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Estimated intraoperative blood loss in dogs undergoing hemilaminectomy and intervertebral disc fenestration

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ABSTRACT: There are no reported estimates of normal or abnormal bleeding in dogs during the hemilaminectomy and intervertebral disc fenestration procedures (HF), and that makes it difficult to study intraoperative complications, hemostasis methods, and the impact of bleeding on surgical performance. This prospective study estimated blood loss during HF procedures in dogs with intervertebral disc extrusion (IVDE). Blood loss was quantified by weighing gauzes during the surgical procedure, in addition to measuring the aspirated blood. Total blood volume was estimated according to body weight, and blood loss as a percentage of the total blood volume. The surgeon also subjectively classified the procedures, dividing them into intraoperative difficulty due to bleeding (G1) and absence of intraoperative difficulty (G2). Thirty-two dogs that underwent HF due to IVDE were included. The median blood loss (%) of dogs submitted to HF was 3.9 ± 9.67 of the total blood volume. There was a weak correlation between blood loss and weight, age, incision size, and procedure time.
Key words: intraoperative complications, hemorrhage, hemostasis, neurosurgery, blood loss.

Estimativa de perda sanguínea transoperatória em cães submetidos a hemilaminectomia e fenestração do disco intervertebral

RESUMO: Não existem valores estimados de sangramento normal ou anormal durante procedimentos de hemilaminectomia e fenestração do disco intervertebral (HF), o que torna difícil o estudo de complicações transoperatórias, métodos de hemostasia e o impacto do sangramento na performance cirúrgica. Este estudo prospectivo objetiva estimar a perda sanguínea durante os procedimentos cirúrgicos de HF em cães com extrusão do disco intervertebral (EDIV). A perda sanguínea foi quantificada pela pesagem de gazes usadas durante o procedimento, além da mensuração do sangue aspirado. O volume de sangue total foi estimado de acordo com o peso do animal, e a perda de sangue como porcentagem do volume de sangue total. O cirurgião também classificou os procedimentos subjetivamente, dividindo-os em dificuldade transoperatória devido ao sangramento (G1) e ausência de dificuldade transoperatória (G2). Trinta e dois cães submetidos a HF devido a EDIV foram incluídos. A perda sanguínea mediana (%) dos cães submetidos a HF foi de 3,9 ± 9,67 do volume de sangue total. Houve uma fraca correlação entre perda sanguínea e peso, idade, tamanho da incisão e tempo de procedimento.
Palavras-chave: complicações transoperatórias, hemorragia, hemostasia, neurocirurgia, perda sanguínea.

INTRODUCTION

The main spinal surgical procedure conducted on dogs is spinal cord decompression (SHORES, 2017). As in all surgical procedures, there is blood loss in the intraoperative period due to dieresis maneuvers in the tissues, as a consequence of arterial and venous injuries (TOOMBS & BAUER, 1998). Excessive blood loss during surgery can cause hemodynamic changes that impair the anesthetic procedure and the patient's recovery in the postoperative period (SHARP & WHEELER, 2005). In addition, bleeding in spine surgeries makes it difficult to visualize the operative site, which can contribute to increased surgical time and iatrogenic injuries (ARAND & SAWAYA, 1986; RENKENS et al., 2001; PLATT & DA COSTA, 2018).

No studies were found in the literature that indicate the estimated blood loss in dogs subjected to hemilaminectomy associated with intervertebral disc fenestration (HF). Therefore, this study estimated the blood loss in dogs subjected to HF, and correlated the variables weight, age, procedure time, and incision size interfere with blood loss during these procedures.

MATERIALS AND METHODS

Thirty-two dogs from the neurology and neurosurgery department of a veterinary hospital were included. The animals were of different breeds

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and ages, of both sexes, presenting exclusively neurological signs due to intervertebral disc extrusion. In the perioperative period, the patients remained hospitalized in a kennel, housed in individual cages, and handled and medicated by the same professionals.

All animals were subjected to general physical, neurological, and laboratory examinations. Laboratory tests conducted included a complete blood count, platelet count, serum biochemistry (albumin, ALT, creatinine, alkaline phosphatase, total proteins, urea), prothrombin time (PT), and activated partial thromboplastin time (aPTT) tests (ANGELOS & HAMILTON, 1986).

Anesthetic induction was performed individually after the appropriate fasting period. The protocols consisted of single intravenous (IV) administrations of propofol 3 to 5 mg/kg or etomidate 1.5 mg/kg, associated or not with diazepam 0.25 to 0.5 mg/kg IV, midazolam 0.2 to 0.3 mg/kg IV, ketamine 1 mg/kg IV, or fentanyl 1 to 2.5 mcg/kg IV, according to the anesthesiologist choice. Intraoperative anesthesia was maintained by isoflurane in 100% oxygen through a calibrated vaporizer, to effect. Intraoperative analgesia was performed by continuous infusion of fentanyl IV, associated or not with lidocaine and ketamine, and a 25 mg/kg IV bolus of sodium dipyrone. All dogs received a 30 mg/kg IV cephalothin sodium bolus 30 min before starting the surgery, and then every 2 h at the same dosage. Fluid therapy was started at a rate of 7 ml/kg/h, which was adjusted as needed. Loading fluids boluses and vasopressor drugs were recorded. During the trans-anesthetic period, heart rate (HR), respiratory rate (RR), esophageal temperature (ET), mean arterial pressure (MAP), systolic blood pressure (SAP), and oxygen saturation were measured constantly and recorded every 5 min.

The surgical procedures performed were hemilaminectomy and intervertebral disc fenestration (BRISSON, 2017; SHORES, 2017), in only one intervertebral space and one side of the spinal column. Skin, subcutaneous, and muscle tissue hemostasis was performed using digital compression and bipolar cautery. Vertebral canal hemostasis was performed using macerated muscle fragments. The surgical time was measured in minutes (min) from the incision to the closing of the last skin suture. The incision size was measured in millimeters (mm). The techniques were performed by one neurosurgeon with more than six years of experience. After the procedure, the surgeon answered whether the intraoperative bleeding made it difficult to see the surgical site and hindered the surgery (yes or no). Based on the surgeon's response, the patients were distributed into Group 1 (G1, transoperative visualization difficulty) and Group 2 (G2, no visualization difficulty).

All procedures were performed in a controlled surgical environment, with temperature adjusted between 22-24 ^{o}C, and relative air humidity between 60-80%. Blood loss was measured by weighing the gauze used in the surgical procedure (1 g of blood = 1 mL of blood) (VITELLO et al., 2015), in addition to the aspirated blood (Figure 1A), stored with an anticoagulant substance during surgery (sodium heparin 5,000 IU/mL) (RISSELADA et al., 2009).

The gauzes were weighed on a precision scale before and after the surgical procedure (Figure 1B and 1C). They were stored in hermetically sealed bags until the weighing moment (RISSELADA et al., 2009). The gauze packings, the sodium heparin, and the saline used during surgery were discounted from the weightings. The animal's total blood volume was estimated according to its weight (77.5 mL/kg) (WELLMAN et al., 2006), and blood loss as a percentage of the total blood volume, according to the formula: percentage (%) of total blood loss = blood measured during the operation (mL) x 100 / 77.5 x patient weight (kg) (RISSELADA et al., 2009).

The quantitative variables weight, age, procedure time, blood loss, and incision size were submitted to the Shapiro-Wilk normality test. A one-way analysis of variance was used to analyze the temperature, HR, and MAP variation throughout the procedure. The Spearman's test was used to correlate the data on procedure time, incision size, age, and weight with blood loss. The Mann-Whitney U test was used to compare the bleeding between G1 and G2 patients. The statistical programs used were Minitab® Statistical Software 20.3.0.0 and GraphPad Prism® (version 5.01). Statistical significance was set at a P-value of < 0.05. The median ± 95% CI was used to create the images.

RESULTS

Of the 32 dogs included in the study, 13 were males and 19 were females. The median ± SD age of dogs was 6 ± 2,51 years old, being 8 youngers than 4 years old, 19 between 4 and 8 years old, and 5 over 8 years old. The median weight of dogs was 7.7 ± 5,79 kg, 4 weighing less than 5 kg, 19 weighing between 5 and 10 kg, and 9 weighing over 10 kg.

In the PT and aPTT tests all dogs presented values within the reference range (4.07 to 9.67 s and 11.9 to 18.3 s, respectively) (LOPES et al., 2005). Other laboratory parameters, including the total platelet count, were also within reference values.

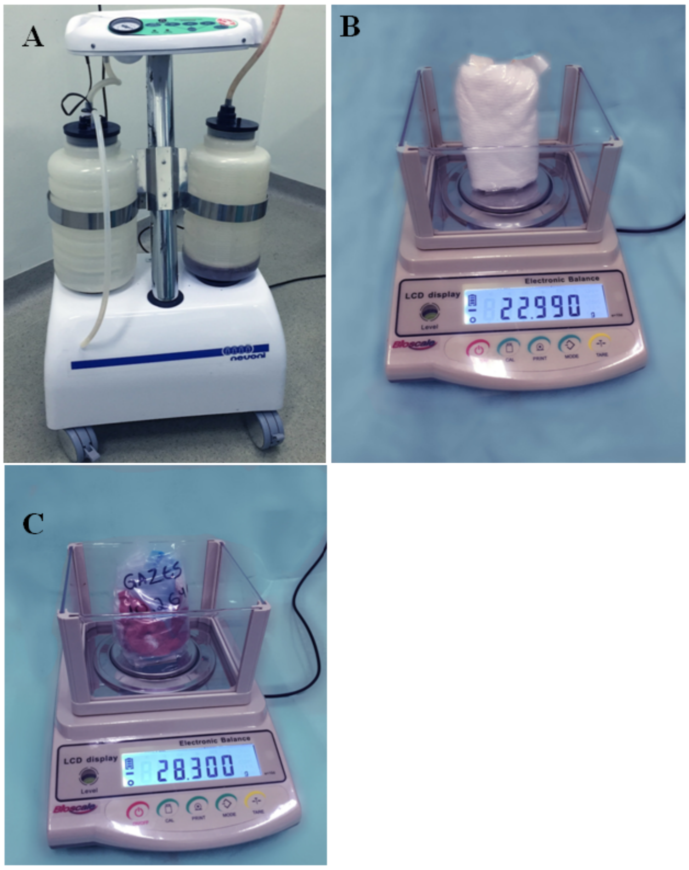

Figure 1 - Methodology used to measure transoperative bleeding in dogs undergoing hemilaminectomy and intervertebral disc fenestration. In A, a surgical aspirator bottle containing blood collected during the operation. In B, weighing gauzes before and, in C, during the surgical procedure.

The MAP, SAP, HR, RR, and ET assessments showed no variation among patients. Of the variables weight, age, procedure time, incision size, and blood loss, only age showed normal distribution ($P > 0.100$). The median value of estimated blood loss (%) was 3.2 ± 9.7 for the HF procedures. The incision size and procedure time medians were 74.5 ±37.7mm and 76.5 ± 33.6 min, respectively (Figure 2). There was a weak correlation between blood loss and incision size, procedure time, age, and weight (r_s= 0.25, 0.32, 0.02, and 0.32, respectively).

According to the surgeon's response, ten patients were included in G1, where intraoperative visibility and performance were difficult due to bleeding, and the remaining 22 patients were included in G2, where there was no difficulty. The median blood loss (%) in G1 was 10.9 ± 14.3, and that in G2 was 2.75 ± 2.14 (Figure 2). The difference in blood loss between G1 and G2 was significant ($P = 0.0001$).

DISCUSSION

The estimated blood loss for HF procedures in dogs has not been reported in the veterinary literature. A study with hemilaminectomy and vertebral stabilization for the treatment of intervertebral disc protrusions observed hemorrhage in 32.14% of dogs, due to laceration of the vertebral venous plexus (DOWNES et al., 2009). However, hemorrhage was only subjectively classified. Our study used the gravimetric method to estimate blood loss and then associated these estimates with the surgeon's evaluation about the procedure difficulty due to bleeding (LEE et al., 2006; VASANJEE et al., 2006; RISSELADA et al., 2009). Our study evaluated the estimated blood loss by percentage (%) and not in milliliters (mL). Therefore, there was no difference between dogs with higher and lower weights (RISSELADA et al., 2009).

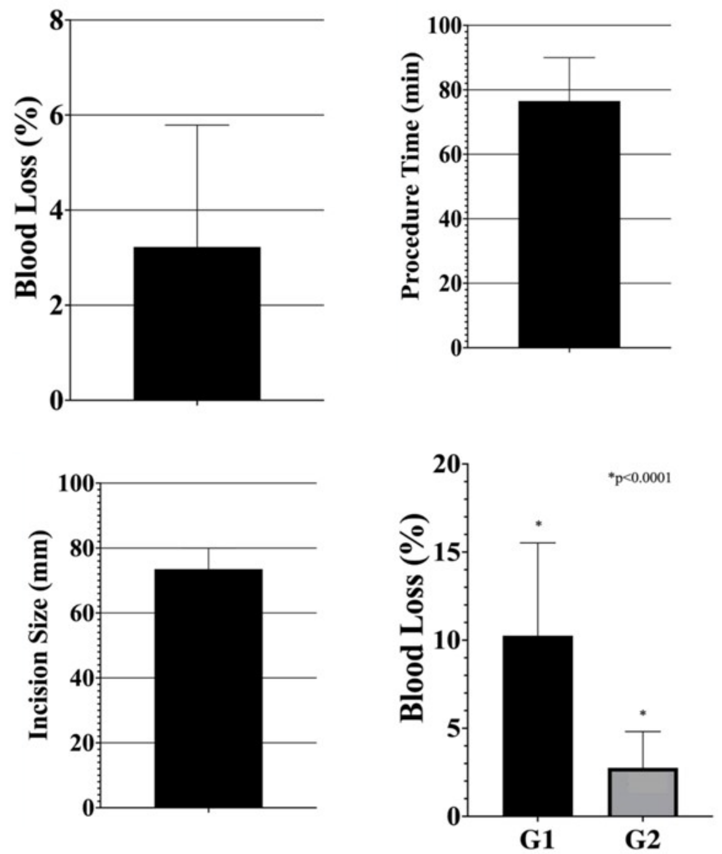

Figure 2 - Median ± SD of blood loss, procedure time, and incision size of dogs undergoing hemilaminectomy and intervertebral disc fenestration procedures and the difference in blood loss between animals from G1 and G2.

*P = 0.0001; mm: millimeters; min: minutes; %: percentage; SD: standard deviation; G1: animals where there was intraoperative difficulty due to bleeding; G2: no intraoperative difficulty due to bleeding.

Several methods are described for measuring or estimating intraoperative blood loss in human and veterinary medicine. Among them, visual estimation (subjective, by surgeon or anesthesiologist), gauzes, sponges and swab weighing method (gravimetric), radioisotopes, weighing the patient before and after the procedure, electrical conductivity, hemodynamic measurements, colorimetric method (hemoglobin), volumetric method (surgical aspirate), direct method (obstetrics), and formulas based on hematocrit values, weight, height, sex, and body area (SHAW & LEWIS, 1981; LEE et al., 2006; JARAMILLO et al., 2019; GERDESSEN et al., 2020; JARAMILLO et al., 2020).

The gold standard for evaluating intraoperative blood loss is the colorimetric method, which uses hemoglobin variations in samples through a spectrophotometer (SHAW & LEWIS, 1981; GERDESSEN et al., 2020). However, this method is considered laborious and not applicable to the surgical routine (LEE et al., 2006). In addition, the gravimetric method has already been validated when compared to the colorimetric, in a study conducted in dogs undergoing three types of procedures, being accurate and less laborious (LEE et al., 2006). Other studies considered the gravimetric method as the second best in the surgical routine (SHAW & LEWIS, 1981), being a viable option when colorimetry is not available.

The median percentage of blood loss in the HF procedures (3.9 ± 9.67) was less than the value mentioned elsewhere for the onset of volemic changes due to bleeding in dogs (WESTPHAL et al., 2007).

The value reported in our study is also considerably below those specified in a canine hemorrhage experiment, which revealed a 50% mortality rate in patients with blood losses between 41-43% and in most patients who lost 45% or more than their total blood volume (SWAN et al., 1959).

Animals from G1 bled more than those where there was no intraoperative difficulty (G2) (10.91% and 2.75%, respectively). In fact, the main concern regarding intraoperative bleeding in HF procedures is not the total loss percentage, as this is well below the limits to cause systemic complications. The relevance of studying transoperative bleeding in these procedures lies in the small size of the surgical field. Even small bleedings can hinder or even prevent the surgery to proceed. Excessive bleeding in these situations can impair the surgeon's visualization of the surgical site, increasing the complication prevalence and resulting in increased morbidity and mortality rates (ARAND & SAWAYA, 1986; RENKENS et al., 2001; SHARP & WHEELER, 2005). In this study, iatrogenesis or other intraoperative implications were not prevalent.

Vertebral venous plexus bleeding and bone bleeding are difficult to control, and methods such as digital compression, clamping, or bipolar cautery are either not feasible or unrewarding (ARAND & SAWAYA, 1986; GRANT, 2007). The hemostasis difficulty in these cases can hinder surgical performance. The use of macerated muscle fragments and synthetic absorbent materials, such as gelatin-based hemostatic sponges, can be used for hemostasis in the spinal canal (SAMUDRALA, 2008; BEHRENS et al., 2014). Macerated muscle fragments were sufficient to control bleeding in our study. Furthermore, the low correlation between incision size and procedure time when compared to blood loss strengthens the hypothesis that bleeding from the vertebral venous plexus and bone bleeding, which are independent of incision size, are the real issues during HF.

There was no statistical difference in blood pressure and temperature among patients, meaning that the animals were homogeneous regarding these parameters. Hypotension was corrected using vasopressor drugs, increasing the rate of fluid therapy and loading boluses (WILSON & SHIH, 2015) when required. We emphasized that not only blood loss but also the anesthetic protocol itself, such as propofol, fentanyl, and isoflurane, can cause hypotension in patients during surgery (IIZUKA et al., 2013).

The main limitations of this study were the number of dogs and the lack of other tests to detect coagulopathies, such as thromboelastogram, rotational thromboelastometry, buccal mucosa bleeding, and activated clotting time (KOL & BORJESSON, 2010; HACKNER & DIFAZIO, 2018). In addition to those used in this study, these coagulation tests would reinforce the exclusion of coagulation deficiencies. The inclusion of a greater number of surgeons, at all levels of the learning curve, would also make our results more reliable.

The clinical relevance of this study was the estimation of blood loss in dogs during hemilaminectomy and intervertebral disc fenestration and low correlation with age, weight, procedure time and incision size. One finding, however, interesting was the difficulty in visualizing the operative field in the dogs in the group with greater blood loss (G1). This finding shows that this difficulty, in addition to increasing the duration of surgery aimed achieving hemostasis, the smallest view can cause difficulty in performing the technique and increase the chances of errors and complications. Therefore, the surgeon, as well as the team, should use other methods of hemostasis that help reduce blood loss, such as the use of tranexamic acid. This compound was used by Ferrarin (2021) in spinal cord decompression surgery in dogs with intervertebral disc extrusion, which found a significant reduction in bleeding when compared to the control group.

CONCLUSION

Based on the results obtained, it can be concluded that there is a variation in blood loss in dogs submitted to hemilaminectomy and intervertebral disc fenestration; there is a low correlation between age, weight, surgery time and incision size with blood loss and greater difficulty in visualizing during surgery in those who had more bleeding.

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AUTHORS' CONTRIBUTIONS

All authors contributed equally for the conception and writing of the manuscript. All authors critically revised the manuscript and approved of the final version.

BIOETHICS AND BIOSSECURITY COMMITTEE APPROVAL

This study was approved by the Institutional Ethics Committee on Animal Use (3512090617).

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