SURGICAL HEMOSTASIS

GENERAL INFORMATION

Tissue incision inevitably leads to the cutting of blood vessels and consequently to hemorrhage. If it is not limited to the emission of a quantity of blood tolerated by the body, hemorrhage can quickly lead to very serious complications; it must therefore be limited as much as possible.

It creates an immediate risk to the life of the operated patient; significant depletion of blood mass can lead to immediate collapse or delayed shock.

In all cases, it weakens the operated patient and contributes to the establishment of surgical illness.

Furthermore, the accumulation of blood in wounds creates an environment favorable to bacterial multiplication and promotes infection.

NOTE

Minimizing hemorrhage during the intervention and preventing it are absolute imperatives for the surgeon.

PHYSIOLOGICAL REVIEW OF SPONTANEOUS HEMOSTASIS

Physiologically, blood circulation can be divided into two:

➢Macrocirculation: includes all vessels that can be individualized anatomically (artery, veins, heart).

➢Microcirculation: includes all vessels too small to be individualized anatomically (arterioles, venules, capillaries).

When a vessel of the main circulation is cut, significant hemorrhage is triggered: in spurts, bright red if it is an artery; as a flow of dark red blood if it is a vein. Cutting elements of the microcirculation causes oozing hemorrhage.

If the injured element is not a large-caliber artery, the bleeding eventually stops after a certain time. This spontaneous hemostasis results from the combination of three factors:

➢Vasoconstriction of the injured vessel

➢Platelet aggregation

➢Coagulation

Vasoconstriction: results from the action of the perivascular sympathetic nervous system for macrocirculation and the inherent reactivity of the muscle cells in the wall of microcirculation vessels. This initial fleeting vasoconstriction is reinforced by the vasoconstrictive action of catecholamines released by blood platelets.

From a surgical point of view, it is important to know that this protective spasm is never instantaneous; it establishes itself in about ten seconds for venules and arterioles and in thirty to sixty seconds for medium-caliber vessels. These phenomena are sufficient to stop bleeding at the microcirculation level and significantly slow down blood extravasation in small vessels; their action is negligible regarding large vascular trunks.

Platelet aggregation: is the second mechanism that stops hemorrhage. The reaction of the vascular contents, platelet agglutination, closes the vascular breach and forms the Hayem's platelet plug, also called the white thrombus.

This mechanism ensures definitive spontaneous hemostasis for small vessels of the microcirculation; it establishes quickly.

Blood coagulation: Is the third mechanism involved, which results from the transformation of a soluble protein (fibrinogen) into an insoluble protein (fibrin) that traps the formed elements of the blood and forms the clot or red thrombus.

This transformation is directed by an enzyme (thrombin) which itself results from the activation of an inactive precursor (prothrombin) under the complex influence of several factors: thromboplastins. All these mechanisms are activated by calcium ions.

From all these reactions, except in pathological cases, it results that bleeding from the microcirculation stops on its own.

Whereas bleeding from large vessels requires intervention by the surgeon through the implementation of a hemostasis technique.

Surgical hemostasis is the set of physicochemical means used to prevent or stop bleeding during a surgical intervention.

Evaluation of the animal

Before any surgical intervention, it is important to identify certain risk factors:

✓Breed: Some breeds are predisposed to certain types of disorders (hemophilia in German Shepherds, for example).

✓Any ongoing diseases, for example, a liver-insufficient animal produces fewer coagulation factors.

✓The type of intervention, as certain surgeries result in significant bleeding, such as prostate or liver surgery, because these organs are very richly vascularized.

✓The existence of ongoing medical treatment, for example, aspirin which inhibits platelet aggregation up to 17 days after administration.

✓Gather the history regarding these risk factors.

✓Assess platelet function; for this, bleeding time is evaluated.

✓Assess coagulation. For this, coagulation time is evaluated, most often in the laboratory. If this is impossible, at a minimum, a coagulation test on a dry tube should be done; coagulation should occur within 10 to 15 minutes.

• To identify blood coagulation disorders and the reactivity state of vessels, it is useful to perform simple clinical tests before the operation such as (Bleeding Time, Clotting Time, Prothrombin Time).

➢ Duration of action

➢ Timing of their initiation

➢ Their principle

Temporary Hemostasis

• Short-term action

• Used to control hemorrhage while other measures are being implemented.

Definitive Hemostasis

• Durable action

• Allows permanent cessation of bleeding.

Preventive Hemostasis

• Implemented before the occurrence of hemorrhage.

Curative Hemostasis

• Implemented after the appearance of hemorrhage.

• Can be temporary or definitive.

• Sometimes used as an extension of preventive hemostasis.

Mechanical

• Compression or ligation of vessels.

Thermal

• Application of heat (cauterization) to coagulate tissues and vessels.

Chemical and Medicinal

• Use of substances to promote coagulation or reduce bleeding.

Temporary Hemostasis

1) Digital compression

2) Application of a tourniquet

3) Placement of an Esmarch bandage

4) Non-traumatic vascular clamps

Mechanical hemostasis by compression

1) Digital compression

2) Application of a tourniquet

3) Placement of an Esmarch bandage

4) Non-traumatic vascular clamps

Digital compression

- A finger is placed on the vessel; this is emergency hemostasis.
- This technique is used for intraoperative bleeding from a vessel and must absolutely be completed with another method.

Application of a tourniquet

This allows stopping blood flow upstream of the hemorrhage.

It must be tightened sufficiently to cut off arterial and venous vascularization; the latter is stopped first because veins are more compressible and more superficially located.

Use of tourniquets:

These are devices intended to compress tissues and temporarily crush vascular elements. They are used during interventions on limbs, tail, and generally appendages.

NOTE

Tourniquets made of non-extensible, small-diameter ties should never be used because the stricture can lead to mortification of crushed tissues and subsequent complications like gangrene.

Conditions of use:

To prevent or stop arterial hemorrhage, the tourniquet should be applied towards the base of the appendage or limb.

To stop venous hemorrhage, it is classic to apply the tourniquet distal to the injury.

For surgical use, tourniquets are always placed towards the base of the limb to interrupt all blood circulation.

Tourniquets should not be left in place for too long because the anoxia caused by the cessation of blood circulation can lead to irreversible tissue damage.

Furthermore, the blood laden with metabolic waste and catabolites can, upon tourniquet release, cause a serious cardiovascular accident. This phenomenon is known as "tourniquet release shock." The application of tourniquets in surgery allows working in completely bloodless fields, but it has the disadvantage of providing a false sense of hemostatic security.

✓ Indeed, upon tourniquet release, toxins of cellular origin related to anaerobic metabolism enter the general circulation and can be responsible for tourniquet release shock due to generalized vasodilation.

✓ In veterinary medicine, it is used as a last resort (in favor of manual compression) because it often leads to significant complications upon release. It is more often used as a complementary technique in certain surgeries (e.g., on the limb). Compression with a clean cloth is preferred as a first intention.

Removal of the tourniquet:

A tourniquet should not be left in place for more than two hours without the risk of serious complications. If the tourniquet is to be removed by the owner themselves, the time should be specified on a prescription to absolve the veterinarian of responsibility.

NOTE 1

If bleeding occurs upon tourniquet release, allow blood to circulate for a few minutes to re-oxygenate the tissues, then reapply the tourniquet for 30 minutes.

NOTE 2

The tourniquet should always be released as a safety measure to check for any possible bleeding before closing the surgical wound.

Esmarch bandage

➢Equipment: It consists of a very flexible rubber band, 5 to 7 centimeters wide and 2 to 5 centimeters long? (Note: The length description seems inconsistent; likely a wide band of certain length).

➢Application technique: The method consists of applying a tight bandage starting at the distal end and moving up towards the base of the limb, essentially applying an elastic tourniquet. The bandage is then removed starting from the distal end.

➢Contraindication:

An Esmarch bandage should never be applied to a limb with a suppurating lesion, as there is a risk of spreading germs via the lymphatic system.

Clamping:

In principle, it is similar to a tourniquet, but here metal forceps are used to allow gentle compression of tissues. For otectomy, a special forceps (Pincemin's limiting forceps) is used. The forceps delimits the incision and simultaneously achieves hemostasis.

In surgery, coprostatic forceps or Hartmann's forceps are used to achieve hemostasis of the intestinal loop; clamps also constitute clamping that is left in place until necrosis of the gonad and its fall.

Chemical Hemostasis by Vasoconstriction

It is interesting to use this especially on mucous membranes.

For example, if omitted during rhinoscopy, the view quickly becomes obstructed because the mucosa is very richly vascularized.

Vasoconstriction with **adrenaline** (1/1000) allows a bloodless surgical field, but unfortunately does not provide very significant hemostasis.

These temporary and basic hemostasis methods are most often followed by definitive mechanical hemostasis.

Definitive Hemostasis

1**. MECHANICAL (the most important)**

➢ Compression

➢ Crushing

➢ Suture

➢ Ligation

2. THERMAL

➢ Electrocoagulation (most used)

➢ Laser

➢ Cryosurgery

3. Chemical and medicinal

➢ Local hemostatic agents

➢ Systemic hemostatic agents

Principle: Mechanically stop blood flow by approximating the vascular walls to promote the activation of hemostatic mechanisms.

Compression

Equipment: A sterile compress.

Procedure: Compression is digital and must be maintained for 5-10 minutes. A clot then forms, and when the finger is removed, the bleeding stops. Care must be taken not to rub, as this would remove necessary coagulation factors.

Limitations: Ineffective for vessels larger than 1 or 2 mm in diameter. It must also be supplemented with another method, as upon the animal's awakening, increased blood pressure may dislodge small clots.

Angiotripsy or Preventive Crushing

Equipment: An appropriate forceps such as Reimers forceps used for castration in horses.

Procedure: It involves prolonged crushing (at least 3 minutes at maximum pressure) of the vascular pedicle before its section using forceps.

This can be done preventively. It is mainly used in rural settings, especially for castrating horses (one of the most frequently used methods) and cattle. The forceps clamps the testicular vessels; the vessels can then be sectioned without the need for additional hemostasis.

Curative Crushing

Equipment: Hemostatic clamp

Procedure: Identify the severed vessel, then place the clamp on its end.

It is, however, impossible to place it on the surrounding tissues. Therefore, it is crucial to correctly identify the vessel and clamp only it.

Furthermore, the clamp must be left in place for at least 1 to 2 minutes.

Limitations: This technique is ineffective for vessels larger than a few millimeters in diameter, and must be supplemented with an additional ligature.

Torsion

Equipment: Hemostatic clamp

Procedure: This is the technique most often used for castration of cats.

The clamp is placed on the free end of the vessel or vascular pedicle and turned to crush the vascular layers until they rupture, achieving definitive hemostasis. This is castration by "bistournage" (twist method). Care must be taken not to pull too hard so that the pedicle does not rupture before hemostasis is achieved.

Limitations: This technique is ineffective for large-diameter vessels and is also quite risky (as mentioned, premature rupture can occur).

Ligation

Equipment: Surgical suture material, usually braided; Vicryl is most commonly used. Its diameter must be sufficient not to cut through the vessel.

Procedure: This is the most common technique; the thread is tied around the bleeding vessel.

A surgeon's knot is not used because it limits tissue crushing, whereas here the goal is to crush the vessel as much as possible.

Ligation in Continuity: the FINOCHIETTO RAZZATTO technique

This technique allows definitive hemostasis of vessels before their section. This technique is particularly applied during organ or tumor removal. A double ligature is placed on the vascular element; its section is performed between these two. This technique has the advantage of not flooding the operative site with blood and minimizes blood loss.

Transfixing Ligation

The ligature can be transfixing, meaning that before encircling the vessel, the thread is passed through its wall to prevent it from slipping along the vessel. This is done especially for large-diameter vessels like the axillary artery.

The ligature can also be anchored, i.e., the vessel is ligated, but the suture also bites into the peripheral tissue.

It does not slip because it is anchored against the wall of the underlying organ.

It is used when one wishes to avoid completely dissecting the vessel, in cases where isolating it is risky.

It is important to master the rules of ligation and compression. However, these are increasingly being abandoned for small vessels in favor of electrocoagulation, which is much less tedious.

The increase in temperature within vessels accelerates enzymatic reactions and also causes protein coagulation. Thus, a hemostatic plug forms.

Electrocoagulation

A generator creates alternating electric fields varying at high frequency, and the electric current is passed through the tissue. The tissue's intrinsic resistance causes friction and a localized increase in temperature.

Depending on the current's characteristics, one can perform cutting, coagulation, or both.

There are two modes for electrocoagulation.

✓ Monopolar

✓ Bipolar

Monopolar:

▪ The current (from a generator) arrives at a sterile forceps (which is the active electrode), passes entirely through the patient's body, and is collected by a neutral plate (the return electrode) before returning to the generator.

▪ Only one electrode is active on the hand-held pen (scalpel), which can be shaped like a needle, snare, or loop. The other electrode is inactive; it's a plate placed under the animal. The current is thus concentrated at a specific point on the scalpel, then passes through the entire animal and is collected by the inactive electrode.

Procedure: The vessel must be identified and grasped with small forceps. The handpiece is applied directly to the forceps; the current passes through the forceps and coagulates the vessel before dissipating throughout the animal's body.

Limitations: For arteries larger than 1 mm and veins larger than 2 mm, the hemostasis achieved is less effective, and bleeding may not stop.

Furthermore, it is necessary to work in a dry field (avoid blood or irrigation fluid), as fluids dissipate the electrical heat.

Bipolar:

▪ This involves a forceps. There is no longer a plate under the animal.

▪ In this case, the current no longer passes through the entire animal's body, but only through the area between the two parts of the forceps. This scalpel can be used anywhere, but especially in sensitive areas, such as near the nervous system.

▪ A bipolar forceps acts as both anode and cathode, so no neutral plate is needed.

Advantages:

- Greater precision, and coagulation is better than with the monopolar scalpel.

- This mode allows working even when the field is not completely bloodless, which is particularly useful in practice.

- The heating is purely local because the current only passes through the targeted vessel; thus, there is no risk of iatrogenic burns.

Limitations:

It only allows hemostasis, not cutting. Therefore, the monopolar mode is more often used unless there is a need for high precision.

- **Warm physiological saline**

Compresses soaked in physiological saline heated to 45°C is a classic means of surgical hemostasis, particularly in neurosurgery. This temperature respects tissue integrity but increases the speed of blood coagulation by 8 times by accelerating enzymatic reactions.

- Infrared rays

They are used in hemostasis, particularly during interventions on parenchymatous organs. They are applied to the cut surface to achieve hemostasis.

Chemical and Medicinal

There are local agents and systemic agents.

Principle: Agents can act in two ways:

- Promote a step in spontaneous hemostasis, triggering the coagulation cascade,

- Or create a hemostatic plug.

Local Hemostatic Agents:

A clear distinction must be made between mechanical agents and active agents.

Mechanical Hemostatic Agents

They absorb blood, swell slightly, and obstruct the vessel, forming a physical clot that acts as a matrix for the blood clot.

✓ Gelatin (e.g., Gelfoam®)

It comes in foam or powder form and is absorbable within a few weeks, so it can be left in situ.

✓ Bovine collagen

It has a mechanical action and also activates platelet aggregation. Unfortunately, due to the antigens present, it causes more inflammatory reaction than gelatin.

✓ Cellulose (Surgical®)

It forms a mechanical clot and is absorbable. Its acidic properties may give it better resistance to bacteria. It is still quite expensive.

Active Hemostatic Agents

Very expensive, they are rarely used in veterinary medicine.

✓ Thrombin (Factor II)

It activates the transformation of fibrinogen into fibrin and thus promotes secondary hemostasis. The cost is quite high (not readily available in veterinary medicine), and allergies that thrombin can cause must be considered.

✓ Calcium alginate (CuraSorb®, Coalgan®, Tegaderm alginate®)

These are calcium ions that activate the coagulation cascade. These are colloidal dressings, with variable effectiveness, and are rarely used in surgery.

Surgical Glues

They allow occlusion of vascular breaches without involving the endogenous system; no clot forms at that site, so there is no thrombus, and vascularization returns normally. These are fibrin-based glues (or synthetic derivatives) and are still rarely used in veterinary medicine.

Systemic Hemostatic Agents

- ✓ Vasoconstriction: Adrenochrome (Hemocardyl ND), Methylergometrine (Methergin ND)
- ✓ Primary Hemostasis: Etamsylate (DICYNONE ND, HEMOCED ND)
- ✓ Secondary Hemostasis: Hemocoagulase (REPTILASE ND)

Most are not sufficiently effective to achieve definitive hemostasis; they serve more to reassure the owner...

They supply the blood with the element it lacks for normal coagulation. They are distinguished as:

➢Anti-coumarins: mainly Vitamin K3, which must be administered 2 or 3 days before the operation to be active, as it must undergo hepatic metabolism for prothrombin synthesis.

➢Anti-heparin agents:

Protamine sulfate and toluidine blue are used in cases of metrorrhagia or to stop the action of heparin in cases of grafting.

➢Carbazochromes:

These are adrenaline derivatives produced by its oxidation; they increase arteriolar tone.

➢Total blood extracts: They provide fibrinogen and plasma coagulation factors.

➢Cyclonamine (Hemocide ND) and etamsylate (Dicynone ND), as well as the supply of calcium in ionic form, facilitate coagulation in vivo.

Adjunctive Hemostasis Techniques:

Surgical hemostasis can be complemented by techniques that promote it.

<u>1) Blood Pressure Control:</u>

• It involves limiting blood flow to reduce capillary bleeding.

• Caution: This is contraindicated in cases of massive bleeding, as one would then need to maintain good blood pressure.

NOTE

Furthermore, anesthetic management contributes to surgical hemostasis. Indeed, hypotension related to anesthesia often facilitates surgical hemostasis. Therefore, care must be taken because upon recovery, the increase in blood pressure often leads to a resumption of bleeding that had stopped.

<u>2) Transfusion</u>

• In cases of coagulation disorders, consider providing platelets.

• The best method for this is blood transfusion, which also provides coagulation factors and red blood cells.

• Hence the importance of preparing blood bags before the operation if it is known that the surgery is risky.

• Although ideal, this solution remains expensive and blood bags are not always available.

Operative Hemostasis

<u>1) Before the intervention:</u>

✓ Identify risk factors.

✓ Perform a hemostasis assessment.

✓ Prepare bags for infusion and/or transfusion if the surgery is known to be risky.

✓ And of course, know the anatomy and surgical approaches: know where vessels originate and their course to limit the risk of iatrogenic bleeding!

<u>2) During the intervention:</u>

✓ Preventive hemostasis is better than curative hemostasis.

✓ Have a stock of compresses and a surgical suction device available. The suction allows localizing the source of bleeding.

✓ Adequate lighting is also essential.

The operator must be reactive and may need assistance; however, one should not immediately panic in the face of significant bleeding, and above all << do not confuse speed with haste >>.

Faced with severe hemorrhage, the first reflex is to compress the vessel with a finger to allow time to think, not to rush for clamps and other tools; indeed, it takes some time for an animal to bleed out, so there are always a few minutes to think.

<u>3) After the operation</u>

✓ If necessary, a compressive bandage can be used,

✓ its role, however, is quite limited.

✓ Good postoperative monitoring is essential.