one. In the cattle, patency of the catheters was 100% until ten days post procedure and in none of them were the catheters closed.

In conclusion, the method for catheterization of the portal and hepatic vessels in cattle by means of an over-the-wire set provides an excellent tool for frequent sampling of the portal and hepatic blood. The procedure is safe, fast and practical as long as it is performed properly. The technique may have greater application either in veterinary practice or in research. It is hoped that this study will be of value to researchers requiring frequent sampling of the portal and hepatic blood in cattle.

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