Haemoabdomen. Part II: Surgery and post-operative care

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DOI: 10.1080/17415349.2016.1211596

ABSTRACT: This is the second of a two-part series of articles on haemoabdomen, the first part of which dealt with diagnosis and patient stabilisation. This article discusses intra- and post-operative care, including anaesthesia, the surgery itself and post-operative management.

Introduction

Haemoabdomen (also known as haemoperitoneum) is defined as free haemorrhagic fluid in the abdominal cavity. There are a number of possible causes for this potentially life-threatening condition.

Indications for exploratory surgery

It is important to understand that not all cases of haemoabdomen require surgery and that the decision to perform an exploratory laparotomy will depend in part on the underlying aetiology. For example, haemoabdomen following trauma and in patients with coagulopathies are often best managed medically, using fluid resuscitation, abdominal counter pressure and transfusion therapy. The indications for surgery are case-dependent and so it is important to consider the patient's history, the findings following repeat clinical examinations, the results of diagnostic tests performed and the patient's response to therapy, before reaching a decision to proceed to surgery.

The most common indications for surgery include:

- decreasing, serial, peripheral packed cell volume (PCV) in combination with an increasing abdominal PCV
- continual decrease in blood pressure with removal of abdominal counter pressure
- deterioration in demeanour and cardiovascular parameters despite appropriate fluid resuscitation
- penetrating abdominal trauma
- evidence of coexisting pneumoperitoneum, diaphragmatic hernia or body-wall hernia
- evidence of peritonitis (for example, secondary to rupture of a hollow viscus such as urinary bladder, intestines or gall bladder)
- evidence of continued retroperitoneal space expansion despite counter pressure
- haemorrhage from an abdominal mass
- organ ischaemia, for example due to a mesenteric torsion, GDV, liver or splenic torsion

Blood transfusion

A transfusion involves intravenous administration of whole blood or blood derivatives, of which there are three main types used in veterinary medicine: whole blood (either fresh or stored), packed red blood cells (PRBC) and plasma – which can be subdivided into frozen plasma (FP) and fresh-frozen plasma (FFP) for the purposes of this article.

There is no specific range of parameters that indicates that a blood transfusion is required, that is, there is no precise "transfusion trigger". Consequently, the decision to perform a blood transfusion relates to the severity of the patient's clinical signs and loss of oxygen-carrying capacity due to loss of whole blood. Important parameters to monitor when coming to a decision to transfuse a patient include:

- heart rate
- respiratory rate and effort
- mucous membrane colour
- temperature
- PCV and total solids
- lactate and acid:base measurements
- platelet count
- assessment of coagulation

Whole blood and blood derivatives

Although stored blood products are now available to all veterinary practices in the UK through Pet Blood Bank UK (http://www.petbloodbankuk.org/), it may not be possible to wait for delivery of such products for individual patients if they are not stored in the veterinary practice. Fresh whole blood from a blood donor may be used as an alternative, as the dog with haemoabdomen has lost whole blood and is likely to need replacement not only of red blood cells but also plasma and coagulation factors. It is advisable to blood-type and cross-match the blood donor with the recipient; however, if the recipient has never previously received a transfusion the likelihood of haemolysis is low as there are no natural alloantibodies to DEA 1.1, the most common canine blood group. If the recipient has had any previous transfusions it is very important to blood-type and cross-match the donor and recipient as red blood cell haemolysis can occur within 12–24 hours following a transfusion of incompatible blood.

An appropriate donor dog can safely donate 15–20% of its blood volume, and a unit of canine blood is considered to be 450 ± 45 ml. To estimate the blood volume of the donor the following calculation may be used:

$$\text{Estimated blood volume } (l) = 0.08 - 0.09 \times \text{body weight (kg)}$$

With regard to a whole-blood transfusion, the recipient's PCV will increase by approximately 1% for every 2 ml/kg of whole blood infused. The volume to be infused can be determined by the following calculation:

$$\text{volume of donor blood} = \text{recipient weight (kg)} \times 85 \text{ (dogs)} \times \frac{\text{recipient desired PCV} - \text{current PCV}}{\text{PCV of donor blood}}$$

An alternative option is to transfuse PRBC that can be stored refrigerated until required. The benefit of using PRBCs in a patient with haemoabdomen is that for every 2 ml/kg transfused the recipient's PCV should increase by 2%. When used to treat acute haemorrhagic anaemia, PRBCs are commonly used in conjunction with FFP, especially in cases of coagulopathy, and colloids or crystalloids to replace associated volume deficits.

Plasma transfusions are the transfusion of choice for coagulopathies. Both FP and FFP can be used to provide immunoglobulins, electrolytes, albumins and clotting factors; however, FP has depleted levels of clotting factors V and VIII in comparison to FFP. The transfusion volume for plasma is 10–30 ml/kg, transfused over 4 hours (Abrams-Ogg, 2000).

All stored blood products should be gently warmed to room temperature where possible prior to transfusion; temperatures greater than this can increase susceptibility to microbial growth within the blood product. The blood products may be transfused into any peripheral or central vein using a blood-giving set containing a filter. The intraosseous route may be used where venous access is not available, as the transfusion will be reabsorbed into the systemic circulation.

The rate of transfusion is clinician-dependent; however, initially, the blood product is transfused slowly as this aids the early detection of transfusion reactions. The authors initially use a rate of 0.5 ml/kg/h for 30 minutes, followed by 1 ml/kg/h for 30 minutes and then the remainder of the required volume over a further 3 hours to minimise the risk of contamination of the blood products. This contamination is most likely to occur at the time of blood donation, and once the blood has been warmed in preparation for transfusion the increased temperature allows proliferation of bacteria within the stored blood. The rate of transfusion can be increased as dictated by the clinical needs of the patient.

Transfusion reaction

All patients undergoing blood transfusion should be closely monitored to allow early detection of transfusion reactions. Transfusion record charts may be downloaded from Pet Blood Bank UK (http://www.petbloodbankuk.org/). During the first 30 minutes of a transfusion the patient should be monitored every 5–10 minutes, with a written record of:

- temperature
- heart rate
- respiratory rate
- mucous membrane colour
- capillary refill time
- electrocardiogram
- blood pressure

Thereafter the patient may be monitored intermittently with the above checks every 15–30 minutes.

The reported incidence of transfusion reactions ranges from 3% to 8% (Abrams-Ogg, 2000). If the patient is considered at increased risk of a transfusion reaction, for example in cases where blood-typing or cross-matching has not been performed, they can be treated pre-emptively with antihistamines.

The clinical signs of transfusion reaction include:

- weakness, depression, recumbency
- tremors, agitation, vocalisation
- polypnoea, dyspnoea
- tachycardia, arrhythmias, pale mucous membranes, weak pulses (hypotension)
- salivation, vomiting, diarrhoea
- seizures, coma
- subcutaneous oedema or urticarial reaction
- cardiopulmonary arrest

In the event of a transfusion reaction, the transfusion must be stopped and the veterinary surgeon alerted immediately. Management of the reaction is based on the clinical signs, with gastrointestinal signs and seizures usually being self-limiting. Once the signs have diminished, the transfusion can usually be restarted at a slower rate, for example 25–50% reduced from the previous rate.

Autologous blood transfusions

Autologous blood transfusions are transfusions in which the intra-abdominal blood is collected aseptically and re-infused. They may be considered where transfusion is required but where other blood products are not available or there are financial constraints to the use of such products. Commonly, blood collected in this way does not need the addition of an anticoagulant. Auto-transfusions are usually administered by gravity, rather than by using an infusion pump, to minimise the risk of haemolysis. They should be administered through a filter to prevent infusion of micro-thrombi and other debris. Further research is required to confirm whether auto-transfusion of blood due to rupture of a neoplasm increases the risk of metastatic spread of the disease.

Blood/cell salvage systems

Blood salvage or cell-saver systems are also described, whereby blood is collected during the surgical procedure and subsequently "washed" in sterile isotonic saline to remove plasma proteins and other cellular components. The "washed" cells may then be administered to the patient. Such systems are rarely used in the general practice setting.

Oxyglobin®

Oxygen-carrying fluids such as Oxyglobin® may be useful for some patients where blood products are not available. Oxyglobin® contains polymerised bovine haemoglobin and it can be a useful alternative to the transfusion of red blood cells, as the bovine haemoglobin binds and delivers oxygen in the same way as haemoglobin in red blood cells. Oxyglobin® has a long shelf life and blood-typing and cross-matching are not required. However, it is not a substitute for FP or FFP, although, as it is a potent colloid, it can be useful during vascular resuscitation.

Surgical preparation

Stabilisation of the patient, where possible, is important prior to surgery as it reduces the risks associated with anaesthesia. Ideally, the patient should be normovolaemic with a PCV > 30% to help maintain adequate oxygen delivery during anaesthesia (Grimm, Tranquilli, & Lamont, 2011). However, in some cases, surgical intervention is required as part of patient stabilisation before this is achieved.

The patient will already be attached to monitoring devices from the initial stabilisation. Where possible, everything should be prepared for surgery prior to induction to reduce anaesthetic time, as a prolonged operating time has been shown to result in hypothermia, decreased tissue perfusion and tissue hypoxia, which can cause a deterioration in metabolic acidosis and worsen coagulation, further impairing haemostatic function (Brasel & Weigelt, 2000; Nicholas et al., 2003).

Emergency dosage calculations for resuscitation drugs such as adrenaline, atropine and lidocaine should be calculated prior to induction so that they can be prepared in the event of an emergency during the surgical procedure. Additional crystalloids, colloids and blood products should be available in the event that they may be required. Some patients may also require a constant rate infusion (CRI) of a vasopressor, for example norepinephrine, to help to maintain their blood pressure.

The surgical clip will vary depending on whether the condition affects the thorax as well as the abdomen, for example if there is a concurrent pneumothorax, haemothorax or diaphragmatic hernia. Providing the abdomen is the only body cavity affected, the patient is placed in dorsal recumbency and the hair clipped from mid-thorax to caudal abdomen, including the inguinal areas. The clip should extend lateral to the planned midline incision by at least 10 cm. Once clipped, the patient should be aseptically prepared as for any surgery to reduce the bacterial load present on the skin. If the patient is male, the prepuce should be thoroughly cleaned to reduce contamination.

Anaesthesia

In cases of haemoabdomen, the anaesthetic will always prove challenging, especially as unstable patients do not tolerate the effects of anaesthesia on the cardiovascular system well. To maintain adequate tissue oxygenation and perfusion, a balanced anaesthetic protocol is crucial to minimise the impact that the inhalational agent will have on the patient's blood pressure.

Pre-oxygenation of the patient is invaluable, as it reduces the risk of hypoxaemia due to haemoglobin desaturation during induction. This is especially relevant in a patient with a haemoabdomen, as their circulating volume of haemoglobin is reduced and therefore transport of sufficient oxygen to the tissues for perfusion is already compromised.

Regurgitation

Where available, it is recommended to have a suction machine set up at the area of induction as the patient may be at risk of regurgitation – emergency procedures are unplanned and therefore the patient may not have been starved prior to anaesthesia. Furthermore, the abdominal effusion may act to increase intra-abdominal pressure and pre-dispose to an increased risk of regurgitation.

To reduce the risk of regurgitation, it is important for the patient to remain in sternal recumbency with its head raised while general anaesthesia is induced and that the endotracheal tube is placed promptly and the cuff inflated to reduce the risk of regurgitation and consequent aspiration.

Monitoring

There are a number of parameters that can be measured throughout the duration of the anaesthetic in order to help monitor the cardiovascular status of the patient. These include:

- blood pressure (direct or indirect)
- heart rate
- pulse quality
- mucous membrane colour
- blood oxygen saturation (pulse oximeter)
- electrocardiogram
- capnography

Supplemental patient heating, for example forced–air warming systems and fluid warmers, are beneficial in theatre to help to limit hypothermia.

Surgery

The approach to a haemoabdomen, regardless of initial cause, is via a midline laparotomy, ensuring that the incision is of a suitable length to allow appropriate assessment of the abdominal cavity; extending the incision from the xiphoid to the pubis is recommended to ensure adequate exposure as the rate of wound healing will not be altered based on the length of the wound. If there is access to surgical suction, a small initial incision can be made through the *linea alba* into the peritoneal cavity, allowing only sufficient space to insert a suction tip, for example a Poole. This allows much of the free blood to be removed before extending the incision to its full length (**Figure 1**).

The falciform fat may be excised to improve exposure prior to placing self-retaining abdominal retractors, such as Balfours. If the source of the haemorrhage is not readily apparent, the abdomen can be packed with laparotomy swabs, placing one or more into each of the four quadrants of the abdomen. They are then removed and replaced in turn, allowing a more complete inspection of the abdomen.

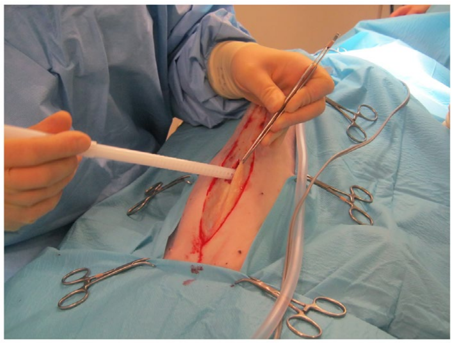

Figure 1. Initially, a small incision is made through the linea alba. This allows a suction tip to be used to drain blood from the abdomen before extending the surgical incision
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Once the affected vessel(s) have been identified, surgical haemostasis can be achieved by the placement of ligatures, vascular clips, electro surgery or vessel-sealing devices, such as advanced bipolar electrocautery or harmonic technology (**Figure 2**). Haemostatic clips decrease the surgical time; however, they have limitations: there is a risk of clip displacement or instability, the implanted material is non-absorbable and this may act as a nidus for adhesion formation (Monarski, Jaffe, & Kass, 2014). In addition, their use is restricted to vessels smaller than 4 mm in diameter (Tillson, 2003; Toombs & Clarke, 2003).

Vessel-sealing devices are becoming increasingly popular in veterinary medicine, as they reduce operating time, there is no implanted foreign material, no risk of ligature slippage and minimal requirement for dissection around the vessels. Depending on the instrument used, they are also capable of sealing larger vessels.

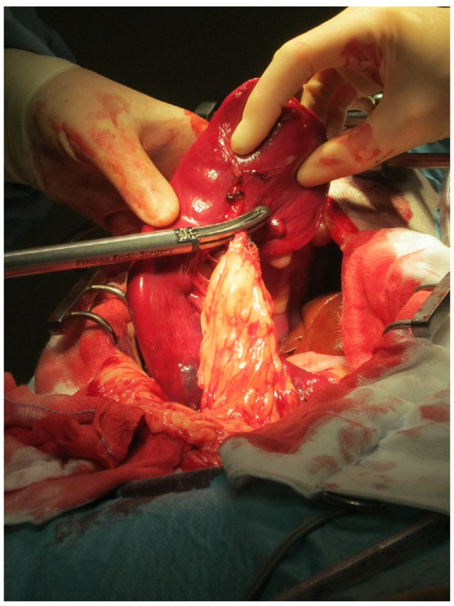

Figure 2. An advanced bipolar vessel-sealing device has been used in this patient to seal and cut blood vessels during splenectomy
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It is beneficial to quantify the patient's blood loss at the time of surgery to aid clinical decisions with regard to volume replacement. This can be achieved through measuring the blood suctioned from the abdomen into suction canisters (**Figure 3**), taking into account the amount of fluid used to irrigate the abdomen. Where suction is not available, or where large volumes of blood have been removed, it is possible to weigh the swabs before and after use to estimate the amount of blood that has been removed via this route.

Prior to closure of the abdomen it is important to examine all organs within the abdominal cavity and take biopsies of any abnormal tissues. This will be useful in providing prognostic information in cases of neoplasia. The abdomen should be lavaged with warm saline and suctioned prior to routine closure. Placement of an abdominal drain may be indicated if there is evidence of coexisting peritonitis (Hayes & Ladlow, 2012; Herold, Devey, Kirby, & Rudloff, 2008).

Histopathology

Histopathology is important in all cases of non-traumatic haemoabdomen as it has been shown that benign and metastatic masses within the spleen and other abdominal organs are grossly indistinguishable (Aronsohn, Dubiel, Roberts, & Powers, 2009). Where possible, all excised tissues should be submitted, as it is often only a small proportion of the tissue that provides diagnostic results. This is especially so in dogs with haemangiosarcoma, as large sections of the apparently affected parenchyma may simply contain clotted blood and necrotic tissue. Grossly identifiable lesions within the liver, such as hyperplastic nodules, may be benign rather than metastatic disease and consequently it is prudent for the veterinary surgeon to wait on the results of histology before commenting on the prognostic significance of the lesions (Hammond & Pesillo-Crosby, 2008).

Post-operative monitoring

Post-operative monitoring is vital to reduce the risk of death by identifying and addressing any post-operative complications quickly. Throughout the post-operative period the patient's temperature, mucous membrane colour, capillary refill time, pulse quality, respiratory rate and heart rate should be monitored, as well as serial PCV and total solids. The veterinary surgeon may order additional tests depending on the underlying problem and the patient's progress.

Figure 3. Suction canister: recording the volume of blood removed at surgery is important to help to quantify operative blood loss
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There are a number of short- and long-term post-operative complications specifically associated with surgery to correct a haemoabdomen (Hayes & Ladlow, 2012).

Post-operative haemorrhage

Post-operative haemorrhage may occur due to inadequate haemostasis during surgery, and this may be exacerbated by coagulopathies. Clinical signs of hypovolaemic shock, such as pale mucous membranes, tachycardia, tachypnoea and hypotension may be an indication of ongoing haemorrhage. This can be diagnosed by abdominal ultrasound and abdominocentesis.

Treatment for this will vary depending on the cause; if due to inadequate ligation of vessels, remedial surgery may be required to locate and ligate the source of the haemorrhage. If the haemorrhage is due to a coagulopathy then a whole blood or plasma transfusion may be required. It is important to be aware that ongoing haemorrhage may not be appreciated at the time of surgery due to anaesthesia-related hypotension.

Decreased vascular reservoir

The spleen acts as a reserve for both red blood cells and platelets and can contract during times of acute hypovolaemia. Following splenectomy the patient's ability to respond to hypovolaemic shock may be reduced.

Decreased capacity for extramedullary haematopoiesis

In healthy patients this is unlikely to cause any significant effects; however, patients with haemolytic anaemias or bone marrow disease rely on extramedullary haematopoiesis.

Pancreatitis

When ligating the splenic artery it is important to ligate the splenic vessels close to their insertion to the spleen, otherwise the blood supply to the left limb of the pancreas may be lost, resulting in ischaemic pancreatitis.

Prognosis

Short-term prognosis largely depends on the ability to correct any perfusion abnormalities and arrest ongoing haemorrhage. Long-term prognosis is variable depending on the aetiology of the haemoabdomen. In relation to haemangiosarcomas, prognosis is closely related to the clinical stage of the disease at the time of diagnosis and survival time is linked to effective medical management of metastatic disease.

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