Three Minimally Invasive Methods of Measuring of Portal Vein Pressure in Healthy Dogs

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ABSTRACT. We compared wedged hepatic venous pressure (WHVP), splenic pulp pressure (SPP) and trans-splenic portal vein pressure (TSPVP) in healthy dogs. We found that portal blood pressure could be measured in dogs using any of these techniques. The WHVP, SPP and TSPVP were 7.8 ± 1.0, 6.2 ± 0.8 and 6.8 ± 1.2 mmHg, respectively. Measuring SPP using ultrasound is most simple and minimally invasive, and it might be useful for evaluating portal hypertension in dogs with liver diseases.

KEY WORDS: canine, catheterization, portal hypertension, portal pressure, ultrasound.


Portal hypertension (PH) is caused by excessive resistance to a given blood flow in the portal circulation, and it is classified based on anatomical localization, such as prehepatic, intrahepatic, and posthepatic. In dogs, intrahepatic PH can be caused by parenchymal liver diseases, such as severe chronic hepatitis/cirrhosis (CH) and primary hypoplasia of the portal vein (PHPV) [3, 16]. Although understanding portal vein pressure (PVP) is important to identify whether these conditions involve PH, PH has been indirectly indicated in dogs based on clinical consequences including the development of ascites and acquired portosystemic collaterals (APSCs) [3, 16]. Therefore, PVP in dogs has been mainly measured during the surgical attenuation of congenital portosystemic shunts (CPSS) under laparotomy [5, 12, 13, 19].

Catheterization is a minimally invasive method of measuring blood pressure. The currently favored method for determining PVP in humans involves catheterizing the hepatic vein and measuring wedged hepatic venous pressure (WHVP) and free hepatic venous pressure (FHVP) using a balloon catheter [1, 2, 6, 10, 11, 14]. The value of WHVP is equivalent to that of indirect PVP in dogs [4, 15]. The splenic pulp can be percutaneously catheterized to obtain PVP using laparoscopic guidance [18], and thus measuring splenic pulp pressure (SPP) in dogs might be quite simple. The technique used for percutaneous trans-splenic catheterization of the portal vein using ultrasound guidance in anesthetized dogs has been described [9], and although it might be useful for managing PH, it has not been used to measure pressure. Furthermore, PVP has not been measured using the three techniques described above under the same conditions. The present study compares the outcomes of three minimally invasive methods of measuring PVP in healthy dogs.

MATERIALS AND METHODS

Animals: Animals used in this study were six healthy beagle dogs, 3 males and 3 females, 3–6 (median, 5.2) years old and weighing 9.4–12.4 (median, 10.1) kg. All of the dogs were confirmed as being healthy by clinical examination, complete blood cell count, serum biochemistry, abdominal radiography and ultrasonography. All the dogs were cared for according to the principles outlined in the Guide for the Care and Use of Laboratory Animals approved by the College of Bioresource Sciences, Nihon University.

Anesthesia: The dogs were premedicated with atropine sulfate (0.04 mg/kg SC), followed by a combination of midazolam (0.1 mg/kg IV) and butorphanol (0.2 mg/kg IV), and then propofol (4 mg/kg IV) was introduced. General anesthesia was maintained using a 2.0% isoflurane in 100% oxygen. All dogs were administered lactated Ringer’s solution at a rate of 10 ml/kg/hr intravenously through a 22-G catheter placed in the cephalic vein. The abdominal and neck areas were shaved, and the skin was moistened with disinfectant.

Measurement of hepatic venous pressure: A 5-Fr venous catheter introducer (Cordis Co., Miami, FL, U.S.A.) was placed in the jugular vein using the Seldinger technique. A guide wire (Cook Japan Co., Tokyo, Japan) was advanced into the left hepatic vein under fluoroscopic control. A 7-Fr balloon-tipped catheter (Terumo Co., Tokyo, Japan) replaced the guide wire, and hepatic venous pressure equivalent to the FHVP was measured. The WHVP was continuously determined by inflating the balloon catheter, and contrast medium was administered to confirm complete vascular occlusion with the dogs in the ventrodorsal posi-
tion (Fig. 1A). After measuring WHVP, pressure in the right atrium (RAP) and in the caudal vena cava (CVP) was evaluated. Each pressure was recorded as described previously [7], using a transducer (OMRON COLIN Co., Tokyo, Japan) in the right lateral recumbent position. The zero point was placed at the level of the heart.

**Measurement of splenic pulp pressure (SPP):** The spleen was visualized by ultrasound (EUB-6500; Hitachi Medical Co., Tokyo, Japan) using a 7–10 MHz microconvex probe. An 18-G over-the-needle intravenous catheter (Terumo Co.) was percutaneously inserted into the body of the spleen, and SPP was measured through the catheter inserted into the center of the splenic parenchyma. SPP values were recorded the tracing for 60 sec to allow the measure to stabilize using a transducer (OMRON COLIN Co.) in the right lateral recumbent position, and the zero point was placed at the level of the heart.

**Measurement of trans-splenic portal vein pressure (TSPVP):** A branch of the splenic vein was visualized by ultrasound (EUB-6500; Hitachi Medical Co.). A 16-G over-the-needle intravenous catheter (Terumo Co.) was advanced through the skin into the splenic parenchyma, are introduced into splenic hilus, and then a guide wire (Cook Japan Co.) was inserted into the portal vein via splenic vein under fluoroscopic control. The guide wire was then replaced with an 18-G intravenous catheter (Medikit Co., Tokyo, Japan) containing heparinized saline. We confirmed the location of a catheter tip in the portal vein of the porta hepatis, and TSPVP was measured. Thereafter, radiographic contrast medium was administered to reconfirm the ventrodorsal position (Fig. 1B). TSPVP values were recorded the tracing for 60 sec to allow the measure to stabilize using a transducer (OMRON COLIN Co.) in the right lateral recumbent position, and the zero point was placed at the level of the heart.

**Statistical analysis:** Data are expressed as means ± standard deviation (SD) and were evaluated using the Kruskal-Wallis test with Dunn’s post-hoc multiple comparisons. All data were analyzed using GraphPad PRISM for the Mac OS X v5.0b. Differences were considered significant when the value of $P$ was<0.05.

**RESULTS**

Pressure was measured in all dogs using the three catheters without complications. Comparison of time requested for catheter positioning and portal blood pressure in dogs is shown in Table 1. The mean time required to catheter positioning for WHVP, SPP and TSPVP was 27 ± 14 (range, 11–51), 10 ± 3 (range, 7–14) and 30 ± 12 (range, 15–50) min, respectively. The mean WHVP, SPP and TSPVP values were 7.8 ± 1.0 (range, 7.0–9.0), 6.2 ± 0.8 (range, 5.0–7.0) and 6.8 ± 1.2 (range, 6.0–9.0) mmHg, respectively. These differences were not statistically significant. The mean FHVP, CVP and RAP were 5.2 ± 1.0 (range, 4.0–7.0), 4.8 ± 0.8 (range, 4.0–6.0) and 4.5 ± 0.8 (range, 4.0–6.0) mmHg, respectively (Fig. 2). The mean hepatic venous pressure gradient (HVPG=WHVP–FHVP) was 2.7 ± 0.8 (range, 2.0–4.0) mmHg.

**DISCUSSION**

Portal hypertension in humans is often evaluated using hepatic vein pressure [1, 2, 7, 10, 11, 17]. This technique is safe when patients have coagulopathy, because the access site for hepatic vein catheterization is usually the jugular vein [1, 2]. The WHVP is equivalent to sinusoidal pressure, which indirectly reflects PVP [2, 6–8, 10]. The reported normal value for WHVP in anesthetized dogs obtained using a manometer is 5.6 ± 1.2 mmHg [15]. The present study confirmed that WHVP could be measured using a transducer. The high WHVP in this study might have been due to a difference in the type of anesthesia and the choice of the zero point. Pressure gradually increased in the order of RAP, CVP, FHVP and WHVP (Fig. 2), which is similar to the situation in healthy humans. Portal hypertension is classified as a change in this profile, namely, no change in the prehepatic PH, increases in all posthepatic PH, or an increase only in the WHVP in intrahepatic PH [2, 6, 7, 10, 14]. Understanding the HVPG is the gold standard for evaluating PH in human liver disease [2, 14] and it might be helpful to evaluate PH in dogs with liver disease such as CH and PHPV.

Splenic pulp pressure has been measured under lapa-
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roscopy in dogs [18]. This procedure can be performed in conjunction with liver biopsy, which is required for a definite investigation of intrahepatic PH in dogs [16, 18]. Spleno-portography can be performed after obtaining pressure measurements demonstrating APSCs that are secondary to PH. Furthermore, measuring SPP might be desirable in pre-hepatic PH when WHVP cannot be evaluated. We measured SPP under ultrasound guidance without complications, and had the shortest time requested for catheter positioning for SPP. This method was simpler and faster than other alternatives, and SPP might be measurable under local anesthesia in cooperative patients.

Ultrasound guided transcutaneous catheterization of the portal vasculature can be used for portography, to obtain portal blood samples and to examine healthy dogs [9]. It might also be helpful when evaluating dogs with CPSS or PH. However, this procedure might be time-consuming and require technique when inserting a catheter into the portal vein, and it might not be applicable to dogs with coagulopathy or ascites. The TSPVP obtained from this procedure is the true PVP, and thus is the most trusted. A previous study [15] found a lower PVP than the WHVP in the dogs examined herein. In addition, SPP was thought to directly reflect PVP in this study, because it is equivalent to TSPVP.

In conclusion, three minimally invasive measurements of PVP were compared in healthy dogs. The SPP measurement is the most clinically applicable approach in performing measurement of intrahepatic PH such as CH and PHPV that require a liver biopsy and/or splenopentography for a diagnosis. Time requested to catheter positioning was shortest in SPP than other methods. Measuring WHVP is effective for evaluating posthepatic and intrahepatic PH with severe liver disease with ascites and coagulopathy, and measurements of TSPVP which is the true PVP can proceed with blood sampling and portography. We believe that these three less invasive methods of measuring portal blood pressure are interchangeable when measuring PVP in dogs, and will help to further our understanding of the pathophysiology of canine PH.

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REFERENCES


Table 1. Comparison of portal blood pressure and time requested to catheter positioning in healthy dogs using three minimally invasive methods

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<thead>
<tr>
<th>Dog</th>
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<td>Mean ± SD</td>
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WHVP: wedged hepatic venous pressure, SPP: splenic pulp pressure, TSPVP: trans-splenic portal vein pressure.

Fig. 2. Changes in right atrium (RAP), caudal vena cava (CVP), free hepatic venous pressure (FHVP), and wedged hepatic venous pressure (WHVP) in healthy dogs.