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RESEARCH PAPER

Q3 Validation of noninvasive blood pressure equipment: which peripheral artery is best for comparison studies in dogs?

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Abstract

Objectives 1) To determine which peripheral artery commonly used for invasive arterial blood pressure (IBP) monitoring yields the least bias when compared with noninvasive blood pressure (NIBP) values obtained at the antebrachium of the dog, and 2) to identify and describe differences in systolic (SAP), mean (MAP) and diastolic arterial pressures (DAP) among different anatomical locations.

Study design Prospective experimental study.

Animals Twenty adult hound dogs weighing 24.5 ± 1.1 kg (mean ± standard deviation).

Methods Four peripheral arteries—dorsal pedal, median caudal, intermediate auricular and superficial palmar arteries—were catheterized with 20 gauge, 3.8 cm catheters. One NIBP cuff was placed in the middle third of the antebrachium. Four sets of IBP and NIBP measurements were simultaneously collected every 2 minutes. A linear mixed model was performed to analyze the collected data.

Results IBP values varied depending on the arterial catheterization site. The difference was greater for SAP. NIBP measured at the antebrachium had the best agreement with IBP measured at the median caudal artery.

Conclusion and clinical relevance IBP varies among anatomical locations. The smallest bias and narrowest limits of agreement were obtained at the median caudal artery, providing the best overall agreement with the equipment studied. The median caudal artery may be the preferable anatomical location for clinical comparison studies between IBP and NIBP in dogs when the cuff is on the antebrachium.

Keywords blood pressure, comparison, direct, IBP, indirect, NIBP.

Introduction

The search for a reliable noninvasive blood pressure (NIBP) monitor for use in dogs and cats that meet veterinary medicine validation criteria has not been an easy task. Most of the published peer-reviewed articles exploring the relationship between invasive blood pressure (IBP) and NIBP monitors in dogs (Hsiang et al. 2008; Bosiack et al. 2010; MacFarlane et al. 2010; Shih et al. 2010; Wernick et al. 2010; Garofalo et al. 2012; Drynan & Raisis 2013; Rysnik et al. 2013; Seliškar et al. 2013; Vachon et al. 2014) and cats (Acierno et al. 2010; da Cunha et al. 2014) show poor agreement between NIBP and IBP. Of the studies showing acceptable agreement between NIBP and IBP in dogs (Garofalo et al. 2012; Drynan & Raisis 2013; Vachon et al. 2014), one of them (Garofalo et al. 2012) was recently criticized for its statistical methodology (Garofalo et al. 2012; Hartnack 2014). None of the current publications exploring the use of NIBP in cats describes the noninvasive technique as reliable for that species.

The most common difference among the previous validation studies comparing NIBP and IBP is the choice of anatomical locations for the positioning of the NIBP cuff and for arterial catheterization. NIBP validation studies have used measurements from catheters placed in the lingual artery (McMurphy et al. 2006) or dorsal pedal artery (McMurphy et al. 2006; Bosiack et al. 2010; MacFarlane et al. 2010; Shih et al. 2010; Garofalo et al. 2012; Drynan & Raisis 2013; Rysnik et al. 2013; Vachon et al. 2014). Some studies have combined data collected from multiple arterial sites (McMurphy et al. 2006; Deflandre & Hellebrekers 2008), which would assume incorrectly that measurements from different arteries are interchangeable. One study comparing invasively measured arterial pressures in three peripheral arteries in the thoracic and pelvic limbs documented differences in pressures, especially systolic arterial pressure (SAP), measured at the different sites (Acierno et al. 2015). In clinical practice, cuff placement for NIBP measurement may be dictated by access available in relation to the procedure. Similarly, cuff placement for NIBP validation studies frequently vary, for example, the antebrachium (Shih et al. 2010), the pelvic limb (Bosiack et al. 2010; MacFarlane et al. 2010; Drynan & Raisis 2013) or the tail (Rysnik et al. 2013), which limits the conclusions from each study to the anatomical sites employed.

The purpose of this study was twofold. First, the intention was to compare NIBP measurements recorded from the middle third of the antebrachium of dogs with concurrent IBP measurements at four arterial sites. The second aim was to describe and compare SAP, mean (MAP) and diastolic (DAP) arterial pressures among four anatomical locations, two cranial and two caudal to the heart.

The goal was to search for the best anatomical location for arterial catheterization to be used in agreement studies between NIBP and IBP in the dog model when an NIBP cuff was applied to the antebrachium. In addition, IBP measurements from the four arterial sites were compared with each another to determine consistency or trends in blood pressure among anatomical locations. Our hypotheses were as follows: 1) the dorsal pedal artery would provide the best agreement between NIBP and IBP measurements, and 2) SAP, but not MAP, measurements from the four arterial locations would differ significantly.

Materials and methods

The Louisiana State University Institutional Animal Care and Use Committee approved this study. A total of 20 purpose-bred research dogs were premedicated intramuscularly (IM) with dexmedetomidine (0.002 mg kg^{-1}; Dexdomitor; Zoetis, NJ, USA) and hydromorphone (0.2 mg kg^{-1}; Hydromorphone Hydrochloride Injection, USP; West-Ward Pharmaceutical Corp., NJ, USA). When sedation was observed, oxygen was administered via an open face mask for 3 minutes, and then anesthesia was induced with propofol (3−5 mg kg^{-1}; PropoFlo; Abbott Laboratories, IL, USA). The trachea was intubated with an optimal size cuffed endotracheal tube with a Murphy eye, and anesthesia was maintained with a vaporizer setting of 1.3−1.6 vol.% of isoflurane (Isoflo; Abbott Laboratories) in oxygen using a circle breathing system with the dog breathing spontaneously. A multifunction monitor continuously monitored the heart rate (HR) and rhythm, pulse oximetry, end-tidal carbon dioxide partial pressure ($P_{E'}CO_2$), and esophageal temperature (Vet Trends V; SystemVET Inc., FL, USA). Manual ventilation was applied as needed to maintain $P_{E'}CO_2$ at 35−45 mmHg (4.6−6.0 kPa). If needed, a convective warmer (3M Bair Hugger Model 505; 3M, MN, USA) was used to maintain esophageal temperature at 37−39 °C. Blood pressure was not modified or corrected during this study.

With the dog in lateral recumbency, a one-tube, disposable, blood pressure cuff was placed around the antebrachium (SunTech Disposable BP Cuff; SunTech Medical, Inc., NC, USA). The circumferences of the proximal and distal borders of the middle third of the antebrachium were measured and averaged (Fig. 1). The cuff chosen for the dog had a width 30−40% of the limb circumference. NIBP cuffs were connected to a multifunction monitor (Vet Trends V; SystemVET Inc.) equipped with an NIBP board (Advantage OEM BP Module - Veterinary Module; SunTech Medical Inc.) using a 290-cm noncompliant tube. All cuffs were placed contralateral to the superficial palmar artery catheter. The NIBP monitor was calibrated by the manufacturer prior to the beginning of the data collection using a National Institute of Standards and Technology (NIST) traceable reference digital manometer.

After hair clipping and a sterile preparation with dilute chlorhexidine and alcohol, 20 gauge catheters (BD Insyte; Becton Dickinson Infusion Therapy System Inc., UT, USA) were placed in the dorsal pedal, intermediate auricular, median caudal and superficial palmar arch arteries. Each arterial catheter was connected to a pressure transducer (BD DTX Plus; Becton Dickinson, UT, USA) via noncompliant tubing