José Rodríguez, together with Guillermo Couto and Jorge Llinás, surprises us again with a new volume of the Small Animal Surgery collection, although this time he focuses on the application of bloodless surgery. The author and his colleagues use their wide experience to show readers the importance of ensuring appropriate haemostasis in surgical procedures.

The basic principles of haemostasis, their practical application in various clinical cases or the different techniques available are explained throughout the book, and the information is complemented by numerous images that will help the clinician to ensure haemostasis (making knots step by step, surgical procedures shown in sequences of images, etc.).

This work also stands out by including high-quality and very didactic videos, with which the reader will be able to gain valuable knowledge.
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Presentation of the book

“If you want different results, don’t keep doing the same thing”
Albert Einstein (1879-1955).

During a surgical procedure proper blood supply to the tissue must be maintained to ensure nutrition and oxygenation, but at the same time the surgical team must prevent the excessive intraoperative bleeding that will inevitably occur upon sectioning and dissecting the tissues. A balance must be struck between vascularisation and haemostasis to complete the operation without complications and enable both the tissue and the patient to make a favourable and rapid recovery.

The success of any surgical procedure depends on skills and abilities of the surgeon and his team to identify and manage bleeding precisely, efficiently and effectively before, during and after the procedure.

Any surgeon must be familiar with the normal coagulation process and why it can be affected, as well as the methods and techniques to achieve and maintain haemostasis during surgery and postoperatively. He must know about drugs that facilitate coagulation, mechanical, chemical, thermal and surgical methods that can be used to control bleeding, as well as how to identify and act in case of coagulation problems and postoperative bleeding.

In this book we have collated all the necessary information to approach and perform any surgical procedure with a minimum amount of bleeding possible, or controlling and minimising this complication. The normal coagulation process is reviewed, and the clinical implications of altering this process, how to detect the issue and how to manage it. The role of the anaesthetist is assessed, and the how drugs modify haemostasis and the control of bleeding. Common, effective and up-to-date new methods and techniques for the control of surgical bleeding are presented.

We are aware that many of the topics covered are already known to the readers, but we believe that it is never a bad thing to take another look and refresh one’s memory. However we also hope to provide new and useful information, and our experience in the control and management of haemorrhages. The purpose is to make surgery simpler and less complicated, reducing the stress on both surgeon and patient and enabling the fastest and best recovery possible.

We hope that the chapters that follow are of interest to you and that they can help you to increase your passion for surgery.

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As cardiovascular diseases in the human species are, nowadays, the first cause of death worldwide (ischaemic cardiopathy and ischaemic stroke in the first and second positions, respectively), antiplatelet drugs and anticoagulants are probably the most common group of prophylactic drugs in human medicine. They are usually used for primary prophylaxis, to prevent a likely event from occurring when there are sufficient risk factors.

In veterinary medicine, because of the physiological differences of carnivores, these drugs are barely used and always as a secondary prevention method; this means they are used for prophylaxis of a new thromboembolic event when one has already occurred or when there are concomitant risks (e.g. hyperadrenocorticism and sepsis).

First of all, it is important to distinguish between the concepts of thrombosis and thromboembolism.

Thrombosis is the formation of a clot (thrombus) inside a blood vessel, which obstructs blood flow through this vessel. An example is portal vein thrombosis, which can occur in animals affected by liver tumours.

Thromboembolism is the obstruction of a blood vessel by a clot that formed in a different part of the organism and travels through the bloodstream to a distal vessel.

An example is thromboembolism of the aortic bifurcation (saddle thromboembolism), in which the thrombus usually forms in the left heart and subsequently breaks loose and plugs the aortic bifurcation, thus causing ischaemia of the hind limbs.

Traditionally, three predisposing factors to thrombus formation in the organism are mentioned. These are known as Virchow’s triad: hypercoagulation, endothelial damage and blood stasis (Fig. 1).

If two of these three points are altered, it is assumed that there is predisposition to thrombosis. Table I shows the most important risk factors in veterinary clinical practice.
The coagulation and fibrinolysis systems are in constant equilibrium in the organism and self-regulate each other. When there is a regulation failure in any one of these systems, alterations of coagulation appear. Table II shows how this balance may be disturbed.

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Table II.

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In the arterial system, due to the elevated blood pressure and to blood flow, conditions such as the immobilisation of the patient do not significantly affect thrombus formation and hypercoagulability plays a minor role in the process. However, turbulences, the interruption of laminar flow and shear stress lead to a very high presence of platelets in arterial thrombi. Strategies to inhibit arterial thrombogenesis should thus focus on antiplatelet therapy.

Venous thrombosis is significantly less common in animals in comparison with the human species. The risk factors associated with bipedalism, such as varicose veins or deep vein thrombosis of the legs, are not present in veterinary medicine.

As opposed to arterial thrombosis, venous thrombosis usually does not put the animal’s life at risk. A conservative therapy with anticoagulants is recommended for its treatment. There is no evidence that the early elimination of the thrombus by surgical means or with a thrombolytic treatment is beneficial in the long term, while on the other hand, haemorrhage secondary to the treatment may occur.

On the other hand, the venous system is greatly affected by blood stasis, patient immobility and the conditions of hypercoagulability. Mature venous thrombi contain a much lower amount of platelets. The strategies to limit venous thrombosis must mainly focus on anticoagulation, although they are also complemented by an antiplatelet treatment.

**The clinical presentation of an arterial thromboembolism is usually acute, with very severe consequences (ischaemia of the area), and treatment must be immediate.**

**The most frequent causes of arterial and venous thromboembolism are different in veterinary and in human medicine.**
Bloodless surgery

Surgical haemostatic techniques

José Rodríguez, Amaya de Torre, Carolina Serrano, Cristina Bonastre, Ángel Ortillés

Haemostatic surgical techniques are those performed by the surgeon during the procedure to prevent bleeding, using specific instruments and materials, such as forcipressure clamps, vascular clamps or surgical thread to make ligatures or to suture the vessels.

It is advisable to use curved haemostatic forceps to make it easy to see how they are placed, and that these forceps are only used for haemostasis. If used for other purposes, they may become misshapen and lose precision and efficacy.

Surgical haemostasis covers all technical procedures that the surgeon may use to control bleeding caused during surgery.

Haemostatic forceps

Haemostatic forceps use two complementary mechanisms. One hand they occlude the vessel to prevent blood loss; on the other they damage the vessel wall to encourage clotting.

Depending on the diameter of the vessel and blood pressure, the haemostasis achieved will be definitive or temporary. If the vascular diameter is small, haemostasis will be achieved in minutes and the forceps can be removed safely. If the vessel is larger and the blood flow expels the clot formed, haemostasis must be completed with the ligature or coagulation of the vessel.

There is a wide range of haemostatic forceps. The authors prefer Halsted mosquito clamps and Rochester-Pean forceps (Fig. 1).

Recommendations for the correct use of haemostatic forceps:

■ Use the smallest size haemostatic forceps possible.

■ Curved forceps are preferable over straight ones so that the surgeon’s hand does not interfere with the view of the bleeding vessel.

■ Hold the forceps with the dominant hand to ensure correct handling (Fig. 2).

■ The forceps should only trap the damaged vessel, or a minimal amount of surrounding tissue.

■ For the occlusion of superficial vessels:
  ■ If the vessel is clearly identifiable, clamp it directly with the instrument tip (Fig. 3).
  ■ If the source of bleeding is observed but not the vessel, clamp the smallest amount of adjacent tissue possible with the convex part of the forceps tip (Fig. 4).

■ In order to occlude important and deep blood vessels, and vascular pedicles:
  ■ Place the forceps perpendicular to the vessel with the convex part turned inwards. This facilitates smooth suturing and helps subsequent ligature (Fig. 5).
  ■ Use the branches of the forceps rather than the tips.
  ■ It must be ensured that no adjacent structures have been trapped.

Haemostasis by clamping of low pressure blood vessels is achieved by waiting several minutes. In order to achieve definitive haemostasis of small vessels the torsion technique can also be used. This consists of clamping the vessel and twisting the forceps oneself several times until it snaps. This method has the advantage of not leaving any sutures inside the body, and can be effective in vessels with a diameter of less than 0.5 mm.

Watch this video on the electronic version
Application of haemostatic forceps on a superficial vessel and definitive haemostasis created by torsion.

Fig. 1. Haemostatic forceps:
A. Rochester-Pean.
B. Halsted mosquito clamp.
Surgical haemostatic techniques are those performed by the surgeon during the procedure to prevent bleeding, using specific instruments and materials, such as forcipressure clamps, vascular clamps or surgical thread to make ligatures or to occlude the vessel. Haemostatic surgical techniques are those the surgeon may use to control bleeding caused during surgery. Surgical haemostasis covers all technical procedures that the surgeon can perform to achieve definitive or temporary haemostasis.

Halsted mosquito clamps and Rochester-Pean forceps (Fig. 1) are examples of haemostatic forceps. The forceps should only trap the damaged vessel, or a minimal amount of surrounding tissue. The closure of superficial blood vessels should be made using the tip of haemostatic forceps. For the occlusion of superficial vessels, the forceps must be facing the surgeon. This makes it easier to slide a suture thread along the convex part, turned towards the patient, to create the relevant ligature.

If the source of bleeding is observed but not the vessel, clamp the vessel on itself several times until it snaps. This method has the advantage of not leaving any sutures inside the body, and can be effective in vessels with a diameter of less than 0.5 mm.

If the vessel is clearly identifiable, clamp it directly with the instrument tip (Fig. 3). The forceps should be held in the dominant hand, following its curvature, without inserting them through the rings. The index and middle fingers rest on the tips of the forceps to keep them steady and use them precisely.

If the point of haemorrhage cannot be seen clearly, the tissue surrounding the vessel can be clamped using the branches of the instrument. The minimum perivascular tissue possible should be affected and with as little trauma as possible. Regardless of how the blood vessel is clamped, the forceps should be placed with the convex edge turned inwards to help the suture run smoothly.

Haemostatic forceps use two complementary mechanisms. One consists of clamping the vessel and twisting the forceps on them—this facilitates smooth suturing and helps to view the vessel correctly and place it as precisely as possible. The other they damage the vessel wall to encourage clotting.

In order to occlude important and deep blood vessels, and vascular pedicles, the haemostatic forceps should be placed with the convex part, turned towards the patient, to create the relevant ligature. If the vessel can be clamped using the branches of the instrument, the minimum perivascular tissue possible should be affected and with as little trauma as possible.

In order to see how they are placed, and that these forceps are easy to see, it is advisable to use curved haemostatic forceps to make it easy to see how they are placed, and that these forceps are easy to see. Depending on the diameter of the vessel and blood pressure, the haemostasis achieved will be definitive or temporary. If the vessel is larger and the blood flow expels the clot formed, haemostasis must be completed with other they damage the vessel wall to encourage clotting.

Recommendations for the correct use of haemostatic forceps:

- The haemostatic forceps should be placed with the convex edge turned inwards to help the suture run smoothly.
- Use the branches of the forceps rather than the tips.
- Place the forceps perpendicular to the vessel with the convex part of the forceps tip.
- The forceps should be held in the dominant hand, following its curvature.
- Use the smallest size haemostatic forceps possible.
- The forceps should only trap the damaged vessel, or a minimal amount of surrounding tissue.
- If the point of haemorrhage cannot be seen clearly, the tissue surrounding the vessel can be clamped using the branches of the instrument. The minimum perivascular tissue possible should be affected and with as little trauma as possible.
**Wide vascular pedicle**

In the case of a wide vascular pedicle, there is an expansive force that makes it difficult to complete a firm ligature.

- The suture thread is passed around the vascular pedicle and the first knot made. In this case two or three twists are made to increase friction on the thread and prevent it slipping backwards (Fig. 10).
- At the same time as the surgeon tightens the first knot, an assistant opens the haemostatic forceps slightly, without removing them, to allow the tissue to be compressed (Fig. 11).
- The assistant then closes the forceps again to facilitate the complete of subsequent knots and control any possible bleeding if the ligature is not completed correctly.

**Fig. 10.** The suture thread is wrapped around the vascular pedicle at a certain distance from the forceps to prevent it sliding off.

**Fig. 11.** On tightening the first knot the haemostatic forceps are released slightly to allow the ligature to be closed with no tension.

*Release the pressure on the haemostatic forceps to allow the tissue to pucker while at the same time tightening the first knot of the ligature. The forceps should not be completely removed until the ligature is finished.*

*Watch this video on the electronic version  
Completion of a modified Miller knot for the ligature of a wide vascular pedicle.*

**For the ligature of wide pedicle it is advisable to use the Miller knot.**
Hidden vascular pedicle

If the bleeding vessel is not identified and cannot be clamped, the haemorrhage can be stopped using a broad mass stitch holding the tissue around the source of the bleeding (Fig. 12).

Sutures

In general, sutures bring the tissue edges together and encourage haemostasis, although there are certain suture patterns that stem bleeding of the sutured tissue even further.

Reverdin’s continuous suture or the Ford interlocking suture will bring the edges of the wound tighter together than a simple continuous suture and are more haemostatic (Fig. 13).

Fig. 12. Completion of a simple mass stitch. This technique can be used to close unidentified blood vessels or ones that are difficult to occlude using haemostatic forceps, as in this case.

The Ford interlocking suture achieves a closer fit along the edges of the wound and better haemostasis.

Fig. 13. The Ford interlocking suture is an adaptation of the simple continuous suture in which, after each stitch is made, the thread is passed through the previous loop with the needle. This achieves a better fit of the edges of the wound and greater haemostasis, as can be seen in this case where the technique has been used to suture the urethral mucous membrane to the skin, after a scrotal urethrostomy.
This case presents a patient suffering from Cushing syndrome as a result of a neoplasm of the left adrenal gland. This surgery is highly delicate and must be performed meticulously.

A supra umbilical laparotomy is performed for exploration of the liver and regional lymphatic glands to search for tumour metastases. Intestinal loops are moved and the adrenal area is isolated with dampened compresses and gauze (Fig. 1).

The delicate and precise dissection of the periglandular area is completed, avoiding injury to the large blood vessels close to the vena cava or renal vessels (Fig. 2).

The phrenicoabdominal vein is located, dissected and closed, on its path through the adrenal gland. The purpose is to avoid the vasoactive substances released upon manipulation of the gland reaching the bloodstream (Figs. 3 and 4).

Preventative haemostasis of the phrenicoabdominal vein is performed using synthetic long-term absorbable ligatures or vascular clips.

Fig. 1. Preparation of the surgical field by displacing intestinal loops and hepatic lobes close to the tumorous gland. The stability of this preparation is very important in order to simplify the surgical technique and control the dissection, section and haemostasis processes as well as possible.

Fig. 2. The dissection of the periglandular tissue should be performed meticulously and with great care, so as not to damage major nearby blood vessels, such as the left renal vein, if the affected gland is on this side, or the vena cava, if the tumorous gland is on the right.

Fig. 3. In this case, the gland was firmly adhered to the left renal vein (arrow). After release, the phrenicoabdominal vein is dissected and closed to prevent vasoactive substances or tumorous cells from entering the bloodstream.
Bloodless surgery

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Fig. 1. Preparation of the surgical field by displacing intestinal loops and hepatic lobes close to the tumorous gland. The stability of this preparation is very important in order to simplify the surgical technique and control the dissection, section and haemostasis processes as well.

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Fig. 4. Preventative haemostasis of the phrenicoabdominal vein is easily achieved using vascular clips as observed in this image.

All the small vessels around the gland are dissected and coagulated using bipolar clamps to prevent bleeding (Fig. 5).

Fig. 5. The adrenal gland has a large number of peripheral blood supply vessels. Preventative haemostasis should be performed using bipolar clamps before sectioning.

After removal of the neoplasm and prior to replacing the abdominal organs and closing the wound, successful haemostasis of the affected area must be confirmed (Fig. 6).

Fig. 6. Before completing the procedure, it must be checked that haemostasis has been successful during the surgery. This image shows the vascular clips used to close the phrenicoabdominal vein (white arrows) and the numerous coagulated arterial vessels (blue arrows).
In some cases a tumorous thrombus can be identified inside the vena cava (Fig. 7). In this situation the vena cava can be clamped in order to perform a venotomy to remove the clot.

Intraoperative or immediate postoperative mortality can be high, caused by uncontrolled bleeding, thromboembolism, peritonitis, renal failure, infection and pancreatitis. For this reason, the surgical technique must be impeccable and thromboembolism must be avoided.

Watch this video on the electronic version
Adrenalectomy of the left gland in a patient with hyperadrenocorticism secondary to a neoplasia of this gland.

Watch this video on the electronic version
Complex adrenalectomy with adhesions and large amount of fatty tissue in the retroperitoneal space.

In these patients it is advisable to close the abdominal cavity with non-absorbable material.

Fig. 7. If the neoplasim of the adrenal gland has invaded the vena cava the tumorous thrombus can be observed (arrow) through the venous wall.
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