The parachutist or feline high-rise syndrome is the accidental and traumatic phenomenon that occurs in cats that fall from a height of two floors or more 7-9 meters. These are usually high-rise buildings, but this is not always the case. It also refers to cats that fall from appreciable heights, whether they are trees, walls, etc.

The syndrome consists of various injuries. The existence of many publications coincide and differ in the presentation of the lesions, based, among others, on the different geographical locations of the patients, height from which they fall, etc., but all agree that it is a polytrauma patient.

Common injuries suffered in cats after a fall include:
1- Broken bones:
   1.1- most likely the jaw bone when the cat's chin hits the ground; a broken jaw and broken teeth are the classic signs of a cat that suffered injuries in a fall.
   1.2- lesions in the appendicular skeleton: injuries in the limbs: articular, metaphyseal, diaphyseal, musculotendinous, ligamentous, separately or in combination.

2- Axial skeletal injuries: less frequent than the previous ones, but also habitual. If we include in this section the cranium, a significant number of cats will present with traumatism of the skull with its different consequences.

3- Internal injuries: mainly pneumothorax and pulmonary contusions. Abdominal injuries: urinary tract, pancreas, etc.

The most common injuries according to different studies are fractures of extremities, facial injuries, pulmonary contusions and pneumothorax. Mostly young cats are affected (1-3 years), without sex preference.

Studies on cats that have fallen from 2 to 32 floors and are still alive when taken to a veterinary clinic show that the overall survival rate is 90% of treated patients.

In a study conducted in 1987, it was reported that cats that fall from less than six floors, and are still alive, have larger injuries than cats that fall from more than six floors. It has been proposed that this could happen because:
1- Cats reach terminal velocity after straightening, in approximately five floors, and after this point they do not accelerate and can no longer feel that they are falling, which causes them to relax, resulting in less serious injuries than in cats that have fallen from less than six floors.
2- Another possible explanation for this phenomenon is that cats that die in falls are less likely to be taken to a veterinarian than injured cats, and therefore, many of the cats dead in falls from upper buildings are not reported in studies about this issue.

Why do cats fall from high places

Cats have a natural fondness for heights. Even not living in high-rise cities, it is usual for the cat to look for areas to climb (trees, walls). If a cat is distracted by a potential prey, playing or falling asleep, it may fall. If this happened in a tree, for example, the cat would often be able to save itself by grabbing its claws. When this happens on the top of a balcony or a window, grabbing becomes more complicated, since many construction materials, such as concrete and painted metal, do not allow a cat to grip successfully.
Having a more restless nature can influence the search for more dangerous areas for the fall by cats. Therefore, it is also understood that it is a more common syndrome in young cats.

**Why such a high survival rate**

During a fall from a high place, a cat can reflexively rotate its body and straighten itself using its sharp sense of balance and flexibility. This is known as the “straightening reflex” of the cat. The first part that usually hits the ground are the limbs. The minimum height required for this to occur in most cats (safely) would be around 90 cm (3.0 ft).

At first, it would seem logical to think that the injuries after falling into the vacuum will be more serious as the height increases; however, the studies show that the corporal damages are greater in falls from floors 2-6 than those of higher heights. The data indicate that from the 6th floor a series of physiological and physical mechanisms are put in place that protect the animal in a certain way.

This was demonstrated in a study carried out in New York (Whitney and Mehlehaff 1987) where the cases of 132 cats that fell from different heights were followed. 17 of them died in the transfer to the hospital or had to be euthanized given the magnitude of the injuries. Of the rest, 104 managed to survive. It can be read of a cat fallen from a floor 32 to which only one tooth was fractured and a certain pulmonary contusion was found, being discharged 48h later.

One reason for this survival rate is to be found in the fact that the cat reaches its maximum speed (terminal velocity) from the 5th floor; this speed is about 90 km/h, that is, even if it falls from a Floor 8, 20 or 32, it will not fall faster.

A person falling from that height would increase his peak speed, and it would need 32 floors to reach his maximum speed, which is about 180 km/h, hence the survival rate of cats is much higher than that of humans when they fall from great heights. It is not the same to weight about 4 kg and to fall at 90 km/h than weighing 80 kg and to fall at 180 km/h.

Other animals, on the other hand, can not control the position of the body during the fall and the limbs will not be the first to strike the ground, but other areas without cushioning, and as vital as thorax or head.

In addition, cats have a large body surface with regard to their weight, which increases the chances of survival. An important fact that must be borne in mind is that until reaching the terminal velocity the cats are in a state of tension and tend to have their limbs rigid; once the speed is overcome, their vestibular system is no longer stimulated and the animal extends its limbs, in such a way that their body acts, to a certain extent, as a parachute, thus minimizing the impact. In general, their limbs are comparatively very muscular and capable of absorbing to a great extent the impact of a fall; it must also be borne in mind that the anterior limbs of the cat are not attached to the trunk by the clavicle bone, although they sometimes present a vestige of it, being therefore more extensible and flexible.

When hitting the ground, the animal will have its feet flexed - as paratroopers do when flexing thighs and hips before touching the ground (this way, the force of the shock dissipates to a large extent to the soft tissues).

Other animals with the same weight as cats, such as small dogs, suffer much greater traumas than cats when falling from high floors.

If the cat landed with its limbs directly below it on a column and kept them hard, it would result in much more damage. But they open to the sides and bend the joints, so they take that energy and put it in the joints, exerting less force to the bone itself.

However, home cats in urban or suburban areas tend to be overweight and in less than optimal physical conditions. That diminishes his ability to right himself in the midst of the air.

The most common injuries found in different studies are:

- Pulmonary contusions: 41.7-68%
- Pneumothorax: 20-63%
- Facial trauma: 37-57%
- Limb fracture: 39-53.2%
- Spinal trauma: 15%
- Pancreatic rupture
- Thoracic / abdominal impalement

When we face a cat that has fallen from a certain height, we should always focus on it as a polytrauma patient. This will prioritize the general condition of the patient and its clinical stabilization, having an action...
protocol where we act in an orderly manner trying to locate lesions with clinical signs while we apply vital support.

The orthopaedic surgeon of the hospital must have immediate knowledge of the arrival of a polytrauma patient, since it will be an important part in the treatment, contributing in a balanced way with the rest of the team to give vital support to the patient while they are getting a diagnostic.

In these clinical cases especially, the traumatologist must understand that we intervene patients, not fractures.

We must have a list as quickly as possible of our patient's injuries: mouth / palate- pulmonary contusions and limb injuries are the trio of most frequent injuries, but others are also described.

From the orthopaedic surgeon's point of view, we must classify the fractures.

**Brain injuries**

Falls from a certain height are the most common cause of feline fractures or manipulative injuries. The origin, direction and force of the impact determine the type, location and number of injuries. Bones, soft tissues, teeth and palate may be affected, concomitantly or not.

Other injuries may coexist, such as eye and brain injuries, fractures of long bones and joints, pneumothorax and pulmonary contusion, and abdominal trauma. Therefore, a complete clinical examination is warranted in all cases of trauma. In addition, these patients must be medically stabilized, any life-threatening injury will be treated first. The analgesic and symptomatic treatment should be implemented as soon as possible. The placement of a nasogastric tube or esophagostomy that may be indicated if the treatment should be delayed.

Diagnostic imaging procedures, which inevitably require deep sedation or general anaesthesia, should be postponed until general anaesthesia can be safely performed. A basic radiographic screening of the skull should be obtained, including a dorsoventral or ventrodorsal view, a laterolateral view and right and left oblique views. Intraoral views using intraoral films without a screen are also very useful. However, CT is the standard diagnostic imaging procedure in cases of maxillofacial trauma, since it has a greater capacity to identify lesions compared to radiography.

Clinically, facial symmetry, retrusion of the eyeballs, the presence of oral or nasal bleeding, dental occlusion, integrity and mobility, the range of motion of the jaw, the integrity of the soft tissues and the palate should be evaluated periorally and intraorally.

Soft tissue injuries may include ecchymosis (often a sign of underlying bone fracture or trauma and dislocation of the joint), erosion, and laceration. Surgical curettage and direct suture of any mucosal or cutaneous laceration should be performed.

Dental lesions are present in up to 72% of patients with maxillofacial trauma, and the canine teeth, the maxillary fourth premolar and the mandibular first molars are more commonly affected. The removal of diseased and injured teeth should be done with great care, to avoid any subsequent displacement of bone fragments and trauma to the soft tissues. In fact, it is recommended to postpone the extraction after bone healing, whenever possible (except in cases of severe periodontal disease, root fracture or teeth that interfere with the reduction of the fracture), since they favour anatomical reduction and stabilization of the fracture. They can also be used as an anchor point for intraoral fixation devices. If periodontal disease is present, it must be addressed at the time of bone fixation. If endodontic disease is present, temporary endodontic treatment can be performed at the time of bone fixation and removal or definitive endodontic treatment after bone healing.

Jaw fracture is a likely event after a maxillofacial trauma. In feline patients, 11 to 23% of all fractures affect the maxillofacial region. The mandibular region most commonly affected is the symphyseal region, followed by the body of the mandible and the mandibular branch. Diastasis along the midline of the hard palate is also common.

Early reduction of the fracture, realignment and adequate stabilization of the bone fragments, rapid functional rehabilitation and atraumatic occlusion should be the main objectives of the treatment. Treatment should be performed as soon as possible (if vital and neurological parameters allow), since a prolonged delay in treatment may increase the chances of infection of exposed fractures, tissue oedema and surgical difficulties.

Proper dental occlusion is very important, since malocclusion can cause excessive leverage forces to the jaw, with an increased risk of non-functional healing, impaired mandibular function and osteoarthritis of the TMJ. In addition, in cats, the minimal mandibular displacement can cause an abnormal contact
between the mandibular canine teeth and the maxillary tissues. Pharyngostomy or transmilohyoid intubations allow evaluation of dental occlusion during fracture repair.

Several techniques can be used to treat jaw fractures in cats, including cerclage wires, intraosseous fixation devices (interfragmentary wires, miniplates, etc.) and intraoral/interdental fixation devices (dental splinting and maxillomandibular fixation). Occasionally, mandibulectomies and partial maxillectomies are necessary in case of severe comminute fractures.

Dental splints have the mechanical advantage of being placed on the side of tension (alveolar margin) of the fracture. They are easy to apply, do not require soft tissue dissection, are well tolerated by patients and are relatively inexpensive. The main indications include the separation of the symphysis, the simple transverse fracture of the body or the incisive area of the mandible and the maxillary fractures. Comminute fractures (with severe bone loss), fractures in young animals (with developing teeth) and caudal mandibular fractures may be a contraindication to the use of splinting techniques.

The splicing technique of acid etching is used. First, curettage and suture of the soft tissues are performed. Then, the teeth that will be included in the splint are scaled and polished. A cerclage wire is applied around the dental crowns, reducing and stabilizing the bone fracture (the interdental wire also increases the mechanical retention of the resin). The teeth are etched with acid for 15 seconds, and a dental resin is applied to completely cover the cerclage, while the bone fragments are kept in reduction. Materials with low exothermic temperature reaction, such as cold autopolymerized composite resins, should be chosen to minimize the risk of thermal pulpitis. A minimum amount of resin should be used to limit the size of the splint and the rise in temperature during polymerization. The splinting material should be placed on the lingual side of the lower teeth and on the vestibular side of the maxillary teeth, to minimize occlusal interference. Adequate reduction of the fracture and the placement of the splint must be confirmed radiographically. The splint should finally be smoothed with an abrasive bur and the occlusion should be checked before recovery.

The splint is removed 2 to 6 weeks after placement, depending on the type and severity of the bone lesion, after the radiographic confirmation of bone consolidation. It should be initially separated at the level of the fracture and the stability of the bone fragments examined manually. If it is stable, the resin (and wire) is measured with a bur and then gently lifted from the tooth surfaces. This must be done with great care, to minimize the risk of dental crown injuries.

Maxillomandibular fixation (MMF) can be used to treat caudal mandibular fractures and recurrent temporomandibular dislocation. The same steps described for dental splints are followed, but the resin is applied between the maxillary and mandibular canine teeth, either unilaterally or bilaterally, to fix the mandible in position. The mandibular opening after placement should be approximately 2 cm, to allow spontaneous nutrition and water consumption. However, placement of an esophagostomy tube may be indicated to allow adequate nutrition. Altered thermoregulation, difficulty eating and swallowing, aspiration pneumonia, and temporomandibular ankylosis (in the case of intra-articular fracture) are all potential complications of MMF. Therefore, the splint time should be as short as possible (10-15 days). It is important to keep in mind that tracheal intubation may be impossible to perform when the splint is placed, and that the removal of the splint should be done under anaesthesia. Other options for MMF include reverse labial suture through buttons and bignathic encircling and retaining device (BEARD).

Appendicular skeletal trauma:

We can find the presence of an isolated fracture or the combination of several of them. Orthogonal radiographs should be taken, that is, obtained in two projections 90° to each other, not only of the fractured or affected limb but also of the thorax and abdomen.

The successful management of a patient who has suffered a traumatic bone fracture relies heavily on careful preoperative decision making. The management of the fracture is a balance between the temporary stabilization of the fracture as well as the respect to vascularization. Bone is a viscoelastic material, its ability to absorb energy is limited and the greater the acceleration in the fall, the more complex the fractures tend to be.

In general, we must meet the following steps:
1. Describe the fracture: closed-open, configuration, displacement ..
2. Classify the fracture as reducible or not.
3. Evaluate and score the fracture to analyse the factors relevant to bone healing.
4. Identify the disruptive forces that will act on the fracture.
5. Choose the most suitable fixing systems.
6. Complete the treatment plan: boarding, specific implants and inventory, capacities, etc.

High energy fractures lead to more lesions in the surrounding soft tissues, which can affect their function and can also negatively affect the biological environment and delay the healing process of the fracture. The direction of the forces on the bone also directly influence the configuration of the fracture. There are five main forces acting on a fracture: Tension, compression, shear, bending and torsion. We must try to neutralize all of them to get a proper healing of the fracture.

The description of each fracture must be carried out separately, and in each case, there may be multiple fractures.

Describe the species, age of the patient, bone fracture (right, left), location within the bone (epiphyseal, metaphyseal or diaphyseal), whether it is articular or extra-articular, its fracture pattern, whether there is displacement of the distal fragment, whether it is open or closed; if epiphyseal, it can be classified as Salter-Harris and, finally, the duration of the injury (acute fracture, not united, in healing, etc.).

Describe whether the fracture is reducible or not. Generally, reducible fractures consist of two or three fragments. The most usual is to reduce them to share the load with the implant during the gait, but the reduction is not always necessary.

On the other hand, when faced with comminute or nonreconstructible fractures, the change of priorities involves respecting the soft tissues as much as possible and manipulating them as little as possible, striving to make incomplete but spatially correct reconstructions for the main load to reside in the implant. In case of doubt regarding the fracture is reducible or not, it should be treated as non-reducible.

A common error in the treatment of fractures is to select the implant by evaluating only the radiograph or by doing exactly the same as in a magazine or book on orthopaedics.

Developing a scoring system to evaluate fractures, although it is a somewhat subjective action, will help us achieve greater success by treating our patients.

Overall assessment: clinical assessment of the fracture + mechanical assessment + biological evaluation. With this score from 1 to 10 we assess the different factors that influence the correct healing of the fracture.

The lower scores indicate factors that do not favour the rapid healing of the fracture. High scores favour a fast and successful result.

Low scores (1-3) require bridge plates, external fixator type III, closed nails or orthogonal plates.

Medium scores (4-7) can be solved with neutralization plates, external fixator type II, closed nail, etc.

High scores (8-10) can be solved with external co-optation, compression plate, external fixator type I/II or intramedullary nail-cerclage.

Given the high chance of combinations of different fractures, the knowledge of the stabilizing techniques in traumatology is essential: use of Kirschner needles, external fixation and osteosynthesis.

**Axial skeleton trauma**

The presence of vertebral fractures/dislocations is always a great challenge in these patients. The decision making not only depends on the type of instability or existing bone lesions, but also on our experience when dealing with this type of procedures, and on the possible damage to the spinal cord, which will condition the evolution of our patient regarding the chance of being ambulatory or not in the future.

Too often the owners accept a spinal surgery to the cat, depending on what we recommend as orthopaedists/neurologists. If they are going to be non-ambulatory, they sometimes ask us not to intervene and perform euthanasia. Therefore, these patients can pose a real challenge, requiring to perform imaging techniques complementary to radiography: MRI or CT.

Based on the clinical examination, complementary tests, economical availability of owners, professional criteria (bi/three-compartment theory), we will recommend: surgical versus conservative treatment.
The use of blocked plates, especially in the lateral approach for vertebral thoracolumbar lesions, is generally my preference. Threaded needles and acrylic cement are my second option.

References:


