Comparative Diagnostic Test Characteristics of Oscillometric and Doppler Ultrasonographic Methods in the Detection of Systolic Hypertension in Dogs

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Evaluation of the accuracy of diagnostic procedures and interpretation of test results in an individual patient are integral to the practice of evidence-based medicine. In general, simpler and less invasive methods of diagnosis are preferred to more elaborate or invasive testing when establishing a diagnosis, but simple tests typically are associated with a higher incidence of misclassification. Knowledge of the diagnostic accuracy of a test compared to an established "gold standard" allows the clinician to calculate the probability of disease in a patient with a given test result.

Blood pressure (BP) in dogs can be measured in several ways, and each method has recognized advantages and disadvantages. Noninvasive blood pressure (NIBP) measurement methods generally are preferable to invasive measurements in clinical situations, but only if the noninvasive methods can accurately differentiate between normal and abnormal pressures. Doppler and oscillometric methods have been commonly used in veterinary medicine to obtain NIBP measurements. Limb or tail cuffs may be used for oscillometric measurements.9–13

The accuracy of NIBP measurement methods has been evaluated in conscious normal dogs4–8 and in conscious hypertensive dogs. These analyses provide information regarding the numerical relationship between results obtained by different methods of measurement, but they do not address the ability of different NIBP measurement methods to accurately categorize animals as affected (ie, hypertensive) or unaffected (ie, normoten- sive). The clinician must decide whether a specific numerical value for SBP (eg, 195 mmHg) measured with the NI method available is indicative of disease (ie, systolic hypertension). This decision is especially important if diagnosis of the disease state is likely to result in therapy. A NIBP measurement method that is sensitive will accurately identify as positive (or abnormal) those dogs with abnormally high BP. If an NIBP method has high specificity, it will accurately identify as negative (or normoten- sive) those dogs with BP in the normal range. High sensitivity (Se) and high specificity (Sp) are both desirable characteristics of an NIBP method, but typically a trade-off exists between these characteristics in a given diagnostic test. Although Se and Sp are important qualities to evaluate in the analysis of test results, they apply to the test itself and therefore cannot be used to determine the disease status of an individual patient. The probability of disease in an individual patient with a positive test result depends on these test characteristics combined with the patient’s prior probability of disease (ie, population prevalence or clinician’s index of suspicion). Calculation of the likelihood ratio (LR) is a method of summarizing Se and Sp information over a range of values that is independent of prevalence, allowing integration of degree of abnormality into calculation of probability of disease. The LR of a given test result is the probability of that test result in patients with disease divided by the probability of that test result in patients without disease (ie, true positive/false positive). LR can be used to calculate the odds that a positive test is indicative of the presence of disease over a range of possible test results.

The purpose of this study was to assess the comparative test characteristics of oscillometric or Doppler BP measurement methodologies to accurately detect invasively measured SBP ≥160 mmHg in dogs. These test characteristics were used to develop optimal cutoff values for diagnosis of systolic hypertension by NI means, and LRs for these values were evaluated.
Materials and Methods

Assessment of test characteristics requires use of a wide range of test values. To obtain a range of values that included both normal and abnormal data, 2 data sets were used: data from clinically normal dogs and data from dogs scheduled for BP measurement as part of their clinical evaluation or follow-up visits at the University of Wisconsin Veterinary Medical Teaching Hospital (ie, dogs considered at risk for hypertension based on concurrent disease, clinical signs, or both). Blood pressure measurement methodology for each technique was identical in the 2 groups of dogs.

Normal Dogs

Twenty-seven clinically normal dogs underwent simultaneous invasive BP and both oscillometric and Doppler ultrasound BP measurement as part of a study to develop normal ranges. A full description of these animals is available. Oscillometric measurements in these normal dogs used a distal limb cuff (n = 27) and Doppler ultrasound methods used a forelimb cuff (n = 27). Both measurements were obtained simultaneously with AP.

Dogs With Suspected Systemic Hypertension

Simultaneous NI (oscillometric or Doppler methods) and AP-SBP measurements were obtained prospectively from 66 untrained, unseparated pet dogs in which SBP measurement was deemed medically necessary. Consent for BP measurement was obtained as part of the client consent for diagnostic testing at the time of admission. Animals were designated to have BP measured by the oscillometric method employing a distal limb cuff (Osc-L), the oscillometric method employing a tail cuff (Osc-T), or the Doppler method based on order of admission, with the exception of dogs with closely docked tails that were allotted to the limb or Doppler group. The first group of consecutively admitted dogs (approximately 30 animals) was allotted to the Osc-L group, the next group was measured by the Osc-T method, and the final group was measured using Doppler methods. Results from dogs in which invasive blood pressure measurements could not be obtained because of size, temperament, or other circumstances were not included in the study. Ultimately, 84 eligible measurements were recorded from 66 dogs; no dog had more than one set of measurements recorded by any single NI technique. In all instances, simultaneous measurement of BP by invasive and oscillometric methods was performed as described previously, and the operator performing the NI test was blinded to the results of the AP method.

Direct BP measurement was performed using AP methods similar to those described in detail in previous reports. Local anesthesia was provided by subcutaneous infiltration of 1–2 mL 2% lidocaine hydrochloride. A commercially available clinical monitoring system with pressure-tracing ability was used for measurements. The transducer was zeroed at the level of the sternum in the laterally recumbent dog. At the time of AP, the pressure waveform was recorded for analysis. Manual pressure was applied to the area of AP for a minimum of 5 minutes after measurement. The mean value of 5 consecutive systolic values read from the calibrated paper tracing was used for statistical evaluation.

Oscillometric BP measurement was performed using a technique similar to one described previously. The instrument is calibrated on a fixed schedule by the manufacturer. An appropriately sized inflatable cuff was positioned around the midmetatarsus of one hindlimb at the level of the superficial plantar arterial arch (n = 27) or at the base of the tail (n = 27). The cuffed leg was positioned level with the heart during measurements. The tail was considered to be at the level of the right atrium in the laterally recumbent animal. Eight to 10 oscillometric measurements were recorded for each dog (1-minute measurement cycles with 15–30 seconds between cycles). Oscillometric measurements were initiated approximately 30 seconds to 1 minute before AP, and measurements were recorded in 1-minute cycles until 8–10 measurements were obtained. Therefore, the moment of AP was included in this time frame. The oscillometric value recorded was the mean value of the 3 systolic readings closest in time to the invasive (AP) measurement. A single operator blinded to the results of the AP measurement recorded oscillometric measurements.

Doppler ultrasound BP measurement was performed using previously described techniques; the sphygmonanometer was calibrated using a mercury manometer. The Doppler ultrasound probe was fixed in position over the superficial palmar arterial arch after the hair had been clipped and coupling gel applied. An appropriately sized inflatable cuff was placed around the midantebrachium. The cuff was inflated to no less than 40 mmHg above the audible cutoff point of the signal. The pressure recorded was the pressure at which the audible pulse signal was again detected. Six Doppler values were recorded and the first value was discarded. The mean value of the 5 remaining consecutive measurements was recorded as the representative BP for statistical evaluation. Doppler BP measurements were initiated while the needle was being positioned in the femoral artery. As in the oscillometric groups, a single operator blinded to the concurrent AP results recorded measurements.

Data from the suspect hypertensive dogs were combined with data from the normal dogs as follows: 27 Osc-L and AP-SBP measurements from normal dogs were added to 27 Osc-L and AP-SBP measurements from suspect dogs to yield 54 total measurements in the Osc-L group (Table 1). Twenty-seven Doppler and AP-SBP measurements from normal dogs were added to 30 Doppler and AP-SBP measurements from suspect dogs to yield a total of 57 measurements in the Doppler group. Lastly, 27 Osc-T measurements from the suspect group were analyzed (Osc-T measurements from normal dogs were not available).

Data Analysis

To establish comparability among groups, variables including age, weight, AP-SBP, gender distribution, and percentage of animals considered hypertensive based on AP-SBP measurements were compared among Osc-L, Osc-T, and Doppler groups using one-way ANOVA or chi-square tests, as appropriate (P < .05).

Systolic BP obtained by AP was categorized as hypertensive or not hypertensive based on a systolic cutoff value of ≥160 mmHg. The Se and Sp of each NI method to detect invasively measured SBP ≥160 mmHg were determined for diagnostic cutoff values ranging from 130 to 220 mmHg using 10 mmHg increments. Se and Sp values were used to generate receiver operator characteristic (ROC) curves for each NI method. ROC curves were analyzed to determine optimal cutoff values (minimizing Type 1 and Type 2 errors) for diagnosis of SBP ≥160 mmHg. Likelihood ratios (LR) were calculated where possible (LR = Se/(100 – Sp)). For comparative purposes, ROC curves were analyzed for AP-SBP ≥180 mmHg.

Results

Of the 66 dogs in the suspect hypertensive group, 13 dogs had testing done by 2 different NI methods on separate occasions, and 3 dogs had BP measured by all 3 methods on 3 separate occasions, but no dog had more than one set of values recorded for each method. Group characteristics for combined normal and suspect hypertension groups by NI method are presented in Table 1. No differences among the groups were found with regard to age, weight, gender distribution, AP-SBP, or proportion of dogs with AP-SBP ≥160 mmHg. The range of body weights in each group

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Table 1. Group characteristics of 54 dogs with blood pressure measured by oscillometric methods with use of a distal limb cuff (Osc-L), 27 dogs with blood pressure measured with oscillometric methods with use of a tail cuff (Osc-T), and 57 dogs with blood pressure measured by Doppler ultrasound methods with use of a forelimb cuff. At the time of non-invasive measurement, each dog had blood pressure measured simultaneously using direct arterial puncture.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Osc-L (n = 54)</th>
<th>Osc-T (n = 27)</th>
<th>Doppler (n = 57)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender a</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M or MN (%)</td>
<td>28 (52%)</td>
<td>15 (56%)</td>
<td>33 (58%)</td>
</tr>
<tr>
<td>F or FN</td>
<td>26</td>
<td>12</td>
<td>24</td>
</tr>
<tr>
<td>Age (years) a</td>
<td>7.8 (3.7)</td>
<td>9.8 (3.6)</td>
<td>7.9 (3.8)</td>
</tr>
<tr>
<td>Range</td>
<td>0.5–15</td>
<td>1–17</td>
<td>0.5–15</td>
</tr>
<tr>
<td>Weight (kg) a</td>
<td>24.7 (11.4)</td>
<td>22.2 (10.3)</td>
<td>26.9 (9.9)</td>
</tr>
<tr>
<td>% of dogs &lt;10 kg</td>
<td>7</td>
<td>11</td>
<td>4</td>
</tr>
<tr>
<td>% of dogs 10–49 kg</td>
<td>83</td>
<td>85</td>
<td>89</td>
</tr>
<tr>
<td>% of dogs ≥50 kg</td>
<td>9</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Systolic blood pressure (mmHg)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Noninvasive method b</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>160 (27)</td>
<td>156 (22)</td>
<td>165 (33)</td>
</tr>
<tr>
<td>Range</td>
<td>95–204</td>
<td>99–191</td>
<td>116–243</td>
</tr>
<tr>
<td>Corresponding AP-SBP c</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>173 (33)</td>
<td>178 (29)</td>
<td>172 (28)</td>
</tr>
<tr>
<td>Number (%) of AP-SBP ≥160 mmHg d</td>
<td>34/54 (63%)</td>
<td>19/27 (70%)</td>
<td>35/57 (61%)</td>
</tr>
</tbody>
</table>

M or MN, male or neutered male; F or FN, female or neutered female; SD, standard deviation; AP-SBP, systolic blood pressure obtained by arterial puncture; kg, kilograms.

a No significant difference among groups (P < .05).

Discussion

Establishing a diagnosis of a specific disease involves accumulating evidence that a sufficiently high probability of disease is present to justify medical action.\textsuperscript{3,27} If the disease is obvious (eg, presence or absence of a bone fracture), relatively few tests are necessary to establish a sufficient probability of the diagnosis. In other instances, however, the likelihood of the presence of a specific disease may be unclear based on the history, physical examination findings, and previous testing. Additional diagnostic testing is then warranted.\textsuperscript{28}

Receiver operator characteristic curves are presented in Figure 1, and the optimal cutoff value above which a SBP value obtained noninvasively can be considered to reflect hypertension is indicated. The Se, Sp, and LR associated with each cutoff value appear in Table 2. When a distal limb cuff was used with an oscillometric method, Osc-L SBP ≥160 mmHg indicated hypertension with Se and Sp of 65% and 85%, respectively. An Osc-L SBP ≥160 mmHg was 4.33 times more likely to be associated with hypertension than to have AP-SBP <160 mmHg. When a tail cuff was used, the optimal diagnostic cutoff value for Osc-T SBP was 150 mmHg (Se, 84%; Sp, 75%). A dog with an Osc-T SBP of ≥160 mmHg was 3.36 times more likely to be hypertensive than to have AP-SBP <160 mmHg. When Doppler methods were used, the optimal cutoff value was 160 mmHg. At Doppler BP ≥160 mmHg, the Se of the value for detection of hypertension was 71%, with an Sp of 86%. Hypertension was 5 times more likely than AP-SBP <160 mmHg in a dog with Doppler BP ≥160 mmHg (Table 2).

ROC curves provide a method of expressing the relationship between Se and Sp for a diagnostic test and are a valuable method of comparing 2 methods used to obtain the same diagnosis.\textsuperscript{3,28} A gold standard method is used to establish the true presence or absence of the disease. Parallel results from the test method in question are compared with the gold standard results. The true-positive rate (Se) and false-positive rate (1-Sp) of various diagnostic cutoff
values for the test in question are plotted as a curve. In most instances, the cutoff value associated with optimal Se and Sp (ie, the highest Se with least loss of Sp) is chosen as the optimal diagnostic cutoff value for the method in question. ROC curves can be compared among methods to discern the technique associated with optimal differentiating ability for the value in question. Classically, tests with high Se are desired when screening a low-risk population, whereas high Sp is desirable in other populations (eg, confirmation of diagnosis in a suspected case). Tests with high Se are associated with more false positives than tests with low Se, but the clinician's level of concern for avoiding false negatives in a low-risk population may alter the choice of test. Comparison of ROC curves may give the clinician guidance as to which test is most appropriate.28

ROC curves of highly accurate tests display Se that rises rapidly with little loss of Sp, rendering a curve with a distinct shoulder toward the upper left corner of the graph (Fig 1b). Curves closest to the corner indicate the most accurate tests (true-positive rate = 1, false-positive rate = 0).1 The presence of a clearly identifiable shoulder indicates a test that is a good discriminator.1 Conversely, a test that is a poor discriminator produces a line with a less distinct shoulder. Ultimately, a straight line from lower left to upper right would indicate a test that is positive or negative by chance. In this study, all 3 noninvasive methods produced ROC curves with reasonable discriminatory capabilities to detect SBP \( \geq 160 \) mmHg. Use of Osc-L and Doppler methods resulted in identical optimal cutoff values for diagnosis, but the maximal Se before excessive loss of Sp was lower for the Osc-L (65%) than for the other 2 methods. In the case of Osc-T methods, the optimal cutoff value for diagnosis of hypertension was lower (150 mmHg) than the optimal cutoff values for Osc-L and Doppler methods.

Although 2 of the 3 methods evaluated produced optimal diagnostic cutoff values identical to the gold standard value, the tests evaluated cannot be assumed to produce cutoff values with the same relationship to the gold standard at different values. For example, if the gold standard for diagnosis of hypertension is considered to be \( \geq 180 \) mmHg (Fig 2), the optimal diagnostic cutoff value for Osc-L is 170 mmHg (Se, 70%; Sp, 90%), for Osc-T, 160 mmHg (Se, 64%; Sp, 85%), and for Doppler, 190 mmHg (Se, 48%; Sp, 89%). The Se and Sp data may be applied only if methodology is identical and if the same criteria are used to define a positive result.28 The Se and Sp data generated by this study therefore could not be applied in the detection of AP-SBP other than at the values analyzed or if the techniques used differed from those of this study.

Positive and negative predictive values may be used to
evaluate the probability of disease given a positive (or negative) test result, but these values are affected by the prevalence of the disease in the population studied. LRs compare the odds that a given test result will occur in a patient with the disease with the odds that the test result will occur in a patient without the disease. The odds that a positive test finding indicates true disease can be assessed by using the LR. The LR value reflects the proportion of true positives to false positives and as such is independent of the frequency of positives in the population. This characteristic

Table 2. Sensitivity (Se), specificity (Sp), and likelihood ratios (LR) of cutoff diagnostic blood pressure (BP) values (mmHg) for detection of AP-SBP ≥160 mmHg based on method of noninvasive measurement. Values associated with optimal diagnostic cutoff values based on analysis of ROC curves appear in bold.

<table>
<thead>
<tr>
<th>Noninvasive Diagnostic BP Value (mmHg)</th>
<th>Osc-L</th>
<th></th>
<th>Osc-T</th>
<th></th>
<th>Doppler</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Se (%)</td>
<td>Sp (%)</td>
<td>LR</td>
<td>Se (%)</td>
<td>Sp (%)</td>
</tr>
<tr>
<td>≥130 mmHg</td>
<td>97</td>
<td>25</td>
<td>1.29</td>
<td>89</td>
<td>13</td>
</tr>
<tr>
<td>≥140 mmHg</td>
<td>91</td>
<td>30</td>
<td>1.30</td>
<td>89</td>
<td>25</td>
</tr>
<tr>
<td>≥150 mmHg</td>
<td>82</td>
<td>60</td>
<td>2.05</td>
<td>84</td>
<td>75</td>
</tr>
<tr>
<td>≥160 mmHg</td>
<td>65</td>
<td>85</td>
<td>4.33</td>
<td>53</td>
<td>88</td>
</tr>
<tr>
<td>≥170 mmHg</td>
<td>53</td>
<td>95</td>
<td>10.60</td>
<td>26</td>
<td>88</td>
</tr>
<tr>
<td>≥180 mmHg</td>
<td>44</td>
<td>100</td>
<td>—</td>
<td>21</td>
<td>88</td>
</tr>
<tr>
<td>≥190 mmHg</td>
<td>29</td>
<td>100</td>
<td>—</td>
<td>6</td>
<td>100</td>
</tr>
<tr>
<td>≥200 mmHg</td>
<td>12</td>
<td>100</td>
<td>—</td>
<td>ø</td>
<td>100</td>
</tr>
<tr>
<td>≥210 mmHg</td>
<td>ø</td>
<td>100</td>
<td>—</td>
<td>ø</td>
<td>100</td>
</tr>
<tr>
<td>≥220 mmHg</td>
<td>ø</td>
<td>100</td>
<td>—</td>
<td>ø</td>
<td>100</td>
</tr>
</tbody>
</table>

Osc-L, systolic values obtained using oscillometric methods with a distal limb cuff; Osc-T, systolic values obtained using oscillometric methods with a tail cuff; Doppler, blood pressure measured with Doppler ultrasound using a forelimb cuff; ø, no values in category.
is useful for tests likely to be used in different populations with varying disease prevalence (eg, screening normal animals as well as confirming suspected cases). In each instance, the LR will reflect the probability of disease based on a multiple of the base risk in the population.

In this study, the LR decreased at higher cut-point values. This finding is counterintuitive and is likely to be an artifact of the decreasing numbers of animals with markedly high NIBP that were available as the NI cutoff values became higher. For biological measurements, the density of extreme values diminishes as the values move away from the central point of the distribution. This phenomenon is more evident in normal populations because most biologic and physiologic parameters are constrained with relatively tight homeostatic limits. Approximately half of the dogs in 2 of the 3 groups studied were clinically normal, and the data from these animals did not display heavy density in the most extreme NIBP values. In addition, NIBP measurement methods are recognized to produce values predictably lower than corresponding values obtained by AP. The practical statistical effect of the sparse distribution of extremely high NIBP values is gaps in the data at the high values. These gaps yield Sp values that remain the same over several intervals of the measurement scale. Calculation of accurate LR for higher cutoff values awaits studies of larger groups of dogs.

ROC curves are an accepted statistical method of identifying a diagnostic cutoff value that maximizes true positives and minimizes false positives, but numerical differences in test characteristics among cutoff values may be small (Table 2). An increase in Se of 5% gained by decreasing the cutoff value by 10 mmHg may not be clinically significant. Nonetheless, knowledge of the test characteristics of an NIBP method may allow the clinician to better evaluate the probability of disease by supplying Se, Sp, and LR information for a given NIBP measurement. An animal with a high probability of disease but a negative test result at the usual cutoff values may be a candidate for reevaluation using a different measurement method or for calculation of probability of disease based on LR. In addition, because ROC curves supply information regarding diagnostic cutoff values, no conclusions can be drawn from this study about use of these tests for monitoring treatment. Information regarding accuracy and precision of some of the techniques used here is available.

Cutoff values may be misleading in populations at the extremes of prevalence, and use of LR allows analysis of probability of disease in populations with variable disease prevalence. For example, on the basis of cutoff values recommended here, a dog with Osc-L = 150 mmHg would be regarded as normal if cutoff values alone are considered. However, if prevalence (pretest odds of disease) is included in calculations and the dog came from a population with a high prevalence of hypertension (eg, dogs with glomerulopathies, approximately 80% prevalence of hypertension, pretest odds = 4:1), the posttest odds of disease are 8.2:1 (probability of disease: 89%) despite his apparently normal BP (see Appendix for calculations). In contrast, if the same Osc-L was measured in a dog from a low-risk population (estimated prevalence of hypertension in clinically normal dogs measured by AP = 5%, odds = 1:20), the probability of disease is 9%. Therefore, diagnostic cutoff values should be viewed as guidelines, and normal and abnormal test results should be analyzed in light of the clinical suspicion of disease.

Determination of the Se and Sp of a diagnostic test in the identification of hypertension requires positive identification of affected animals (ie, a gold standard for positive diagnosis must be used). In this study, the gold standard for identification of hypertensive dogs was AP-SBP ≥160 mmHg. Although use of instantaneous direct BP values as a gold standard in conscious dogs has been criticized as inaccurately reflecting the resting BP of the dog in question because of the stress of measurement or other factors, studies using chronic indwelling arterial catheters in mongrel dogs have produced values similar to those using instantaneous AP. Although the true SBP of suspect hypertensive dogs is pertinent to their disease management, the issue of whether the AP-SBP reflects the true SBP in these dogs and in the normal dogs was immaterial to this study, because we sought to evaluate test characteristics of the NIBP methods and used the AP values as a discrimination point only.

We analyzed only SBP in this study because the majority of dogs showing clinical signs of systemic hypertension appear to have systolic hypertension, but diastolic hypertension may occur concurrently in some affected animals. Diastolic hypertension has been documented in normal dogs and in dogs with some disease conditions, but the prevalence and importance of isolated diastolic hypertension in dogs remains unclear. In addition, oscilometric and Doppler BP measurement methods are somewhat less reliable in the measurement of diastolic BP with SBP measured by these methods correlating more closely with AP values. As information on the prevalence and importance of isolated diastolic hypertension in dogs becomes available, information similar to that presented in this study can be generated.

Dogs used in this study were not randomly assigned to measurement groups, and some dogs provided measurements in more than one category. In addition, some dogs could not be evaluated by a particular technique (eg, tailless dogs) and thus were assigned to an alternative technique. Each of these factors may have introduced some bias. Al-
though the suspect hypertensive animals were assigned to BP measurement techniques consecutively rather than randomly, no differences in age, weight, or AP-SBP were detected among the 3 groups. The proportion of dogs in each group having AP-SBP ≥160 mmHg did not differ significantly, allowing each technique a similar opportunity to detect abnormal SBP over a similar range of pressures. The purpose of this study was to generate test characteristics for the NIBP methods rather than to assess accuracy of NIBP measurements. Consequently, each measurement period was considered a single measurement occasion, generating 1 data point unrelated to any past or future measurements on that animal. Thus, any bias inadvertently introduced by group assignment would not have affected the results. Although the weight distributions among the groups were similar, few very small or very large dogs were available for study. Femoral artery size and ease of venipuncture can be a limiting factor in very small dogs. In this study, no attempt was made to record weights of dogs in which venipuncture was not possible due either to size or to temperament. Thus, differences in the ROC characteristics of each technique in dogs of varying weights are not addressed in this study. Lastly, because dogs were sequentially assigned to technique groups, changes in the reliability of the invasive measurements due to training effects cannot be ruled out.

Knowledge of the Se, Sp, and LR of various cutoff values for diagnosis may aid the clinician in the confirmation of a suspected disease. Suggested diagnostic cutoff values for hypertension documented here must be interpreted in light of the clinician’s assessment of the likelihood of systolic hypertension based on the patient’s clinical signs and the presence or absence of associated diseases. LRs can be used to assess the probability of hypertension associated with various NIBP values, and cutoff values should be used only as guidelines for diagnosis.

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Footnotes

^ Eagle 4000 GE, Marquette Medical Systems, Milwaukee, WI

^ Ultrasonic Doppler Flow Detector 811-AL, Parks Medical Electronics Inc, Aloha, OR

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References