Developments in surgical fluid therapy rates in cats and dogs

A Knowledge Summary by

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ISSN: **2396-9776**
Published: **09 Jul 2020**
in: **Vol 5, Issue 3**
DOI: **10.18849/VE.V5I3.299**
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Next Review Date: **22 Jul 2021**

KNOWLEDGE SUMMARY

PICO question

Is there sufficient evidence to show surgical fluid therapy delivered at the recommended 3 mL/kg/hour for cats and 5 mL/kg/hour for dogs leads to a better outcome compared with widely accepted rates of 10 mL/kg/hour for both cats and dogs?

Clinical bottom line

Category of research question

Treatment

The number and type of study designs reviewed

Five studies were appraised. Two of these were opinion pieces, with one non-comparative prospective study, one randomised controlled trial, and one case control study

Strength of evidence

Weak

Outcomes reported

Currently there is limited evidence to show that the surgical fluid therapy recommendations made by the 2013 Journal of the American Animal Hospital Association guidelines (Davis et al., 2013) for cats and dogs lead to a better outcome than accepted fluid therapy rates used. Fluid overload in humans can cause long-term adverse effects, however the same effects have yet to be shown specifically in veterinary patients

Conclusion

No evidence was found that provides strong, conclusive evidence that the 2013 recommendations by the American Animal Hospital Association and American Association of Feline Practitioners leads to a better outcome for both cats and dogs. The resulting research outlined below identifies a need to conduct clinical studies on the effects of fluid therapy on cats and dogs, and identify clear monitoring protocols to minimise and ideally avoid, fluid overload. When adequate, valid clinical studies have been carried out, this will provide sufficient information for the development of evidence-based recommended rates of fluid therapy for veterinary medicine, in a range of contexts

How to apply this evidence in practice

The application of evidence into practice should take into account multiple factors, not limited to: individual clinical expertise, patient's circumstances and owners' values, country, location or clinic where you work, the individual case in front of you, the availability of therapies and resources.

Knowledge Summaries are a resource to help reinforce or inform decision-making. They do not override the responsibility or judgement of the practitioner to do what is best for the animal in their care.

The evidence

The author of this Knowledge Summary was unable to find any specific evidence supporting the fluid rates recommended by Davis et al. (2013). However, there was also no evidence found to support the widely accepted higher recommended rate of fluid (typically 10–20 mL/kg/hour) used for cats and dogs (Davis et al., 2013; and Hopper et al., 2018).

There has, however, been some research around the effects of fluid therapy on the cardiovascular system. A small study carried out on dogs assessed the delivery of fluid therapy at 1 mL/kg/minute for 1 hour to healthy, normovolaemic dogs when various depths of anaesthesia were induced. Dogs were maintained under light anaesthesia with an end tidal isoflurane (ETI) of 1.3%, (1.0 minimum alveolar concentration (MAC)) for at least 15 minutes, then anaesthesia was increased to 3% ETI (2.3 MAC) for at least 15 minutes to induce a hypotensive state from anaesthesia, when fluid therapy was begun. This deep state of anaesthesia was maintained for 45 minutes, until the last 15 minutes of fluid therapy when MAC was reduced to 1.2 (ETI of 1.6%). This intervention impacted cardiovascular function, primarily stroke volume variation (SVV) (Valverde et al., 2012). SVV measures the change in volume of blood expelled from the left ventricle to the aorta, with each heartbeat, and was found to decrease by 67%, 60 minutes after the commencement of fluid therapy, with a concurrent reduction in isoflurane concentration. Valverde et al. (2012) reports that SVV is well-documented to be a sensitive measure of responsiveness to fluid therapy, namely by demonstrating improvements to venous return.

Valverde et al. (2012) also noted that high rates of isotonic fluid therapy did not affect arterial blood pressure in the short-term (arterial blood pressure was measured up to 60 minutes following administration of fluids). This result suggests that solely monitoring arterial blood pressure is not the most accurate measure of fluid balance – a conclusion also noted in more recent studies that report hypovolaemia-induced hypotension occurring only after 30–40% of estimated blood volume has been lost (Drozdzynska et al., 2018; and Hopper et al., 2018).

Valverde et al. (2012) also noted that cardiac output and stroke volume did not increase at high rates of fluid therapy (60 mL/kg/hour), when hypotension was due to deep anaesthesia. Packed cell volume (PCV) did however decrease significantly, due to plasma dilution. A PCV decrease of 16% at 30 minutes and 24% at 60 minutes was noted, and attributed to blood volume expansion of 32%. This change in PCV due to plasma dilution by fluid therapy is an important one to note, when interpreting results on an intra-operative haematocrit of an animal receiving fluid therapy. A smaller PCV decrease would be expected with a lower rate of fluid therapy.

Urine output was not influenced until up to 60 minutes after fluid therapy was begun, however this is more likely due to the effects of a lighter anaesthetic plane also achieved at this point of the study (Valverde et al., 2012).

Brodbelt et al. (2007) offered some evidence that fluid therapy in cats had increased mortality rates fourfold, compared to cats not receiving fluid therapy. While this was a large study, with results provided by over 100 veterinary clinics, specific details around the data received from clinics was not fully described in the report. A lack of information in the study about the selection criteria for clinics, the fluid rates given to cats in the study, and any correlation between postoperative mortality and pre-anaesthetic health assessments, may have confounded the data. It should also be remembered that cats are more susceptible to overhydration than dogs, due to the lower total blood volume of cats (approximately 170 mL for a 3 kg cat). Many clinics did not measure central venous pressure, or use infusion pumps – with the latter being a factor in accuracy of fluid rate delivery (Brodbelt, 2010).

A number of human studies have identified increased mortality rates, and an increased incidence of acute kidney injury (AKI) due to fluid overload (McDermid et al., 2014; Ostermann et al., 2015; and Wang et al., 2015). However, there is limited information currently available about the relationship between fluid overload and AKI in a veterinary context. Much information for veterinary patients has been extrapolated from human data.

Research around the efficacy of fluid therapy in humans focuses on fluid therapy volumes, and often refers to goal directed therapy (GDT) or zero-balance fluid therapy (Voldby & Brandstrup, 2016). Zero-balance fluid therapy in humans focuses on not adding more than 1 kg of body weight to a patient following surgery with concurrent fluid therapy (Voldby & Brandstrup, 2016). GDT uses parameters such as stroke volume and pulse pressure variation analysis to determine appropriate fluid rates, in order to maximise cardiac output and oxygen delivery (Drozdzynska et al., 2018; Licker et al., 2016; and Voldby & Brandstrup, 2016). In veterinary medicine, current practice typically does not include measuring any of these parameters following clinical examination, and of these parameters, weight is typically the only measurement taken (K. N. pers. obs.). The purpose of these two approaches to fluid therapy is to minimise tissue inflammation, wound dehiscence, and poor collagen regeneration, perioperative morbidity and mortality – all of which can be caused by excessive positive fluid balance (Drozdzynska et al., 2018; Licker et al., 2016; and Voldby & Brandstrup, 2016).

The complications detailed above were considered in depth by Kehlet (1997), who proposed a multimodal approach in human medicine to control general post-operative dysfunction – with avoidance of fluid overload specifically noted to minimise cardiopulmonary complications. This concept, coined enhanced recovery after surgery (ERAS), was revisited almost 20 years later, when collaboration was further emphasised between anaesthesiologists, surgeons, surgical nurses and post-surgical rehabilitation services such as physiotherapy, in order to minimise complications (Kehlet, 2015).

The approaches noted above to fluid therapy in humans should also be considered in two contexts – low-risk patients undergoing low-risk procedures, and high-risk patients undergoing higher risk procedures. In lower risk human patients, high-volume crystalloid fluids (20–30 mL/kg, or 2 litres over 30 minutes for an average adult) proved beneficial to recovery, while high-risk patients, undergoing major procedures benefitted from a lower fluid rate, that was undefined by the authors but assumed an intraoperative urine output of 0.5–1.0 mL/kg/hour (Doherty & Buggy, 2012). These approaches may be applicable to veterinary medicine.

Recommended fluid rates in human surgery range from not exceeding 6–8 mL/kg/hour for thoracic surgery (Licker et al., 2016) to 15 mL/kg/hour for the first hour of general surgery and then decreasing as required (Voldby & Brandstrup, 2016). Current trend in veterinary surgical practice is to provide a generic rate of fluid therapy for a range of surgical procedures (Davis et al., 2013). This may vary in clinics where blood pressure, (in addition to other more standard parameters such as heart rate, and respiratory rate) is monitored intra-operatively, with fluid therapy levels adjusted in response to variance in this parameter (pers. obs.). This parameter may have limited uses as a measure of overhydration of animals, given fluid overload in humans is not measurable via blood pressure (Voldby & Brandstrup, 2016). Kehlet's (2015) principle of a multimodal approach to minimise postoperative complications in human medicine has been applied to veterinary medicine, with recommendation that the ERAS programme be used in animals (Gurney, 2018). While Gurney (2018) does not recommend specifics around fluid therapy, it is noted that overload of fluids be avoided, and the GDT approach be used in veterinary medicine, in order to avoid postoperative complications.

This limited amount of evidence suggests further research is required to identify the impact of current recommendations for fluid therapy in cats and dogs.

Summary of the evidence

Davis et al. (2013)	
Population:	Cats and dogs
Sample size:	n/a – recommendation
Intervention details:	n/a – recommendation
Study design:	Opinion article
Outcome studied:	n/a – recommendation
Main findings: (relevant to PICO question):	• Fluid therapy should be individualised for each patient • Fluid selection may need to be adjusted from one type of fluid to another during hospitalisation • While blood pressure is often used to assess tissue perfusion, intraoperative hypotension may not always be related to dehydration. Anaesthetic depth should be considered prior to administering or increasing fluid rates • There is limited evidence-based research for fluid therapy rates in a veterinary context
Limitations:	• The recommendations in the report are based on a limited number of research articles, providing minimal evidence to support these new recommendations • The recommendations used are based on human evidence of over-infusion of fluids, including damage to the kidneys and the endothelial glycocalyx. This may or may not hold true for cats and dogs • This recommendation is not based on clinical studies for cats and dogs

Valverdeet al. (2012)	
Population:	Normovolaemic adult dogs between the age of 1 and 4-years-old
Sample size:	Six mixed-breed dogs (three male, three female), with a mean weight of 22.1 kg (±2.8)
Intervention details:	• Anaesthesia was induced and maintained using gaseous agents of isoflurane and oxygen, until a steady haemodynamic state was achieved at 1.3% end tidal isoflurane • Baseline cardiovascular parameters (including heart rate, arterial blood pressure, central venous pressure, stroke volume variation and cardiac output) were taken at this point, and again 10, 30 and 60 minutes following the commencement of fluid therapy • Diagnostic samples of urine and blood were collected to measure blood gases, electrolytes, PCV and plasma volume at 30 and 60 minutes after fluid therapy began

	• A hypotensive state under deep anaesthesia (3% end tidal isoflurane) was induced and maintained for at least 15 minutes, with cardiovascular parameters taken again at this point • Isotonic fluids (Plasma-Lyte A solution) were administered at a rate of 1 mL/kg/minute for 1 hour • End tidal isoflurane was gradually reduced 45 minutes after fluid therapy began, to 1.6% • Dogs were recovered from anaesthesia and administered intravenous meloxicam 0.1 mg/kg
Study design:	Non-comparative prospective study
Outcome studied:	The effect of high-volume isotonic fluid therapy on normovolaemic dogs with isoflurane-induced hypotension
Main findings: (relevant to PICO question):	• Intravenous fluid therapy at high volumes (15–80 mL/kg/hour) does not increase arterial blood pressure in anaesthetised normovolaemic patients, during normotensive and hypotensive states • Isotonic fluid therapy at 1 mL/kg/minute does not increase cardiac output or stroke volume, in dogs where hypotension is a result of a deep anaesethetic plane • Plasma volume increased by 41% at 30 minutes after fluid therapy began, and by 49% at 60 minutes
Limitations:	• No control group was used to assess the cumulative cardiodepressive effects of 3% end tidal isoflurane • The sample size used in this study was small, with only six dogs • The sample was a group of healthy, normovolaemic dogs, and application of any results is limited to this type of patient

Silverstein et al. (2014)	
Population:	Healthy client-owned female dogs undergoing elective ovariohysterectomy
Sample size:	48 dogs
Intervention details:	• Dogs were premedicated, anaesthesia was induced with propofol and diazepam, and maintained using isoflurane and oxygen • Baseline cardiovascular parameters were measured at intubation, including arterial blood pressure (using a Doppler flow detector), heart rate, mucous membrane colour, capillary refill time, with tissue oxygen saturation data was collected using pulse oximetry • The same cardiovascular parameters were measured 30 and 60 minutes following induction of anaesthesia • A video microscope was used to assess microcirculation in the buccal mucosa dorsal to the maxillary canine of all dogs

	upon induction, then again 30 and 60 minutes following induction • Dogs were randomly assigned one of three fluid therapy treatments using Lactated Ringer's Solution – none, 10 mL/kg/hour, or 20 mL/kg/hour, with 16 dogs in each treatment group • All dogs were recovered successfully from anaesthesia
Study design:	Randomised controlled trial
Outcome studied:	The effects of intravenous fluid administration on microcirculatory blood flow to the oral mucosa in healthy anaesthetised dogs
Main findings: (relevant to PICO question):	• Blood vessels < 20µm in diameter show no change in vessel density for any of the three treatment groups • Vessel diameter was found to be significantly different in vessels < 20µm, between the group receiving 20 mL/kg/hour and the group receiving 0 mL/kg/hour of fluid • Density of vessels ≥ 20µm (most likely venules and/or arterioles) was significantly more in dogs receiving 20 mL/kg/hour compared with dogs receiving 0 mL/kg/hour of fluid • Overall, no significant association was found between intravenous fluid administration and tissue perfusion
Limitations:	• The study reported primarily on one parameter only (tissue perfusion in the oral mucosa) and does not consider tissue perfusion of other organs • The fluid balance of the sample was not reported, giving no suggestion if dogs were normovolaemic • Small sample size of 48 dogs (one dog excluded from the study due to excessive pigmentation of the oral mucosa interfering with the video microscope's ability to collect data)

Brodbelt et al. (2007)	
Population:	Cats admitted to 117 veterinary clinics in the United Kingdom for procedures where sedation or anaesthesia was required
Sample size:	79,178 cats
Intervention details:	No specific interventions. Cats were already being sedated/anaesthetised and monitored to that veterinary clinic's usual standards
Study design:	• Case control study • Details of patient, procedure, and perioperative management for all cats in 117 participating clinics were recorded, however not included in the report. The study was carried out with a control group nested in the main cohort of cats • The 'study' cohort consisted of all cases, with details of each case recorded for 48 hours post-anaesthesia or sedation.

	Outcomes for the main study cohort were limited to alive, dead or euthanised. Treatment types for the cohort were not included • A nested ‘control’ cohort consisted of randomly selected cats that were alive more than 48 hours post-anaesthesia or sedation. It was not noted if these cats received fluid therapy or not. The ratio of study to control cases was 1:4. Demographics and procedure data of the control cohort was compared to that of the study cohort
Outcome studied:	The frequency of risk (including death) for sedated or anaesthetised cats in British veterinary clinics
Main findings: (relevant to PICO question):	• Cats receiving fluid therapy experienced a mortality rate four times that of cats not receiving fluid therapy • Current usage of fluid therapy may have adverse effects on anaesthetised and/or sedated cats, and there is room for improvement in the monitoring and general management of fluid therapy in cats • The potential for fluid overload in cats due to the lower fluid volume in cats – careful administration and monitoring is recommended
Limitations:	• This study focused on feline deaths in clinical practice, due to anaesthetic complications, with limited data provided on fluid therapy • The study did not identify causality, and authors suggested a lack of monitoring could be related to the increased mortality rate for cats receiving fluid therapy • The rate of fluid therapy (where given) was not stated, which could have assisted with understanding of the high mortality rate in cats receiving fluid therapy • The study did not identify how veterinary clinics were selected, or what criteria were required for participation in the study • Minimum monitoring and treatment standards were not identified • The study did not specify or categorise cats according to risk factor (for example, anaesthetic risk assessment [ASA] risk levels), which may have had an impact on the outcome studied

Thomovsky et al. (2016)	
Population:	n/a – review
Sample size:	n/a – review
Intervention details:	n/a – review
Study design:	Opinion article
Outcome studied:	Defining “fluid overload” in small animals, and means of avoiding this in small animals

Main findings: (relevant to PICO question):	• Heart rate and blood pressure do not change in dogs with fluid overload, demonstrating the limitations of these two parameters as measures of fluid overload • Fluid overload causes fluid to leave the vascular space and move into the interstitial space, damaging the endothelial glycocalyx in the process • Oedema in abdominal organs (due to fluid overload) may add pressure to abdominal blood vessels and the vena cava, impeding blood flow to other organs and restricting venous return to the heart • Fluid overload can be avoided using the ROSE principle (Resuscitation, Optimisation, Stabilisation, Evacuation) for phases of fluid delivery • Fluid therapy should be considered with the same principles as delivery of drugs or other medical interventions
Limitations:	• Limited methods of identifying fluid overload are provided • While a link between fluid overload, and increased mortality and acute kidney injury is noted, the article does not explore the physiological pathway of mortality due to fluid overload • The article provides one example case of fluid overload (a 10-years-old female desexed domestic shorthaired cat) and one theoretical case (a 9-years-old entire male dog with parvovirus) showing a comparison of a traditional approach to fluid therapy vs the ROSE approach

Appraisal, application and reflection

The concept of the need to replace lost body fluids, either via trauma, illness, or surgery, has existed for hundreds of years (Driessen & Brainard, 2006), and intravenous fluid therapy has been administered to humans since 1832 when salt water solutions were first used by Robert Lewins to treat cholera (Stanzani & Chan, 2010). In these early days of using fluid as a therapy to treat disease, Lewins was already considering the decision over the volume of fluid that would be required. His objective was to replace the volume of serum lost, in order to return the patient to normovolaemia (Myburgh & Mythen, 2013).

The first use of fluid therapy in animals is not well documented, however studies on the use of crystalloid fluids on veterinary patients were carried out in the 1960s (Silverstein et al., 2014). Fluid therapy plays a vital role in stabilising patients in shock, and improving cardiac output (Marshall et al., 2016).

There is currently a paucity of research that has been carried out in veterinary medicine in terms of the rate that this fluid therapy should be delivered. Traditionally, a rate of 10 mL/kg/hour was delivered to anaesthetised veterinary patients (Davis et al., 2013; and Hopper et al., 2018) – how this rate was calculated is unclear, although may be based around human recommendations of 6–8 mL/kg/hour for patients undergoing thoracic or abdominal surgery (Borland & Bennett, 2018; and Licker et al., 2016), and 15 mL/kg/hour for patients undergoing other procedures (Voldby & Brandstrup, 2016). The most recent literature (Davis et al., 2013), recommends lower rates of fluid therapy, with a rule of thumb guide given as 3 mL/kg/hour for cats, and 5 mL/kg/hour for dogs. Davis et al. (2013) also recommended the following: provide maintenance rate plus necessary replacement at less than 10 mL/kg/hour; adjust fluid rates based on patient assessment and monitoring; patients with cardiovascular disease and renal disease should be administered a lower rate of fluid; and rates should be decreased if anaesthesia is more than one hour, with suggested reduction to be 25% per hour until fluid is being delivered at maintenance rate (assuming a stable patient). These recommendations appear to be based on human research identifying excessive fluid therapy causing a range of postoperative complications mentioned earlier in this Knowledge Summary. While many clinics are adopting this lower rate of fluid therapy, a recent survey of 113 New Zealand veterinary clinics found that more than half the respondents currently administer fluids at a rate of 10 mL/kg/hour during surgery (Sano et al., 2018). Members of the Veterinary Information Network (VIN) stated that determining fluid rates for animals remained the most challenging aspect of fluid therapy (Hopper et al., 2018).

To determine optimal assessment methods of fluid therapy, it should be remembered that two of the key goals of this therapy are to improve cardiac output and improve oxygen delivery (Licker et al., 2016; and Marshall et al., 2016). Several articles suggest monitoring of central venous pressure (CVP) (Lunn, 2011; Marshall et al., 2016; and Siemionow et al., 2012) as a good starting point to ascertain the risk of fluid overload, with Marshall et al. (2016) also suggesting some less invasive methods, however there is emerging strong evidence that blood pressure is an inaccurate measure of fluid overload, and CVP is no longer considered an adequate method of measuring fluid responsiveness in an animal (Borland & Bennett, 2018; Drozdzynska et al., 2018; Fantoni et al., 2017; and O'Dwyer, 2011). Pulse pressure variation (PPV) is reported to be the most sensitive measure of fluid responsiveness, with changes in PPV occurring earlier than arterial blood pressure, heart rate or CVP (Celeita-Rodríguez et al., 2019; Drozdzynska et al., 2018; Fantoni & Shih, 2017). PPV is expressed as a percentage, and measures the difference in maximum and minimum pulse pressure in one respiratory cycle, which is then divided by the mean of these two values (Drozdzynska et al., 2018). PPV is measured non-invasively in humans, with a finger cuff that transmits data to a multi-parameter monitor, and some recent studies have compared the use and accuracy of PPV measurement in anaesthetised dogs. In a study comparing the use of CVP and MAP with PPV, the latter was found to predict fluid responsiveness to volume expansion, when CVP and MAP did not (Fantoni et al., 2017). This study used "non-invasive methods" (a multi-parameter monitor) to calculate PPV on mechanically ventilated, hypotensive (MAP <60 mmHg), anaesthetised dogs administered a fluid challenge of 15 mL/kg over 15 minutes. Gonçalves et al. (2020) also compared the accuracy of invasive arterial blood pressure monitoring with the use of PPV and found the latter method predicted fluid responsiveness in hypotensive anaesthetised, mechanically ventilated dogs (MAP <65 mmHg), administered a fluid challenge of 5 mL/kg over 15 minutes, reliably as invasive methods. While this study stated PPV was assessed in a non-invasive manner, the placement of an arterial catheter was still required for calculation of PPV via the multi-parameter monitor.

An additional method of assessing fluid responsiveness and guiding GDT is pleth variability index (PVI), a method that uses a pulse oximeter (equipment that is commonplace in veterinary clinics) to measure changes in the perfusion index, over one respiratory cycle (den Boogert et al., 2018). This method would be considered completely non-invasive, with no arterial catheterisation required. Human studies have found PVI and PPV both optimised fluid preload outcome in patients undergoing low- to moderate-risk abdominal surgery (Coeckelenbergh et al., 2019). PVI has been shown to be less consistent in detecting fluid responsiveness in patients undergoing renal transplant (Coeckelenbergh et al., 2019), and is not suitable in critically ill or haemodynamically unstable adults (den Boogert et al., 2018).

The choice to administer fluids in non-anaesthetised patients is usually based on signs of dehydration in cats and dogs: skin tenting, dry mucous membranes, oliguria, systolic hypotension. Many anaesthetised patients are administered fluids during surgery based on anaesthesia-induced hypotension, or blood loss. However, the question remains, what is an appropriate fluid rate, based on the physiological changes caused by anaesthesia and surgery? What is clear is that monitoring of fluid therapy is vital – the use of fluid therapy should be likened to using substances such as antibiotics, opioid analgesics, or non-steroidal anti-inflammatory drugs on cats and dogs, and should be administered in such a way. Anaesthetised patients are monitored constantly to assess basic cardiovascular, neurological and respiratory functions. Monitoring currently often only focuses on the anaesthetic depth of the patient, and this may be a very blinkered approach to our care of anaesthetised patients. This approach to monitoring omits the renal system entirely, and monitoring of the pulmonary system is often limited to respiratory rate and depth and end tidal carbon dioxide, with little consideration often given to actual blood loss volumes. Weighing saturated swabs, sponges and any blood removed via suction should also be considered as an additional assessment tool of blood loss. It should be remembered that many of the fluid products commonly used during anaesthesia, do not replace the blood components lost as part of a surgical procedure. Blood products such as plasma, whole blood or packed red blood cells may be more appropriate to use in some situations.

Due to the limited amount of evidence in veterinary medicine, some research included in this Knowledge Summary is from human medicine. While this is valid in a human medical context, it should be remembered that there are still physiological differences between animals and humans, which may impact the transferability of results (Valverde et al., 2012; and Yozova et al., 2017).

It was challenging to find a range of comprehensive clinical studies that looked at the effect of fluid rates and hence fluid overload in a veterinary context, suggesting there is still a great need to carry out clinical research in this area of veterinary medicine. In the interim, robust pre-anaesthetic assessment of hydration status, type of surgical procedure (and therefore likely risk of blood and/or fluid loss), and pre-existing medical conditions of the patient should all be considered and should be used to determine the need for fluid therapy. This, combined with intra-operative monitoring of patients on fluid therapy (non-invasive and invasive where equipment and expertise exists to carry this out) are currently the only available techniques in minimising potential physiological trauma to patients caused by excessive fluid therapy. In terms of specific rates for fluid therapy in veterinary patients, it is difficult at this stage to definitively state a generic rate for a species, without considering comorbidities, procedures and existing hydration status. In the healthy cat or dog, 3 mL/kg and 5 mL/kg, respectively, may suffice as a starting point for fluid therapy. Veterinarians and veterinary nurses should consider a collaborative approach to fluid rates, based on an animal's pre-, post and intra-operative hydration status, and underlying health conditions, and adjust rates accordingly. Investigation into the use of non-invasive methods of assessing fluid responsiveness, such as PVI, would be recommended for those practitioners providing fluid therapy on a regular basis.

Methodology Section

<table>
<tr><th colspan="2">Search Strategy</th></tr>
<tr><td>Databases searched and dates covered:</td><td>CAB Abstracts 1973–2019, week 28
PubMed Central 1950–2019</td></tr>
<tr><td>Search terms:</td><td>CAB Abstracts (using OVID):

1. (dog or dogs or canine or canines or cat or cats or feline or felines or 'small animal' or 'companion animal').mp. or exp dogs/ or exp cats/ fluid therapy.mp. or exp Fluid Therapy/
2. (surg* or intraoper* or perioper*).mp.
3. (rate or overload).mp.
4. 1 and 2 and (3 or 4)

PubMed (via NCBI website):

1. dog or dogs or canine or canines
2. fluid therapy
3. surgery or surgical or interoperative or perioperative
4. rate or overload
5. 1 and 2 and (3 or 4)</td></tr>
<tr><td>Dates searches performed:</td><td>22 Jul 2019</td></tr>
</table>

Exclusion / Inclusion Criteria	
Exclusion:	Non-English language journals, articles pre-2009, journals related to human medicine
Inclusion:	Veterinary journals, peer-reviewed journals

Search Outcome							
Database	Number of results	Excluded – non-peer reviewed journals	Excluded – non-English language	Excluded – pre-2009	Excluded – not from small animal veterinary specific	Excluded – not relevant to PICO question	Total relevant papers
CAB Abs	557	145	58	194	0	156	4
Medline	508	5	15	266	2	217	3
Total relevant papers when duplicates removed							**5**

CONFLICT OF INTEREST

The author declare no conflicts of interest.

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