High-rise syndrome in cats

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Summary: *High-rise syndrome was diagnosed in 132 cats over a 5-month period. The mean age of the cats was 2.7 years. Ninety percent of the cats had some form of thoracic trauma. Of these, 68% had pulmonary contusions and 63% had pneumothorax. Abnormal respiratory patterns were evident clinically in 55%. Other common clinical findings included facial trauma (57%), limb fractures (39%), shock (24%), traumatic luxations (18%), hard palate fractures (17%), hypothermia (17%), and dental fractures (17%). Emergency (life-sustaining) treatment, primarily because of thoracic trauma and shock, was required in 37% of the cats. Nonemergency treatment was required in an additional 30%. The remaining 30% were observed, but did not require treatment. Ninety percent of the treated cats survived.*

High-rise syndrome[1] is the term used to describe the traumatic injuries sustained by any animal falling from a substantial height, usually 2 or more stories. The term was originally and is most commonly used in reference to cats falling from windows in urban areas. There has been 1 report on high-rise syndrome.[1] The purpose of the study reported here was to describe the pertinent findings in 132 consecutive cases of high-rise syndrome in cats examined over a 5-month period. Our hypotheses were that (1) most cats with high rise syndrome survive, and (2) there is a correlation between types of injury and their rate of occurrence and distances fallen. A theory is proposed to explain the correlation.

Materials and methods

All cats (132) examined because of high-rise syndrome at the Animal Medical Center between June 4 and Nov 4, 1984 were included in this study. Only cats that had an opportunity to fall or jump from an open window and whose owners were certain that a fall had occurred were included. Historic information and results of physical examination were recorded for each cat. Appropriate treatment was administered according to injuries sustained, except when the owners requested euthanasia. Thoracic radiography was recommended in all cats and was performed in 91 cats. Other pertinent radiographs also were obtained, as indicated by findings on physical examination. Serum biochemical and hematologic tests were performed when the age of the cat or severity of the injuries indicated. Necropsies were performed when permitted by owners. Cats were reexamined when necessary. Telephone contact was used to complete case histories in cats not reexamined or when additional history was needed. Owners also were asked pertinent questions regarding their cats' path of fall.

The distance fallen by each cat was recorded in number of stories fallen. Each story equaled approximately 12 feet. The need for treatment, including surgery, was determined in each case whether or not treatment was permitted by the owners. Types of injury and rate of occurrence were compared with the number of stories fallen to determine factors of prognostic value.

Results

The mean age of the cats was 2.7 ± 0.3 years (range, 3 months to 16 years). Sixty-four percent (84/132) of the cats were <3 years old. Forty-eight percent (64/132) were male and 48% (63/132) were female (in 5 cats, the sex was undetermined). Twenty-three percent (30) of the males were castrated and 27% (36) of the females were spayed. There was no breed predilection.

The distance of the fall was recorded in 129 of 132 cats. The mean fall was 5.5 stories (SEM = ± 0.3); the range was 2 to 32 stories. Four cats (3%) had each fallen once previously. Two cats fell together. Twenty-six percent (34/132) fell during daylight hours, and 40% (53/132) fell at night; in 45 cats, the time of the fall was unknown. Three cats were seen falling by their owners; 2 were described as having fallen while turning on a narrow ledge and the third had jumped for an insect. According to the owners, most cats apparently fell freely to concrete pavement.

The injuries sustained by the 132 cats are given in Table 1. Seventeen cats were euthanatized, not

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Table 1—Results of examination in 132 cats with high-rise syndrome

Injury	No. of cats (%)
Respiration	
Eupneic	53 (40)
Tachypneic	57 (43)
Dyspneic	14 (11)
Agonal	2 (2)
Unknown	3 (2)
Apneic (DOA)	3 (2)
Ambulation	
Lame	57 (43)
Normal	37 (28)
Nonambulatory	35 (27)
Paresis (ataxia)	3 (2)
Abrasions, lacerations, contusions, shear wounds	
Facial (including epistaxis)	74 (56)
Extremity	16 (12)
Truncal	4 (3)
Extremity fracture	52 (39)
Shock	32 (24)
Hypothermia	23 (17)
Dental fractures	23 (17)
Hard palate fractures	22 (17)
Mandibular fractures	12 (9)
Pelvic fractures	4 (3)
Temporomandibular joint luxations	5 (4)
Pyrexia	3 (2)
Hematuria	5 (4)
Traumatic abdominal hernia	2 (2)
DOA	3 (2)

DOA = dead on arrival.

necessarily because of a poor prognosis, but primarily because owners said they could not afford treatment. Of the remaining 115 cats, 8 died because of shock and thoracic injuries (5 within 2 hours of examination and 3 between 2 and 24 hours after examination), and 3 were dead on arrival. None of the cats died after the first 24 hours of hospitalization. Thus, 10% (11/115) of the treated cats died, and 90% (104/115) lived.

Thoracic radiography revealed thoracic injuries in 90% (82/91), pulmonary contusions in 68% (62/91), and pneumothorax in 63% (57/91). Approximately one third (27/91) of the cats with thoracic trauma had both of these injuries.

Thoracentesis was performed in 53 of 73 cats with abnormal respiration, and the results are given in Figure 1. We did not perform thoracentesis on eupneic cats even though some had radiographic evidence of mild pneumothorax. Twelve of 14 cats (86%) clinically assessed as dyspneic had >75 ml of air aspirated from each side of their thorax; the other 2 had severe pulmonary contusions. Small to moderate amounts of blood were aspirated from cats with severe contusions. Ten of 39 cats (25%) with air aspirated from their pleural space required multiple thoracentesis procedures. Only one cat required a thoracic drain to resolve its pneumothorax.

Thirty-nine percent of the cats (52/132) had fractures of 1 or more extremities (81 fractures; Table 2). Multiple metacarpal or metatarsal bone fractures of the same limb were counted as 1 fracture. Ten cats had simultaneous forelimb and hind limb fractures.

Table 2—Location of 81 limb fractures in 52 of 132 cats with high-rise syndrome

Location	No. (%)
Forelimb	44 (54)
Radius	18 (22)
Ulna	15 (19)
Carpus/metacarpus	7 (9)
Humerus	4 (5)
Hind limb	
Femur	37 (46)
Tibia	15 (19)
Tarsus/metatarsus	9 (11)
Patella	0 (0)

Twenty-two cats had multiple extremity fractures; this number includes 12 that had fractures of the radius and ulna. Two, 7, and 13 cats each had 4, 3, and 2 fractured long bones, respectively. Fourteen of the 15 femoral fractures (93%) were in cats <1 year old; 9 of these were distal Salter II fractures, and 2 were capital physeal fractures. Four cats had pelvic fractures, and 4 cats had rib fractures. Three cats had vertebral fractures—1 thoracic, 1 lumbar, and 1 caudal. The cats with thoracic and lumbar fractures both had secondary spinal cord trauma and paraparesis. The cat with a fracture of the caudal vertebra had no clinical signs. One cat had a peripheral nerve injury—sciatic nerve entrapment secondary to an ilial fracture. Twenty-three cats had 26 traumatic luxations (Table 3) confirmed radiographically, with the exception of temporomandibular luxations, which were diagnosed by palpation.

Mandibular, dental, and hard palate fractures were commonly seen in combination with facial trauma (Table 1). The 22 cats with split hard palates were managed conservatively with antibiotics and a moist diet. In all cats, granulation tissue filled in the defect created by the fracture within 3 to 4 weeks, making further treatment unnecessary.

Nine cats had radiographic evidence of hydro- or hemoperitoneum, and all 9 underwent abdominocentesis. Three of the 9 cats had free urine in their

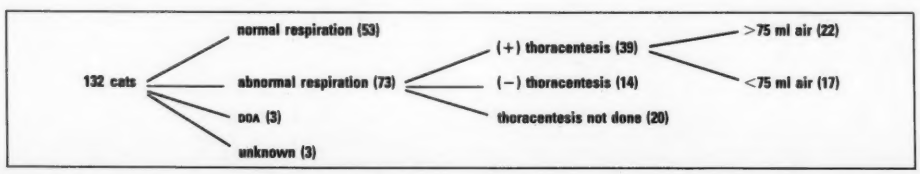

Figure 1—Results of thoracentesis in 73 of 132 cats with high-rise syndrome; + = positive; − = negative; DOA = dead on arrival.

Table 3—Location of 26 traumatic luxations in 132 cats with high-rise syndrome

Location	No. of luxations
Forelimb	8
Shoulder	0
Elbow	1
Carpus	7
Hind limb	10
Hip	5
Stifle	1
Tarsus	4
Temporomandibular joint	5
Unilateral sacroiliac	1
Bilateral sacroiliac	1
Traumatic medial patellar	1

abdomen, and all 3 had a ruptured bladder confirmed at surgery. Two cats (2/9) had blood in their abdomen, and in both cats, abdominal hemorrhage resolved without transfusion or surgery. Four of 9 cats had no fluid aspirated from their abdomen. Five cats had hematuria without bladder rupture. In all 5, the hematuria resolved spontaneously.

Overall, 67% (88/132) of the cats required treatment. Emergency (life-sustaining) treatment, primarily because of thoracic trauma and shock, was required in 37% (49/132). Nonemergency treatment was required in 30% (39/132). Surgery was performed in 30% of the cats (39/132); orthopedic surgery in 29 cats and soft tissue surgery in 10 cats. The mean duration of hospitalization in cats treated medically was 1.2 days; this figure includes 24 cats that were treated as outpatients. The mean duration of hospitalization in cats requiring surgery was 5.1 days. Treatment was not required in 32% (44/132); 20 of the 44 were admitted to the hospital for observation.

Results of comparing types of injuries and rate of occurrence to number of floors fallen are given in Figure 2. For the purpose of this comparison, cats falling 7 and 8 stories were grouped together as were cats falling ≥9 stories.

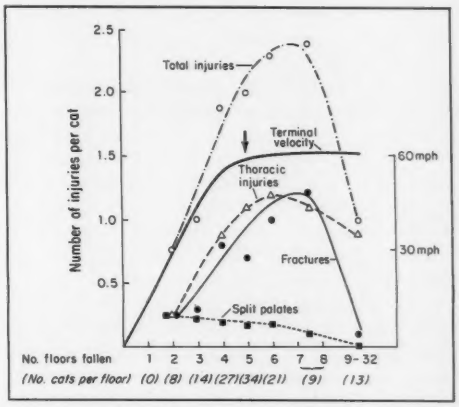

Figure 2—Relationship of injuries to distance fallen and velocity in 132 cats with high-rise syndrome: ↓ points to terminal velocity (—); total number of injuries/cat (○, –·–·–); number of thoracic injuries (pulmonary contusions +pneumothorax)/cat (△, – – –); number of fractures/cat (●, —); number of split palates/cat (■, – – – – –).

Discussion

High-rise syndrome represents a wide variety of traumatic injuries of varying severity sustained by cats falling ≥2 stories. The syndrome is seen predominantly in young cats, without sex or breed predilection. For most cats in this study, the circumstances that led to them falling or jumping from an open window were not known. Only 3% were observed falling—and these 3 cats fell accidentally. The fact that there were more nighttime than daytime falls probably is related to the large nighttime emergency caseload at our hospital. It is likely that in many of the cats of this study, the signs of shock resolved spontaneously by the time they were examined, because many cats were examined several hours after falling and only 24% were in shock at the time of examination.

The survival rate of the cats of this report was high (90%), even though many of the cats were critically injured. Death excluding euthanasia was invariably related to shock, stress, and respiratory distress secondary to thoracic trauma. All deaths (excluding those associated with euthanasia) occurred within 24 hours of examination, emphasizing the importance of emergency management. It is imperative that injuries be accurately prioritized. In some cats, respiratory distress was exacerbated (one cat had respiratory arrest) during initial attempts to obtain diagnostic radiographs or to place an intravenous catheter before thoracic trauma was treated properly. Fifty-three percent (39/73) of the cats with labored breathing on examination had air in the pleural space on thoracentesis; thus, we recommend that cats suffering from respiratory distress undergo immediate bilateral thoracentesis followed by placement in an oxygen cage. Intravenous catheterization, unless the cat is recumbent or cooperative, should frequently be delayed for up to 2 hours, depending on the severity of shock. Once catheterization is achieved, a cat in shock should be treated appropriately, with intravenous administration of fluids and corticosteroids. Overzealous administration of fluids can be harmful in cats with severe pulmonary contusions. In critically injured patients, radiographs should be routinely delayed 12 to 24 hours. All procedures should be performed in such a way as to minimize the stress to the cat, and the cat should be allowed to rest for several minutes in a high oxygen tension environment, preferably an oxygen cage, before and after each procedure. Continued close monitoring of respiration is important—25% of cats required a second or third thoracentesis before pneumothorax resolved. The clinician should then proceed to perform other diagnostic tests and treatments as indicated by results of physical examination. Placement of a thoracic drain was necessary in only 1 of

the 132 cats. This procedure usually is unnecessary and should be reserved for cats with persistent pneumothorax.

After life-threatening injuries are stabilized, a thorough orthopedic examination should be performed in cats with high rise syndrome. There was a high percentage of fractures (39%) and luxations (18%) in the cats of this study, and accurate evaluation of orthopedic injuries was essential for an accurate prognosis. Also, treatment of cats with fractures, especially those with multiple fractures, often was cost-prohibitive for the owners. This was the most common reason for euthanasia in 17 cats; only 8 cats died despite treatment. The fractures were caused by high velocity impact; thus, many were severely comminuted. Open fractures were not uncommon. The number of forelimb fractures was not notably higher than the number of hind limb fractures. Most of the forelimb fractures (92%) were located distal to the elbow. The tibia, femur, radius, and ulna were fractured with similar frequency. Femoral fractures almost invariably occurred in young cats and typically involved the supracondylar region of the femur.

We have seen oronasal fistula with secondary chronic sinusitis as a sequela to hard palate fractures in cats with high-rise syndrome at our hospital; however, we believe that this is uncommon, because it was not seen in any of the 22 cats with hard palate fractures in this study, which were all managed conservatively. On the basis of these results, we recommend at least 1 month of conservative management before considering surgery.

Only 3 cats had ruptured urinary bladders; some cats might have partially voided before impact, preventing a rupture. Diaphragmatic hernias were seen infrequently in cats with this syndrome, possibly because of simultaneous increases in thoracic and abdominal pressures on impact.

A variable that makes it difficult to predict injuries in high-rise cats is the presence of projections in the paths of falling cats, such as fire escapes, awnings, and trees. A projection might help to prevent serious injury by breaking the fall or it might result in more injury by causing an untimely spin or awkward landing. The deceleration distance during impact is a major factor in determining both the deceleration force and the amount of energy absorbed at impact.[2] Compliant surfaces such as mud, snow, and water yield greater stopping distances and reduce the severity of injuries when compared with hard surfaces.[2] According to their owners, most cats in this study fell freely to a concrete surface. In some cats, the surface landed on was unknown. However, the difference in the coefficient of restitution (compliance) between hard-packed ground surface and concrete probably had little influence on injuries in cats of this study.[a]

[a]Brandt R, Professor, Department of Physics, New York University, New York, NY: Personal communication, 1985.

In comparing types of injuries and rate of occurrence to number of floors fallen, the rate of injury was approximately linear up to a distance fallen of approximately 7 stories (Fig 2). Surprisingly, these injury rates did not continue to increase with falls of >7 stories, and the fracture rate decreased. Only 1 of 22 cats falling >7 stories died as a result of its injuries, and there was only 1 fracture among the 13 cats that fell >9 stories. The cat that free-fell 32 stories onto concrete was released after 48 hours of observation, having suffered mild pneumothorax and a chipped tooth. A possible explanation for this phenomenon, based on results in the 132 cats, is the following: during free fall, cats have a unique ability to quickly minimize postural torque, rotation, and tumbling to maintain a feet-first landing position. One would assume that the velocity of a falling cat is related to the force of impact that occurs on landing and that this would affect the number and severity of injuries. However, cats, like parachutists, achieve a maximum velocity (terminal velocity) during free flight. An average-sized man achieves a terminal velocity of 120 mph after falling 32 stories in a vacuum.[2] However, in a natural environment (excluding wind factors), an average-sized (4-kg), horizontally outstretched cat maximizes drag and achieves a terminal velocity of approximately 60 mph after falling approximately 5 stories.[a] Cats falling from higher heights do not accelerate beyond this speed, but continue to fall at terminal velocity (60 mph). As might be expected, the rate of injury in our cats was proportional to distance and speed of fall up to about 7 floors, a point just after terminal velocity is achieved. It was surprising, however, that the fracture rate decreased in cats falling >7 floors. To explain this, we speculate that until a cat achieves terminal velocity it experiences acceleration and reflexively extends its limbs, making them more prone to injury. After terminal velocity has been reached, however, and the vestibular system is no longer stimulated by acceleration,[3] the cat might relax and orient its limbs more horizontally, much like a flying squirrel. This horizontal position allows the impact to be more evenly distributed throughout the body. Although it does not alleviate thoracic injury, it might explain the decrease in number of fractures in cats falling >7 stories.

Free falls are the most common cause of traumatic death in children under the age of 15 years[4] and account for more than 13,000 deaths annually in the United States.[5] A considerable seasonal trend (late spring through early fall) exists in man[2] and cats. The prevalence of accidental fall is highest in children, but the overall highest prevalence in man is in the 22- to 40-year-old age group, many of which are suicides. The syndrome in man is different from that seen in cats. Almost 100% of human falls >6 stories to a hard surface are fatal.[2] Head trauma, followed by abdominal hemorrhage, are the main reasons for mortality in man, whereas these injuries do not often

cause morbidity in cats. Human patients most commonly land with the body in a vertical (feet-first) position,[2] whereas we speculate that cats fall and land horizontally (feet-first), distributing the force of impact more evenly. In addition, the outstretched horizontal position during the fall decreases velocity by increasing drag, which is directly proportional to the surface area of a falling object. The force of impact also is governed by the Newtonian equation $F = ma$, where F is the force at impact, m is the mass of the object, and a is the acceleration or, in the case of free falls, the deceleration at impact. Because the deceleration force, F, is related directly to the mass of the falling object, larger patients will sustain a greater deceleration force than lightweight patients falling from the same height.[2] This supports our clinical impression that dogs with high-rise syndrome sustain more severe injuries than cats.

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Experimental infection of weanling pigs with *Salmonella typhisuis:* Effect of feeding low concentrations of chlortetracycline, penicillin, and sulfamethazine

Clinical and pathologic variables of *Salmonella typhisuis* infections were studied in weanling pigs. The influence of daily feeding of low concentrations of chlortetracycline, penicillin, and sulfamethazine on *S typhisuis* infection also was determined.

Ten pigs (group 1) given feed containing low concentrations of chlortetracycline, penicillin, and sulfamethazine when orally inoculated with *S typhisuis* became pyretic, developed mild neutrophilia, and had increased serum agglutinating antibody titers, but were clinically normal. Lesions were not present, and *S typhisuis* was not isolated from 2 group-1 pigs that were killed and necropsied on postinoculation day 8. Then, the antimicrobial agents were withdrawn from the feed of the remaining 8 pigs for 6 days. The pigs were inoculated with *S typhisuis* on postinoculation day 16 and developed mild clinical disease with sustained high rectal temperatures. Severe necrotizing typhlocolitis and ulcerative proctitis were found at necropsy in all 8 of the pigs. Similar findings were induced in 7 additional pigs (group 2) that were concurrently inoculated with *S typhisuis*, but which had no previous exposure to *S typhisuis*.—*B. W. Fenwick and H. J. Olander in Am J Vet Res 48 (November 1987):1568.*