THE IMPACT OF OBESITY ON ANESTHESIA

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Abstract

Over one-third of pets are overweight or obese. These pets will require anesthesia for a wide range of procedures both elective and emergent and are considered high-risk patients. In human medicine obesity is considered a disease. Many obese animals have additional co-morbidities such as osteoarthritis, diabetes and increased airway reactivity. If we understand the physiologic and physical impact that excess adipose tissue has on anesthesia we can plan accordingly and decrease adverse outcomes. The risks to overweight animals include hypoxemia, hypoventilation, airway obstruction, an exaggerated inflammatory response to surgery and changes in normal coagulation. The requirements on mg/kg basis of injectable induction agents is lower therefore the risk of overdosing is real.

Keywords: obesity, dog, cat, body condition score, inflammation, pre-oxygenation

Introduction

An estimated one in three dogs and cats are overweight or obese; these numbers have been increasing over the past decade and show no signs of slowing down. A score of 8-9/9 using the 9-point body condition score (BCS) is considered obese and equates to a body fat percentage of approximately 35%. Obesity is an important medical issue in humans and animals with many widespread harmful effects. Unfortunately, it is easy to recognize but much more difficult to treat. Overweight pets have abnormal respiratory and cardiac function, are at risk for metabolic

and endocrine disorders, exacerbation of degenerative joint disease and cognitive dysfunction. Quality of Life and life expectancy are also reduced. Research data from humans and animal models of obesity indicate that one common denominator of obesity-related disorders is low grade inflammation. Rather than being a storage site for energy the adipocyte is now considered an endocrine organ and major source of proinflammatory cells.[1] Proinflammatory adipokines include leptin, interleukin-6 (IL-6) and tumor necrosis factor-alpha. Plasma markers of inflammation (IL-6 and C-reactive protein) have been confirmed in naturally overweight and obese dogs.[2]

Obese pets will require anesthesia for a wide range of procedures both elective and emergent and are considered high-risk patients. Obesity was related to a higher incidence of anesthetic related death in a large multi-center study that included 79,178 cats, conducted between 2002 and 2004. Compared to cats between 2 and 6 kg, those over 6 kg were three-times more likely to die.[3,4]

Anesthesia and obesity

The main concerns for anesthesia in overweight or obese patients include:

1. Comorbidities (e.g. diabetes)
2. Respiratory changes and the need for ventilatory support
3. Cardiovascular changes including hypertension
4. Changes in body composition which alter the pharmacokinetics and pharmacodynamics of anesthetic and analgesic drugs (Figure 1)

The veterinary literature on obesity lags behind that in humans therefore some information is extrapolated across species. However, the studies that have been done in dogs and cats confirm what we know in humans; for example, decreased requirements for some of the intravenous

induction drugs on a mg/kg basis.5 An excellent review on what we currently know about obese small animal patients and anesthesia is available.[6]

Respiratory system

Securing an airway can be challenging in overweight dogs and cats as fat deposition may cause visual interference, narrowing of the upper airway or external compression. Many brachycephalic breeds are overweight which adds to the issues related to their abnormal respiratory anatomy. With obesity, lung volumes are altered; there is a decrease in functional residual capacity and residual volume. Tidal volume (milliliters/kg) is decreased and respiratory rate is increased. Airway resistance is increased, and chest wall and pulmonary compliance are decreased. Overall these changes increase the work of breathing and increase the risk of sudden and rapid oxygen desaturation. A study of oxygenation and ventilation of heavily sedated dogs (medetomidine, midazolam and butorphanol) when they were obese then after weight loss documented lower arterial oxygen levels and increase pulmonary shunting of blood when the dogs were obese.[7] In that study dual-energy X-ray absorptiometry scans (DEXA) were used for morphometric measurement and the authors concluded the increase in thoracic fat explained the respiratory changes. Manens and others demonstrated increased airway reactivity (to inhaled histamine) in obese dogs and a blunted response to doxapram.[8]

Cardiovascular system

Increased heart rate, blood pressure, cardiac output and systemic vascular resistance and decreased baroreflex sensitivity are reported in obese dogs. Pelosi and others reported concentric left ventricular hypertrophy and ventricular dilation when body weight increased by approximately 30%.[9] The same authors reported that the method used for weight loss influenced "cardiac recovery"; calorie restriction with no forced exercise resulted in a complete resolution

of cardiac hypertrophy whereas calorie restriction plus treadmill exercise led to partial recovery and if dogs exercised with a weight vest almost no recovery was reported.[9]

Hemostasis

In a study comparing 37 naturally overweight and obese dogs with 28 normal weight dogs, the total platelet count and activity of factor X and factor VII were significantly higher in the former group.[2] Activated partial thromboplastin time (aPTT) was significantly lower in the overweight and obese dogs. This indicates a hypercoagulable state with both primary and secondary hemostasis being affected. Weight excess promotes a prothrombotic state even in apparently otherwise healthy dogs.[2]

Pharmacological changes

As an animal's total body weight (TBW) increases fat and lean tissue also increase but not in a parallel fashion resulting in a decrease in the ratio of lean body weight to TBW. Blood volume is not a constant fraction of body weight or body surface area. In humans blood volume does not increase proportionally to the increase in body weight and degree of obesity, with obese patients having a lower blood volume on a milliliter/kg basis.[10] Equations have been developed to estimate blood volume over wide weight ranges in humans but not yet in dogs and cats. There are no clear guidelines on how and if fluid administration rates should be changed but it seems prudent to adjust them to the animal's ideal body weight, and to follow the American Animal Hospital Association and American Association of Feline Practitioners fluid therapy guidelines.[11]

Pharmacokinetic variables including bioavailability, volumes of distribution and clearance are altered by changes in body composition. Sedation / premedication of overweight animals may result in subcutaneous (SC) or "intra-fat" administration instead of the intended intramuscular

route. The uptake of drugs from SC tissue and fat is unreliable and the intended effect (e.g. analgesia or sedation) may not be achieved or may be reduced.[12,13] How these changes affect different drugs varies. Boveri and others reported no difference in sedation scores (IM dexmedetomidine and butorphanol) between lean and overweight dogs when dosed on actual body weight.[5] However a significantly lower dose of propofol on a mg/kg basis was required to reach a level of anesthesia suitable for intubation in obese dogs compared to those with normal BCS; 1.8 ± 0.4 mg/kg and 2.2 ± 0.5 mg/kg respectively.[5] Dosing scalars are available for some drugs used in human anesthesia but vary from drug to drug and currently there is no simple way to predict required doses to achieve a desired effect in animals.

Clinical management

Because of the unpredictability of uptake and requirements of anesthetic drugs in obese cats and dogs the following tips are suggested:

1. Use short acting drugs which can be "topped up" or used as infusions if needed (e.g. fentanyl, lidocaine and ketamine)
2. Use reversible drugs (e.g. opioid agonists, dexmedetomidine, benzodiazepines)
3. Use drugs intravenously whenever possible so they can be titrated to effect
4. Use locoregional techniques to decrease anesthetic requirements and post-operative analgesics

Other challenges in this patient population include intravenous access. Difficult venous access, defined as > 4 attempts to achieve access ± the need for special equipment such as ultrasound guided placement is well documented in obese humans.[14]

Tips for these IV placement:

- Pay close attention to sterile technique because of the increased risks of skin and wound infections in obese patients
- Choose a longer catheter than you normally use
- Look at and palpate several different sites before choosing one – it may not be your usual "go to" site
- Consider using a tourniquet or blood pressure cuff to apply pressure around the leg proximal to the IV site
- Use topical local anesthetic cream prior to placement (e.g. lidocaine-prilocaine eutectic mixture or topical lidocaine cream)
- Make a "pilot hole" to prevent dulling the stylet tip as it traverses skin and SC tissues
- Use a steeper angle of insertion
- Don't tape too tightly

Preoxygenation

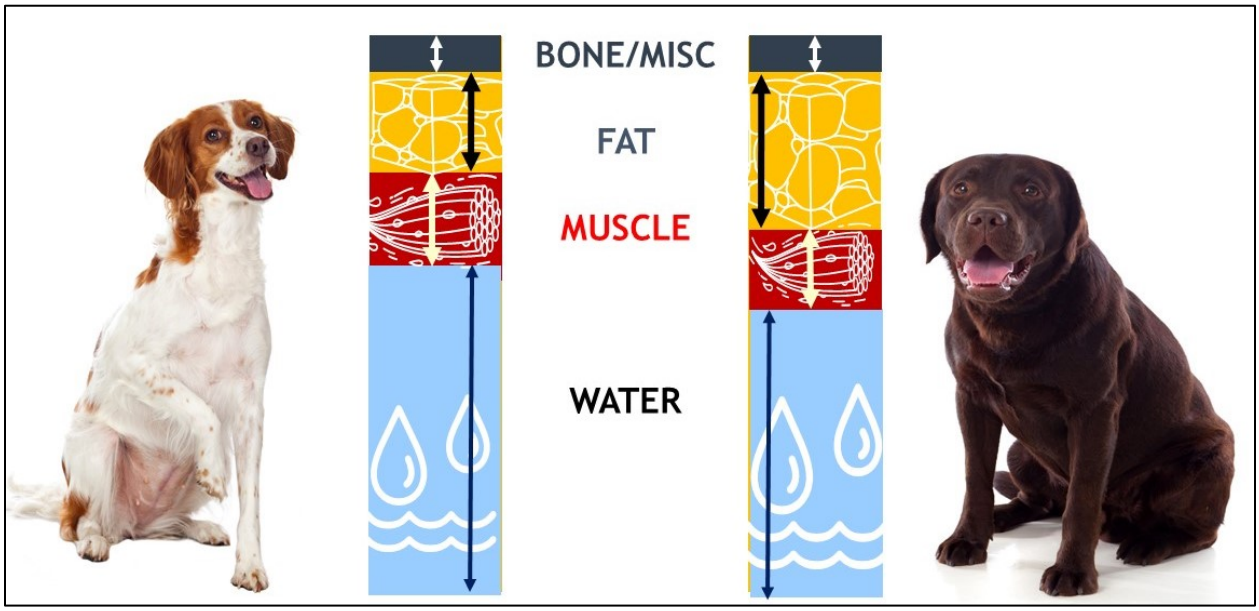
Pre-oxygenation will increase the time to hemoglobin desaturation.[15] If dogs and cats will tolerate a mask, do this for 3 minutes prior to induction and continue administering oxygen until an airway is secured. Flow-by oxygen was less effective than using a mask but was significantly better than no supplemental oxygen in sedated dogs.[16] While intubating, use a red-rubber catheter or the end of the breathing circuit to direct oxygen towards the larynx. A reverse Trendelenburg position with the animal in sternal during induction can help prevent abdominal contents and excess fat pressing on the diaphragm. During surgery, if the dog or cat is in dorsal recumbency the reverse Trendelenburg position is ideal, but if this is not possible, placing triangular wedges under their thorax will serve a similar purpose. Monitoring oxygen saturation of hemoglobin (SpO_2) with a pulse oximeter and ventilation (end-tidal carbon dioxide) with a

capnometer are strongly recommended. It should be noted that capnography reflects ventilation; when a patient is receiving 100% oxygen, desaturation may not occur despite a very high $PaCO_2$ value. When placed in dorsal recumbency most overweight animals will require manually assisted or controlled ventilation.

Most anesthetic deaths in dogs and cats occur in the first three hours following anesthesia therefore close observation of patients is essential during this time and until they can ambulate.[4] One of the most likely adverse events during recovery is oxygen desaturation or airway obstruction. Oxygen should be readily available and all the equipment plus drugs required for reintubation should be on hand.

Overweight and obese dogs and cats are high risk and challenging anesthesia patients. The key to success is understanding the risks and planning to prevent these.

Figure 1. Changes in body composition related to obesity alter blood volume and the central compartment requiring adjustments in drug dosing and fluid therapy.



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