Trakia Journal of Sciences, Vol. 18, Suppl. 1, pp 24-28, 2020

Available online at:
http://www.uni-sz.bg

ISSN 1313-3551 (online) **doi:10.15547/tjs.2020.s.01.005**

KEEL BONE DAMAGE IN LAYING HENS – DIAGNOSTIC METHODS AND SEVERITY EVALUATION

S. Slavchev[1], L. Lazarov[2]*

[1]Student, Faculty of Veterinary Medicine, Trakia University, Stara Zagora, Bulgaria
[2]Department „Internal Noninfectious Disease“, Faculty of Veterinary Medicine, Trakia University, Stara Zagora , Bulgaria

ABSTRACT
Modern industrial egg production is accompanied by a number of clinical problems related to the welfare of laying hens. Sternum injuries are some of the most common pathologies in this animal species. The sternum in hens is 9-12 cm long and is located in the ventral sagittal plane (1). This is the largest bone in the body of the hen and serves as the basis of the entire skeleton. Bone growth and ossification is a process that begins in the cranial part and gradually ends in the caudal part. In the early stages of the egg-laying period (between 28 and 40 weeks of age), it is not yet fully ossified, and the caudal tip often remains cartilaginous (1). This makes the sternum more vulnerable to damage than other long bones that complete their ossification in time (2).
A large percentage of birds housed in aviary breeding systems are affected by sternal fractures. Due to the way chickens are raised, the sternum is affected by morphological changes that are important for animal welfare. The main concern stems from the pain experienced by laying hens with fractures and deformities of the sternum.

Key words: keel bone, fractures, diagnostic methods, laying-hens.

OVERVIEW

Fractures can extend from the ventral to the dorsal surface in the sagittal plane and from the rostral to the caudal surface of the sternum. In addition to fractures, which are characterized by a disruption of bone structure and rupture of the periosteum, there are also deformities. Terms to describe these injuries include bending, S-curvature, dislocation, or torsion of the bone (3, 4). They can easily be misinterpreted without a visual image. In addition, depressions along the ventral surface can also be classified as deviations.

Determining the prevalence of sternal fractures is necessary in order to assess the impact they have on the well-being and productivity of hens and to validate the effectiveness of preventive measures. Studies have shown that the use of radiographic methods such as traditional radiography (X-rays), computed tomography (CT), magnetic resonance imaging (MRI) and sonography (ultrasound) are useful and very accurate in detecting sternal damage (5). However, these methods are often impractical for large-scale applications due to concerns about radiation safety in radiography and computed tomography, affordability, and cost. All of the above methods can be performed on live birds and thus be useful for reducing losses in egg production and overall mortality.

Palpation

Palpation is a method of diagnosis that in the past was presented as a vital inexpensive technique. It is the most common technique used to assess sternal injuries, but due to a lack of accuracy, it is being replaced by imaging methods. The technique is performed with the thumb and forefinger on either side of the sternum, palpating from beginning to end.

Correspondence to: *Lazarin Lazarov, Department of Internal Noninfectious Diseases, Faculty of Veterinary Medicine, Trakia University, 6000 Stara Zagora, Bulgaria; Office tel.: +359 42 699 699; Cell: +359 988 346 405; E-mail: lazarin.lazarov@trakia-uni.bg*

Special attention should be paid to the caudal end of the sternum (6). Palpation most often reveals the presence of callus on the ventral and lateral surface, due to bone healing. The presence of a callus can be quite obvious by palpation, although this varies depending on the size and location of the fracture. The initial phase of the regeneration process begins with an inflammation that leads to the formation of hematoma and granulation tissue. This is followed by the formation of a soft callus at the fracture site, consisting of cartilage or chondroid tissue. In the third phase, ossification of the soft callus occurs to form a hard or bony callus (7). For callus characteristics to appear, the fracture must be old enough. (8). In recent fractures, pain and swelling may be found in the area of the affected bone. Evidence of new fractures based on an inflammatory reaction is rarely found.
In fourth degree fractures (complete rupture of the bone), crepitation and / or movement of bone fragments may be detected.

X-ray

In the form of electromagnetic radiation, X-rays can be directed into and through the animal's body. The tissues of the body have different absorption capacity and therefore the detector displays shadows of different densities. Radiographic equipment is widely available and has been used successfully to assess sternal bone damage in anesthetized birds (9). Recently, portable X-ray equipment has been used, which allows images to be taken directly in the production facility without anaesthesia. The birds are fixed upside down. One of the advantages of radiography is that it allows the identification of recent fractures and deformities in the dorsal aspect of the sternum that cannot be detected by palpation. Non-anesthetized hens can be positioned in the left lateral position by two assistants. One pulls the limbs caudally, and the other fixes the wings above the spine. The hen is positioned so that the sternum is at an angle to the X-rays (10).

Unlike palpation, radiographic examination allows the preservation of images and allows for evaluation of the finding by several observers or for direct comparison with radiographs from other studies. The detailed information obtained from the radiographic examination can be used as an aid to palpation training to improve the accurate and reliable detection of a bone fracture. The comparison of palpation directly with the corresponding X-rays was used successfully during training in sternum assessment at the University of Bern, where the accuracy of palpation was increased by 10% with the help of radiography (11).

The technique is limited because the created images are two-dimensional. In addition, repeated exposure to X-rays can be a potential hazard to the patient and the attending physician, but reasonable precautions can reduce this risk. However, the probability of this technique completely replacing palpation to assess sternal bone damage in laying hens is very small.

Ultrasound

Using high-frequency sound waves, sonography captures the reflection of sound from structures in the body, giving an image of different tissues. The main advantage is that the patient and the human operator are not exposed to radiation. This method is used to assess deformities in adult hens, but is not widely validated. The animals are fixed in a supine position, and the plumage in the area of the bone is removed. The transducer is moved along the ventral ridge of the bone in the sagittal plane and the resulting image is evaluated for the presence or absence of fractures. The biggest challenge in using ultrasound is determining the appropriate size and shape of the probe to best identify fractures. A 5-8 MHz probe was used (1). Another advantage is that this method is cheaper than radiography. The disadvantage is that the muscles in this area can affect the effectiveness of this technique.

CT

This research method provides an opportunity to perform 3D modeling of the sternum. Tomography uses a narrow beam with a low level of radiation, and a full scan can be performed in a few minutes. Depending on the size of the device used, several hens can be scanned at the same time. The test is performed on anesthetized animals. The results of two-dimensional images can be processed using software to create three-dimensional models of the sternum, which in turn can be used for additional calculations, such as average bulk density in each specific cross section of the bone (12). The resulting three-dimensional images have a very precise geometry. A major advantage of computed

tomography over the other methods described is that the three-dimensional image can be rotated in all planes (360 °) to identify minor fractures. Impairments that cannot be diagnosed by the methods listed above can be detected. As a disadvantage, it can be pointed out that this method is expensive and the equipment is not portable.

Dissection

An autopsy can provide very detailed information regarding the form and location of the lesions (13). A pathological examination can serve as a confirmation of lifelong diagnostic methods.

Severity evaluation

In medicine, the severity of a fracture is assessed by its location, morphological features such as its complexity, fragment displacement, treatment difficulty, and prognosis. Determining the severity is important because more serious injuries lead to higher levels of pain, which in turn disrupts the welfare of birds. Radiography is a sensitive method for determining the number and characteristics of fractures. The tagged visual analogue scale (tVAS) is an evaluation system using radiography methods and consists of two elements: six visual markers serving as a rough scaling tool (first step) and a catalogue of "sample values" with the help of which the tendency to a lower or higher value between two markers is specified (second step) (14).

tVAS is a 10 cm line marked with numbers from 0 to 5 at a distance of 2 cm. Each number corresponds to a certain degree of fracture, from 0 - "no fracture", to 5 - "extremely severe fracture". For each of the six markers, a sample X-ray image is provided **(Figure 1).**

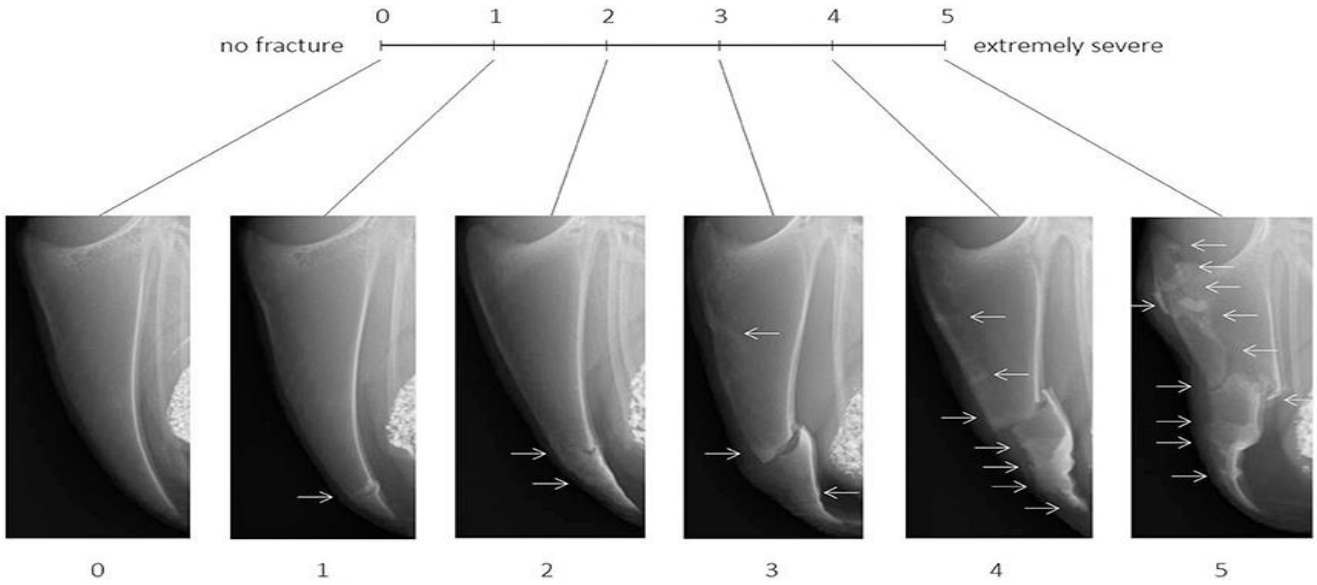

Figure 1. Tagged visual analogue scale ranging from 0 (no fracture) to 5 (extremely severe) with intermediate scores and corresponding example images. Arrows indicate the location of one or multiple fresh, healing, or healed fractures (14).

The first step in classification is to mark the location of this scale, which roughly corresponds to the severity of the damage. In addition to the classification tool thus described, Christina Rufener (14) also offers a catalog with multiple images for each of the six markers in order to better describe the scope of a given assessment. The need for multiple images for each assessment stems from the complexity of the injuries, especially in multiple fractures. Their number, location and other characteristics impose the need for a larger number of sample images falling into one category according to the scale. Thus, after initially categorizing the severity of a fracture - for example a score of 3, the catalogue gives 11 photos, ranging from a score of 2.5 to 3.49, which allows us to refine the score - for example 2.7.

Some author groups prefer palpation as a method of assessment in live birds. The overall accuracy of the estimates in large-scale studies suggests that this method would be appropriate for determining the prevalence of old lesions in laying hens (8). Casey-Trott (15) proposes a Simplified Keel Assessment Protocol (SKAP). This study addresses both fractures and

abnormalities, but as two separate, mutually exclusive categories. It is not known whether non-fractured bone abnormalities are associated with pain or affect the well-being of the animal, although they may weaken the bone structure, making it more susceptible to breakage. In other words, deformations have a direct effect on well-being, as well as indirectly contribute to the appearance of fractures **(Table 1).**

Table 1. *Prevalence of keel bone damage scored using the Simplified Keel Assessment Protocol (SKAP) with data from both palpation of live birds and visual assessment during dissection (n= 202). Absolute numbers as well as percentages of the total in parentheses are provided. (5)*

Assessing Keel Bone Damage by palpation Deviation				
		Yes	No	Total
Fracture	Yes	71 (35%)	35 (17%)	106 (52%)
	No	22 (11%)	74 (37%)	96 (48%)
	Total	93 (16%)	109 (54%)	202 (100%)

Assessing Keel Bone Damage by dissection Deviation				
		Yes	No	Total
Fracture	Yes	70 (35%)	43 (21%)	113 (56%)
	No	37 (18%)	52 (26%)	89 (48%)
	Total	107 (53%)	95 (47%)	202 (100%)

CONCLUSION

Palpation is the most widely used method of examination because it is easily accessible and inexpensive. In order for this method to be reliable, the researcher is required to have skills and experience. In addition, exercises that encourage visual-spatial thinking train the brain to use tactile skills more effectively to create a mental three-dimensional image and improve the researcher's ability to visualize the structure. (15)

Improvement of the palpation examination can be obtained by combining it with the methods of diagnostic imaging. In addition, these methods can serve to confirm the diagnosis by offering a thorough visualization of the sternum.

REFERENCES

1. Linnea M. Tracy, S. Mieko Temple, Darin C. Bennett, Kim A. Sprayberry, Maja M. Makagon and Richard A. Blatchford. The Reliability and Accuracy of Palpation, Radiography, and Sonography for the Detection of Keel Bone Damage. doi: 10.3390/ani9110894, 2019.
2. Buckner G.D., Insko W.M., Henry A.H., Wachs E.F. Rate of growth and calcification of the sternum of male and female New Hampshire chickens. *Poult. Sci.* 27:430–433. doi: 10.3382/ps.0270430, 1948.
3. Fleming, R. H., H. A. McCormack, L. McTeir, and C. C. Whitehead. Incidence, pathology and prevention of keel bone deformities in the laying hen. *Br. Poult. Sci.* 45:320–330, 2004.
4. Habig, C., and O. Distl. Evaluation of bone strength, keel bonestatus, plumage condition and egg quality of two layer lines keptin small group housing systems. *Br. Poult. Sci.* 54:413–24, 2013.
5. Casey-Trott T., Heerkens J. L. T., Petrik M., Regmi P., Schrader L., Toscano M. J., Widowski T. Methods for assessment of keel bone damage in poultry. *Poultry Science* 94:2339, 2015.
6. Petrik, M. T., M. T. Guerin, and T. M. Widowski. Keel fracture assessment of laying hens by palpation: inter-observer reliability and accuracy. *Vet. Rec.* 173:500, 2013.
7. Einhorn, T. A. The science of fracture healing. J. Orthop.Trauma 19:S4–S6, 2005.
8. Wilkins, L. J., S. N. Brown, P. H. Zimmerman, C. Leeb, and C. J.Nicol. Investigation of palpation as a method for determining the prevalence of keel and furculum damage in laying hens.*Vet. Rec*. 155:547–549, 2004.

9. Richards, G. J., M. A. Nasr, S. N. Brown, E. M. G. Szamocki, J. Murrell, F. Barr, and L. J. Wilkins. Use of radiography to identify keel bone fractures in laying hens and assess healing in live birds. *Vet. Rec*. 169:279, 2011
10. Beryl Katharina Eusemann, Ulrich Baulain, Lars Shrader, Christa Thöne-Reineke, Antonia Patt, Stefanie Petow. Radiographic examination of keel bone damage in living laying hens of different strains kept in two housing systems. doi: 10.1371/journal.pone.0194974, 2018
11. Gebhardt-Henrich, S. G., and E. Fröhlich. Laying rate and foot health influenced keel bone fractures in laying hens. in Proceedings of the 9th *European Symposium on Poultry Welfare.* Uppsala, Sweden., 2013.
12. Regmi, P., K. E. Anderson, and D. M. Karcher. Comparison of bone quality between strains and housing systems in end-of-lay hens. *Poult. Sci.* 92:83, 2013.
13. Wilkins, L. J., J. L. McKinstry, N. C. Avery, T. G. Knowles, S. N. Brown, J. Tarlton, and C. J. Nicol. Influence of housing system and design on bone strength and keel bone fractures in laying hens. *Vet. Rec.* 169:414, 2011.
14. Christina Rufener, Sarah Baur, Ariane Stratmann, Michael J. Toscano. A Reliable Method to Assess Keel Bone Fractures in Laying Hens From Radiographs Using a Tagged Visual Analogue Scale. doi: 10.3389/fvets.2018.00124, 2018.
15. Casey-Trott T.M., Guerin M.T., Sandilands V., Torrey S., Widowski T.M . Rearing system affects prevalence of keel-bone damage in laying hens: A longitudinal study of four consecutive flocks. *Poult. Sci.* 2017;96:2029–2039. doi: 10.3382/ps/pex026, 2017.