Article

Effect of routine pre-anesthetic laboratory screening on pre-operative anesthesia-related decision-making in healthy dogs

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Abstract — The usefulness of pre-anesthetic laboratory screening of healthy veterinary patients is controversial and clear evidence-based guidelines do not exist. The purpose of our study was to determine the influence of pre-anesthetic laboratory screening on peri-anesthetic plans in canine patients undergoing elective surgery. One hundred medical records were randomly selected between the years 2008 and 2013 and patient information was presented to 5 Diplomates of the American College of Veterinary Anesthesia and Analgesia (ACVAA) for review. They were given pre-anesthetic laboratory screening test results for each patient and asked whether the results would change the way they managed the case from an anesthesia perspective. Peri-operative anesthetic management was altered in 79% of patients based on pre-anesthetic screening results; however, the overall agreement among anesthesiologists was weak with 64% of changes made by only a single anesthesiologist. Pre-anesthetic laboratory screening test results may influence pre-operative anesthesia case management but major discrepancies can occur among ACVAA diplomates.

Résumé — Effet du dépistage de laboratoire pré-anesthésique de routine sur la prise de décisions préopératoires liées à l'anesthésie chez des chiens en santé. L'utilité du dépistage de laboratoire pré-anesthésique des patients vétérinaires en santé est controversée et des lignes directrices claires basées sur des données probantes n'existent pas. Le but de notre étude consistait à déterminer l'influence du dépistage de laboratoire pré-anesthésique pour la péri-anesthésie chez les patients canins subissant une chirurgie non urgente. Cent dossiers médicaux choisis au hasard entre les années 2008 et 2013 et des données sur les patients ont été présentés à cinq diplomates de l'American College of Veterinary Anesthesia and Analgesia (ACVAA) aux fins d'examen. On leur a donné les résultats des tests de dépistage de laboratoire pré-anesthésiques pour chaque patient et on leur a demandé d'évaluer si les résultats auraient modifié la façon dont ils auraient géré le cas du point de vue de l'anesthésie. La gestion anesthésique péri-opératoire a été modifiée chez 79 % des patients en se basant sur les résultats du dépistage pré-anesthésique. Cependant, le consensus général parmi les anesthésiologistes était faible avec 64 % des changements apportés par seulement un seul anesthésiologiste. Les résultats des tests de dépistage de laboratoire pré-anesthésiques peuvent influencer la gestion des cas d'anesthésie préopératoire mais des écarts majeurs peuvent se produire parmi les diplomates de l'ACVAA.

(Traduit par Isabelle Vallières)

Can Vet J 2018;59:773–778

Introduction

A good history and thorough physical examination are the main components of assessment of health prior to general anesthesia and surgery. The goal is to understand and decrease the risk of morbidity and mortality associated with anesthesia. Several studies in human anesthesia (1–8) and a few studies in veterinary medicine (9–13) question the necessity for pre-anesthetic laboratory testing in healthy patients as part of the pre-operative assessment.

Pre-anesthetic laboratory screening, defined as a complete blood (cell) count (CBC), serum biochemistry, and urinalysis (UA), is performed to detect subclinical disease such as hypoproteinemia and anemia that may affect how the patient responds to anesthesia (14). Abnormal test results may influence anesthesia-related case management decisions that could improve overall quality of care for the patient. Another purpose is to establish baseline values for future testing.

Disadvantages of pre-anesthetic laboratory screening of healthy patients include cost, patient stress, additional potentially risky and unnecessary tests, delay of surgical procedures and potentially harmful treatments with questionable significance. It has been estimated that a human hospital could save

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Table 1. Questions to anesthesiologists regarding anesthesia case management based on pre-anesthetic screening results.

Would you postpone or cancel the surgery?
Would you repeat the blood work?
Would you change the patient's ASA Grade?
Would you change fluid therapy?
Would you change the monitoring equipment used?
Would you change patient management excluding drug protocol (i.e., pre-oxygenate or avoid an epidural)?
Would you change client communication (i.e., risk)?
Would you perform further diagnostic testing (i.e., coagulation testing or ultrasound)?
Would you avoid the use of nonsteroidal anti-inflammatory drugs?

Table 2. The percentage of anesthesiologists who believed that 1 or more changes should be made to anesthesia-related case management of 100 healthy dogs due to abnormal pre-anesthetic screening laboratory test results.

Anesthesiologists (%)	Cases (%)
100	3
≥ 80	9
≥ 60	32
≥ 40	48
≥ 20	79
0	21

$80 000 US annually if pre-anesthetic tests deemed unnecessary were eliminated (8).

In the human medical literature, pre-anesthetic screening in apparently healthy patients is not recommended as it has not been shown to predict perioperative complications, change patient management, or affect outcome (1–5,7,15–18). Further studies in human medicine have shown that a large amount of money could be saved if such tests were eliminated, although the practice of routine pre-anesthetic testing is difficult to change with general surgeons being more likely than anesthesiologists to order unnecessary tests (6,8).

In the veterinary literature, fewer studies exist and the usefulness of pre-anesthetic laboratory screening in apparently healthy patients is less clear. One study found subclinical disease that resulted in modification of the anesthetic plan in 4% of cats and 3% of dogs with no clinical signs due solely to abnormal pre-anesthetic laboratory test results (12). Pre-procedural laboratory screening has been recommended ideally within 2 wk of anesthesia in all senior dogs and cats (19) and a CBC and total plasma protein determination have been recommended in all horses prior to general anesthesia (20). Other veterinary studies have concluded that pre-anesthetic laboratory screening results often had little clinical relevance and did not prompt major changes to the anesthetic protocol in healthy patients (9,10,13). The Association of Veterinary Anesthetists (AVA) voted in 1998 to declare that routine pre-anesthetic screening is unnecessary if the clinical examination was adequate (21).

The American Society of Anesthesiologists (ASA) grade is used to categorize the health status of a patient prior to undergoing general anesthesia. Pre-anesthetic screening may detect abnormalities that would reclassify a patient as a higher ASA grade, which has been associated with increased odds of anesthetic death (22–26). A change from ASA I or II to ASA III was found to increase risk of anesthetic death by 6.6-fold (24). Higher risk patients may require more extensive perioperative management and monitoring.

There are many anesthesia-related case decisions besides drug protocol that can improve patient quality of care while under general anesthesia. Only a handful of decisions, notably a change in drug protocol, have been addressed in previous veterinary studies (9,10,13). The objective of this study was to determine if routine pre-anesthetic laboratory screening, including CBC, biochemistry, and urinalysis (UA), provided information that might change the anesthetic management of the patient. The hypothesis was that pre-anesthetic laboratory screening in apparently healthy dogs would detect abnormalities leading to alteration of the patient's peri-operative anesthesia-related case management from the usual standard anesthetic management for a healthy patient at the University of Georgia Veterinary Medical Center (UGA VMC).

Materials and methods

The clinical record of all dogs presenting to the UGA VMC between the years 2008 and 2013 were screened retrospectively, out of which 29 488 patients had CBC, serum biochemistry, and urinalysis (UA) performed. Of these, 945 dogs underwent elective orthopedic surgical procedures, had no evidence of concurrent disease, and had pre-operative blood analysis performed purely to satisfy the hospital's established protocol. One hundred medical records were randomly selected and information including patient's age, weight, breed, presenting complaint/diagnosis, and surgical procedure was presented to 5 Diplomates of the American College of Veterinary Anesthesia and Analgesia (ACVAA) for independent review. They were given pre-anesthetic screening test results for each patient and asked whether the results changed the way they would manage the case in the peri-operative period from an anesthesia perspective (Table 1). A change was defined as a change from the standard of care at the UGA VMC for a healthy patient undergoing elective orthopedic procedures. Standard monitoring includes capnography, pulse oximetry, electrocardiography, noninvasive blood pressure, temperature, pulse rate, and respiration rate. Mean arterial blood pressure is maintained above 60 mmHg and systolic arterial blood pressure is maintained above 90 mmHg. Fluid therapy consists of lactated Ringers solution at a rate of 5 mL/kg body weight (BW) per hour and all patients undergoing orthopedic surgical procedures receive a non-steroidal anti-inflammatory drug (NSAID) and an epidural injection of morphine (0.1 mg/kg BW) and bupivacaine (0.5 mg/kg BW) if indicated for the procedure. Healthy patients are not routinely pre-oxygenated before induction and further hematological testing such as checking blood glucose levels at the time of anesthesia are not performed unless indicated. All patients included in the study were considered to be a baseline ASA grade of 1 or 2 prior to pre-anesthetic laboratory screening test results based on history and physical examination findings from the medical record. A change in ASA grade was defined as a change based only on pre-anesthetic laboratory test results.

Table 3. The most common blood analysis abnormalities.

Abnormality	Cases (%)
High mean platelet volume	60
Low mean corpuscular volume	54
Hypercholesterolemia	20
Hyperkalemia	19
High alkaline phosphatase	17
Hypophosphatemia	17
Hyperglycemia	16
Thrombocytopenia	14
Hyperalbuminemia	14
Hypermagnesemia	13

Table 4. Total number of anesthesia-related changes made in each category by individual anesthesiologists.

Category	EH	SK	MB	MS	JQ	Total
Further surgery	0	0	0	0	0	0
Postpone/cancel	1	0	1	1	5	8
Fluid therapy change	16	4	18	24	4	66
Repeat laboratory test later	5	2	13	15	14	49
Change monitoring	4	0	0	6	0	10
Change management	5	2	0	5	4	16
Do further testing	7	0	0	23	5	35
Change ASA status from 1/2	9	0	2	0	5	16
Change client communication, i.e., risk	0	0	0	9	5	14
Avoid NSAIDS	46	0	3	35	27	111

American Society of Anesthesiologists grades were defined according to a previously described ASA grading scale with an ASA grade of I representing a normal healthy patient and an ASA grade of II representing a patient with mild systemic disease such as a localized infection or fracture without shock (14). The interpretation of test results was based on the normal range of values recommended by the UGA VMC laboratory. Pre-anesthetic screening was defined as CBC, serum biochemistry, and UA.

Agreement between anesthesiologists on changes made to anesthesia-related case management was assessed using Fleiss' kappa (κ). Significance was set at alpha < 0.05. Kappa is a measure of agreement on a scale of -1 to 1. A value of 1 indicates perfect agreement, 0 indicates agreement expected by chance, and negative values indicate agreement less than chance (27).

Results

One hundred dogs with a median weight of 32.4 kg [interquartile range (IQR) = 21.2 to 41.4 kg] and mean +/− standard deviation (SD) age of 7.3 +/− 2.6 y were included in the study. Fifty-four percent of dogs were female (52 spayed and 2 unaltered), and 46% were male (40 neutered and 6 unaltered). Elective procedures included cranial cruciate ligament repair (83%), total hip replacement (8%), medial patellar luxation repair (5%), femoral head ostectomy (3%), and a partial tarsal arthrodesis (1%). A variety of breeds were represented.

The overall agreement amongst anesthesiologists on changing the anesthesia-related case management was slight (κ = 0.15, 95% CI: 0.09 to 0.21, $P < 0.001$). The agreement amongst anesthesiologists on modifying the patient's management (κ = 0.29, 95% CI: 0.23 to 0.35, $P < 0.001$) and fluid therapy (κ = 0.23, 95% CI: 0.17 to 0.29, $P < 0.001$) was fair and the agreement was poor for whether or not to postpone or cancel surgery (κ = 0.11, 95% CI: 0.05 to 0.17, $P < 0.001$), repeat laboratory tests later (κ = 0.17, 95% CI: 0.11 to 0.24, $P < 0.001$), change monitoring (κ = 0.03, 95% CI: −0.03 to 0.09, $P = 0.333$), do further testing (κ = 0.06, 95% CI: 0.00 to 0.12, $P = 0.046$), change ASA status (κ = 0.1, 95% CI: 0.03 to 0.16, $P = 0.002$), change client communication (κ = 0.08, 95% CI: 0.02 to 0.14, $P = 0.010$), and avoid NSAIDs (κ = 0.10, 95% CI: 0.03 to 0.16, $P = 0.002$).

One or more anesthesiologist(s) decided to cancel or postpone surgery in 6% of cases, change fluid therapy in 38% of cases, repeat laboratory testing in 32% of cases, change monitoring in 9% of cases, change management in 10% of cases, do further testing in 28% of cases, change ASA status in 13% of cases, change client communication in 11% of cases, and avoid NSAIDs in 63% of cases due to abnormal pre-anesthetic screening test results. Sixty-four percent of changes (134/210) were made by a single (1/5) anesthesiologist and 21% of cases had no changes made by any of the anesthesiologists (Table 2).

Only 13% of dogs had all values within the UGA VMC reference range. The most common abnormalities are summarized in Table 3. None of the animals had potassium values > 5.7 mmol/L. Eleven percent of dogs had alkaline phosphatase values > 190 U/L and 5% of dogs had values > 300 U/L. None of the animals had blood glucose levels > 8.7 mmol/L, platelet counts $< 140 \times 10^3/\mu L$, albumin > 49 g/L or magnesium values > 1.2 mmol/L.

All 5 anesthesiologists agreed to alter case management in 3% of patients. Of these cases, abnormal test results indicated renal dysfunction in 1 dog, dehydration in another, and a high nucleated red blood cell count, moderate eosinophilia, and mild increase in serum creatinine with a urine specific gravity of 1.008 in the third dog. For the patient with renal dysfunction, all 5 anesthesiologists changed fluid therapy and 4 out of 5 anesthesiologists changed management, monitoring, and avoided NSAIDs. For the dehydrated patient, 4/5 anesthesiologists changed fluid therapy and one avoided NSAIDs and for the third patient, 4 out of 5 anesthesiologists avoided NSAIDs and decided to repeat laboratory tests later. The remaining anesthesiologist decided to change patient management by adding diagnostic techniques that commonly accompany urinalysis abnormalities suggestive of urinary tract infections. Overall, the avoidance of NSAIDs was the most affected decision due to abnormal test results; however, there was only slight agreement amongst anesthesiologists and one anesthesiologist did not avoid NSAIDs in any of the cases (Table 4).

Discussion

The objective of this study was to determine if anesthesiologists changed peri-anesthetic plans based on routine pre-anesthetic laboratory screening in healthy dogs anesthetized for elective procedures. Peri-operative anesthetic management was altered in 79% of patients based on pre-anesthetic screening results; however, there was only slight agreement amongst the 5 anesthesiologists. Unfortunately, there is no gold standard for the appropriate course of action based on abnormal test results and

all 5 anesthesiologists agreed to alter case management in only 3% of patients (Table 2). Individual anesthesiologists altered case management in as few as 7% of cases and as many as 55% of cases. Previous studies reported alteration of anesthetic management in 3% (12) and 0.9% (9) of healthy dogs due to abnormal pre-anesthetic laboratory test results. Abnormal CBC results did not lead to alteration of anesthetic management in healthy horses (13). These studies, however, did not take into account as many specific anesthesia-related decisions as the present study.

Interestingly, most of the anesthesia-related case decisions made in our study had only slight agreement amongst anesthesiologists with a Fleiss' kappa value between 0.01 and 0.2, which suggests major discrepancies can occur among ACVAA diplomates. This has also been reported amongst anesthetists for the assignment of ASA physical status to small animal cases leading to over- or under-estimation of the anesthetic risk of the patient (28). Possible explanations for the discrepancies amongst anesthesiologists found in our study include the large amount of personal interpretation and subjectivity required for these decisions, how risk-averse each anesthesiologist is, previous personal experience, which may influence how aggressively abnormal test results are addressed, and differences in personal opinion where clear evidence-based guidelines do not exist; for example, deciding whether or not to avoid NSAIDs. The data sheets of NSAIDs warn that impaired kidney function is a contraindication to NSAID therapy. However, one study showed less progression of stable chronic kidney disease (CKD) in cats receiving meloxicam once daily for over 6 mo compared to cats with a similar stage of CKD not receiving meloxicam (29). Another similar study supports the routine use of ketoprofen in humans with mild chronic renal insufficiency (30).

Based on the results of this study, pre-anesthetic laboratory screening may be of benefit in healthy dogs since it did influence anesthesia-related decisions to varying extents for each anesthesiologist. The majority of anesthesiologists (3/5) made one or more change(s) to case management in 32% of cases, which we consider to be significant. Poor agreement amongst anesthesiologists, however, could suggest that many of these changes may not have been necessary. One or more anesthesiologist(s) decided that no change in anesthesia-related case management was necessary in 97% of dogs. Interestingly, there were 3 cases in which 1 out of the 5 anesthesiologists decided to postpone/cancel the procedure due to abnormal test results, while 2 anesthesiologists in 2 cases and 3 anesthesiologists in the other case did not make any change at all based on the same pre-anesthetic test results. The influence of these decisions on patient outcome is unknown and it was not the goal of the current study. Our objective was to determine if abnormal pre-anesthetic laboratory screening affected the anesthesiologist's decision. A direction of future studies could be to correlate these specific anesthesia-related decisions to patient outcome.

A good history and thorough physical examination are heavily relied upon in humans when determining whether or not pre-anesthetic screening tests are necessary. When comparing the preoperative assessment of human patients *versus* veterinary patients, it is important to keep in mind several differences. Veterinarians work with either an unknown or second-hand history from the owner who may or may not pay close attention to their pet. A thorough physical examination is only possible in co-operative patients and interpretation of results can be difficult in nervous patients. Breed-related differences in aging and risks further complicate matters. Finally, veterinary anesthesiologists do not often have the opportunity to take their own anesthesia-related history from the client, unlike human anesthesiologists. Due to these differences, a good history and physical examination may not be as thorough in veterinary patients compared with human patients, and pre-anesthetic screening of low-risk veterinary patients may be of greater value.

To the authors' knowledge, the only hematologic parameter that has been specifically linked to an increased risk of anesthetic-related death in dogs is a hematocrit value outside the reference range (37% to 55%), increasing the risk by 5.5-fold (26). More abnormal test results were found in our study compared to similar human studies. A similar veterinary study also reported several blood abnormalities in healthy dogs. Most deviated only slightly from reference values; however, 8% of patients were allocated a higher ASA category, 0.9% would have had pre-anesthetic therapy initiated, and 0.8% would have had their surgery postponed based on the results (9). A veterinary study looking at pre-anesthetic screening in both cats and dogs found that blood analysis indicated an unsuspected problem in only 0.9% of patients, 4 of which had elevated alkaline phosphatase and 2 patients had high urea (10). Finally, a study looking at the value of pre-anesthetic CBC in healthy horses found abnormal values in 54% of the subjects, 8% of which were considered to be important, although none of them developed surgical complications or had their anesthetic management altered (13).

Our study population consisted of a broad age range of dogs between 2 to 12.5 y old. There is some evidence in the veterinary literature that pre-anesthetic screening in geriatric patients may be valuable (11,31). One study looked at the benefits of pre-anesthetic screening in 101 geriatric dogs presenting for elective procedures. They reported 30 new diagnoses made based on pre-anesthetic screening laboratory test results. Thirteen of these dogs had their surgery cancelled and 6 had further diagnostic tests performed. No specific anesthetic management changes were reported (11). Of the 32% of cases in our study in which the majority of anesthesiologists made 1 or more change(s) to case management, 75% (24/32) of the dogs were $>$ 6 y of age. It is possible that if we had selected for healthy patients less than 7 y old, fewer abnormal test results may have been found.

Various breeds with different associated risk factors are represented in our study. In humans, pre-anesthetic laboratory testing and imaging are used to screen patients at risk for disease (16). This concept has also been explored in veterinary medicine by assessing the value of laboratory screening in 53 clinically normal golden retriever dogs $>$ 6 y old (31). Abnormalities indicative of potentially significant disease were revealed by laboratory tests (CBC, biochemistry, UA) in 54.7% of dogs and by abdominal ultrasound in 64.2% of dogs. Occult splenic masses were found in 53% of patients suggesting that routine ultrasonography of this breed and age group may be beneficial. This study supported the implementation of routine testing in

older patients but the sample size was too small to make concrete recommendations.

On the human side, the UK National Institute for Health and Care Excellence (NICE) has published guidelines regarding routine pre-anesthetic tests for routine surgeries. These guidelines take into account both the age of the patient and the grade of surgery being performed. Complete blood cell count is considered for all ASA III and IV classifications undergoing surgery graded intermediate and recommended for all classifications undergoing surgery graded major/complex. Biochemical testing is recommended for ASA II to IV and considered for ASA I patients undergoing surgery graded major/complex. Interestingly, an ovariohysterectomy is considered to be a major/complex surgery requiring a CBC due to the potential for blood loss and lengthy surgical times especially in a teaching hospital (18). Perhaps the grade of surgery being performed should also be considered along with age and ASA grade when deciding the necessity of pre-anesthetic screening in veterinary patients.

Due to the retrospective nature of our study, a major limitation is the reliance on medical records, which may give a different impression than direct observation and interaction with each patient. Other limitations include the small sample size (n = 100) compared to similar studies, wide age range and inability to correlate case management decisions with patient outcome as the decisions made were hypothetical. We believe our sample size is reasonable for a preliminary study. Future studies should include more cases and consider geriatric patients separately. The number of changes made to anesthesia-related case management depends on the usual techniques used and their alternatives. Our study only considered changes from the standard of care at the UGA VMC and the opinions of boarded anesthesiologists. Perhaps if the same study were repeated at an institution with a different standard of care, the results would be different. Finally, our study did not take into account drug protocol in any of the case management decisions. Various premedication protocols are used at the University of Georgia, and drug choice is based on both the needs of the individual patient and the anesthesiologist's preference. Although interesting, it would have been difficult to assess the effect of pre-anesthetic screening tests on drug protocol choice due to differences in experience and comfort level amongst anesthesiologists with a greater variety of drug protocol choices.

A previous study reported a change in drug protocol for only 0.2% of dogs based on pre-anesthetic blood analysis; however, the usual anesthetic protocol at this clinic consisted of a benzodiazepine and an opioid (9). This drug combination could also be considered safe for dogs with a higher ASA physical status. Since 8% of dogs in the same study were assigned a higher ASA grade based on pre-anesthetic blood analysis, it would be interesting to know if a higher percentage of drug protocol change would have occurred at this clinic if a greater variety of premedication drugs were routinely used.

In conclusion, pre-anesthetic laboratory screening in healthy dogs anesthetized for elective procedures may influence perianesthesia-related decisions, but this change can be very subjective and the effect on patient outcome is unknown. The aim of pre-anesthetic screening is to reduce risk and increase quality of care by identifying pre-existing medical conditions and potential anesthetic difficulties. Further studies are required to determine if decisions made based on pre-anesthetic laboratory screening tests result in improved patient outcome. Test results should be interpreted carefully and viewed as part of an overall assessment of the patient. CVJ

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