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Vertebral Heart Score: A Useful Parameter in Determination of Resuscitation Endpoint in Dogs with Hemorrhagic Shock

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Abstract

BACKGROUND: GReliable prediction of patient response to fluid resuscitation is a crucial issue in the management of hemorrhagic shock.

OBJECTIVES: This study was designed to investigate vertebral heart score (VHS) variation in fluid resuscitation of hemorrhagic shock patients and the feasibility of this method in determining resuscitation endpoint.

METHODS: VHS values were assessed using previously published standard method in left to right lateral view. After induction of anesthesia (control assessments), hemorrhagic shock was induced by blood withdrawal to a mean arterial pressure of 40 to 50 mmHg within 30 minutes and then maintained in hypovolemic situation for an additional 30 minutes (second and third stages of assessments). Afterward, the dogs were randomly assigned to two groups which received 20 ml/kg lactated Ringer's solution or 5 ml/kg Hydroxyethyl starch, in four consecutive 15 minute intervals (fourth stage of assessments). One hour after the last resuscitation step, final radiographic assessments were performed.

RESUTLS: Hemorrhagic shock caused significant decrease in VHS values to a mean of 7.7 vertebrae (P<0.05). Following the fluid resuscitation VHS increased and returned to pre-shock values in both groups.

CONCLUSIONS: This study confirms that the breed-specific VHS assessment can be a useful method in monitoring of patient's response to fluid therapy and determination of resuscitation endpoint in dogs with hemorrhagic shock.

KEYWORDS: Dog, hemorrhagic shock, hydroxyethyl starch, lactated Ringer, vertebral heart score

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Introduction

Hemorrhagic shock as a trauma-related condition can be one of the major causes of morbidity and mortality in veterinary critical care patients (Ko et al., 2012). Rapid fluid therapy with crystalloids or colloids remains the routine intervention in resuscitation of patients suffering hemorrhagic shock (Gao et al., 2018). However, subsequent monitoring to evaluate the efficacy of resuscitation is vital, because excessive fluid therapy or uncorrected hypovolemia can lead to deleterious effects (Ko et al., 2012; Marik, 2010). Therefore, understanding the tools and methods accessible for intravascular volume assessment is critical.

Thoracic radiography is one of the most important and frequently performed diagnostic modalities to evaluate heart diseases and has the potential to provide information equivalent to other cardiac diagnostic modalities (Gugjoo et al., 2013). Also, it is commonly employed to assess volume status and serial thoracic radiography may be helpful in determining effects of fluid therapy (Kalantari et al., 2013). Vertebral heart score (VHS) is an accessible, applicable, and interpretable diagnostic method for objectively evaluating cardiac size on radiographs as well as for the sequential assessment of cardiac size on serial radiographs of the same patient (Gugjoo et al., 2013; Johnson et al., 2008).

Recently, many studies have been carried out to determine the normal values of VHS in different breeds of dogs such as Yorkshire Terrier, Boston Terrier (Jepsen-Grant et al., 2013), Belgian Malinois (Almeida et al., 2015), Indian Spitz (Bodh et al., 2016), German Shepherd, and Iranian native dogs (Ghadiri et al., 2010). Although VHS changes in hypovolemic and hypervolemic conditions have been documented, to our knowledge its variation during fluid therapy in hemorrhagic shock condition has not been investigated previously. Therefore, the objective of the study reported here was to assess breed-specific VHS as a novel parameter for endpoint determination in fluid resuscitation phases of dogs with severe hemorrhagic shock using lactated Ringer's solution and 6% Hydroxyethyl starch.

Materials and Methods

Animals: The present experimental study was approved by Animal Care and Research Committee of Shahid Chamran University of Ahvaz. Ten male native dogs, 1.5 to 3.5 years old and weighing 18.56 ± 4.80 kg were used. They were in good body condition and considered healthy by physical examination, electrocardiography, echocardiography, and some hemato-biochemical parameters.

Animals Preparation and Instrumentation: After cannulation of right cephalic vein with an 18-gauge catheter (for drugs and fluid administration), the anesthesia was induced with an intravenous bolus dose of propofol (Lipuro 1%, Braun, Melsungen, Germany) (6.0 mg/kg) and fentanyl (Caspian Tamin, Rasht, Iran) (5 µg/kg) (Braz et al., 2004). Followed by intubation with an 8.0 to 8.5 mm cuffed endotracheal tube the animals were placed in right lateral recumbency and anesthesia was maintained with isoflurane (1.8%) in 100% oxygen (Ko et al., 2012). The right femoral artery was exposed by sterile technique and cannulated with a 16-gauge catheter that was connected to a 3-way stopcock for induction of bleeding and to measure arterial blood pressure. Body temperature was maintained at 37° to 38°C with a heating blanket (Nascimento et al., 2006). Also, an experienced investigator

evaluated physical parameters including mucous membrane color, capillary refill time and peripheral pulse quality routinely at the end of each step.

Experimental Protocol: Assessment of VHS was performed at the end of each step (A1 to A8) in five distinct stages as follows:

Control stage (A1): Baseline assessment was obtained after induction of anesthesia and instrumentation.

Hemorrhagic stage (A2): Each dog was then hemorrhaged to a mean arterial pressure (MAP) ranging from 40 to 50 mmHg (Braz et al., 2004). The procedure lasted approximately 30 min and blood was collected into sterile empty blood bags.

Hypovolemic stage (A3): The animals were left in shock situation for an additional 30 min period during which no fluid was administered. If a physiologic compensatory mechanism developed and MAP increased above the purpose values, more blood was removed to restore the MAP back to 40 to 50 mmHg.

Resuscitation stage (A4 – A7): Animals were then randomly allocated into two equal groups. Group A was resuscitated with lactated Ringer's solution (LR) (Iranian Parenteral and Pharmaceutical Co., Tehran, Iran) at 20 ml/kg in 15 min for four consecutive times. Group B was resuscitated with 6% Hydroxyethyl Starch (HES) (Voluven, Fresenius Kabi, Homburg, Germany) at 5 ml/kg in a similar manner to group A.

Post-resuscitation stage (A8): The last assessment was performed one hour after termination of resuscitation. Then, animals were allowed to recover from anesthesia.

Radiographic assessment: Right lateral recumbent thoracic radiographs of each dog were obtained using a digital radiography (DR) system (Aero DR detector, Konica-Minolta, Japan, 35 mAs and 65 kVp). VHS was determined by a veterinary radiologist based on the previously described method (Buchanan and Bücheler, 1995). Briefly, the cardiac long axis (LA) was measured from the ventral border of the left main stem bronchus to the most distant point of the apex. The cardiac short axis (SA) was measured perpendicular to the long axis at the level of the caudal vena cava. The measurements of the two axes were positioned over the thoracic vertebra, starting at the cranial edge of the 4th thoracic vertebra (T4) and the number of vertebra (v) spanned was estimated to the nearest 0.1 vertebral body length. The VHS was calculated from the sum of the short and long axes.

Statistical analysis: Data of this study were evaluated by repeated measures analysis of variance and LSD post hoc using SPSS 16.0 statistical software (SPSS, Inc., Chicago, USA). All data were presented as mean ± standard deviation (SD). A p value of less than 0.05 was considered as statistically significant.

Results

The average blood volume loss was 54 ± 4 ml/kg, which corresponded to approximately 62% ± 4% of the estimated circulating blood volume (88 ml/kg); so that there were no significant differences between the groups ($p>0.05$). In both groups, the animals responded to fluid therapy and were successfully resuscitated with no mortality. Dogs in group A received 386 ± 102.85 ml LR, whereas dogs in group B received 89.5 ± 22.17 ml HES at each step of fluid resuscitation. There was no significant difference between the studied groups according to MAP during all study stages ($p>0.05$).

Figure 1 shows VHS variation during fluid

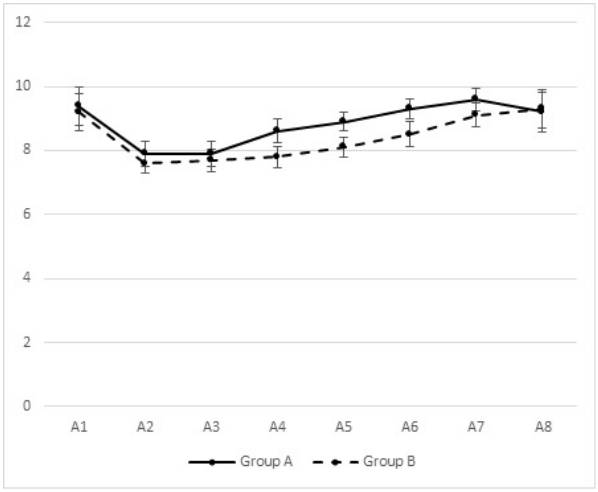

Figure 1. Mean ± SD values of VHS in dogs with experimental hemorrhagic shock after resuscitation with LR and HES.

therapy in dogs with hemorrhagic shock. The mean ± SD of VHS in both groups before induction of shock was 9.3 ± 0.59, which was significantly reduced in A2, as shown in Fig. 2.

Following the fluid resuscitation, this value increased and approximately returned to pre-shock values at steps 6 and 7 in groups A and B, respectively. It is worth noting, the statistical analysis indicated no significant difference between solution types ($p>0.05$).

Discussion

In this experimental model of hemorrhagic shock, the short-term effects of LR and 6% HES, as the most frequently used crystalloid and synthetic colloid fluids, on the VHS were studied from the clinical point of view.

Although there are many subjective and semiquantitative methods of assessing heart size, the VHS is the preferred method at present (Woolley et al., 2007). It gained popularity among veterinary radiologists due to various advantages such as justifiable anatomic markers for measurement of cardiac silhouette, good correlation with both echocardiographic and electrocardiographic parameters, and is independent of the observer experience (Almeida et al., 2015; Gugjoo et al., 2013).

It is very important that the breed and recumbent side of radiographic view should be taken into consideration while calculating VHS in dogs to have a high specificity for normal heart size (Bodh et al., 2016). In our country, native dogs account for a large number of companion animals. Although they are

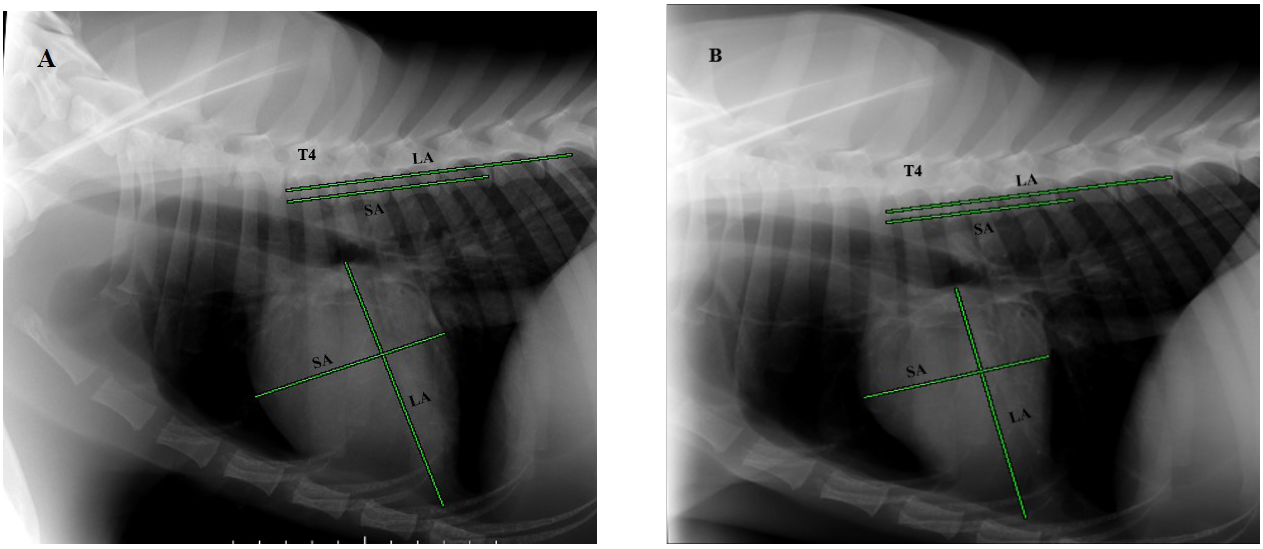

Figure 2. Demonstration of VHS in control (A) and hemorrhagic (B) stages (9.6v and 8v respectively).

not a registered breed, Ghadiri et al. (2010) established normal VHS values for Iranian native dogs with mean of 9.4 vertebras. Our results at the control stage also confirm this finding. It is proposed that the cardiac silhouette may have a different shape on a right lateral versus a left lateral radiographic view (Olive et al., 2015). But interestingly, according to the study by Ghadiri and his colleagues (2010), no significant difference was found between the VHS of right lateral and left lateral radiographs in native dogs. Furthermore, in the present study, we used right lateral radiographs in order to obtain the most accurate information about cardiac size (Greco et al., 2008).

The heart is an organ in which notable changes in intravascular volume can affect its size. Wilson et al. (2010) demonstrated that severely anemic cats have high VHS values, which can be due to volume overload caused by hemodynamic compensatory mechanisms. In another study it was documented that primary hypoadrenocorticism in dogs can lead to a significant reduction in VHS, that may be attributed to hypovolemia (Melián et al., 1999). Normal mean VHS value in dogs is 9.7 v, and values between 8.7 and 10.7 v are generally considered to be physiological (Kraetschmer et al., 2008). However, in our investigation, induction of hemorrhagic shock led to significant decrease in VHS values to a mean of 7.7 v in the studied groups. This phenomenon can be explained by the severe hypovolemia that results in decline of filling pressure with subsequent decrease in the diameters of the cardiac chambers and the fiber length of cardiac muscles (Traber et al., 1993).

Restoration of intravascular volume is the first therapeutic goal in hemorrhagic shock (Bouglé et al., 2013). The amount of fluid required to restore intravascular volume is very variable and so frequent assessment is needed. Also, it is crucial during the resuscitation phase to assess whether the patient is fluid-responsive or not (Kalantari et al., 2013). In the current study, following administration of intravenous fluids, the VHS values increased slightly and almost returned to the control values that can indicate successful resuscitation. Hence, assessment of the VHS can be a reasonable method to monitor the response to fluid resuscitation. The lack of significant difference in VHS values between the two types of solutions that were used, despite different dosage, probably is due to the discrepancy in mechanisms of action as well as the stability time in the vessels (Nascimento et al., 2006).

Because of the similarity of our recorded VHS values in the control stage with standard values reported for native dogs by Ghadiri et al., (2010), utilization of this method in breeds of dogs with a predetermined standard VHS can be valuable in estimating resuscitation endpoint. However, some studies mentioned that noncardiac factors such as body condition score (Jepsen-Grant et al., 2013), recumbency side (Greco et al., 2008), training (Zahabpour et al., 2016), and interobserver variability (Olive et al., 2015) can affect VHS. Therefore, to increase the reliability of this method in determination of resuscitation endpoint, it is necessary to establish a universal protocol.

Conclusion

The findings of this study indicate that VHS assessment can guide clinicians in the estimation of volume status in dogs with hemorrhagic shock as well as monitoring the response to fluid resuscitation. Moreover, in daily practice, serial assessment of VHS

along with a comprehensive physical examination, can be helpful as a novel resuscitation endpoint in breeds of referring dogs with pre-standardized VHS.

Acknowledgments

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Conflicts of Interest

The author declared no conflict of interest.

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مجله طب دامی ایران، ۱۳۹۷، دوره ۱۳، شماره ۳، ۲۵۰-۲۴۳

اندازه مهره‌ای قلب: پارامتری مفید در تعیین نقطه پایان احیاء در سگ‌های دچار شوک هموراژیک

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چکیده

زمینهٔ مطالعه: پیش‌بینی قابل اعتماد پاسخ بیمار به مایع درمانی یک مسئله بسیار مهم در مدیریت شوک هموراژیک است.

هدف: هدف از این مطالعه، ارزیابی تغییرات اندازه مهره‌ای قلب (VHS) در مایع درمانی بیماران دچار شوک هموراژیک و امکان استفاده از این روش در تعیین نقطه پایان احیاء است.

روش کار: مقادیر VHS با استفاده از روش استاندارد که قبلا منتشر شده بود در نمای جانبی چپ به راست بررسی شد. پس از القای بیهوشی (ارزیابی‌های مرحله کنترل)، شوک هموراژیک از طریق خونگیری تا رسیدن به فشار متوسط سرخرگی ۴۰ تا ۵۰ میلی‌متر جیوه طی ۳۰ دقیقه ایجاد و سپس به مدت ۳۰ دقیقه در شرایط هیپوولمی (مراحل دوم و سوم ارزیابی) حفظ گردید. سپس سگ‌ها به صورت تصادفی به دو گروه تقسیم شدند و در چهار بازه زمانی متوالی ۱۵ دقیقه‌ای محلول رینگر لاکتات با دوز ۲۰ میلی‌لیتر/کیلوگرم یا هیدروکسی‌اتیل استارچ با دوز ۵ میلی‌لیتر/کیلوگرم را دریافت کردند (ارزیابی‌های مرحله چهارم). یک ساعت پس از آخرین مرحله احیاء، ارزیابی نهایی رادیوگرافی انجام شد.

نتایج: شوک هموراژیک موجب کاهش معنی‌دار میزان VHS به میانگین ۷/۷ مهره گردید ($P<0/05$). پس از احیاء، VHS افزایش یافت و در هر دو گروه به مقادیر پیش از شوک بازگشت.

نتیجه‌گیری نهایی: این مطالعه نشان داد که ارزیابی VHS اختصاصی هر نژاد می‌تواند یک روش مفید در پایش پاسخ بیماران به مایع درمانی و تعیین نقطه پایان احیاء در سگ‌های دچار شوک هموراژیک باشد.

واژه‌های کلیدی:

سگ، شوک هموراژیک، هیدروکسی اتیل استارچ، رینگر لاکتات، اندازه مهره ای قلب

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